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Natural Resource Stewardship and Science

Focal Terrestrial Plant Communities Monitoring Protocol

Pacific Island Network

Natural Resource Report NPS/PACN/NRR—2011/410

ON THE COVER

The wet forest plant community at Kalaupapa National Historical Park, Molokai, Hawaiʻi, including the endangered species *Cyanea solenocalyx* in the foreground.

Photograph courtesy of Kalaupapa National Historical Park.

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Change History

Only changes in the protocol narrative will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) for major changes. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) for minor modifications.

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Executive Summary

This document describes a protocol to monitor five focal terrestrial plant communities in seven national parks within the Pacific Island Network (PACN). Plant communities are important to monitor for a variety of reasons: (a) they are key indicators of ecosystem health, (b) they represent essential habitat for other biotic vital signs (e.g., land birds, bats), (c) plant communities reflect the dynamic relationship between invasive plant species and native species, and (d) their status and trends help to shape management needs and to evaluate the effectiveness of previous management practices at the community level.

Of the many plant communities in PACN parks, scientists, and resource managers identified five plant communities to monitor based on relative intactness, distinct species compositions made up of endemic species with limited ranges, prevalence across parks, and usefulness as indicators of environmental change. These plant communities include: (1) wet forests found within Hawaiʻi Volcanoes National Park (HAVO), Haleakalā National Park (HALE), Kalaupapa National Historical Park (KALA), and the National Park of American Samoa (NPSA), (2) subalpine shrublands of HAVO and HALE, (3) coastal strand plant communities of KALA and Kaloko-Honokōhau National Historical Park (KAHO), (4) limestone forests of War in the Pacific National Park (WAPA), and (5) mangrove forests of American Memorial Park (AMME). These five plant communities overlay much of the habitat diversity found in PACN parks which encompass a wide range of ecosystems, climates, and topographic extremes across the Northern Mariana Islands, Hawaiʻi, American Samoa, and Guam.

To date, most vegetation studies in PACN parks have consisted of non-repeatable plant inventories used to describe and map the plant communities, or short-term monitoring associated with the control of nonnative ungulates, nonnative plants, or with restoration efforts. None of these studies were designed to detect specific levels of change over time at the park community level. This protocol takes a long-term systematic approach to monitor many of the major plant communities within parks in Hawaiʻi, American Samoa, and the Mariana Islands to assess the status and trends of plant community composition and structure at five-year intervals. Specifically, data will be collected on selected plant community parameters including native and nonnative plant species diversity, cover, density, frequency, and coarse woody debris.

This monitoring effort will provide park managers with new information that can be used to determine if current management actions are adequate to maintain the natural biological resources at acceptable levels. For example, if monitoring results indicate a significant increase in the number of or cover of invasive species, additional efforts may need to be taken to reduce these impacts. Similarly, if the data show that native species are being maintained or increasing relative to ungulate control and invasive species are decreasing, it may be possible to reduce active nonnative plant control within those management units. Additionally, monitoring will provide a temporal baseline that can be used to assess impacts and recovery potential relative to major landscape events such as fire, drought, hurricanes, and global climate change.

Each park will be surveyed once every five years, on a rotating basis, by a team of scientists and technicians who will measure a variety of plant community parameters from a set of randomly

located plots. Both fixed (permanent) and rotational (temporary) plots will be surveyed using a split panel design. This design allows for the use of permanent, fixed panel plots to detect temporal changes and temporary, rotational panel plots to assess status as well as increase spatial sampling over time. Together permanent and temporary plots provide greater ecological and statistical inference than either method alone. After each field season, the project lead will analyze that year's data and produce an annual report. After each five-year cycle, when all parks and plant communities have been surveyed, the project lead will produce a more comprehensive report focusing on broader spatial and temporal trends in the data for all parks surveyed.

This protocol contains three broad sections. The first section consists of a protocol narrative divided into seven chapters that cover the protocol's background, rationale, sampling design, methods, data management, personnel requirements, and operational needs. Following the narrative are several appendices that provide supplemental information for the narrative. Lastly, the protocol has twenty-three standard operating procedures that provide step-by-step details on how to carry out various tasks and procedures within the protocol.

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Acronyms

AMME	American Memorial National Historical Park
ANOVA	Analysis of Variance
COLA	Cost of living allowance
DEM	Digital Elevation Model
DNR	Department of Natural Resources
DBH	Diameter at Breast Height
FGDC	Federal Geographic Data Committee
FP	Fixed Panel
FPC	Finite Population Correction
FOIA	Freedom of Information Act
FMH	Fire Monitoring Handbook
GIS	Geographic Information System
GPS	Global Positioning System
GzLM	Generalized Linear Model
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
MS	Microsoft
NPS	National Park Service
NPSA	National Park of American Samoa
P/A	Presence/Absence
PACN	Pacific Island Network
PCSU	Pacific Cooperative Studies Unit
PDA	Personal Digital Assistant
PPS	Probability Proportional to Size sampling
QA/QC	Quality Assurance / Quality Control
RP	Rotational Panel
SOP	Standard Operating Procedure
SRS	Simple Random Sampling
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WAPA	War in the Pacific National Historical Park

Chapter 1: Background and Objectives

This protocol provides the rationale and methodology for monitoring plant communities in the National Park Service's Pacific Island Network (PACN) parks. Plant communities are important to monitor for a variety of reasons: (a) they are key indicators of ecosystem health (Peet 1992), (b) they represent essential habitat for other biotic vital signs (e.g., land birds, bats), (c) plant communities reflect the dynamic relationship between invasive plant species and native species (Walker and Smith 1997), and (d) information on their status and trends helps managers prioritize management needs and to evaluate the effectiveness of previous management practices at the community level (Elzinga et al. 2001). Invasive plant species are one of the overriding threats and biological resource management issues in most of the PACN parks. Habitat fragmentation, climate change, and catastrophic disturbance such as hurricanes and fire also may alter the composition and structure of these island plant communities (Cuddihy and Stone 1990, D'Antonio and Vitousek 1992). Trends within plant communities allow scientists and resource managers to evaluate how present conditions compare with the historical conditions and desired future condition of the vegetation.

National parks provide important reference levels in environmental monitoring in that they often include relatively intact ecosystems compared to adjacent habitats that may be highly altered by human impacts. Changes in species composition and community or stand structure may be indicators of changing physical (e.g., soil, hydrology, nutrient processes) and biological conditions (e.g., invasive plants, animals, insects, and disease). Analysis of trends of basic plant community level parameters, such as cover and density, can be used as the basis for developing predictive models to determine the future outcomes of plants, communities, and ecosystems. These models enable park managers to assess and modify management practices, as needed, and to ensure the long-term persistence of native ecosystems.

System of Interest

PACN parks encompass a diverse array of national parks, historical parks, memorial parks, and a historic trail that span a wide range of plant communities, ecosystems and topographic extremes across the Northern Mariana Islands, Hawai‘i, American Samoa, and Guam. The parks within the PACN network initially identified their focal plant communities in Phase II of the PACN Monitoring Plan (HaySmith et al. 2006), based on relative intactness, distinct species compositions made up of endemic species with limited ranges (Price 2004), usefulness as indicators of ecosystem change, and prevalence across the different parks. These communities included wet forest/cloud forest in Hawai‘i Volcanoes National Park (HAVO), Haleakalā National Park (HALE), Kalaupapa National Historical Park (KALA), and the National Park of American Samoa (NPSA), and subalpine/alpine communities in HAVO and HALE. The network parks also identified plant communities unique to their areas, such as limestone forest and savannas at War in the Pacific National Historical Park (WAPA), mesic forest at HALE and HAVO, wet summit shrub community at NPSA, lava flow/kipuka mosaics at HAVO, selected coastal communities at Kaloko-Honokōhau (KAHO), KALA, and HAVO, montane bogs at HALE, and wetland and mangrove communities at American Memorial National Historical Park (AMME).

Due to fiscal and logistical constraints only a subset of these focal terrestrial plant communities across the network has been selected for monitoring. For each of the PACN parks, the primary focal plant communities to monitor were identified by PACN park resources managers, assisted by a team of Pacific based U.S. Geological Survey (USGS) scientists. The criteria used for selection were the same criteria used in Phase II of the PACN 2005 Monitoring Plan (relative intactness, distinct species compositions made up of endemic species with limited ranges , usefulness as indicators of ecosystem change, prevalence across the different parks, and uniqueness to their areas) and were evaluated based on site visits and literature reviews. In the end, five focal communities were selected for long-term monitoring: (1) wet forest plant communities found in HAVO, HALE, KALA, and NPSA; (2) subalpine shrublands of HAVO and HALE; (3) coastal strand plant communities of KALA and KAHO; (4) limestone forests of WAPA; and (5) mangrove forests of AMME. These five plant communities include much of the diversity found in PACN parks which encompass a wide range of ecosystems, climates, and topographic extremes some of which are found nowhere else in the National Park system.

Other Vegetation Monitoring Efforts Past and Present

Many different sampling approaches have been used to quantify the status and trends of vegetation, and at least four different standardized monitoring programs have been implemented in the Pacific Region during the past ten years (table 1.1). A plant community is typically characterized by composition (i.e., what species are present) and structure (Mueller-Dombois and Ellenberg 1974, Elzinga et al. 2001). Community structure data include the vertical stratification of the vegetation in layers and a measure of canopy cover, abundance (e.g., density), or biomass for each species by layer. The monitoring protocols from these existing programs were examined because they were designed to measure these vegetation attributes. The use of these earlier protocols as a starting point also allows for comparison and synthesis of data at multiple scales, directly pertinent to developing the PACN Focal Plant Terrestrial Communities Monitoring Protocol.

Table 1.1. Vegetation monitoring protocols implemented and associated vegetation attributes measured in the Pacific Region during the past ten years.

Monitoring Protocol Source	Agency	Location	Measured Vegetation Attributes		
			Presence	*Cover*	*Density*
Fire Monitoring Handbook (NPS 2003)	NPS	Hawaii	All Species	Point-intercept	Trees and Shrubs
Forest Inventory and Analysis for the Pacific Region (USDA Forest Service 2005)	USFS	American Samoa, Guam		Ocular estimate (nearest %)	Trees (>42 cm ht)
Dunn Protocol (Dunn 1992)	State of Hawai‘i	Hawaii	All Species	Ocular estimate (Braun-Blanquet)	Trees (>5 m ht)
Makua Implementation Plan (US Army Garrison 2003)	DOD	Hawaii	All Species	Pole-intercept	Trees and Shrubs

The techniques used to estimate vegetation composition and structure in a community should be tied directly to the monitoring objectives but may be limited by logistical constraints and often

influenced by legacy protocols. It is not surprising that the four previously developed protocols differ in which attributes are measured and what data collection techniques are used since these protocols were developed to meet a variety of monitoring objectives. For example, trees are more intensely sampled than understory species in the Forest Inventory and Analysis Protocol (USDA Forest Service 2005) which was developed by the U.S. Forest Service to quantify the distribution and health of forests with emphasis on trees. In contrast, the Fire Monitoring Handbook (FMH) (NPS 2003) and Implementation Plan for Makua Military Reservation (US Army Garrison 2003) protocols include techniques for all plant life forms. The Makua monitoring protocol was designed primarily to allow the military to assess the status and stability of 28 target plant taxa and their habitats as they may potentially be impacted by Army training activities. The Army Natural Resources staff started establishing plant community monitoring plots for the Makua protocol in 2008. The FMH protocol is a guide to provide park resource and fire manager's potential strategies to sample vegetation recovery following fire, but few plots have been installed in the PACN parks to date. The Dunn Protocol (Dunn 1992) provides a design for collecting detailed data on both vegetation layers and species cover. It was implemented partially by some organizations such as the State of Hawaii Natural Area Reserve System (NARS) and the Nature Conservancy. However, neither program has ever had a large enough budget or the required resources to implement this protocol fully. Few benefits would be realized by directly adopting any of these established protocols for the National Park Service (NPS) Inventory & Monitoring Program (I&M) because most do not adequately sample all plant life forms, all lack detailed data analysis and processing techniques, and few have historical plots and data for comparison. Nonetheless, many of the basic methods used in these earlier protocols represent standard vegetation sampling techniques and have been adapted or modified for the current PACN community monitoring effort. NPS I&M developed this plant community protocol to fit within its proposed I&M budget and with the hope of avoiding some of the implementation difficulties of prior monitoring efforts.

Protocol Objectives

This protocol takes a long-term systematic approach to monitor many of the major plant communities within parks in Hawaii, American Samoa, and the Mariana Islands to assess status and trends of plant community composition and structure at five-year intervals. Two kinds of objectives are met by this protocol.

Monitoring Objective: Determine the status and trends in plant community composition and structure at five-year intervals in the five focal plant communities identified at PACN parks. Specifically, plant community composition and structure will be assessed in terms of vascular plant species diversity, understory cover (at two different structural layers), species density (of woody species by height or size class), species distribution frequency, and coarse woody debris.

Sampling Objective: 80% probability of detecting 25% change over a 25 year period, with 10% Type I (false change) error for the selected vegetation variables. This objective drives the parameters of the sampling design (Chapter 2).

Management Significance

This monitoring effort will provide park managers with new information on the condition of park resources. The status of key vegetation community parameters within entire focal communities

in parks as opposed to only sites where current management is occurring will aid managers in the prioritization of management resources. These data can be used to determine if management actions are adequate to maintain the natural biological resources at acceptable levels relative to historical baselines and to future conditions as they may be modified by global climate change. For example, if monitoring results indicate a significant increase in the number of or, cover of, invasive species, additional efforts may need to be taken to reduce these impacts. Similarly, if the data show that native species are being maintained or are increasing relative to ungulate control and invasive species are decreasing, it may be possible to redirect some management resources to other priority actions. Additionally, monitoring will provide a temporal baseline that can be used to assess impacts and recovery potential relative to major landscape events such as fire, drought, hurricanes, and global climate change.

Relationship to Other I&M Protocols in the PACN

The Focal Terrestrial Plant Communities Protocol and the Established Invasive Plant Species Monitoring Protocol (Ainsworth et al. *In Prep*) will be implemented by the same I&M personnel including the botanist who serves as the project lead for both projects, the field leader, and field crew biological technicians. By sharing personnel between these two protocols, NPS I&M will be able to minimize hiring, training, and travel costs since the field crews for these two protocols require overlapping knowledge and botanical skills. Much of the remote field work for both protocols (e.g., in AMME or NPSA) can be done quickly and efficiently by one field crew on one trip.

The Focal Plant Communities Protocol has also been developed, as much as possible, to use the same transects and access routes as the PACN Landbirds Protocol (Camp et al. 2011). Both protocols conduct a substantial amount of monitoring in relatively inaccessible wet forest environments. Thus, using the same transects to access plant community plots and Landbird stations reduces logistical requirements (e.g., establishing fixed and random transects, helicopter support), limits site impacts, and minimizes the potential for accidental introductions of nonnative species into remote areas. Transects used for the Established Invasive Plant Species Monitoring Protocol (Ainsworth et al. *In Prep*) also will be co-located with monitoring transects for the Plant Communities and Landbirds Protocols as much as possible.

Chapter 2: Sampling Design

The proposed monitoring study aims to describe the status of focal plant communities and their long term trends over time. The objective is to detect a moderate change (25%) in all vegetation parameters over 25 years at 80% power. In order to accomplish these goals the PACN focal plant community protocol utilizes a split panel design with both fixed and rotational plots. This design allows for the use of fixed plots to estimate trends and rotational plots to estimate status and increase spatial coverage across the sampling frame. Together the fixed and rotational panels are well-suited for both status and trend analysis, providing a design compromise that works better than either method alone (Skalski 2005).

Background and Rationale for Selecting this Sampling Design

Many different sampling approaches have been used to quantify the status and trends of vegetation including the standardized monitoring programs described in Chapter 1 (table 1.1) and many smaller monitoring studies conducted on some of the focal plant communities within PACN parks. Most focal community studies were short term studies associated with the control of nonnative ungulates, nonnative plants, or restoration efforts (Appendix B, table B.2). Inventories have also been performed in support of vegetation mapping, though scale of the resulting maps as well as methods vary between studies (Appendix B, table B.1). None of these studies were designed to detect specific levels of change over time, and statistical inference is generally limited to the area sampled. Despite these limitations, many of these past studies were useful in designing this monitoring protocol because they provided estimates of variance and precision for select vegetation parameters (Appendix C “Precision, Power, and Sample Size”).

Most previous studies occurred in the wet forest community. At HAVO a combination of reports (Cuddihy et al. 1986, Pratt et al. 1986, Loh and Tunison 1999, Ainsworth 2007) and raw data (Loh 1994, 1997) from previous studies provided estimates of vegetation parameters for sections of ‘Ōla‘a, Thurston, and East Rift wet forests, while at HALE a study by Yoshinaga (1977) provided information on vegetation parameters. A study by Whistler (1995) provided data on tree composition and structure in wet forests of Tutuila and Tau in NPSA. Another series of studies in NPSA examined the effects of topography, site age, and substrate on the diversity, structure, and succession stages of the wet forests of Tutuila and Tau (Webb and Fa'aumu 1999, Webb et al. 1999, Webb et al. 2006). Although the data from Webb and his co-researchers provide estimates for many vegetation parameters, their studies do not span multiple time periods to allow for trend analysis.

The studies listed above and in Appendix B provide critical insight and rationale for the sampling design of this protocol. For example, previous wet forest studies such as the ‘Ōla‘a study by Loh and Tunison (1999) use square plots (10 x 10 m) whereas this protocol will use larger rectangular plots (20 x 50 m) to try to capture variance within plots rather than between plots. Another example of the influence of prior studies is the decision to stratify the KALA coastal community. The rationale for this decision was a direct result of the different variance estimates for parameters from the clay and crushed coral substrates (Medeiros 1997, Trainer et al. 2001). In the following sections, the sampling design as well as the rationale behind the design is described in greater detail.

Site Selection

Target Population

The target populations for this monitoring protocol are five terrestrial plant communities found in seven PACN parks: wet forest, subalpine shrubland, coastal, limestone forest, and mangrove forest (table 2.1). These five focal communities represent discrete plant assemblages identified from a continuum of possible communities. Inferences based on this protocol are limited to the five target communities defined above as opposed to entire parks. However it is presumed that monitoring these five communities will allow park managers to detect major changes in their parks since these communities are large, integral components of each park's vegetation.

Table 2.1. Number of sampling frames for each focal plant community and park.

Focal Plant Community	HAVO	KAHO	HALE	KALA	NPSA	WAPA	AMME
Wet Forest	3		1	1	2		
Subalpine Shrubland	1		1				
Coastal		1		2			
Limestone Forest						1	
Mangrove Forest							1

In terms of specific communities, the wet forest constitutes the largest relatively intact land areas in the PACN network and varies in substrate age, topography, and dominant species both within and across parks. In Hawaii (HAVO, HALE, and KALA) the wet forests consist of tree fern dominated forests as well as cloud forest and transitional mesic-wet forests. In Samoa (NPSA), the wet forest dominates the terrestrial area of the park on Tutuila and Tau islands. Wet forests in the PACN greatly contribute to watershed integrity and contain substantial species diversity including many rare and endangered plants and animals. The subalpine shrubland was identified as a focal plant community at HAVO and HALE where changes in treeline may reflect changing climatic conditions associated with the height and consistency of the thermal inversion layer. The coastal strand community at KALA and KAHO represents intact coastal vegetation communities in the Hawaiian Islands. The limestone forest of WAPA and the mangrove forest of AMME are small and largely relict fragments, containing much of the terrestrial native species diversity (both plants and animals) remaining in these parks.

In order to accurately determine the status and trends of a focal community, it is important to include the full extent of a plant community (i.e., regions that have been disturbed as well as those that are intact, regions on the community edge as well as regions at the core, etc.). A few of the difficulties inherent in defining plant community extent include the following: (1) unclear boundaries between plant communities, (2) continuous rather than clearly delineated environmental conditions (e.g., gradation of wet to mesic conditions), and (3) shifting plant community boundaries that continually respond to restoration, management, species invasions, natural disturbance, and climate change. The extent of each focal plant community was defined by substrate and climatic criteria that remain relatively stable over time rather than existing plant community boundaries which tend to reflect recent events such as fires or hurricanes. Although substrate and climate do change over time, the temporal scale of these changes is generally decades and centuries; thus given the time horizon of this protocol, it was considered appropriate

to use these criteria to limit and define the geographic extent of each community. For example, the wet forest at HAVO was delineated based on moisture availability indices (i.e., median annual rainfall minus potential evapotranspiration) and substrate (Price et al. 2007), rather than on current vegetation patterns that reflect recent fires, disease outbreaks, and nonnative species invasions.

Sampling Frame

The focal terrestrial plant communities sampling frames—the portion of the population to which sampling is limited—include all safely accessible (<100% [45°] slope) land area within each defined community. Multiple sampling frames are necessary for some focal plant communities where park units and/or plant communities exhibit marked differences in environmental variables (table 2.1). For HAVO the wet forest community is stratified into three sampling frames (‘Ōla‘a, Thurston/East Rift and Kahuku) based on differences in geographic location and substrate age. The diverse wet forest community at NPSA was also stratified into two noncontiguous sampling frames, one for each island being monitored (Tutuila and Tau). The coastal plant community at KALA was stratified into two sampling frames based on substrate. Unlike the wet forest stratification, these frames are contiguous. Two frames are appropriate in this community because variance estimates for community parameters generated from transect survey raw data (Medeiros 1997, Trainer et al. 2001) differed greatly between clay and sand/crushed coral substrates (Appendix C “Precision, Power, and Sample Size”).

For many of the communities, past inventories and studies were of limited use in distinguishing sampling frames and until additional data are generated these communities are each treated as single sampling frames. These communities include: KALA and HALE wet forest, HALE and HAVO subalpine shrublands, KAHO coastal, WAPA limestone forest, and AMME mangrove forest. Sampling frames for each focal plant community and park are listed in Table 2.1 and graphically displayed in Appendix A “Target Populations and Sampling Frames.”

Sampling Units

The sampling unit for monitoring the status and trends of focal terrestrial plant communities is the rectangular sampling plot. Among previous PACN plant community studies, plot configuration varies depending on the monitoring objectives, vegetation community, and legacy data (Appendix B “Vegetation Monitoring in PACN Park Units”). Because plant populations tend to be aggregated or clumped on the landscape, rectangular plots are more likely to include both clumps and gaps for most species (Elzinga et al. 2001). This allows sampling to capture variability within the plot as opposed to between plots. As a result, rectangular plots yield more precise estimates of vegetation attributes than circular or square plots of the same size (e.g., Mueller-Dombois and Ellenberg 1974, Elzinga et al. 2001). Additionally, rectangular plots are relatively easy to establish in the field. Because of their greater perimeters, rectangular plots do have a higher risk of over- or under-counting individuals along plot edges than do circular or square plots. However, well defined boundary decision criteria limit these risks (see SOP#8 “Conducting Community Vegetation Surveys”).

Plot dimensions vary between communities in order to adequately capture the diversity of plant life forms. For the shrubland and three forest communities, plot dimensions are 20 x 50 m while the dimensions for the coastal strand are 10 x 20 m (figs. 2.1, 2.2). Each plot contains nested

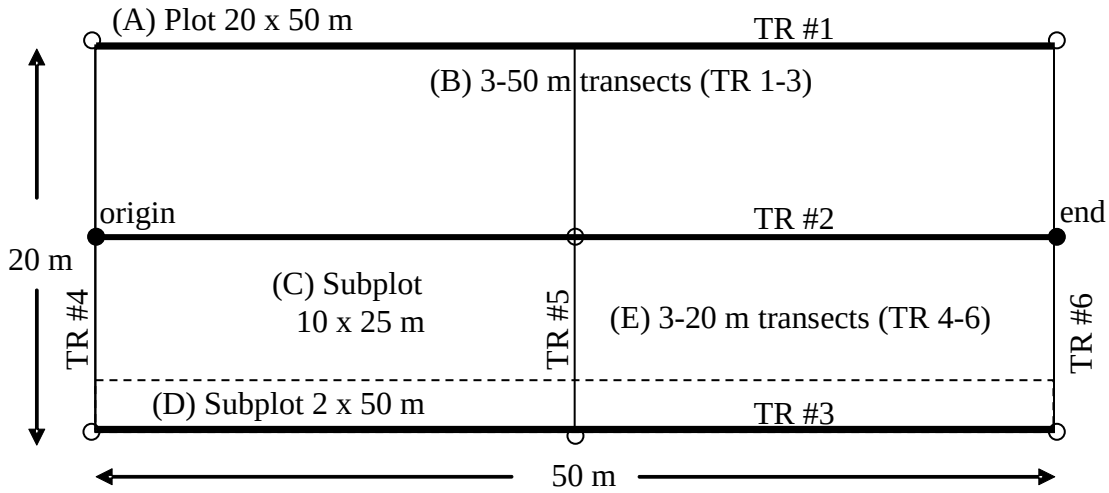

Figure 2.1. Wet forest, subalpine shrubland, limestone forest, and mangrove forest sampling plot layout used to quantify vegetation composition and structure. (A) Species presence and large tree species density are read in the 20 x 50 m plot. (B) Plant species cover is recorded in two height layers (<1 m and 1-2 m) every 0.5 m along three 50 m transects. When standing at the origin facing the plot, TR 1 (points 1-100) is located to the left, TR 2 (points 101-200) in the center, and TR 3 (points 201-300) to the right. (C) Small tree and large tree fern density are measured in the 10 x 25 m subplot which lies between TRs 2 and 3 from the 0 m mark to the 25 m mark. (D) Tree seedling and small tree fern densities are recorded in the 2 x 50 m subplot which is read along the inside of Transect 3 from the 0 m mark to the 50 m mark. (E) Dead downed wood and tree fern logs (≥7.6 cm) are quantified along the 50 m centerline (TR 2) and two 20 m end lines (TR 4 and TR 6).

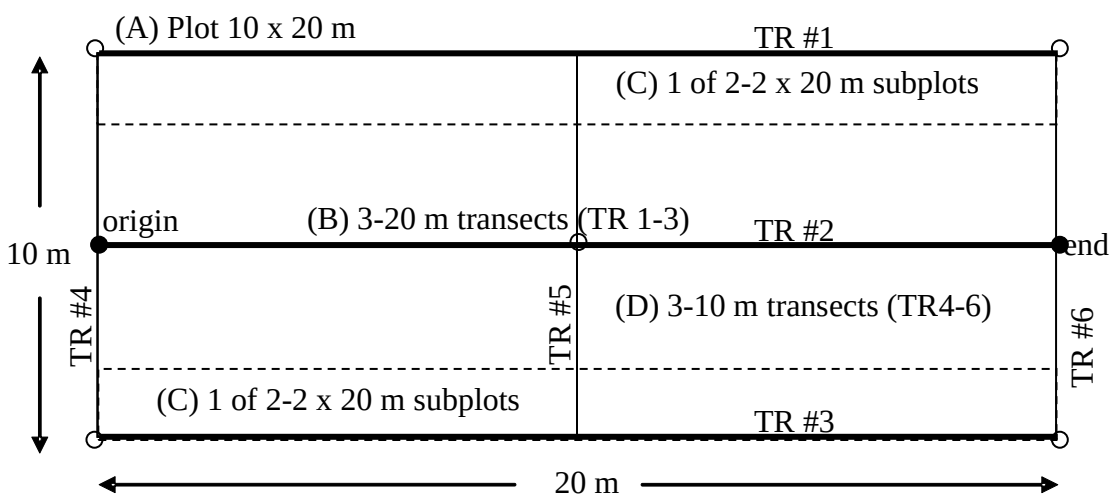

Figure 2.2. Coastal communities sampling plot layout used to quantify vegetation composition and structure. (A) Species presence and large tree density will be recorded in the entire 10 x 20 m plot. (B) Plant species cover will be recorded in two height layers (<1 m and 1-2 m) every 0.2 m along three 20 m transects. When standing at the origin facing the plot, TR 1 (points 1-100) is located to the left, TR 2 (points 101-200) in the center, and TR 3 (points 201-300) to the right. (C) Small tree, tree seedling, and shrub densities are read within two 2 x 20 m subplots which lie along the inside lengths of TRs 1 and 3 from 0 m to 20 m. (D) Dead downed wood (≥7.6 cm) is quantified along the 20 m centerline (TR 2) and the two 10 m end lines (TR 4 and TR 6).

subplots while edges of the plots and subplots serve as transects. The use of nested subplots and transects allow different plant life forms to be sampled in the same location without grossly oversampling (e.g., Mueller-Dombois and Ellenberg 1974, Elzinga et al. 2001). Organisms such as large trees and snags that are relatively sparse on the landscape are sampled in larger plots and more abundant plant life forms and age classes such as tree seedlings, herbs, and shrubs are sampled in smaller subplots. The sizes of plots and subplots are based on variance around the mean estimates from previous wet forest studies (Appendix C "Precision, Power, and Sample Size") and generally correspond to NPS's Fire Monitoring Handbook (2003). This design greatly increases field efficiency yet provides an adequate sample size for a maximum number of parameters. As more data become available for these communities, plot and subplot size will be reevaluated if the precision and coefficients of variation differ greatly from the values found in prior wet forest studies.

Many vegetation parameters are assessed in each plot in order to adequately quantify plant species composition and structure. The full list of parameters that will be measured is provided in Table 2.2. Greater detail regarding plot layout and sampling techniques is provided in Standard Operating Procedure (SOP) #8 "Conducting Community Vegetation Surveys."

Table 2.2 Sampling methods and summary statistics for each parameter collected during focal plant community monitoring. Sample unit dimensions differ between communities (F = forest, S = shrubland, C = coastal). Refer to Figures 2.1 and 2.2 for sampling plot layout.

Parameter	Sampling Method	Sample Unit Dimensions	Summary Statistics
Species Presence/ Absence	All plant species in plot	F/S = 20 x 50 m C = 10 x 20 m	Species richness % flowering/ fruiting Diversity Frequency
Understory Cover	Pole-intercept along 3 transects	F/S = every 0.5 m, 50 m transects C = every 0.2 m, 20 m transects	% cover by species and life form in structural tiers (<1 m and 1-2 m)
Substrate Type	Pole-intercept along 3 transects	F/S = every 0.5 m, 50 m transects C = every 0.2 m, 20 m transects	% cover by substrate type
Large Trees (≥10 cm DBH)	Density in plot	F/S = 20 x 50 m C = 10 x 20 m	Large trees/ ha (combined and by species) Diameter at Breast Height (DBH) Number of boles/ tree % of trees/ vigor class % of trees flowering/ fruiting % trees/ rooting height class Volume of root sprouts
Large Snags (≥10 cm DBH)	Density in plot	F/S = 20 x 50 m C = 10 x 20 m	Snags/ ha DBH Height
Tree Canopy Height	Measure five trees	F/S= 20 x 50 m C = 10 x 20 m	Canopy height

Table 2.2 Sampling methods and summary statistics for each parameter collected during focal plant community monitoring. Sample unit dimensions differ between communities (F = forest, S = shrubland, C = coastal). Refer to Figures 2.1 and 2.2 for sampling plot layout. (Continued)

Parameter	Sampling Method	Sample Unit Dimensions	Summary Statistics
Large Tree Ferns (≥10 cm diam)	Density in plot	F = 10 x 25 m	Large tree ferns/ ha Diameter % tree ferns/ rooting height class % tree ferns/ foliar height class Stem length
Large Dead Tree Ferns (≥10 cm diam)	Density in plot	F = 10 x 25 m	Large dead tree ferns/ ha Diameter Stem length
Small Trees (<10 cm DBH)	Density in subplot(s)	F = 10 x 25 m S = 20 x 50 m C = 2 - 2 x 20 m	Small trees/ ha (combined and by species) DBH category % trees/ rooting height class
Small Snags (<10 cm DBH)	Density in subplot(s)	F = 10 x 25 m S = 20 x 50 m C = 2 - 2 x 20 m	Snags/ ha DBH Height
Small Tree Ferns (<10 cm DBH)	Density in subplot	F = 2 x 50 m	Small tree ferns/ ha (combined and by species) Living status % tree ferns/ rooting height class % tree ferns/ foliar height class
Small Dead Tree Ferns (<10 cm DBH)	Density in subplot	F = 2 x 50 m	Small dead tree ferns/ ha % tree ferns/ rooting height class
Tree Seedlings (≥0.5 m <1 cm DBH)	Density in subplot(s)	F/S = 2 x 50 m C = 2 - 2 x 20 m	Tree seedlings/ ha (combined and by species) Living status % tree seedlings/ rooting height class % tree seedlings/ foliar height class
Shrubs (≥0.5 m)	Density in subplot(s)	F/S = 2 x 50 m C = 2 - 2 x 20 m	Shrubs/ ha (combined and by species) Living status % shrubs/ rooting height class % shrubs/ foliar height class
Down Dead Wood (≥7.6 cm)	Planar-intercept	F/S = 90 m C = 40 m	Woody logs/ ha DBH % woody logs/ decay class
Down Dead Tree Ferns (≥7.6 cm)	Planar-intercept	F/S = 90 m C = 40 m	Tree fern logs/ ha Diameter % tree fern logs/ decay class

Procedures for Selecting Sampling Locations (Spatial Design)

The focal terrestrial plant communities spatial sampling design ensures that sampling units or plots are (1) randomly located within the sampling frame and (2) are well interspersed throughout the sampling frame. For each sampled community, the zone of inference is the

sampling frame. This level of inference is justified since the plot selection process is unbiased and ensures that samples can be drawn from anywhere within the delineated sampling frame.

Several spatial sampling methods were considered for this protocol including: stratified, cluster, and Generalized Random Tessellation Stratified (GRTS) sampling (DeBacker et al. 2005). Stratified and cluster sampling involve dividing the population into subgroups prior to sampling. In the absence of long-term monitoring results from the focal plant communities, further stratification (beyond the stratification previously detailed for selecting communities or for dividing target populations into multiple sampling frames) or cluster sampling methods were deemed unnecessary or inappropriate. As data become available from this protocol after several sampling cycles, vegetation parameters in some communities may be found to exhibit different responses to clearly definable habitat features (e.g., ridge top versus valley bottom in wet forest at NPSA), at which point further stratification of some sampling frames may be considered. The GRTS system combines aspects of both Simple Random Sampling (SRS) and stratified sampling in that plots are randomly distributed yet spatially balanced. The largest drawback of GRTS for this protocol is that it is difficult to implement in terrain that has limited access as is the case for many of the focal plant communities within the PACN. In order to accommodate differences in sampling frame size, complexity and accessibility, as well as differences in existing transects, SRS, Probability Proportional to Size (PPS) stratified random sampling, and transect-based stratified random sampling techniques were used. These strategies ensure that every point within the sampling frame has an equal probability of being selected for plot establishment.

Simple Random Sampling (SRS)

For the coastal strand and mangrove forest communities a SRS design is used to establish plots within sampling frames. This design represents the simplest kind of random sampling and works for these sampling frames because they are relatively accessible and each frame is a single contiguous spatial unit (Elzinga et al. 2001).

Probability Proportional to Size (PPS) Stratified Random Sampling

For the subalpine shrubland and limestone forest communities a PPS design is used to ensure interspersion or adequate spatial coverage of sampling plots across the sampling frame extent. The sampling frames for these communities consist of noncontiguous units. These irregularly shaped frames were subdivided into zones and then weighted by zone area. Unlike the process of stratifying select target populations into multiple sampling frames (e.g., KALA coastal), subdividing the frame into zones is based on geographic discontinuities within sampling frames as opposed to substrate or environmental differences. For example, the limestone forest sampling frame for WAPA consists of four zones where each zone is a small independent park unit (Appendix A “Target Populations and Sampling Frames”). Due to the importance of each unit, it is imperative that at least one plot is located within each zone or unit. Consequently the number of plots selected in each of the four units is proportional to the area of each unit; in this manner, no park unit is excluded from sampling. Similarly, the subalpine shrubland sample frame for HAVO consists of four zones separated by recent lava flows, state, and private land owners.

For the SRS and PPS designs plot locations are generated randomly for each sampling frame using ArcGIS® 9.3 and the extension Hawth’s Tools. In order to screen out infeasible locations, buffer restrictions are applied to existing fixed plots and rotational plots, sampling frame boundaries, roads, trails, streams, coastlines, cultural features, and other unrepresentative

features. Additionally, sites with extreme slopes (>100%) are excluded. SOP #5 "Generating Sampling Point Locations with GIS" details the plot selection procedure for each sampling frame, while Appendix A presents maps and tables of the plots.

Transect-Based Stratified Random Sampling

For the wet forest communities, a transect-based stratified random sampling design is used to establish plots within each sampling frame. Unlike the previously described designs, transect-based stratified random sampling uses a series of random transects on which plots are placed at random. Since transects can occur anywhere within the sampling frame, plots along these transects have an equal probability of being located anywhere within the sampling frame. Thus the level of inference for transect-based stratified random sampling is the entire sampling frame rather than the transect.

In this protocol two types of transects are used: (1) newly established transects and (2) existing legacy transects. Where applicable, transects are shared with the Landbirds Protocol (Camp et al. 2011) and the Established Invasive Plant Species Protocol (Ainsworth et al. *In Prep*). New transects are generated in ArcGIS® 9.3 using the Hawth's Tools extension. These transects have a random starting point and azimuth and extend up to 1500 m within the sampling frame unless the transect traverses impassable terrain or reaches a sampling frame boundary. Transects less than 600 m in length are discarded because it is not practical to access and sample isolated plots in the wet forest community. All newly established transects are divided into stations (at 150 m intervals) that serve as Landbirds sampling stations where applicable and act as a pool from which plant community sampling plots are selected. All stations are pooled within the sampling frame prior to random selection; thus the selected plots are not distributed equally across transects. Additional constraints on transect generation are applied to the Kahuku frame at HAVO and the wet forest frame at HALE. The Kahuku frame consists of two discontiguous units that are divided into zones and weighted by area, ensuring that plots occur in each zone in proportion to area. For the HALE wet forest, in order to limit disturbance and nonnative species introductions newly established transects must intersect existing "access corridors." This procedure introduces a potential bias because not all locations can intersect existing corridors; however, this bias was assessed in the Landbirds Protocol and found to be acceptably low (Camp et al. 2011). Detailed procedures for establishing new transects within each sampling frame are available in SOP #5 "Generating Sampling Point Locations with GIS."

Legacy transects used to sample birds and their habitats exist in many PACN parks (e.g., HALE, HAVO, KALA, and NPSA). These transects were established with a random starting point and follow a systematic layout that is unbiased with respect to topographic features (Scott et al. 1986). Thus, since these legacy transects use probabilistic sampling, inference can be made to the entire sampling frame. For HALE, HAVO, and NPSA, this protocol uses a random subset of these legacy transects as fixed transects. For KALA, where legacy transects appear to exhibit a bias towards ridge locations, new fixed transects were generated to ensure a probabilistic design. Using legacy transects limits the area of disturbance within the wet forest and reduces the potential for widespread nonnative species introductions.

Modified SRS similar to this protocol's transect-based stratified random sampling has been shown to outperform SRS in terms of precision for larger sampling frames where vegetation density tends to be clumped (Elzinga et al. 2001). This type of design ensures adequate spatial

coverage across these large frames, increases field sampling efficiency by reducing travel and access difficulties, and incorporates transect locations from previous and on-going studies (such as for collocation with the PACN Protocols for landbirds (Camp et al. 2011) and established invasive species (Ainsworth et al. *In Prep*). Additionally, shared transects allow for coordination and data sharing among programs and limit the potential for invasive species introductions by multiple monitoring teams.

Sampling Frequency and Replication (Temporal Design)

Plant communities vary in space and time and are therefore sampled using a split panel design (McDonald 2003) with two panels: (1) permanent plots that are reread each sampling event (fixed panel plots) and (2) temporary plots that are visited only once (rotational panel plots) (tables 2.3 and 2.4). This design allows for the use of fixed plots to detect temporal changes and rotational plots to assess status and increase spatial coverage over time. Sampling new plots each period minimizes the bias in estimates of status and updates prior estimates through time series calculations (Skalski 1990). Appendix A "Target Populations and Sampling Frames" lists the number of fixed and rotational plots for each sampling frame and displays maps of plot locations for each sampling frame.

For the wet forest and subalpine shrubland sampling frames, half of the plots are fixed (n = 15) and half are rotational (n = 15) during each sampling event (table 2.3). The recommended sample size of 30 plots per sampling frame is based on the results of previous studies (Appendix C "Precision, Power and Sample Size") and the maximum of what I&M and the parks can feasibly survey during a sampling year due to logistical and financial constraints. Exceptions include the limestone forest and coastal communities which are small enough to be covered adequately by ten fixed and five rotational plots and the mangrove forest which can be covered adequately by ten fixed plots alone constituting nearly 5% of sampling frame's total area (table 2.3). For smaller sampling frames it is important to limit the number of plots in order to avoid spatial autocorrelation. The ratio of fixed to rotational plots is determined by examining correlations among vegetation parameters over time (Appendix D "Allocation of Sampling Units to Panel Members"). For previous studies in the ʻŌlaʻa section of the wet forest in HAVO, most measured parameters had low inter-sampling correlations ($r < 0.40$) (Loh 1998) indicating that the proportion of fixed to rotational plots should be between 45% and 50%. The resampling of plots for all communities will improve power estimates over time.

All of the focal plant communities are resampled every five years. Ideally, sampling should be conducted more frequently (1-3 year interval), particularly when rapid changes are predicted in measured parameters (e.g. following a disturbance event or park management action); due to logistical and financial constraints, more frequent monitoring is not planned at this time. The timing of sampling within a year is dictated primarily by weather patterns on each of the PACN islands as well as staff availability. To coordinate staff with other PACN I&M vegetation projects, sampling will occur between April and October.

Fixed Panel

Fixed or permanent plots that are resampled each sampling event are typically preferred over temporary plots for detecting change in most ecological systems because statistical power is increased. When attribute values are highly correlated over time or between sampling events as is typically the case with large long-lived plant life forms such as trees, statistical power to detect

change is increased (Elzinga et al. 2001). Fixed plot data are also useful for quantifying the effects of disturbance events on vegetation composition and structure. Some of the limitations of using fixed plots are: (1) the extra time required initially to mark the plots, (2) difficulty relocating plots at subsequent sampling periods, (3) negative impacts from previous sampling events, (4) the need for multiple sample events before it can be determined if sample size is adequate, and (5) limited spatial coverage of the sampling frame because no new sampling units are installed over time.

Fixed sample plots are selected from the pool of randomly generated plot centroids for the subalpine shrubland, limestone forest, mangrove forest and coastal communities. For the wet forest community, fixed sample plots are selected from the pool of stations along fixed transects within each sampling frame. Fixed transects in many cases are legacy transects except for the wet forests at KALA and portions of the Tutuila unit at NPSA. Where legacy transects are not available or deemed unacceptable, new fixed transects are generated randomly. Because most fixed plots lie on legacy transects, fixed plots are generally offset by 50 m in a random direction perpendicular to the transect bearing to avoid nonrepresentative “transect effects” such as trampling and species introductions from previous use. For all communities, fixed plots are resampled every sampling occasion (table 2.3). After the first cycle of sampling, the I&M project lead should verify that no bias exists between the fixed plot panel and rotational plot panel.

Rotational Panel

Rotational or temporary plots are faster to install, generally are not impacted by previous surveys, and over time can result in greater spatial coverage providing a better assessment of status. Greater spatial coverage is important particularly in large plant communities where environmental gradients may influence vegetation composition and structure (e.g. wet forest in NPSA). In these communities, spatial variability across the landscape may be greater than temporal variance. If vegetation attributes are found to be highly correlated between years, plots may be grouped or combined across years resulting in greater coverage of the area. Additionally, sampling new plots each sampling event minimizes the bias in estimates of status and updates prior estimates through time series calculations (Skalski 1990).

Rotational plots are only sampled once (table 2.3) and are selected from the pool of randomly generated plot centroids for the subalpine shrubland, limestone forest, mangrove forest and coastal communities. For the wet forest community, rotational plots are selected from rotational transects which are newly generated within each sampling frame prior to each sampling event. Plots are established on transects as opposed to being offset because the newly established transects have no history of use or impact.

Table 2.3. Survey schedule for a sample frame given split panel design. The rotational panels are denoted by R and the sampling year. In wet forest and subalpine communities, each panel consists of 15 plots. In the limestone forest, coastal strand, and mangrove forest communities, each fixed panel consists of 10 plots and each rotational consists of 5 plots. Due to the small area of the sampling frame, sampling in the mangrove forest only occurs in fixed panel.

Panel	Year				
	0	5	10	15	20
Fixed	X	X	X	X	X
R_{yr0}	X				
R_{yr5}		X			
R_{yr10}			X		
R_{yr15}				X	
R_{yr20}					X

Level of Change Detection

Power (1-β) to detect a moderate change (25%) in vegetation parameters based on previous studies in the wet forest community of HAVO is lower (1-β <50%; Appendix C "Precision, Power and Sample Size") than the targeted 80%. Low power for the understory species of this study is due to high variance presumably due to small plot sizes and inadequate sample sizes. Because no repeated sampling data was available for the coastal community (KALA), subalpine shrubland, limestone forest, and mangrove forest, power estimates for detecting future changes in these communities were not calculated.

Statistical power in future monitoring efforts is expected to be higher than the values presented here because both plot size (20 x 50 m) and sample size (n = 30) are larger than in previous studies, and variance among sampling years across each focal community should be lower except when large disturbance events occur (e.g. wildfire, hurricane, tsunami). While the disturbance frequency varies widely between communities and changes dynamically with climate, most plant communities are unlikely to experience catastrophic disturbances in the first few (if not several) cycles of sampling. Additionally, power estimates will be improved over time because 50% of the plots will be re-sampled (Appendix D "Allocation of Sampling Units to Panel Members"), allowing for the refinement of parameter estimates using multiple years of data. These methods have been used to significantly increase statistical power in other monitoring programs (Skalski 2005). The true power of this design will need to be revisited after 15 to 20 years of consecutive sampling, and the sample sizes adjusted accordingly.

Changes of greater than 25% in one or more of the plant community parameters should be considered as trigger points and management action should be considered. Obviously if multiple parameters are experiencing changes of this magnitude, then a stronger case can be made for action. Changes of less than 25% may or may not reflect lasting biological trends, while changes greater than 25% could represent irreversible transitions. Depending on which parameters are changing, increased replication and/or monitoring frequency may be necessary. At the very least park managers will be informed of both quantitative and qualitative changes in their local parks as well as other PACN parks.

Chapter 3: Field Methods

Field Season Preparations, Field Schedule and Equipment Setup

Prior to each field season, the project lead, field leader, and three biological technicians review this protocol including all SOPs and appendices. The field leader should pay particular attention to the tasks described in SOP #1 “Before the Field Season” and SOP #2 “Training Field Crew Members.” Before conducting field work in each PACN park all field crew members must read and be familiar with SOP #3 “Safety Protocol” and SOP #4 “Sanitation Protocol.” 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 and park staff with varying levels of vegetation sampling experience and plant identification skills. Park staff may be very familiar with the vegetation but may lack experience with the proposed sampling schemes. Alternatively, traveling I&M staff may know the sampling techniques but lack site-specific vegetation identification skills. Because the proposed sampling frequency is five years it is likely that personnel turnover will occur and require new field staff to be trained in species identification and sampling methodology.

Equipment and supplies listed in SOP #1 “Before the Field Season” are organized and made ready for the field season, and copies of the field data forms (Appendix E “Data Forms for Recording Field Data”) are made on water resistant paper. If data loggers or personal data assistants (PDAs) are used for field collection, the database is installed on each unit, and the field crew must be trained in how to enter and manage data. Temporary plot locations are selected (SOP #5 “Generating Sampling Point Locations with GIS”) and their coordinates uploaded onto Global Positioning System (GPS) units (SOP #6 “Using GPS to Navigate and Mark Waypoints”). Similarly, permanent plot locations and necessary access transects are uploaded to GPS units following SOP #6.

The project lead and field leader must schedule field sampling and organize logistics for each park at least two months prior to initiating sampling. Housing for traveling field crews and vehicle use must be secured prior to sampling and may need to be arranged up to six months in advance depending on the park. Helicopter support and/or additional field support are necessary to establish backcountry camps in the wet forest areas for four PACN parks (HAVO, HALE, KALA, and NPSA).

Field Methods

Locating and Installing Sampling Plots

Methods for selecting and locating plots are detailed in SOP #5 “Generating Sampling Point Locations with GIS” and SOP #6 “Using GPS to Navigate and Mark Waypoints.” A GPS unit is used to navigate to the selected plots, but when satellite coverage is poor compasses, altimeters, measuring tapes, and maps are used. To the greatest extent possible, plot locations are pre-screened using a GIS to eliminate steep or dangerous sites beforehand; however, in some instances field crew members may encounter unforeseen conditions that make a potential plot location impossible or undesirable to survey. When the site for a potential new plot is reached, the field leader determines if the randomly chosen plot location is acceptable (i.e. no unsafe working conditions such as steep cliff faces). If the plot location is rejected, the field leader first

attempts to establish the plot using a new random azimuth. If still not satisfactory, the field leader attempts to establish a new plot origin using one of three methods depending on plot type: (1) for plots selected using SRS or PPS sampling, the field crew moves 50 m in a random direction (0–360°) to establish a new plot; (2) for wet forest plots on fixed transects, the field crew shifts to the other side of the transect by 50 m (i.e., 50 m off transect in the opposite direction of the original plot); (3) for wet forest plots that lie on rotational transects, the field crew moves off-transect by 50 m to either the left or right (chosen randomly) of the transect. If still unsuccessful, the field leader may repeat this process to locate a new plot: (1) for SRS or PPS sampling plots return to original pre-selected plot location and move 50 m in a new random direction; (2) for fixed wet forest plots move an additional 50 m away from the transect such that the plot is established 100 m off-transect on the opposite side of the original plot; (3) for rotational wet forest plots move to 50 m off-transect on the opposite side of the transect. For each attempt the field leader uses the original transect azimuth and if unsuccessful uses the alternate azimuth. At this point, if the field leader still rejects the sites, the field crew will navigate to the next pre-selected randomly chosen plot location. Further details for establishing plots are described in SOP #7 "Establishing and Marking Permanent Vegetation Monitoring Plots." Once a plot is deemed acceptable the origin, or 0-meter mark along the center transect is marked following procedures described in SOP #7.

Plot layout and installation methods differ among community types and are detailed in SOP #7. In all forest and shrubland communities, four person field crews are used, and the time to establish and collect data in each plot should take between 1 and 2 days, depending on travel time and distance between plots. For sampling the coastal community, two person field teams should establish and sample 3 to 4 plots per field day. In all community types, the plot azimuth relative to true north is selected randomly, and the centerline extends either 20 m (coastal) or 50 m (forest and shrubland communities) along this azimuth from the origin point. Four additional tapes are used to lay out the plot boundaries. The short sides of the rectangle (forest and shrubland: 20 m; coastal: 10 m) are installed perpendicular to the centerline. The long sides of the rectangle (forest and shrubland: 50 m; coastal: 20 m) are parallel to the plot centerline with the zero ends closest to the plot origin. In the forest and shrubland community plots, one additional 20 m tape is laid perpendicular to the center line at 25 m along the centerline dividing the plot into four quadrants. Tapes are laid out to measure slope distance rather than horizontal distance when the plot encompasses variable slopes (e.g., ravine) because this represents the ground area of the plot more accurately (NPS 2003).

Specific marking and labeling methods are detailed in SOP #7 for permanent plots, but temporary plots are not marked (except for temporary flagging to mark the plot when sampling) or labeled since they will never be revisited. Permanent plots are marked with 0.5 m stainless steel rods and PVC pipes and labeled with aluminum tags attached with plastic coated aluminum wire at the origin (0 m) and the end (forest and shrubland: 50 m; coastal: 20 m) of the centerline. The permanent pipes at the ends of the center and two parallel edge transects are offset (0.1 m) beyond the measured end of the plot so that the marker does not disturb the vegetation and interfere with data collection. The four corners of the plot are flagged with blue pin flags and durable blue flagging. Alternative plot marking techniques may be employed for some areas if sensitive features (i.e., archeological) are present within the sampling frame. The project lead will consult with the local park staff regarding cultural resources issues prior to monitoring to

protect these resources and ensure compliance with the National Historic Preservation Act (1966).

Once tapes are installed a minimum of eleven photographs are taken for fixed plots: two photos of the plot posts to aid in relocation, four photos from the midpoints of each side to the plot center point, four photos from the plot corners looking down the long edge of the plot, and one vertical photo of the canopy taken from the plot center point. For rotational plots only three photos are required: two photos into the plot from each end of the long center line and one vertical photo of the canopy. The diagram in SOP #7 illustrates the location and direction of each photo. These photo locations are similar to the ones described in the Fire Monitoring Handbook developed by the NPS (2003). Photos provide qualitative information that can aide in communicating patterns of vegetation change to a wide audience, as well as help to verify the location of the corner points. Additional photos that document the qualitative character of the vegetation inside and outside the plot may be necessary.

Field maps are created and updated for all permanent plots during each sampling event to ensure future monitoring teams are able to relocate the plots. The field leader includes detailed driving and parking locations on the field form. All plot locations are mapped using GIS and permanent plot locations are also marked on a topographic map of the area and/or orthophoto quad or aerial photograph. In addition, the field leader creates a hand-drawn route map to the plot including key geographic features and associated instructional text. It is important that the text include information on the plot azimuth and distances to reference features so that the plot can be reread even if some markers are missing.

Collecting Vegetation Data from the Sampling Plot

Measures of plant composition (presence/absence) and structure (cover and density) are recorded in each plot using an array of techniques (SOP #8 “Conducting Community Vegetation Surveys”). Vegetation data collected at each plot include (1) a complete species checklist for plants; (2) measurement of understory vegetative cover along three transects; (3) counts of individuals for woody species and tree ferns within the entire plot or in subplots, depending on plant life form and plant size; and (4) tallies of large (>7.6 cm diameter) coarse woody debris or downed wood with measured widths. Sample data collection forms can be found in Appendix E “Data Forms for Recording Field Data.”

Species presence in the plot provides information on the distribution or status of a species across the community. Once a plot is installed, field crew members explore the plot and compile a list of all vascular plant species present within the plot and whether they are flowering and fruiting. Any additional species found during the sampling are also added to the species checklist.

Plant canopy cover is one of the most widely used attributes collected to measure the quantitative value of a species within a community. While cover is not equivalent to species abundance, it is generally considered to be a better index of biomass than is density (Daubenmire 1968, Mueller-Dombois and Ellenberg 1974) and equalizes the contribution of species that are small but abundant with species that are large but few (Elzinga et al. 2001). Additionally, it is the only consistent value that can be collected for plants that cannot easily be counted individually (e.g., rhizomatous grasses and ferns), or dense thicket-forming shrubs. Field crew members sample understory cover in the plots using the pole-intercept method, which is a variation of the point-

intercept technique (Mueller-Dombois and Ellenberg 1974, Elzinga et al. 2001). Cover is measured at set intervals (forest and shrub: 0.5 m; coastal: 0.2 m) along the main three transects (centerline and long plot edges) for a total of 300 points per plot. At each point a 2 m rigid measuring pole is held plumb to the ground. Surface substrate type (e.g., rock, sand, soil, litter, tree trunk, bryophytes, etc) and all species in contact with any part of the pole are recorded for two layers (<1 m and 1–2 m) on the understory cover data form (Appendix E "Data Forms for Recording Field Data"). Recording understory species cover by height class provides layer specific cover data to detect differences among understory layers and to identify changes over time in each layer. Surface substrate data characterizes the micro habitat sites that are found within the plot. A subset (20%) of permanent plots are sampled twice to test for repeatability of the sampling process, observer error, and to calculate an average estimate of measurement error. If measurement error appears significant (>10%) the project lead will work to identify the source of this error (e.g., observer, field methodology) and correct it.

Density data (the number of individuals per species per unit of area) are collected for all woody plants and tree ferns to provide information on abundance and population structure. Tree and shrub species that are at least 0.5 m in height or length if prostrate are divided among the subplots for sampling based on diameter at breast height (DBH). Tree ferns must be at least 0.5 m in foliar height to be counted and are also divided among subplots based on stem diameter measured at the point 0.1 m below the lowest live fronds or at 1.4 m if the vertical trunk is >2 m tall. Tree, shrub, and tree fern individuals along the plot boundary are included when greater than 50% of the bole of a woody species or the terminal end of a tree fern (i.e. where the fiddleheads originate) is within the plot or subplot. Plot and subplot sizes differ for woody species among community types in order to maximize sampling efficiency. Plot and subplot size may be modified following the initial sampling event if too few individuals are recorded or if sampling is impractical because too many individuals must be tallied.

In the forest communities, large trees (DBH ≥10 cm) are measured within the 20 x 50 m plot, but large tree ferns (stem diameter ≥10 cm) are sampled only within a 10 x 25 m nested subplot due to greater abundance when present in wet forest communities (table 3.1). Quantitative measures for large trees and tree ferns include: species, living status (live or dead), number of boles, diameter (trees: DBH; tree ferns: stem diameter), tree health described by vigor class (see SOP #8), reproductive status (trees: flowering or fruiting), and rooting height class (terrestrial, <0.5 m off ground, low epiphyte 0.5 – 2 m on dead material, low epiphyte 0.5 – 2 m on live material, or high epiphyte ≥ 2 m). Additional parameters recorded specifically for tree ferns include: foliar height class (0.5 - < 1 m, 1 - < 2 m, ≥2 m) and stem length measured from where the rhizome or stem emerges from the ground to where the fronds originate. Small trees and tall shrubs at least 1.4 m tall with a measurable DBH (1 - <10 cm) are also measured in the 10 x 25 m nested subplot, and individuals are tallied in two diameter groups (DBH <5 cm and DBH ≥5 cm) by species, living status, and rooting height class. Tree seedlings (<1cm DBH and greater than 0.5 m in height or length), shrubs not counted in the small tree/ tall shrub category, and small tree ferns (<10 cm stem diameter) are measured within a 2 x 50 m belt transect established on the inside of the right-hand edge transect and tallied by species, living status, rooting height class and foliar height class.

Table 3.1. Woody species and tree fern parameters collected in each forest plot or subplot. Tree fern attributes are collected only in the wet forest communities of Hawai'i.

Plot Size (m)	Sample Group	Living Status	Diam.	No. of Boles	Vigor Class	Flr/ Frt	Rooting Height Class	Foliar Height Class	Stem Length
20 x 50	Large Trees	X	X	X	X	X	X		
10 x 25	Large Tree Ferns	X	X				X	X	X
10 x 25	Small Trees	X	X[1]				X		
2 x 50	Tree Seedlings	X					X	X	
2 x 50	Small Tree Ferns	X					X	X	
2 x 50	Shrubs	X					X	X	

[1] Individuals are tallied within two DBH categories (<5 and ≥5 cm).

Table 3.2. Woody species parameters collected in each shrubland plot or subplot.

Plot Size (m)	Sample Group	Living Status	Diam.	No. of Boles	Vigor Class	Flr/ Frt	Foliar Height Class
20 x 50	Large and Small Trees	X	X	X	X	X	
2 x 50	Tree Seedlings	X					X
2 x 50	Shrubs	X					X

Table 3.3. Woody species parameters collected in each coastal strand plot or subplot.

Plot Size (m)	Sample Group	Living Status	Diam.	No. of Boles	Vigor Class	Flr/ Frt	Foliar Height Class
10 x 20	Large Trees	X	X	X	X	X	
2 - 2 x 20	Small Trees	X	X[1]				X
2 - 2 x 20	Tree Seedlings	X	X[1]				X
2 - 2 x 20	Shrubs	X	X				X

[1] Individuals are tallied within three DBH categories (<1, 1 - <5, ≥5 cm)

In the subalpine shrubland community, all small and large trees (DBH ≥ 1 cm) are measured within the 20 x 50 m plot due to the paucity of trees in this community (table 3.2). Similar to the large trees in the forest community each individual will be recorded by species, living status, diameter, number of boles, vigor class, and reproductive status. Rooting height class is omitted because individuals rarely grow epiphytically in this community. Tree seedlings and shrubs are recorded in the same manner as previously described for the forest community (within a 2 x 50 m belt transect and tallied by species, living status, and foliar height class).

The same density measurements are recorded for woody plants in the coastal community plots, but plot and subplot sizes differ due to the restricted linear nature of this community (table 3.3). Large trees are recorded for the entire 10 x 20 m plot by species, diameter, number of boles, vigor class, and reproductive status. Small trees, tree seedlings, and shrubs are measured within

two 2 m-wide belt subplots established on the inside of the long edge transects. Two belt subplots are required to adequately capture seedlings and shrubs in this community because the plots are smaller than the forest and shrubland plots. Individuals are tallied by species, living status, diameter category (<1 cm DBH, 1 - <5 cm DBH, and ≥5 cm DBH), and foliar height class.

Large downed wood and tree ferns provide valuable substrate for seedling establishment within many tropical forests (Corray 1974, Scowcroft 1992, Santiago 2000) and can constitute a significant portion of the community above ground biomass. Downed wood is monitored along the centerline and two outer short transects for each plot using a planar intercept technique. All dead downed logs and tree ferns greater than or equal to 7.6 cm in diameter are measured (diameter at intersection) and assigned one of five (wood) or three (tree fern) decay classes ranging from sound to rotten using the coarse woody debris data form (Appendix E "Data Forms for Recording Field Data"). From this information, the percent of ground covered by logs may be generated.

After the Field Season

Following the field season, the field leader is responsible for collecting all field gear and data books. General post season logistics and tasks are detailed in SOP #11 "After the Field Season." All field data must be compiled in the project database and maps submitted following procedures described in the Data Handling, Analysis and Reporting sections, and in SOPs #15 "Data Entry and Verification" and #16 "Data Quality Review and Certification." In addition, the project lead and field leader are responsible for conducting summary analyses, generating the season's annual report (SOP #22 "Reporting") and providing resource briefs to PACN staff and park management staff.

Chapter 4: Data Handling, Analysis, and Reporting

Data handling, analysis, and reporting are treated as three interrelated steps in managing information from the Focal Plant Communities Monitoring Protocol. Additional details and context for this chapter may be found in the PACN Data Management Plan (Dicus 2006), which describes the overall information management strategy for the network. The PACN website (NPS 2007b) also contains guidance documents on various information management topics (e.g., report development, GIS development, GPS use, etc.).

Project Information Management Overview

Project information management may be best understood as an ongoing or cyclic process, as shown in Figure 4.1. Specific yearly information management tasks for this project and their timing are described in Appendix G "Yearly Project Task List". Readers may also refer to each respective section below for additional guidance and instructions.

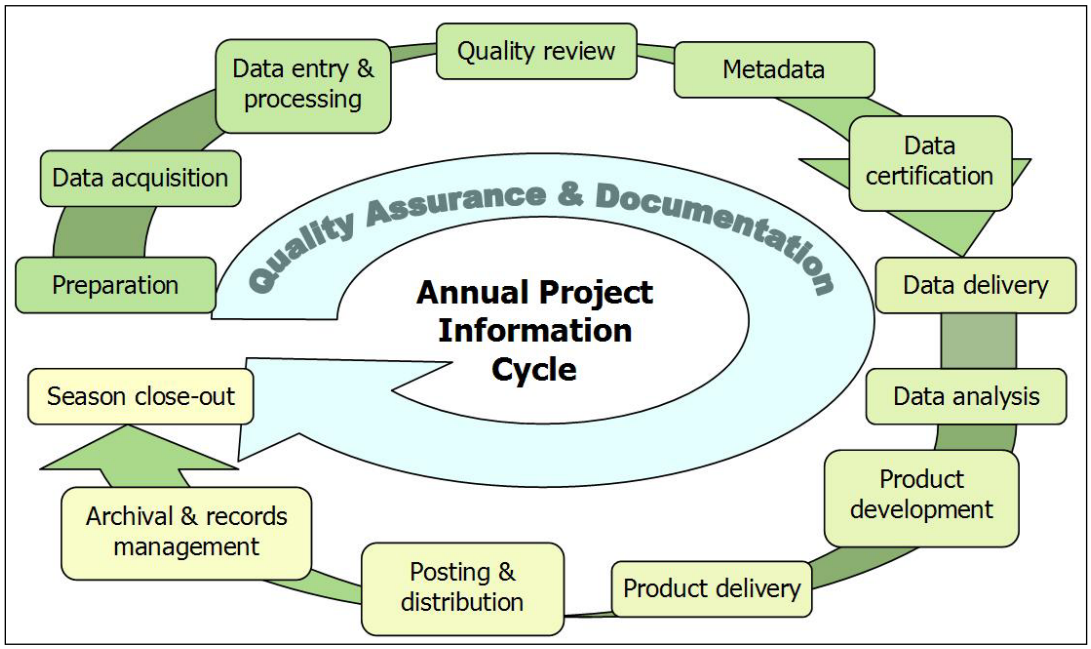

Figure 4.1. Idealized flow diagram of the cyclical stages of project information management, from pre-season preparation to season close-out. Note that quality assurance and documentation are thematic and not limited to any particular stage.

The stages of this cycle are described in greater depth in later sections of this chapter but can be briefly summarized as follows:

- *Preparation* – Training, logistics planning, print forms and maps
- *Data acquisition* – Field trips to acquire data
- *Data entry & processing* – Data entry and uploads into the working copy of the database, GPS data processing, etc.
- *Quality review* – Data are reviewed for quality and logical consistency
- *Metadata preparation* – Documentation of the year's data collection and results of the quality review
- *Data certification* – Data are certified as complete for the period of record

- *Data delivery* – Certified data and metadata are delivered for archival and uploaded to the master project database
- *Data analysis* – Data are summarized and analyzed
- *Product development* – Reports, maps, and other products are developed
- *Product delivery* – Deliver reports and other products for posting and archival
- *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 19 (NPS2001). Retained files are renamed and stored as needed.
- *Season close-out* – Review and document needed improvements to project procedures or infrastructure, complete administrative reports, develop work plans for the coming season

Pre-season Preparations for Information Management

Set Up Project Workspace

A section of the networked file server at each host park 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 information is lost. Additional details may be found in SOP #12 "Workspace Setup and Project Records Management".

GPS Loading and Preparation

The GIS specialist and project lead will work together to ensure that target coordinates 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. Additional details on GPS use and GPS data handling may be found in SOP #6 "Using GPS to Navigate and Mark Waypoints" and on the PACN website (NPS 2007c).

Implement Working Database Copy

Prior to the field season, the data manager will produce 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 data associated with this project. The design of the Focal Terrestrial Plant Communities Monitoring Database follows the hierarchical data table organization of the Natural Resource Database Template (NPS 2007a), the standard for the NPS I&M Program. For additional details see the table relationships diagram, data dictionary, and other documentation in Appendix F "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 – one for entering, editing, and error-checking data for the current season (i.e., the "working database copy") and another that contains the complete set of certified data for the monitoring project (i.e., the "master project database"). A functional comparison of these two components is provided in Table 4.1.

Table 4.1. Functional comparison of the master project database and the working database.

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

MS = Microsoft

Each of these components is based on an identical underlying data structure (tables, fields, and relationships, as documented in Appendix F "Database Documentation". The working database is implemented in Microsoft Access to permit greater flexibility when implementing on computers with limited or unreliable network access. Eventually, the master database may be implemented in Microsoft 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, queries, etc.) implemented in Microsoft Access. The working database application has separate screens for data entry, data review, and quality validation 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 (i.e., an 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 has no need to open the back-end file, thereby reducing the risk of improper deletions or other inadvertent data loss occurring within the protocol-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 its own copy of a working database into which they enter, process, and quality-check data for the current season (refer to the next section and SOP #15 "Data Entry and Verification". 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 and Processing

After each field trip, technicians will examine data forms to correct obvious errors and incomplete information as soon after the field data collection as is practical and enter 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.

The functional components for data entry into the working database are described in SOP #15. 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 validation 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.

Data Backups

Upon opening the working database, the user will be prompted to make a backup of the underlying data as described in SOP #15. 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. It is also recommended that backups be made after lengthy data entry sessions. 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

Analyses performed to detect ecological trends or patterns require data that are recorded properly and have acceptable precision and minimal bias. Poor quality data can limit detection of subtle changes in ecosystem patterns and processes and may lead to incorrect conclusions. Quality assurance/quality control (QA/QC) procedures applied to ecological data includes four 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
- 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 Focal Terrestrial Plant Communities Monitoring Database application incorporates QA/QC 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 validation phase. For more details see the section entitled “Data Quality Review” and SOP #16 “Data Quality Review and Certification”.

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 (this step is described in greater detail in the section “Data Quality Review” and also in SOP #16).

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 photocopies or duplicates stored in a separate location (e.g., on the PACN data server). Refer to SOP #13 “Field Form Handling Procedures” for more details.

If data loggers or PDAs 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 PDA dataset should be printed and stored following the procedures developed for field data sheets.

Image Handling Procedures

Photographic images should also be handled and processed with care. Refer to SOP #14 “Managing Photographic Images” for details on how to handle and manage these files.

GPS Data Procedures

The following general procedures should be followed for GPS data as described in SOP #6 “Using GPS to Navigate and Mark Waypoints” and Appendix G “Yearly Project Task List”:

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 (see SOP #12, “Workspace Setup and Project Records Management”).
2. Raw files should be sent to the GIS specialist for processing (e.g., creating shape files for plot 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 leader should periodically review the processed GPS data to make sure that any problems are identified early on.

Data Quality Review

After the data have been entered and processed, they need to be reviewed by the project lead 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, 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 (see Metadata Procedures and Data Certification and Delivery, and SOP #16: "Data Quality Review and Certification").

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 previous day's state. After certification, all data edits in the master database are tracked in an edit log (refer to Appendix F "Database Documentation") 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, a separate, read-only copy of the original, certified data for each year is also retained in the PACN Digital Library (refer to SOP #19: "Product Delivery Specifications and Schedule").

Geospatial data

The project lead and GIS specialist may work together to review the surveyed coordinates and other geospatial data for accuracy. The purpose of this joint review is to make sure that geospatial data are complete and reasonably accurate and also to determine which coordinates will be used for subsequent mapping and field work.

Metadata Documentation 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 data sets, thus making them available to a broad range of potential data users. Metadata for all PACN monitoring data will conform to Federal Geographic Data Committee (FGDC) guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed, and synthesized. In terms of spatial data the ArcCatalog application along with NPS Metadata Tools & Editor should be used for metadata management.

At the conclusion of the field season (according to the schedule in Appendix G "Yearly Project Task List"), 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. Refer to SOP #17 “Metadata Development” for location of the interview forms and specific instructions.

Data Certification and Delivery

Data certification is a benchmark in the project information management process that indicates that: 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks (Quality Review); and 3) that they 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. This brief form should be submitted with the certified data according to the timeline in Appendix G “Yearly Project Task List”. Refer to SOP #16 “Data Quality Review and Certification” and SOP #19 “Product Delivery Specifications and Schedule” for specific instructions.

Data Analysis

Refer to Appendix G “Yearly Project Task List” for the specific analysis tasks and their timing, and to SOP #21 “Data Analysis” for a more detailed description of analytical procedures.

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. For instance, prior to running an analysis on percent cover for a given understory species the point-intercept data needs to be converted from the number of hits along three transects into a percent value. Database queries will handle this type of conversion and tabulation, while statistical software such as SAS or SPlus will be used for more advanced analyses.

Using the raw certified data as well as database query results, the project lead will perform two general types of analysis at the end of the field season: summary statistics and trend analysis. Chapter 5 outlines the roles of the project lead and the data manager. In short, the data manager is responsible for query design and writing database routines, while the project lead will use the extracted data to run analyses. As outlined in SOP #21 the project lead will compute summary statistics (means, variances, confidence intervals, etc.) for each of the vegetation attributes measured. Depending on the attribute, these statistics are aggregated across all species or grouped by life form (i.e., tree, shrub, fern, herbaceous), native, nonnative, and/or individual species. In some instances the summary statistics are broken down by percent (e.g., for large trees, the percent of trees with and without damage is computed).

In terms of detecting change, two distinct types of analysis will be pursued. For presence/absence data, changes over time in the presence/absence values for a specific species will be evaluated using a chi-square test or McNemar’s test of symmetry. For the other vegetation data collected,

changes over time will be evaluated using a paired t-test, repeated measures ANOVA, or a generalized linear model following the methodology described by Schneider (2007). SOP #21 provides further details including summary statistics and trend analysis procedures for each measured vegetation attribute.

Reporting and Product Development

Refer to Appendix G "Yearly Project Task List" and SOP #19 "Product Delivery Specifications and Schedule" for the complete schedule for project reports and other deliverables and the people responsible for them. Detailed reporting guidelines and table structures are provided in SOP #22 "Reporting."

Report content

A summary report will be produced annually, with a more detailed report produced every five years. The annual report focuses on the current year's monitoring effort and results, while the five-year report brings together five years of results at the close of each complete monitoring cycle. The annual report should:

- List project personnel and their roles.
- List sampling frames and plots completed during the current year.
- Provide a map (one per sampling frame) and brief discussion of the plots sampled during the current year.
- Present summary statistics for all vegetation parameters outlined in SOP #21
- Provide trend analysis results including when management trigger points were exceeded for parameters with multiple years of data for communities sampled during the current year.
- Identify any data quality concerns and/or deviations from protocols that affect data quality and interpretability.

A more comprehensive analysis and report will be produced every five years after each round of cycling (i.e., after each selected park and community is sampled). In addition to the above, the five-year report should also:

- Summarize the annual results by plant community and park, allowing for comparisons between the communities and parks (e.g., how do wet forest vegetation attributes vary from one park to the next and how do various vegetation parameters vary from one community to another).
- Assess spatial patterns in the density, percent cover and presence/absence data. Where applicable these analyses will be correlated to park management and include pertinent recommendations.
- Identify any possible species distributional changes within the parks (applicable after the second and subsequent rounds of sampling in each community).
- Place network results within the larger context of focal plant population changes throughout the Pacific.
- Evaluate operational aspects of the monitoring program, such as whether any sampling locations need to be eliminated or moved (e.g., due to access problems), changes that

may be needed to sampling methods or design, or whether the sampling period remains appropriate (the optimal sampling season could conceivably change over time in response to climate change), etc.

Standard report format

Annual reports and trend analysis reports will use the NPS Natural Resource Publications Template (NPS 2007a), a pre-formatted Microsoft Word template document based on current NPS formatting standards. Annual reports will use the Natural Resource Report template (NRR template), and trend analysis and other peer-reviewed technical reports will use the Natural Resource Technical Report template (NRTR template). Reports will include standard vegetation community summary tables and figures for all results previously identified in table 2.2.

Review products for sensitive information

Certain project information related to the specific locations of rare or threatened taxa or cultural resources may meet criteria for protection and, as such, should not be shared outside NPS except where a written confidentiality agreement is in place prior to distribution. Before preparing data in any format for sharing outside NPS – including presentations, reports, and publications – the project lead should refer to the guidance in SOP #18 "Sensitive Information Procedures" and discuss the matter with the data manager. Certain information that may convey specific locations of sensitive resources may need to be screened or redacted from public versions of products prior to release.

Product Delivery, Posting and Distribution

Refer to SOP #19 "Product Delivery Specifications and Schedule" for the complete schedule of project deliverables, the people responsible for them, and detailed instructions on how to deliver the final products. Upon delivery products will be posted to NPS websites and the Natural Resource Information Portal (NR Info) as appropriate (NPS 2011). Refer to SOP #20 "Product Posting and Distribution" for more information.

Holding period for project data

To permit sufficient time for priority in publication, certified project data will be held upon delivery for a period not to exceed two years after it was originally collected. After the two year period has elapsed, all certified, non-sensitive data will be posted to NR Info. Note that this hold only applies to raw data and not to metadata, reports, or other products which are posted immediately after being received and processed.

Special procedures for sensitive information

Products that have been identified upon submission by the project lead as containing sensitive information will either be revised into a form that does not disclose the specific locations of sensitive resources, or withheld from posting and distribution. When requests for distribution of the unedited version of products are initiated by the NPS, by another federal agency, or by another partner organization (e.g., a research scientist at a university), the unedited product (e.g., the full data set that includes protected information) may only be shared after a confidentiality agreement is established between NPS and the other organization. Refer to SOP #18 "Sensitive Information Procedures" for more information.

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 discard should be made following guidelines stipulated in NPS Director's Order 19 (NPS 2001), which provides a schedule indicating the amount of time that the various kinds of records should be retained. Refer to SOP #12 "Workspace Setup and Project Records Management".

Season Close-out

After the conclusion of the field season, the project lead, data manager, and GIS specialist should meet to discuss the recent field season and to document any needed changes to the field sampling protocols, the working database application, or to any of the SOPs associated with the protocol. Refer to Section Data Entry and Verification for additional close-out procedures not specifically related to project information management.

Chapter 5: Personnel Requirements and Training

Roles and Responsibilities

Implementation of this protocol requires using a combination of park staff and PACN I&M staff. Required PACN staff include a project lead (GS-11), a field leader (GS-07), and three field technicians (GS-05), as well as assistance from the data manager (GS-11), GIS specialist (GS-11), and program manager (GS-13). Table 5.1 summarizes these roles and responsibilities. All positions have responsibilities beyond this protocol and are full time though the three field technicians are seasonal hires. The project lead is responsible for project administration, implementation, facilitating communication between NPS and cooperators, overseeing data collection and entry, quality assurance/quality control, data verification and validation, 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 three field technicians although the program manager is the direct supervisor for the field technicians. The field leader and field technicians 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 field technicians should be skilled botanists and field researchers capable of performing any of the required vegetation monitoring tasks, including plant species identification.

The project lead will oversee the hiring and training of the field technicians and the field leader. In addition, the project lead should directly participate in at least some of the field monitoring in order to ensure consistency of this effort. Field crew members must be proficient at: (1) identifying native and nonnative plants and making voucher collections as needed, (2) using field equipment (such as GPS units, clinometers, etc.), and (3) data entry using Microsoft (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 monitoring 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 protocol data products (datasets, data analysis products, and metadata), and dissemination of data, while the project lead is responsible for database use (overseeing data 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 monitoring is primarily the responsibility of the project lead. The GIS specialist assists with plot selection techniques, GPS use, map generation and metadata development. The PACN program manager is responsible for general vegetation program oversight and supervision of the project lead. This includes periodic reviews of reports, decisions regarding appropriations of I&M budget to the PACN vegetation monitoring program, and the overall quality and performance of the project lead in relation the PACN vegetation program.

Table 5.1. Roles and responsibilities for focal terrestrial plant communities monitoring.

Role	Responsibilities	Position
Project Lead	• Project administration, operations, and implementation • Track project objectives, budget, and requirements • Coordinate and ratify changes to protocol • Lead training of field crew • Acquire field equipment • Certify each season's data for quality and completeness • Oversee completion of reports, data summaries and analysis, metadata, and other products according to schedule • Maintain and archive project records • Facilitate communications between I&M and NPS parks	Botanist
NPS Lead	• The project lead is the NPS Lead for this protocol	N/A
Park Ecologists / Botanists	• Assist with logistics, planning, and coordination • Review reports, data, and other project deliverables • Assist in training of field crew members	
Field Leader	• Assist in training and ensuring safety of field technicians • Plan and execute field visits • Maintain field equipment • Oversee data collection and entry, verify accurate data transcription into database • Complete a field season report	Biological Science Technician
Field Technicians (3)	• Collect, record, enter and verify data • Prepare plant voucher specimens, as needed	Biological Science Technicians (3)
Data Manager	• Consultant on data management activities • Facilitate check-in, review and posting of data, metadata, reports, and other products to national databases and clearinghouses according to schedule • Maintain and update database application • Provide database training as needed	Data Manager
Statistician	• Consultant on statistical design, analysis and programming	May be hired, Statistician
GIS Specialist	• Consultant on spatial data collection, GPS use, and spatial analysis techniques • Facilitate spatial data development and map generation • Work with project lead to analyze spatial data and develop metadata for spatial data products • Primary steward of GIS data and products	GIS Specialist
Network Coordinator	• Review annual reports for completeness and compliance with I&M standards and expectations	PACN Network Program Manager
Park Curator	• Receive and catalogue voucher specimens	Park Curator, or other designated staff
USGS Liaison	• Consultant on technical issues related to project sampling design, statistical analyses, or other issues related to changes in protocol and SOPs	Botanist, USGS-Pacific Island Ecosystems Research Center

Qualifications and Training

All technical field staff will be trained and responsible for familiarity with the information contained with the protocol narrative, SOP's, and the protocol database. SOP #2 "Training Field

Crew Members" provides details on hiring and training all personnel associated with the PACN Focal Plant Communities Protocol. 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 at minimum 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 communities is a competent field staff. The quality of the data collected will be directly related to the quality of the field team. The field crew, composed of the field leader and field technicians, is required to have some 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 crew members will be required to participate in training before the field season (see SOP #2 for details). 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 protocol, 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 plants. The field component will include selected site visits to locations where team members will encounter most if not all plants on the species list. Field training will culminate in the group doing plots together, as a means of developing consistency in species identification, collection of specimens, plot establishment, monitoring methods, and data recording on field forms. Approximately five days of training are anticipated prior to the start of sampling, four of which will be in the field. The project lead will work with PACN specialists familiar with the local flora to coordinate the training of all crew members.

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.

Chapter 6: Operational Requirements

Annual Workload and Field Requirements

Field sampling will be conducted in five community types in seven PACN parks. Table 6.1 lists the parks visited each year, the communities monitored, and the time required to monitor these communities. The protocol is designed to allow for exclusion of select PACN communities or units if required due to future unforeseen fiscal constraints. For example, the wet forest of Tau in year 4 may be omitted resulting in only three months of field work at NPSA. Note that in year 3 KALA park staff will work with the project lead to complete the coastal sampling effort, while the PACN field leader and field technicians monitor the wet forest community thereby reducing the total time in the field from 6.5 to 5.5 months. Year 5 requires the least amount of time but the most travel.

The field season typically begins each year on 1 April and ends between mid-September and mid-October, depending upon the park, community, and sample frame. The schedule consists of a 5-year rotating cycle, with field crews visiting 1-2 parks each year and revisiting each area every 5 years. The project lead and field leader will plan to visit specific parks at approximately the same time of year every sampling period in order to minimize seasonal differences from one sampling event to the next.

Before the beginning of the field season on 1 April, the field crew needs to spend an appropriate amount of time on training (sampling methodology, plant identification) and field skills (e.g., navigation, marking plots, use of field equipment). The amount of time will vary by year, park and field crew. SOP #2 “Training Field Crew Members” discusses the training requirements in

Table 6.1. Estimated number of months to conduct focal plant communities monitoring for each year and park.

Year	Park	Sample Frame	Community	Community (mos.)	Annual Total (mos.)
1	HAVO	‘Ōla‘a, Thurston/East Rift	wet forest	4	4.0
2	HAVO	Kahuku	wet forest	2	4.25
	HAVO	Subalpine Shrubland	subalpine shrubland	1.5	
	KAHO	Coastal Strand	coastal strand	0.75	
3	HALE	Wet Forest	wet forest	2	6.5
	HALE	Subalpine Shrubland	subalpine	1.5	
	KALA	Wet Forest	wet forest	2	
	KALA	Coastal Strand	coastal strand	1	
4	NPSA	Tutuila	wet forest	3	5.0
	NPSA	Tau (optional)	wet forest	2	
5	WAPA	Limestone Forest	limestone forest	1.5	3.0
	AMME	Mangrove	mangrove	1.5	

more detail. Also before each field season, the project lead, field leader, and GIS specialist will need to generate a list of temporary plots to be used in the rotational panel for each sampling frame (see SOP #5 "Generating Sampling Point Locations with GIS"). Note that for the first cycle in each park both the fixed and rotational plots have been generated already.

Facility and Equipment Needs

The nature of terrestrial 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. SOP #1 "Before the Field Season" contains a list of equipment needed in the field to perform the required monitoring.

Startup Costs and Budget Considerations

Table 6.2 summarizes the budget for the Focal Plant Communities Monitoring Protocol by park and year, breaking down the costs into personnel salary, travel, equipment, and supplies. Personnel salaries are based on the 2010 pay schedule with 18% COLA and 25% benefits. Salary costs are expected to increase with step increases if initial hires remain in their positions. The project lead will supervise the field leader, oversee field operations and analyze and report annual findings (25%). Most of the field leader's time (75%) will be spent implementing this vital sign. Primary duties include: preparing for the field season, leading field operations, entering and summarizing data, and reporting. Three field technicians will conduct field work during the four month field season (35%). The program manager will assist by reviewing reports (4%), and the data manager and GIS specialist will aid in pre- and post-field season data management (8%). All positions have responsibilities and funding beyond this protocol and are full time though the three field technicians are seasonal hires.

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 2010 lodging and per diem schedule and the estimated amount of time required per park (Table 6.1). The field leader will be duty-stationed in each park (except KAHO and AMME) during extended field sampling. When possible field technicians will be hired from the community to maximize local plant knowledge and reduce travel costs (e.g., NPSA, HALE, WAPA). Lodging ranges from $0 (camping) to $180 (KAHO) per day and meal per diem ranges from $25 (camping) to $86 (KAHO). Travel estimates for AMME are highest because current lodging ($121/ day) and meal ($79/day) estimates are relatively high, and the four person field crew will travel from WAPA for the entire 1.5 month field season. HALE travel estimates are also high, but this is due to the fact that most of the field sites are only accessible by helicopter (~ 10 hours of helicopter time at $800/ hour) and require extensive back country camping. Similarly, an estimated six hours of helicopter time are required to access remote wet forest sites in HAVO and KALA.

Equipment and supplies required for implementation of the Focal Terrestrial Plant Communities Monitoring Protocol include standard field monitoring gear (e.g., cameras, field packs, measuring tapes, flagging, etc) and larger items such as vehicle rental (estimated at $500/month). Note that no vehicle rental money is allotted for sampling on Tutuila at NPSA (Year 4) because I&M purchased a vehicle for use on this island.

The annual cost estimate averaged across the five years required to complete one round of monitoring of the focal terrestrial plant communities is approximately $146,000 per year in FY10 dollars (computed by averaging the last line of Table 6.2). 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 may aid in reducing implementation costs or increasing the sampling effort (e.g., more frequent sampling and/or additional communities). However, what is presented in this protocol should be able to be accomplished regardless of collaborative efforts.

Table 6.2. Estimated annual costs for the Focal Terrestrial Plant Communities Monitoring Protocol. At HAVO, sampling in year 1 occurs in ‘Ōla‘a and Thurston/East Rift and in year 2 in Kahuku and subalpine shrubland. Year 4 at NPSA is divided between ([a])Tutuila and ([b])Tau, as monitoring Tau is optional.

Budget Item	Year 1	Year 2		Year 3		Year 4*		Year 5**	
	HAVO	HAVO	KAHO	HALE	KALA	NPSA[a]	NPSA[b]	WAPA	AMME
Personnel									
Project Lead (GS11.1; 25%)	18,066	13,550	4,517	9,033	9,033	9,033	9,033	9,033	9,033
Field Leader (GS7.1; 75%)	36,623	27,467	9,156	18,311	18,311	26,857	26,857	18,311	18,311
Field Technicians (3 x GS5.1; 35%)	41,391	31,043	10,348	20,696	20,696	13,797	13,797	14,783	14,783
Program Manager (GS13.2; 4%)	4,257	3,193	1,064	2,129	2,129	2,129	2,129	2,129	2,129
Data Manager (GS11.3; 8%)	6,166	4,625	1,542	3,083	3,083	3,083	3,083	3,083	3,083
GIS Specialist (GS11.1; 8%)	5,781	4,336	1,445	2,891	2,891	2,891	2,891	2,891	2,891
Travel (with per diem)	7,200	11,088	4,702	23,511	16,275	11,340	10,880	15,747	41,125
Equipment and Supplies	4,000	3,500	1,000	10,500	4,000	1,000	5,500	3,250	3,250
Total Cost	*123,485*	*98,801*	*33,773*	*90,153*	*76,417*	*70,129*	*74,169*	*69,226*	*94,604*
Annual Cost	**123,485**	**132,574**		**166,570**		**144,298**		**163,830**	

* Year 4 will employ two GS7's (field leader and I&M biological technician stationed in NPSA) and only two GS5's
** Year 5 will employ three GS5's at only 25% FTE due to the shorter field season

Permits, Permissions and Cooperative Agreements

Various research permits and compliance procedures are required to implement this monitoring. As this protocol 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 permitting 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. Some specific permits already known to be required for this protocol are described in the following sections. The project lead is responsible for following all stipulations identified through the compliance process.

National Park Service

National Park Service research permits will be obtained, in advance of any field activities, for each park where monitoring occurs. Permits are evaluated on an annual basis, or other time frame as stipulated in the permit itself. The research permit review process also includes NEPA compliance documentation, as discussed below. The project lead (or designee) in cooperation with NPS contacts will maintain all appropriate documentation. NPS research permit applications will be submitted online to *NPS Research Permit and Reporting System* (NPS 2010).

National Environmental Policy Act (NEPA)

At present, under NEPA (1970), it is anticipated that this protocol falls under a Categorical Exclusion, i.e., "a category of actions which do not individually or cumulatively have a significant effect …and for which, therefore, neither an environmental assessment nor an environmental impact statement is required" (40 CFR 1508.4). Under Directors Order 12 (NPS 2001), a Categorical Exclusion is "an action with no measurable environmental impact which is described in one of the categorical exclusion lists in section 3.3 or 3.4 and for which no exceptional circumstances (section 3.5) exist." NEPA compliance review and documentation will occur as part of the NPS research permitting process.

National Historic Preservation Act (NHPA)

Compliance with the National Historic Preservation Act (1966) must occur prior to monitoring and the establishment of permanent plots which requires burying stainless steel threaded rods as markers. Most likely, digging or burying will be prohibited in areas with valuable cultural resources. The project lead is responsible for consulting with each park's Cultural Resources staff prior to conducting field work, ensuring compliance with the NHPA and conducting field work in a manner that does not have any adverse effects on cultural resources.

U.S. Fish and Wildlife Service (USFWS)

In compliance with the Endangered Species Act (1973), appropriate permissions will be secured through the USFWS. All wildlife activities conducted under the USFWS permit in Hawaiʻi will be coordinated with the Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife.

State of Hawaiʻi

No permits are needed from the state of Hawaiʻi for work conducted on NPS lands.

Territory of American Samoa

The territory requires that a Scientific Study and Collection Permit be obtained through the Department of Marine and Wildlife Resources, American Samoa Government.

Village permission: On Tutuila and Tau Islands, American Samoa, village permission should be obtained by personally contacting each mayor of the village near the park unit where monitoring may occur (i.e., Afono, Fagalea, Fitiuta, Luma Tau, and Vatia, villages). Field crew members should describe what the study is about prior to initiating any work, according to park cultural resource staff guidelines. Surveying is typically not allowed in or near villages on Sundays.

Sa, or time for prayer, is observed at dusk (around 18:00 hrs), so if entering or traveling through villages via vehicle or on foot at this time, field crew members must stop until Sa is over. Ringing bells in the villages indicate the beginning and ending of Sa. If field crew members are on the main roads of Tutuila, it is not necessary to stop. On other islands, it is required that all persons be indoors during the time of Sa.

Cooperative Agreements: A cooperative agreement should be developed with the Department of Marine and Wildlife Resources for conducting and sharing plant community survey data on American Samoa.

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Appendix A: Target Populations and Sampling Frames

This appendix lists the focal communities and sampling frames by park, provides figures showing the locations of each sampling frame and plot, and provides tables that describe each plot in detail. Table A.1 summarizes the schedule of sampling by year and park, and provides an overview of the number and type of plots for each sampling frame. It also contains information on the methodology employed to generate plot locations. Since this methodology depends on whether collocation with the Landbird Protocol (Camp et al. 2011) occurs, Table A.1 presents an additional column to note whether collocation applies to each frame.

Following the summary table, this appendix presents maps of proposed plot locations and plot description tables in chronological order of a monitoring cycle. Alternative plot locations, to be used when a location is rejected in the field, are listed in the tables but are not on the figures. Plot locations were generated according to the guidelines in SOP #5 "Generating Sampling Point Locations with GIS." Locations for rotational plots are only valid for the first cycle of monitoring; new rotational plot locations will be generated at the start of a new cycle following the procedure in SOP #5.

The coordinates for the plot centroids are UTMs based on the following projections and zones.

- Hawai‘i Island: ESRI (or EPSG) POSC code of 26905 (NAD83 UTM zone_5N).
- Maui Island: ESRI (or EPSG) POSC code of 26904 (NAD83 UTM zone_4N).
- Molokai Island: ESRI (or EPSG) POSC code of 26904 (NAD83 UTM zone_4N).
- Oahu Island: ESRI (or EPSG) POSC code of 26904 (NAD83 UTM zone_4N).
- Guam: ESRI (or EPSG) POSC code of 32602 (WGS 84 UTM zone_55N).
- Saipan: ESRI (or EPSG) POSC code of 32602 (WGS 84 UTM zone_55N).
- American Samoa: ESRI (or EPSG) POSC code of 32775 (WGS 84 UTM zone_2S).

Table A.1. Overview of the sampling years, parks, focal plant communities, frames and plots. For focal communities with only one sampling frame, the community and sampling frame have the same name. The total number of plots represents the sum of the fixed and rotational plots sampled in a given year, while the number of alternate plots represents the number of plots generated in case the field crew cannot sample one or more of the fixed or rotational plots. The number of alternate plots varies from frame to frame, based on conservative estimates of how many alternates might be required as well as how many plots could fit in particular frames given buffer constraints. In the case of simple random sampling, the list of alternate plots can be applied to either fixed or rotational plots as needed; however, for transect-based sampling two sets of alternate plots were generated, one set along fixed transects and the other along the rotational transects (e.g., in the HALE wet forest frame, 10 alternate plots were generated along fixed transects and 10 along the rotational transects).

Year	Park	Focal Plant Community	Sampling Frame	Total Plots	Fixed Plots	Rotational Plots	Alternate Plots	Landbirds Collocation	Sampling Methodolgy[1]
1	HAVO	Wet Forest	Thurston / East Rift	30	15	15	10 /10	Partial	Transect
1	HAVO	Wet Forest	ʻŌlaʻa	30	15	15	10 / 10	Partial	Transect
2	HAVO	Wet Forest	Kahuku	30	15	15	15 / 15	Coincidental	Transect
2	HAVO	Subalpine Shrubland	Subalpine Shrubland	30	15	15	15	No	SRS
2	KAHO[2]	Coastal	Coastal	15	10	5	5	No	SRS
3	HALE	Wet Forest	Wet Forest	30	15	15	10 / 10	Yes	Transect
3	HALE	Subalpine Shrubland	Subalpine Shrubland	30	15	15	25	No	SRS
3	KALA	Wet Forest	Wet Forest	30	15	15	15 / 15	No	Transect
3	KALA	Coastal	Rocky Substrate	15	10	5	10	No	SRS
3	KALA	Coastal	Calcareous Substrate	15	10	5	10	No	SRS
4	NPSA	Wet Forest	Tutuila	30	15	15	10 / 10	Yes	Transect
4	NPSA	Wet Forest	Tau	30	15	15	8 / 8	Yes	Transect
5	WAPA	Limestone Forest	Limestone Forest	15	10	5	10	No	SRS
5	AMME	Mangrove Wetland	Mangrove Forest	10	10	0	3	No	SRS

[1] Sampling methodology follows one of two approaches: (1) transect-based sampling, or (2) simple/ stratified random sampling (SRS).
[2] The buffer restrictions for the coastal plots at KAHO will be slightly less rigid than the buffer restrictions for KALA.

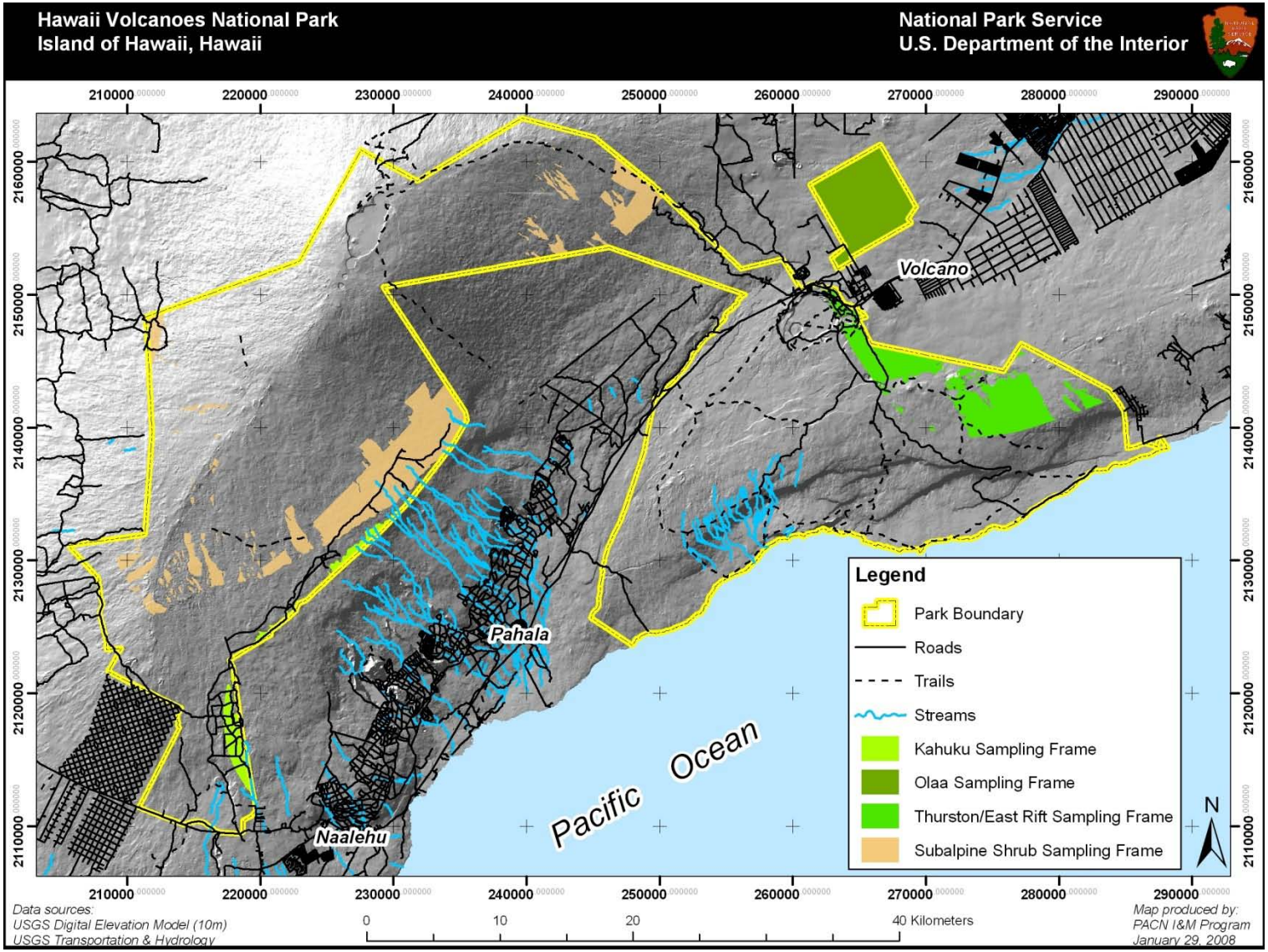

Figure A.1. Map of the three wet forest and one subalpine shrubland sampling frames at HAVO.

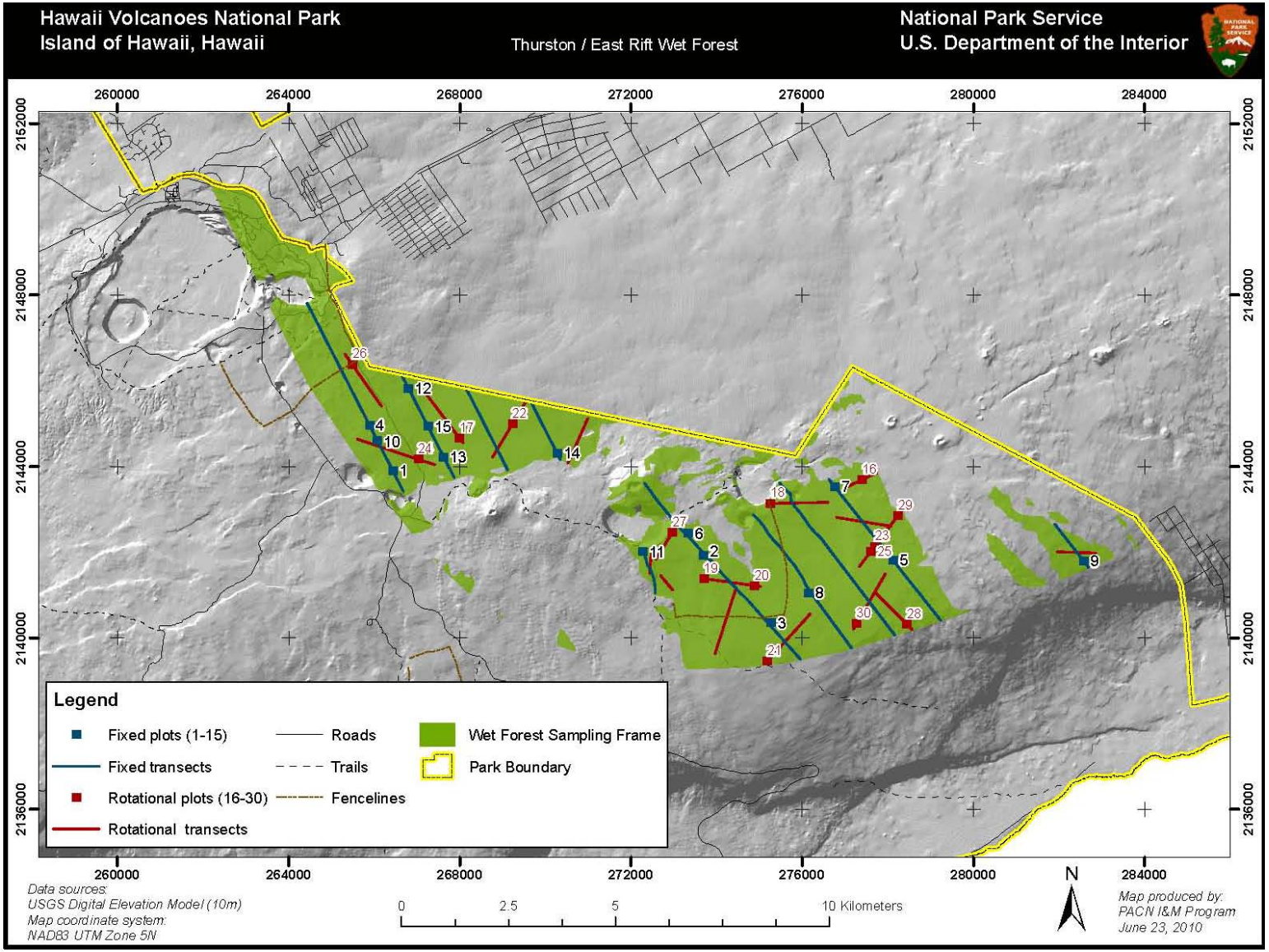

Figure A.2. Map of fixed and rotational plots for the Thurston/East Rift wet forest sampling frame at HAVO.

Table A.2. Fixed plot locations for the Thurston/East Rift wet forest sampling frame at HAVO. Alternate locations are provided in case any of the fixed plots cannot be established and surveyed.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Fixed Transect	Collocation with Landbirds
1	Fixed	6	266435.4	2143899.9	7	No
2	Fixed	107	273689.0	2141925.1	2	Yes
3	Fixed	299	275270.5	2140347.2	2 Ext*	No
4	Fixed	192	265889.5	2144966.8	7	No
5	Fixed	82	278124.5	2141813.2	5	No
6	Fixed	224	273337.5	2142437.1	2	Yes
7	Fixed	250	276758.7	2143533.9	5	No
8	Fixed	233	276152.0	2141052.7	3	Yes
9	Fixed	353	282585.3	2141788.7	6	No
10	Fixed	38	266071.4	2144611.2	7	No
11	Fixed	355	272280.5	2142006.3	1	No
12	Fixed	207	266800.3	2145822.9	8	No
13	Fixed	37	267619.3	2144222.6	8	No
14	Fixed	16	270273.4	2144304.2	10	No
15	Fixed	36	267255.3	2144933.8	8	No
A1	Alternate	95	275648.6	2141818.2	3	Yes
A2	Alternate	288	268581.9	2144974.3	9	No
A3	Alternate	102	268945.9	2144263.1	9	No
A4	Alternate	328	278745.3	2141031.1	5	No
A5	Alternate	297	275499.6	2140014.8	2 Ext*	No
A6	Alternate	212	275632.4	2139865.6	2 Ext*	No
A7	Alternate	0	266162.4	2144433.4	7	No
A8	Alternate	101	274872.1	2140794.7	2 Ext*	No
A9	Alternate	88	265343.5	2146033.7	7	No
A10	Alternate	243	266344.4	2144077.7	7	No

*Plots are located on extensions along fixed transects.

Table A.3. Rotational plot locations for the Thurston/East Rift wet forest sampling frame at HAVO. Alternate locations are provided in case any of the rotational plots are rejected in the field.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Rotational Transect
16	Rotational	67	277400.3	2143694.8	22
17	Rotational	104	267994.7	2144663.5	28
18	Rotational	100	275254.6	2143138.8	15
19	Rotational	106	273699.1	2141383.1	10
20	Rotational	137	274887.5	2141216.1	10
21	Rotational	75	275186.3	2139452.6	21
22	Rotational	282	269227.2	2144991.0	27
23	Rotational	256	277691.4	2142133.8	20
24	Rotational	325	267027.7	2144171.9	26
25	Rotational	148	277601.3	2142014.1	20
26	Rotational	29	265483.4	2146380.4	24
27	Rotational	108	272968.6	2142464.9	13
28	Rotational	147	278448.2	2140315.1	19
29	Rotational	227	278232.2	2142851.6	20
30	Rotational	58	277268.8	2140329.5	17
A1	Alternate	341	274348.2	2140832.5	14
A2	Alternate	117	278051.9	2142612.3	20
A3	Alternate	209	265913.1	2145766.8	24
A4	Alternate	136	267543.9	2145261.7	28
A5	Alternate	144	273997.4	2139684.9	14
A6	Alternate	352	274172.8	2140258.7	14
A7	Alternate	58	277345.3	2142725.5	18
A8	Alternate	94	269535.8	2145504.6	27
A9	Alternate	164	270685.1	2144436.4	25
A10	Alternate	232	277049.4	2142772.0	18

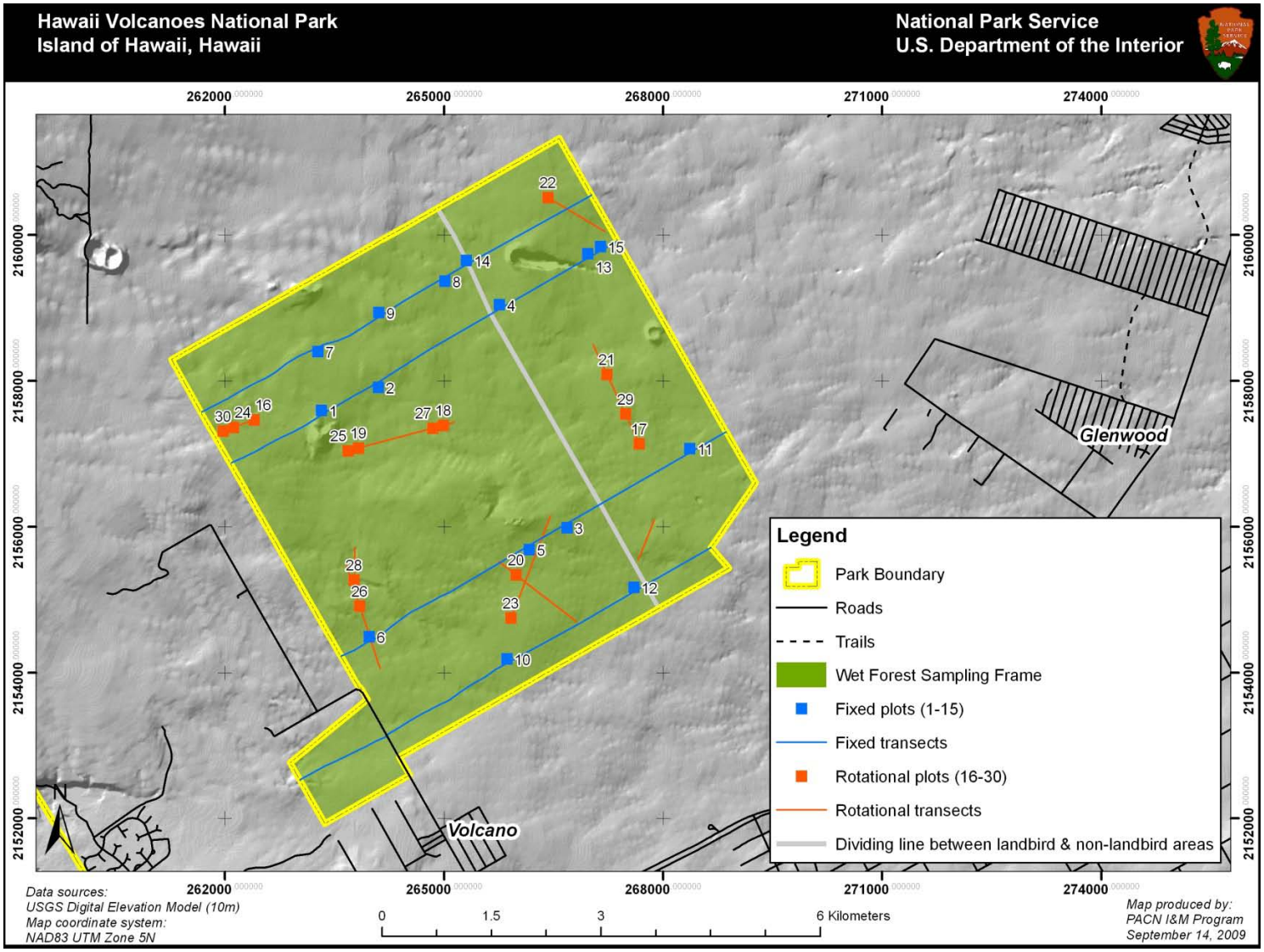

Figure A.3. Map of fixed and rotational plots for the ‘Ōla‘a wet forest sampling frame at HAVO. The sampling frame overlaps with the Landbirds Protocol to the west of the gray dividing line, allowing collocation with the Landbirds transects. In the non-overlapping area, new fixed and rotational transects were generated.

Table A.4. Fixed plot locations for the ʻŌlaʻa wet forest sampling frame at HAVO. Alternate locations are provided in case any of the fixed plots are rejected in the field. Transect locations and numbers coincide with transects from the Landbird Protocol, except this protocol extends the existing Landbird transects to span the width of the wet forest sampling frame.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Transect[1]	Plot Placement[2]
1	Fixed	119	263322.0	2157598.2	5	L
2	Fixed	46	264100.0	2157911.8	5	R
3	Fixed	140	266683.8	2155990.2	14 Extension	R
4	Fixed	92	265759.5	2159044.1	5 Extension	L
5	Fixed	182	266165.5	2155689.4	14 Extension	R
6	Fixed	0	263977.4	2154494.5	14	L
7	Fixed	75	263271.4	2158404.5	3	R
8	Fixed	176	265011.5	2159365.9	3	R
9	Fixed	131	264108.7	2158936.7	3	L
10	Fixed	271	265860.5	2154189.5	19 Extension	L
11	Fixed	337	268363.2	2157075.7	14 Extension	L
12	Fixed	299	267601.1	2155169.2	19 Extension	L
13	Fixed	195	266970.3	2159743.4	5 Extension	L
14	Fixed	170	265306.8	2159651.7	3	L
15	Fixed	56	267143.3	2159843.3	5 Extension	L
A1	Alternate	56	262408.5	2157909.2	3	R
A2	Alternate	226	266451.4	2159443.7	5 Extension	L
A3	Alternate	37	262859.0	2157213.8	5	R
A4	Alternate	38	266806.8	2156176.6	14 Extension	L
A5	Alternate	6	265147.0	2153754.2	19	L
A6	Alternate	235	265599.5	2155471.4	14 Extension	L
A7	Alternate	26	262495.0	2157013.8	5	R
A8	Alternate	214	266035.6	2154285.7	19 Extension	L
A9	Alternate	282	263839.0	2154296.8	14	R
A10	Alternate	165	264393.0	2153312.2	19	L

[1] Transects denoted as “Extension” represent a continuation of existing Landbird transects.

[2] To mitigate “transect” effects, plots are randomly placed 50 meters to the left (L) or right (R) of the existing transects.

Table A.5. Rotational plot locations for the ʻŌlaʻa wet forest sampling frame at HAVO. Alternate locations are provided in case any of the rotational plots are rejected in the field. Since these plots will be surveyed only once and we do not anticipate any "transect" effects, plot centroids lie on the transects rather than being offset by 50 m.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Rotational Transect
16	Rotational	334	262402.0	262402.0	1
17	Rotational	29	267674.7	267674.7	7
18	Rotational	212	264991.5	264991.5	3
19	Rotational	118	263832.4	263832.4	3
20	Rotational	144	265985.5	265985.5	2
21	Rotational	69	267231.6	267231.6	7
22	Rotational	297	266425.2	266425.2	6
23	Rotational	61	265918.9	265918.9	4
24	Rotational	190	262120.1	262120.1	1
25	Rotational	74	263687.5	263687.5	3
26	Rotational	253	263845.9	263845.9	0
27	Rotational	34	264846.6	264846.6	3
28	Rotational	35	263772.4	263772.4	5
29	Rotational	244	267484.8	267484.8	7
30	Rotational	32	261979.1	261979.1	1
A1	Alternate	193	267195.7	267195.7	6
A2	Alternate	333	266080.2	266080.2	4
A3	Alternate	236	266938.9	266938.9	6
A4	Alternate	177	266812.9	266812.9	2
A5	Alternate	166	266340.1	266340.1	2
A6	Alternate	272	265867.3	265867.3	2
A7	Alternate	195	266810.5	266810.5	6
A8	Alternate	163	267105.0	267105.0	7
A9	Alternate	128	267821.9	267821.9	9
A10	Alternate	53	267765.8	267765.8	9

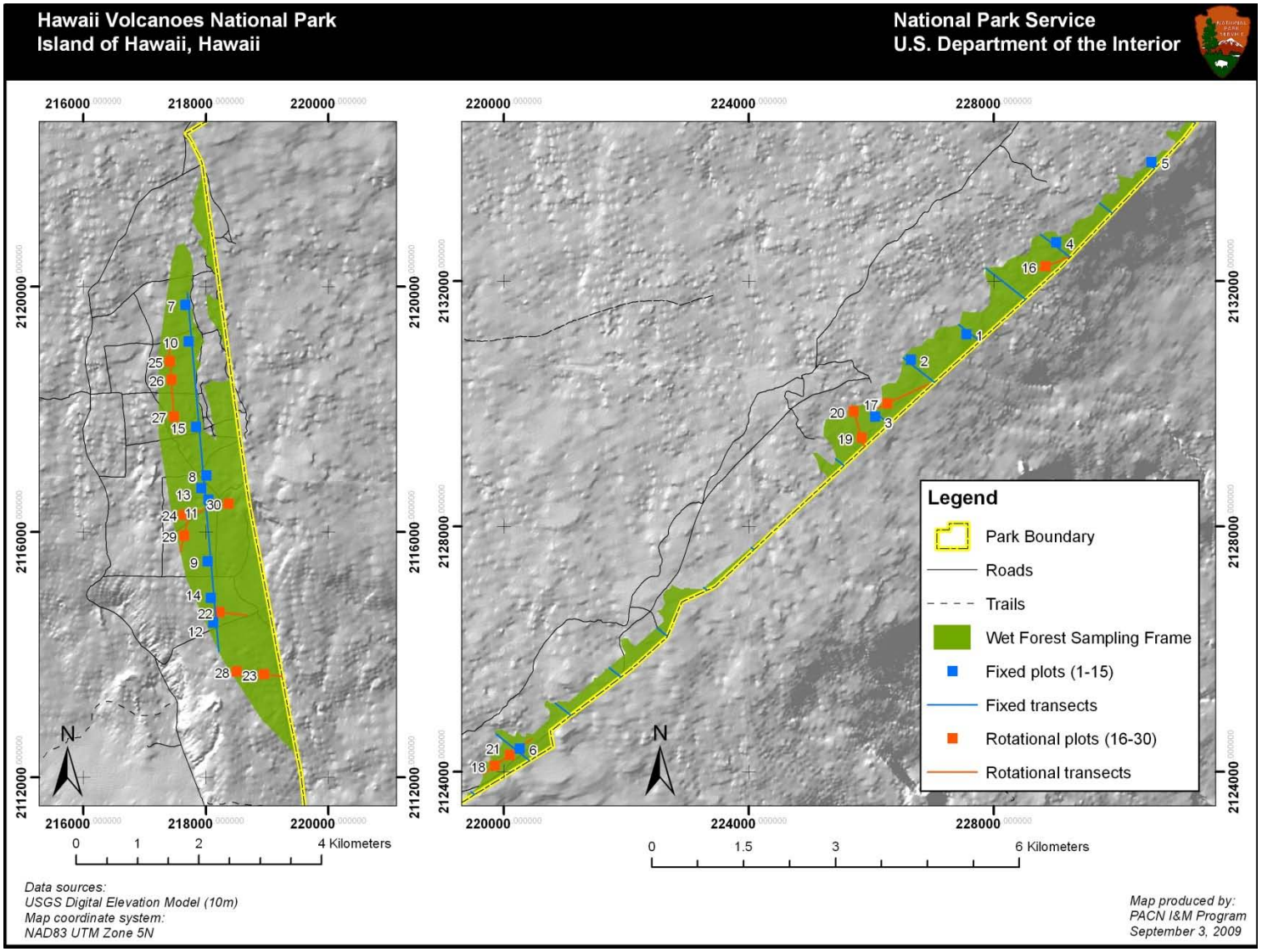

Figure A.4. Map of fixed and rotational plot locations for the Kahuku wet forest sampling frame at HAVO. The map on the left shows the southern flank of Mauna Loa (zone 1), while the one on the right shows the area above the Kāʻu Forest Reserve (zone 2; see Figure A.1 for an overview of the Kahuku area). The number of plots selected in each of these two regions is proportional to the area of each zone.

Table A.6. Fixed plot locations for the Kahuku wet forest sampling frame at HAVO. Alternate locations are provided in case any of the fixed or rotational plots are rejected in the field. The number of plots selected in each of the zones (south = 1 and northeast = 2) is proportional to the area of each zone. This sampling frame has a very small amount of overlap with the Landbirds Protocol; thus collocation does not occur by design although it does occur minimally by coincidence.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Zone	Plot Placement[1]
1	Fixed	352	227549.2	2131128.0	2	R
2	Fixed	341	226640.3	2130712.9	2	L
3	Fixed	137	226058.3	2129788.6	2	R
4	Fixed	100	229014.4	2132628.0	2	L
5	Fixed	232	230574.8	2133935.7	2	L
6	Fixed	102	220253.9	2124371.0	2	L
7	Fixed	37	217662.9	2119695.9	1	R
8	Fixed	87	218006.3	2116916.7	1	L
9	Fixed	354	218028.7	2115514.0	1	R
10	Fixed	207	217715.1	2119098.5	1	R
11	Fixed	250	218041.2	2116518.5	1	L
12	Fixed	296	218115.9	2114518.4	1	R
13	Fixed	352	217924.2	2116708.8	1	R
14	Fixed	212	218081.0	2114916.6	1	R
15	Fixed	359	217837.1	2117704.5	1	R
A1	Alternate	108	226736.6	2130511.4	2	R
A2	Alternate	57	228795.1	2132671.9	2	R
A3	Alternate	58	229852.7	2133232.4	2	L
A4	Alternate	16	221044.2	2125017.5	2	L
A5	Alternate	144	228416.2	2131713.0	2	R
A6	Alternate	106	225544.2	2129057.7	2	L
A7	Alternate	327	218093.4	2115921.1	1	L
A8	Alternate	5	217767.4	2118501.1	1	R
A9	Alternate	287	217645.5	2119895.0	1	R
A10	Alternate	81	217976.4	2116111.4	1	R
A12	Alternate	192	217871.9	2117306.3	1	R
A13	Alternate	38	217954.0	2117514.1	1	L
A11	Alternate	243	217819.6	2117903.7	1	R
A14	Alternate	298	218250.3	2114128.9	1	L
A15	Alternate	36	217680.3	2119496.7	1	R

[1] To mitigate transect effects, plot placement is either 50 meters to the left (L) or right (R) of each transect.

Table A.7. Rotational plot locations for the Kahuku wet forest sampling frame at HAVO. Alternate locations are provided in case any of the fixed or rotational plots are rejected in the field. The number of rotational plots selected in each of the zones (south = 1 and northeast = 2) is proportional to the area of each zone. Since this sampling frame has little overlap with the Landbirds Protocol, collocation does not occur for the rotational transects or plots.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Zone
16	Rotational	20	228841.3	2132235.9	2
17	Rotational	108	226258.1	2130001.1	2
18	Rotational	134	219847.2	2124092.0	2
19	Rotational	278	225838.5	2129441.5	2
20	Rotational	293	225706.8	2129871.5	2
21	Rotational	310	220089.7	2124268.4	2
22	Rotational	5	218224.3	2114684.9	1
23	Rotational	19	218949.3	2113671.0	1
24	Rotational	38	217640.6	2116276.2	1
25	Rotational	81	217412.9	2118775.2	1
26	Rotational	354	217434.0	2118476.1	1
27	Rotational	100	217476.1	2117877.9	1
28	Rotational	131	218502.0	2113717.5	1
29	Rotational	233	217641.9	2115937.1	1
30	Rotational	352	218367.8	2116458.0	1
A1	Alternate	5	225794.6	2129584.9	2
A2	Alternate	208	226529.7	2130127.9	2
A3	Alternate	255	220453.5	2124532.9	2
A4	Alternate	284	219968.4	2124180.2	2
A5	Alternate	341	228980.3	2132292.0	2
A6	Alternate	346	228563.3	2132123.5	2
A7	Alternate	207	218075.2	2114700.4	1
A8	Alternate	250	217402.3	2118924.8	1
A9	Alternate	243	218373.4	2114669.3	1
A10	Alternate	276	218800.2	2113686.5	1
A11	Alternate	296	217455.0	2118177.0	1
A12	Alternate	298	217465.6	2118027.5	1
A13	Alternate	327	217423.4	2118625.7	1
A14	Alternate	225	217444.5	2118326.6	1
A15	Alternate	359	218522.5	2114653.7	1

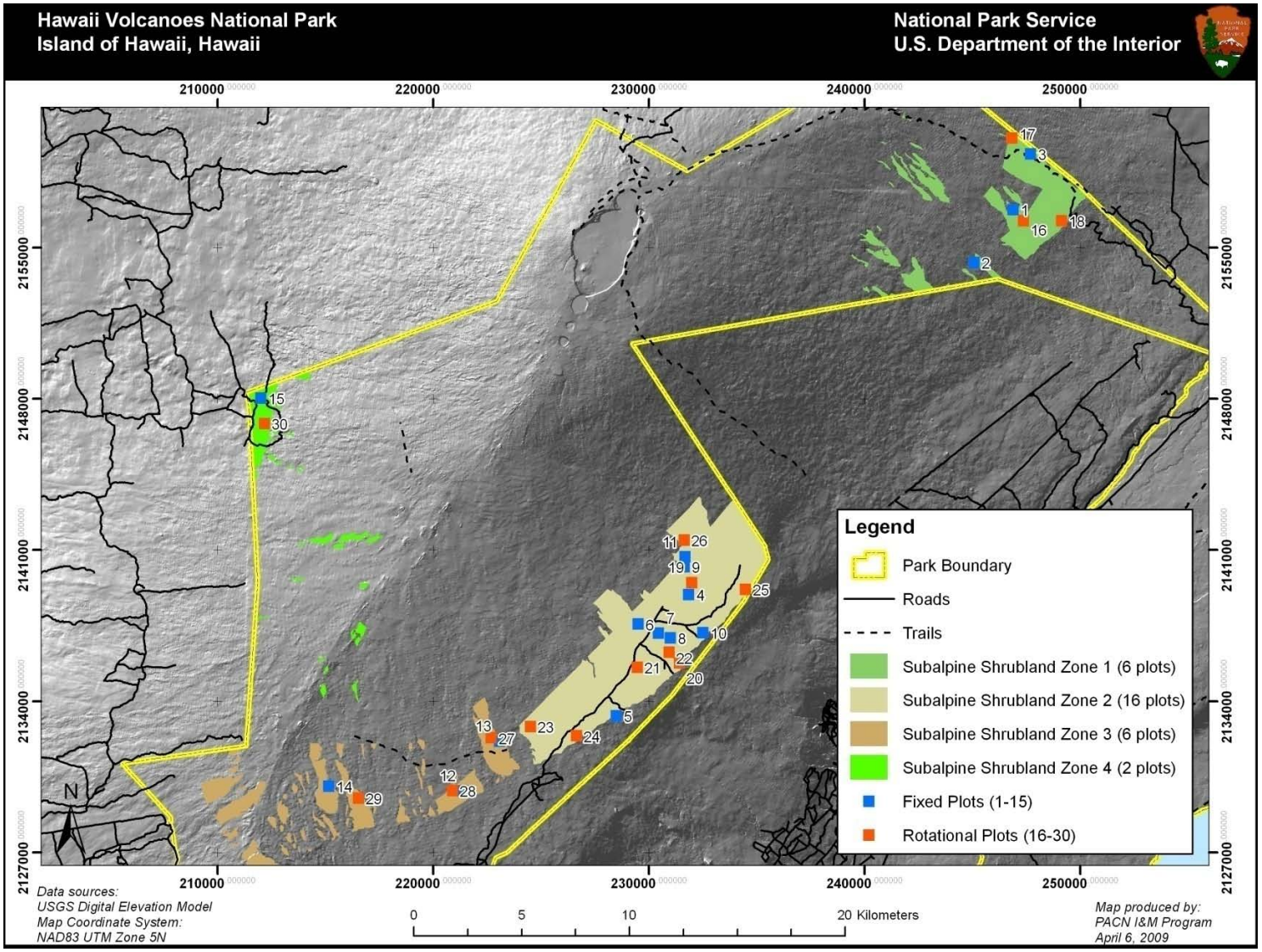

Figure A.5. Map of plot locations across four zones in the subalpine shrubland sample frame at HAVO. Zones represent disjointed geographic regions and were established to ensure well-interspersed plots across a geographically complex sampling frame. The number of sampling plots in each zone is proportional to the area of each zone. We will analyze the HAVO shrubland as one sampling frame.

Table A.8. Fixed and rotational plot locations for the subalpine shrubland sampling frame at HAVO. Alternate locations are provided in case any of the fixed or rotational plots are rejected in the field.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Zone	Percent Slope
1	Fixed	106	246880.0	2156773.9	1	12
2	Fixed	108	245072.1	2154331.5	1	14
3	Fixed	341	247698.8	2159359.9	1	10
4	Fixed	352	231848.1	2138952.4	2	7
5	Fixed	144	228480.9	2133329.7	2	8
6	Fixed	100	229498.6	2137577.9	2	6
7	Fixed	57	230449.7	2137158.8	2	13
8	Fixed	58	230986.0	2136950.9	2	14
9	Fixed	232	231632.6	2140247.1	2	13
10	Fixed	147	232507.4	2137175.8	2	17
11	Fixed	148	231671.9	2140693.7	2	20
12	Fixed	154	221414.2	2129856.7	3	6
13	Fixed	35	223071.7	2132158.4	3	7
14	Fixed	201	215165.6	2130075.6	3	6
15	Fixed	154	212007.7	2148049.8	4	19
16	Rotational	287	247356.3	2156258.3	1	18
17	Rotational	16	246834.9	2160081.8	1	8
18	Rotational	137	249123.3	2156260.9	1	22
19	Rotational	256	231988.2	2139509.7	2	9
20	Rotational	117	231411.6	2135778.3	2	8
21	Rotational	227	229460.3	2135581.2	2	1
22	Rotational	74	230934.3	2136283.1	2	16
23	Rotational	66	224505.6	2132841.6	2	7
24	Rotational	210	226642.6	2132402.8	2	17
25	Rotational	29	234474.8	2139191.0	2	13
26	Rotational	164	231629.0	2141469.0	2	6
27	Rotational	250	222689.1	2132312.6	3	13
28	Rotational	328	220898.8	2129871.7	3	3
29	Rotational	300	216534.8	2129523.4	3	5
30	Rotational	244	212168.4	2146875.2	4	6
A1	Alternate	36	247819.0	2156922.2	1	14
A2	Alternate	37	247695.3	2155999.3	1	25
A3	Alternate	102	243220.6	2157904.3	1	13
A4	Alternate	326	232491.9	2142551.8	2	11
A5	Alternate	94	227818.5	2135395.4	2	12
A6	Alternate	282	226832.9	2134783.6	2	9
A7	Alternate	136	233326.2	2141265.5	2	12
A8	Alternate	104	224411.1	2132949.2	2	7
A9	Alternate	330	234151.7	2142567.6	2	22
A10	Alternate	227	227851.6	2134827.7	2	11
A11	Alternate	225	231738.0	2139658.7	2	9
A12	Alternate	8	222457.3	2133380.8	3	12
A13	Alternate	195	214819.6	2130300.6	3	5
A14	Alternate	329	216097.2	2129984.0	3	5
A15	Alternate	180	212439.8	2148532.0	4	11

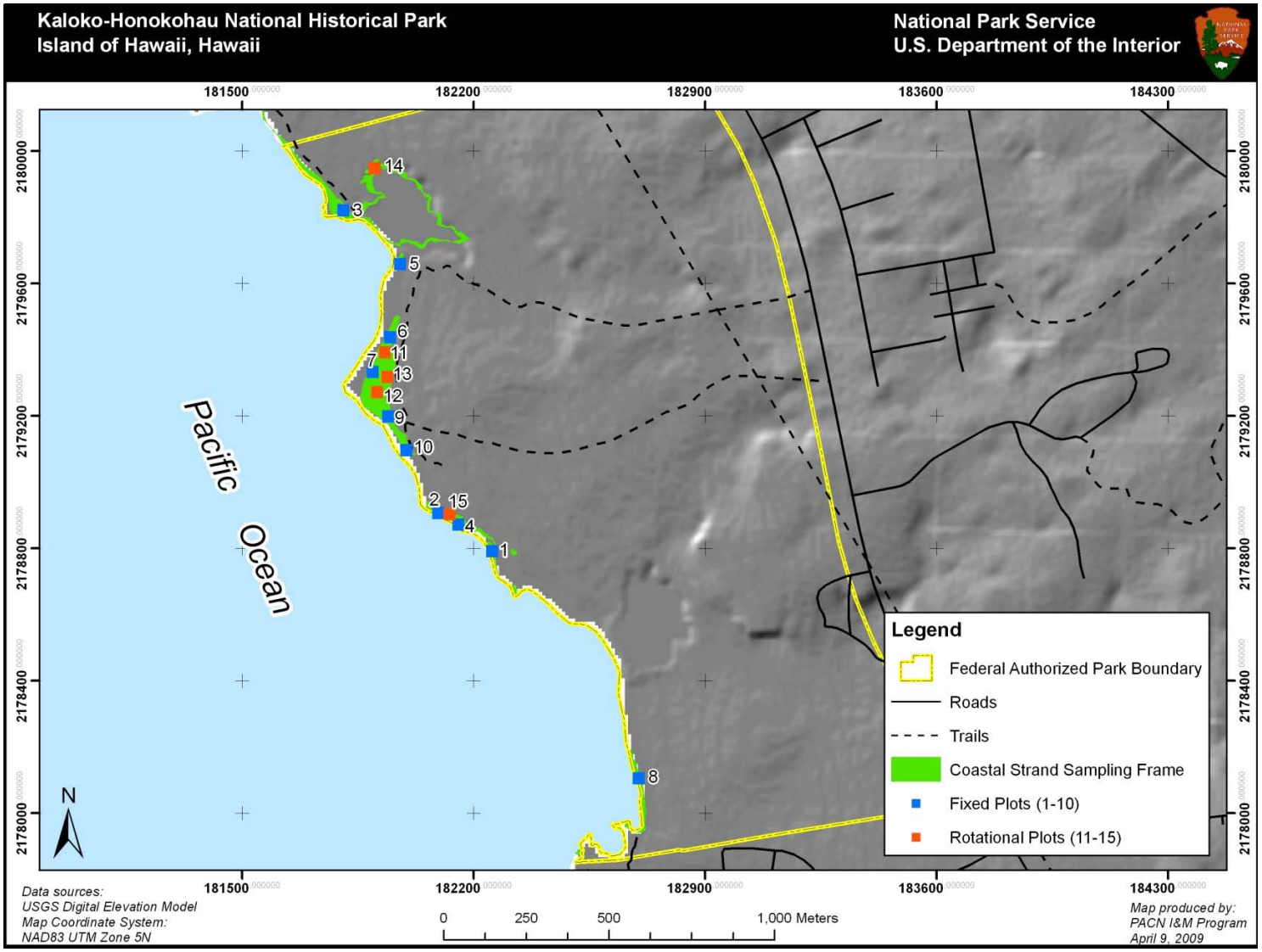

Figure A.6. Map of fixed and rotational plot locations for the coastal strand sampling frame at KAHO. In lieu of the legislated park boundary, we used the smaller, authorized park boundary (shown in yellow), which does not include any state or private land that may be difficult to access and survey.

Table A.9. Fixed and rotational plot locations for the coastal strand sampling frame at KAHO. Alternate locations are provided in case fixed or rotational plots are rejected in the field.

Centroid Number	Plot Type	Plot Azimuth	X (centroid)	Y (centroid)
1	Fixed	26	182255.6	2178791.3
2	Fixed	118	182091.5	2178906.8
3	Fixed	210	181805.2	2179820.5
4	Fixed	137	182153.4	2178871.8
5	Fixed	16	181976.7	2179658.9
6	Fixed	173	181947.0	2179437.8
7	Fixed	6	181893.6	2179333.4
8	Fixed	346	182699.1	2178106.2
9	Fixed	76	181940.3	2179199.3
10	Fixed	318	181996.1	2179096.7
11	Rotational	137	181930.6	2179391.8
12	Rotational	324	181906.9	2179271.5
13	Rotational	192	181938.4	2179317.1
14	Rotational	219	181900.5	2179947.8
15	Rotational	261	182126.7	2178903.6
A1	Alternate	13	181958.5	2179481.5
A2	Alternate	143	181776.2	2179854.1
A3	Alternate	144	181922.7	2179350.1
A4	Alternate	6	181940.8	2179279.7
A5	Alternate	328	181903.4	2179302.7

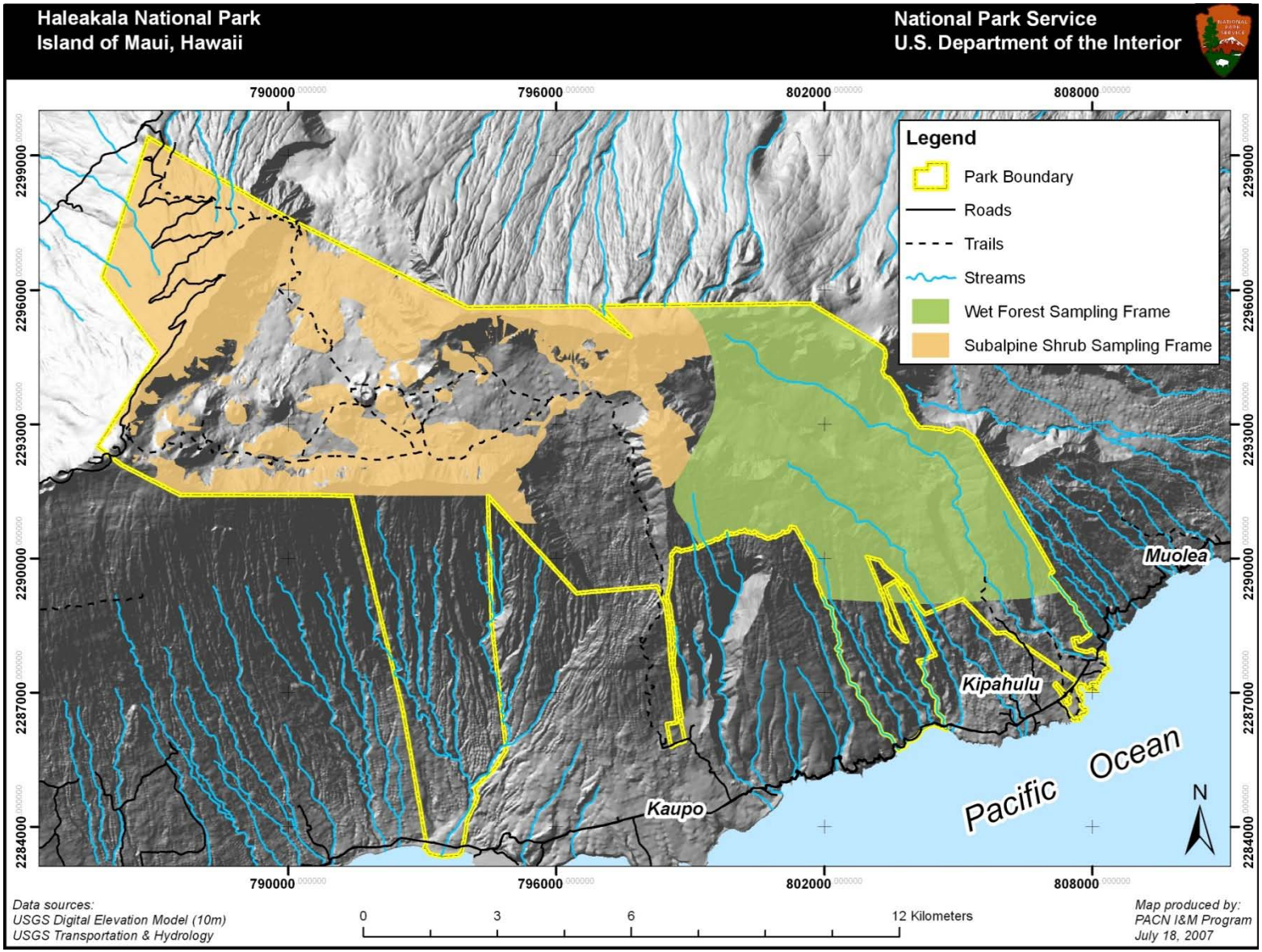

Figure A.9. Map of wet forest and subalpine shrubland sampling frames at HALE.

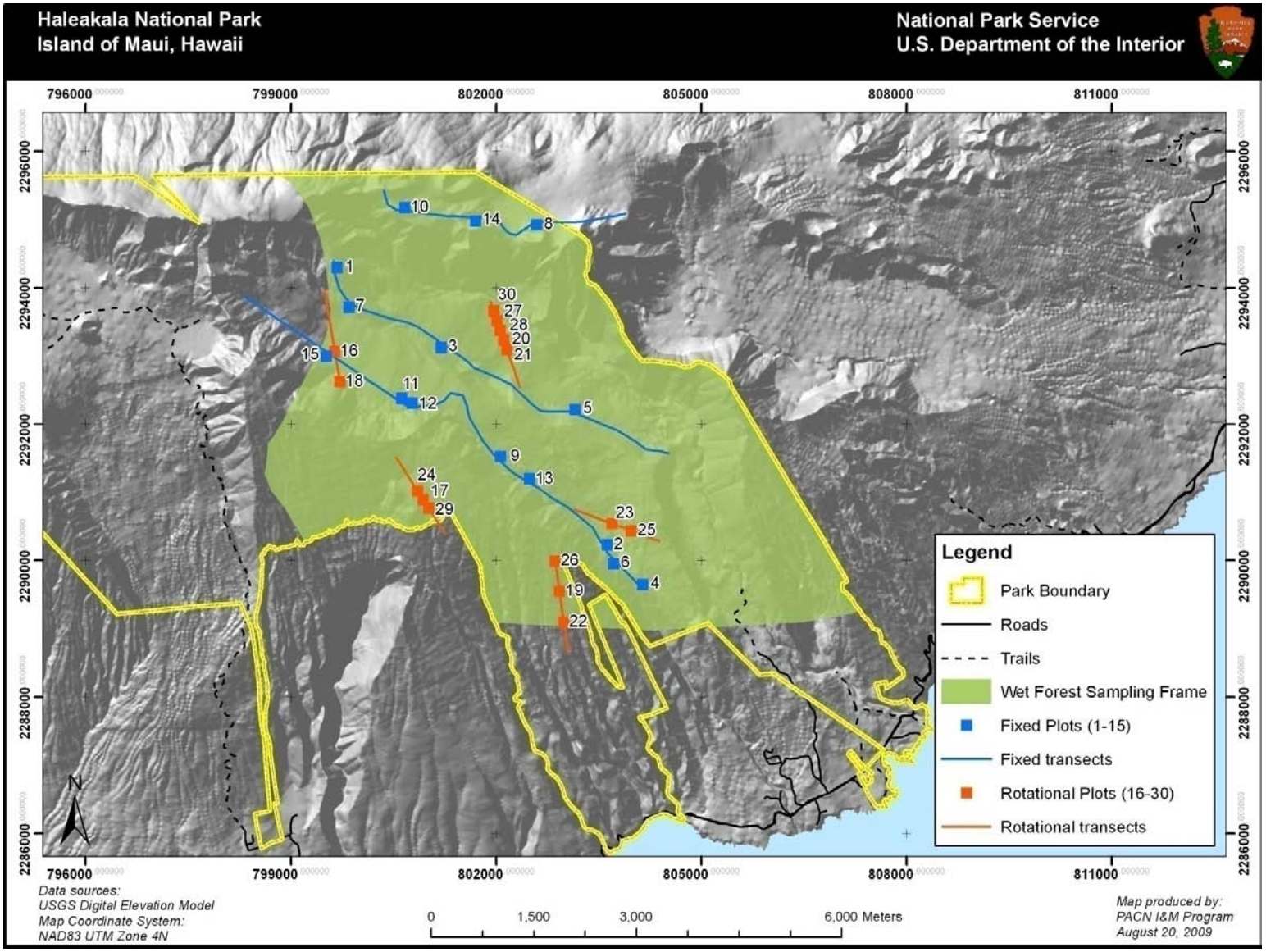

Figure A.10. Map of fixed and rotational plot locations for the wet forest sampling frame at HALE.

Table A.14. Fixed plot locations for the wet forest sampling frame at HALE. All plots with slopes greater than 100% were excluded. Alternate locations are provided in case any of the original fixed sites are rejected in the field. Transect locations and numbers coincide with transects from the Landbird Protocol.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Fixed Transect	Plot Placement[1]
1	Fixed	108	799676.5	2294293.9	16	L
2	Fixed	19	803627.8	2290233.7	17	L
3	Fixed	5	801195.6	2293122.1	16	R
4	Fixed	168	804144.2	2289650.6	17	L
5	Fixed	16	803154.3	2292215.3	16	L
6	Fixed	213	803719.0	2289955.3	17	R
7	Fixed	278	799853.0	2293711.5	16	R
8	Fixed	104	802596.8	2294921.9	10	R
9	Fixed	341	802065.7	2291528.0	17	L
10	Fixed	192	800668.9	2295175.5	10	L
11	Fixed	134	800623.0	2292375.5	17	L
12	Fixed	346	800771.1	2292306.6	17	L
13	Fixed	131	802491.8	2291198.9	17	L
14	Fixed	208	801707.1	2294976.0	10	R
15	Fixed	284	799521.3	2292996.0	17	R
A1	Alternate	276	803338.1	2290611.3	17	L
A2	Alternate	149	803644.5	2292012.0	16	L
A3	Alternate	255	802197.6	2292537.5	16	R
A4	Alternate	273	801373.8	2293121.6	16	L
A5	Alternate	310	804417.7	2291651.2	16	L
A6	Alternate	253	800510.9	2295097.0	10	R
A7	Alternate	293	801707.5	2292864.4	16	L
A8	Alternate	313	801119.2	2292347.1	17	L
A9	Alternate	188	803081.2	2290817.9	17	L
A10	Alternate	20	801522.4	2292258.5	17	R

[1] To mitigate transect effects, plot placement is either 50 meters to the left (L) or right (R) of an existing transect.

Table A.15. Rotational plot locations for the wet forest sampling frame at HALE. All plots with slopes greater than 100% were excluded. Alternate locations are provided in case any of the original rotational sites are rejected in the field. Transect locations and numbers coincide with transects from the Landbird Protocol.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Rotational Transect
16	Rotational	253	799641.1	2293067.7	2
17	Rotational	192	800935.8	2290895.2	3
18	Rotational	208	799717.6	2292624.3	2
19	Rotational	104	802927.4	2289551.6	5
20	Rotational	108	802110.7	2293233.1	1
21	Rotational	278	802159.3	2293091.2	1
22	Rotational	5	802989.1	2289105.8	5
23	Rotational	273	803696.2	2290543.4	4
24	Rotational	293	800854.3	2291020.2	3
25	Rotational	255	803976.9	2290437.6	4
26	Rotational	16	802865.7	2289997.3	5
27	Rotational	149	802013.6	2293516.9	1
28	Rotational	310	802062.2	2293375.0	1
29	Rotational	284	801017.4	2290769.8	3
30	Rotational	134	801965.0	2293658.9	1
A1	Alternate	346	800691.2	2291271.9	3
A2	Alternate	313	799666.4	2292919.8	2
A3	Alternate	20	802256.5	2292807.4	1
A4	Alternate	341	802353.7	2292527.1	1
A5	Alternate	131	804257.7	2290331.7	4
A6	Alternate	188	800531.4	2291523.7	3
A7	Alternate	276	804398.0	2290278.8	4
A8	Alternate	19	802906.8	2289700.2	5
A9	Alternate	213	802948.0	2289403.0	5
A10	Alternate	168	802886.2	2289848.8	5

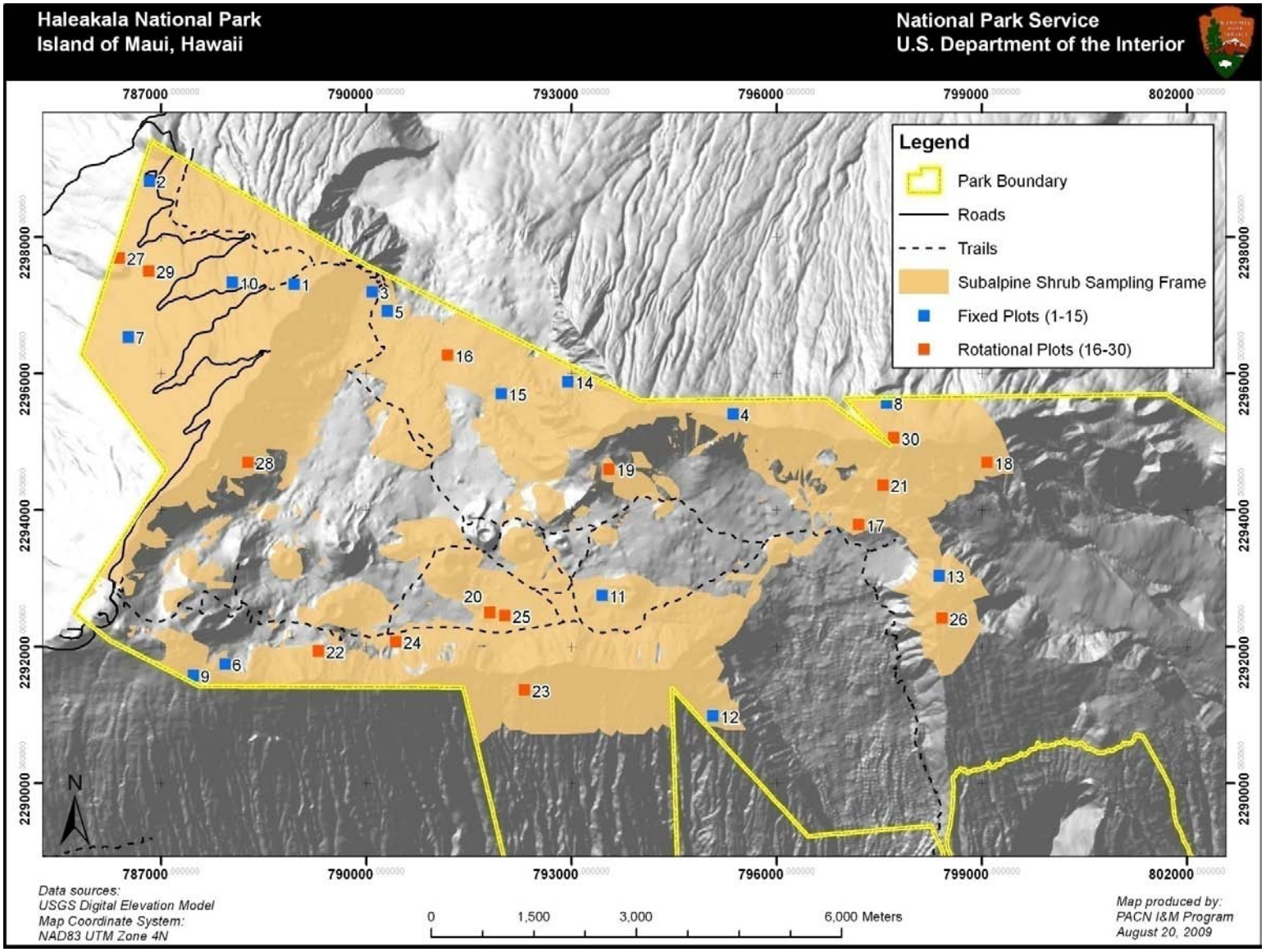

Figure A.11. Map of fixed and rotational plots for the subalpine shrubland sampling frame at HALE.

Table A.16. Fixed and rotational plot locations for the subalpine shrubland sampling frame at HALE.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)
1	Fixed	253	788949.3	2297310.5
2	Fixed	192	786834.7	2298825.1
3	Fixed	208	790091.7	2297196.8
4	Fixed	104	795363.2	2295411.6
5	Fixed	108	790310.7	2296917.4
6	Fixed	278	787939.9	2291750.0
7	Fixed	5	786526.5	2296537.1
8	Fixed	273	797605.4	2295571.3
9	Fixed	293	787474.0	2291579.5
10	Fixed	255	788048.4	2297336.9
11	Fixed	16	793448.6	2292754.8
12	Fixed	149	795071.0	2290988.7
13	Fixed	310	798373.0	2293042.4
14	Fixed	284	792951.0	2295882.5
15	Fixed	134	791974.3	2295706.8
16	Rotational	346	791191.2	2296271.7
17	Rotational	313	797202.1	2293790.7
18	Rotational	20	799076.9	2294699.3
19	Rotational	341	793550.9	2294601.0
20	Rotational	131	791806.6	2292507.8
21	Rotational	188	797552.7	2294370.6
22	Rotational	276	789304.9	2291938.1
23	Rotational	19	792316.5	2291368.0
24	Rotational	213	790433.0	2292074.9
25	Rotational	168	792031.1	2292456.4
26	Rotational	107	798417.3	2292421.6
27	Rotational	224	786392.0	2297693.9
28	Rotational	233	788271.8	2294702.7
29	Rotational	94	786823.2	2297501.1
30	Rotational	100	797713.6	2295060.7

Table A.17. Alternate plot locations for the subalpine shrubland sampling frame at HALE. Alternate locations are provided in case any fixed or rotational plots are rejected in the field. Given the simple random sampling scheme, alternates can be used as either fixed or rotational plots.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)
A1	Alternate	298	796508.6	2293533.9
A2	Alternate	296	793933.8	2291658.4
A3	Alternate	212	792683.6	2294099.2
A4	Alternate	354	791999.5	2294988.8
A5	Alternate	327	789963.5	2297262.2
A6	Alternate	81	794129.0	2291516.8
A7	Alternate	250	789210.6	2296787.9
A8	Alternate	352	787524.2	2291807.0
A9	Alternate	87	790313.6	2295723.1
A10	Alternate	192	792778.4	2292706.0
A11	Alternate	38	792523.9	2296120.2
A12	Alternate	359	788755.4	2297722.2
A13	Alternate	243	789832.2	2296329.9
A14	Alternate	5	794839.2	2292721.6
A15	Alternate	207	786866.8	2296118.7
A16	Alternate	36	793909.6	2295555.6
A17	Alternate	37	792647.7	2291109.1
A18	Alternate	287	792980.1	2291837.6
A19	Alternate	102	795684.8	2295362.9
A20	Alternate	16	787907.5	2295384.2
A21	Alternate	106	788044.2	2297545.7
A22	Alternate	137	787388.2	2298306.1
A23	Alternate	108	791271.3	2291519.5
A24	Alternate	341	790798.9	2292155.8
A25	Alternate	352	792800.6	2296090.1

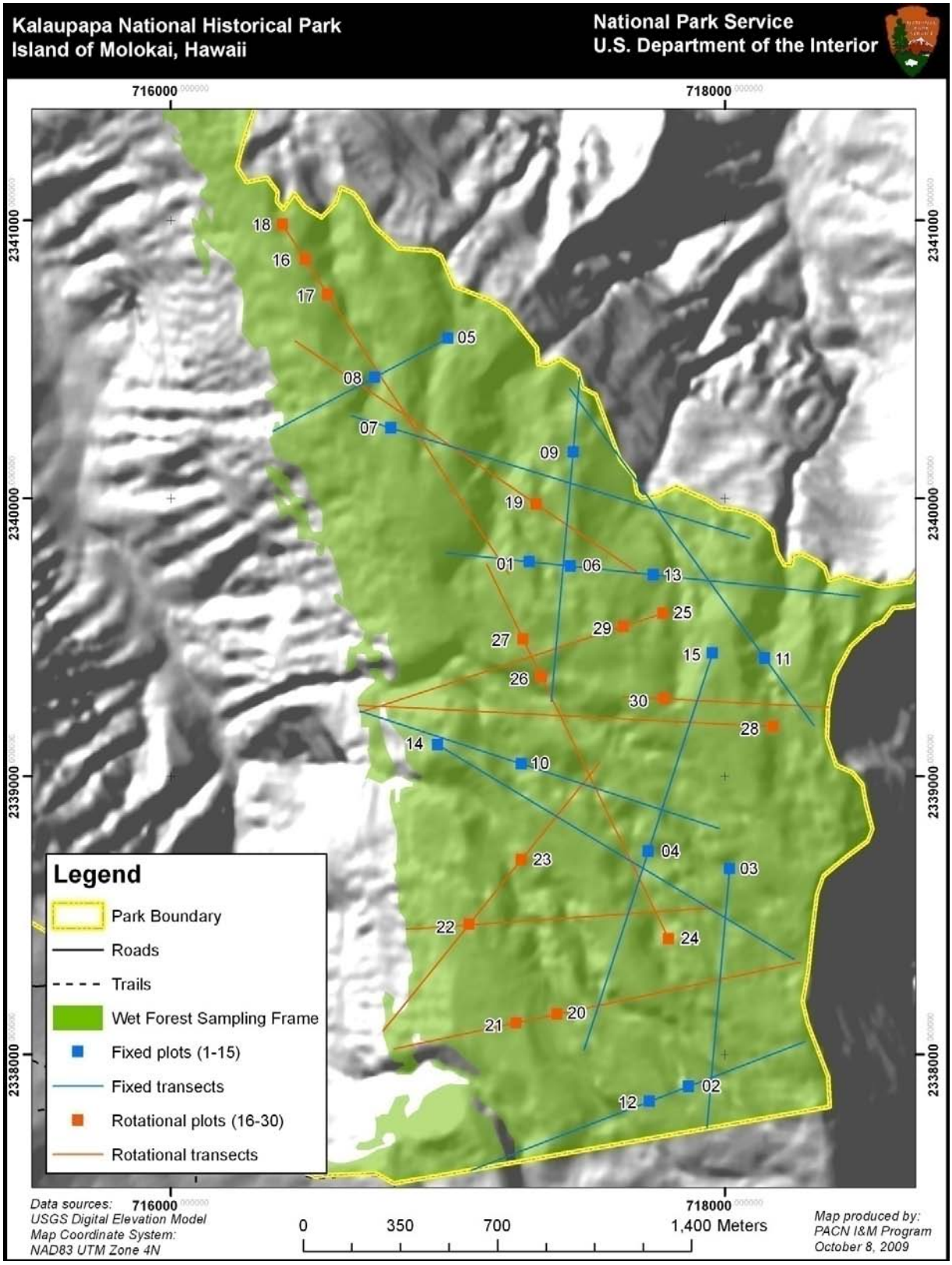

Figure A.12. Map of fixed and rotational plot locations within the wet forest sampling frame at KALA.

Table A.18. Fixed plot locations for the wet forest sampling frame at KALA. Alternate locations are provided in case any of the fixed plots are rejected in the field. Given the steep and treacherous terrain in this sampling frame, field crews will access plots via the trail system rather than by following transects.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Distance to Nearest Trail (m)
1	Fixed	167	717294.3	2339771.9	31
2	Fixed	301	717868.6	2337885.0	87
3	Fixed	352	718017.2	2338668.1	36
4	Fixed	202	717723.4	2338730.9	45
5	Fixed	282	717001.8	2340576.7	103
6	Fixed	185	717443.5	2339756.2	55
7	Fixed	226	716795.2	2340252.8	45
8	Fixed	165	716736.9	2340435.9	103
9	Fixed	244	717452.5	2340166.8	52
10	Fixed	56	717266.3	2339044.8	53
11	Fixed	141	718144.2	2339425.2	100
12	Fixed	8	717728.6	2337831.2	43
13	Fixed	181	717741.9	2339724.9	141
14	Fixed	97	716964.3	2339114.6	51
15	Fixed	329	717955.2	2339444.2	82
A1	Alternate	155	717426.4	2339867.9	39
A2	Alternate	250	717908.9	2339301.5	134
A3	Alternate	35	717677.1	2338588.2	75
A4	Alternate	127	717145.1	2339787.6	86
A5	Alternate	146	716996.0	2339803.3	47
A6	Alternate	330	717374.1	2339270.2	34
A7	Alternate	93	716938.7	2340208.9	76
A8	Alternate	88	717864.3	2338573.8	51
A9	Alternate	39	717967.9	2339667.9	66
A10	Alternate	141	717978.0	2338219.8	96
A11	Alternate	131	717964.9	2338070.3	47
A12	Alternate	182	718232.4	2339303.9	100
A13	Alternate	56	717512.4	2340033.5	72
A14	Alternate	154	717491.7	2338017.6	107
A15	Alternate	20	717350.0	2338882.8	74

Table A.19. Rotational plot locations for the wet forest sampling frame at KALA. Alternate locations are provided in case any of the rotational plots are rejected in the field. Given the steep and treacherous terrain in this sampling frame, field crews will access plots via the trail system rather than by following transects.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Distance to Nearest Trail (m)
16	Rotational	0	716485.2	2340859.8	71
17	Rotational	243	716566.9	2340734.0	84
18	Rotational	38	716403.5	2340985.6	42
19	Rotational	36	717319.6	2339979.6	118
20	Rotational	106	717394.0	2338144.4	73
21	Rotational	16	717247.3	2338113.2	55
22	Rotational	100	717076.9	2338467.1	51
23	Rotational	144	717265.7	2338700.3	85
24	Rotational	59	717797.6	2338415.1	109
25	Rotational	136	717776.3	2339585.3	199
26	Rotational	117	717337.3	2339358.8	52
27	Rotational	228	717271.5	2339493.6	61
28	Rotational	165	718174.6	2339178.5	81
29	Rotational	104	717633.6	2339539.0	66
30	Rotational	331	717781.6	2339280.3	34
A1	Alternate	326	717962.9	2338527.7	70
A2	Alternate	6	716648.6	2340608.2	110
A3	Alternate	288	716449.1	2340566.8	64
A4	Alternate	102	717100.6	2338082.1	44
A5	Alternate	138	717687.4	2338206.8	41
A6	Alternate	108	717834.2	2338238.0	75
A7	Alternate	29	718024.8	2339186.3	39
A8	Alternate	148	717600.3	2338819.5	64
A9	Alternate	149	717534.5	2338954.4	61
A10	Alternate	75	717205.8	2339628.4	84
A11	Alternate	353	717360.1	2338816.8	45
A12	Alternate	207	717138.7	2339853.4	85
A13	Alternate	94	717663.7	2338506.7	60
A14	Alternate	227	717931.4	2339272.5	120
A15	Alternate	226	718231.0	2339256.8	69

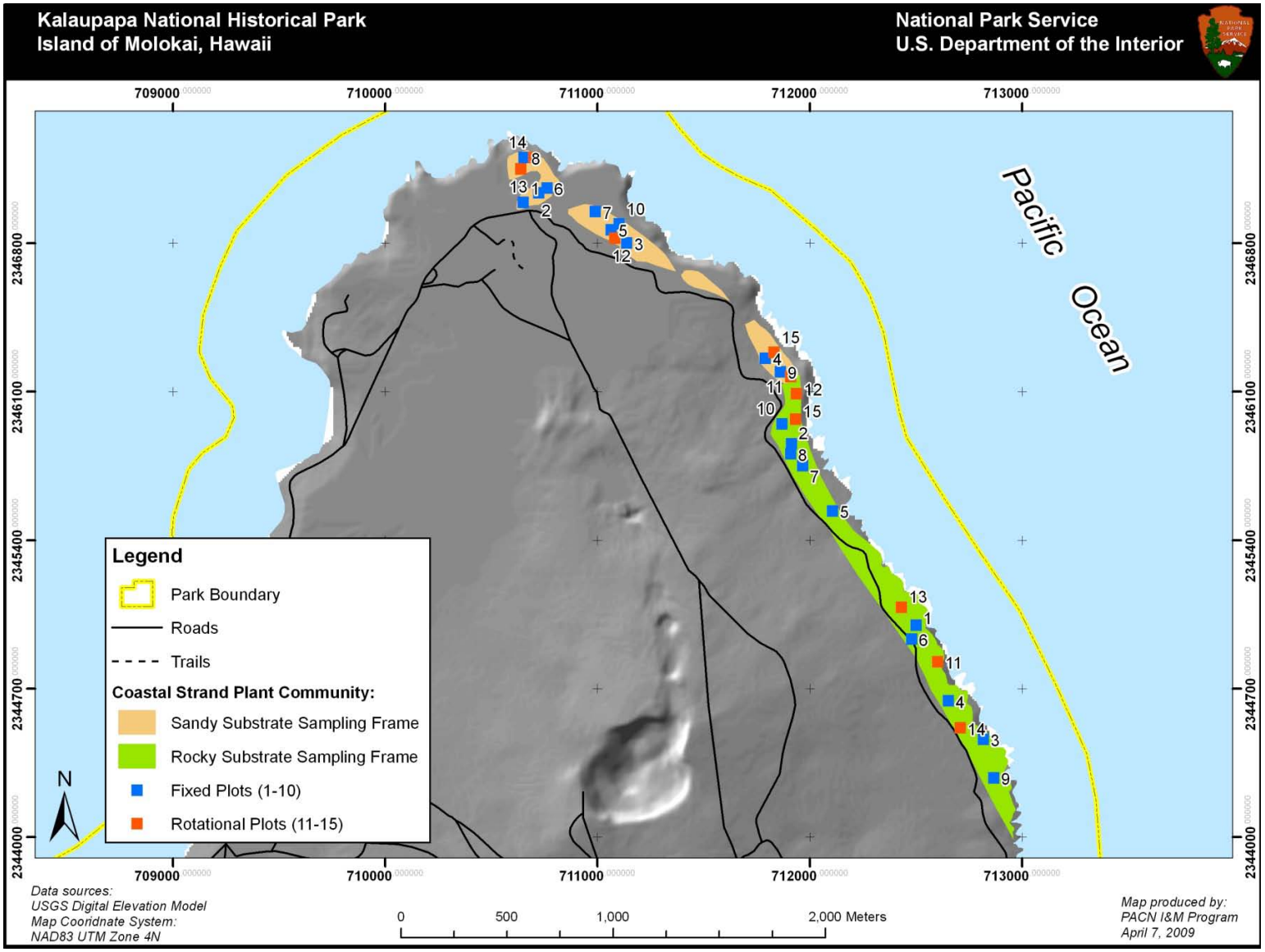

Figure A.13. Map of fixed and rotational plot locations within the two coastal strand sampling frames at KALA. Sampling frame boundaries are based on work done by Canfield (1990).

Table A.20. Fixed and rotational plot locations for the sandy substrate coastal sampling frame at KALA. Alternate locations are provided in case any of the fixed or rotational plots are rejected in the field.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)
1	Fixed	100	710652.0	2346993.4
2	Fixed	298	710723.8	2347037.7
3	Fixed	296	711139.5	2346800.9
4	Fixed	212	711792.3	2346257.9
5	Fixed	354	711065.5	2346863.5
6	Fixed	327	710763.3	2347060.2
7	Fixed	81	710990.3	2346949.0
8	Fixed	250	710654.9	2347204.0
9	Fixed	352	711861.9	2346193.8
10	Fixed	87	711102.8	2346892.2
11	Rotational	192	711911.3	2346171.8
12	Rotational	38	711082.9	2346824.7
13	Rotational	359	710640.0	2347150.5
14	Rotational	144	710702.6	2347204.5
15	Rotational	5	711832.8	2346286.3
A1	Alternate	207	711531.3	2346594.2
A2	Alternate	36	711731.7	2346392.6
A3	Alternate	37	711195.8	2346824.4
A4	Alternate	287	710930.7	2346961.5
A5	Alternate	102	711180.7	2346763.3
A6	Alternate	16	711429.1	2346650.7
A7	Alternate	106	711011.4	2346875.8
A8	Alternate	137	711866.7	2346241.7
A9	Alternate	108	711239.3	2346778.0
A10	Alternate	341	711123.7	2346846.5

Table A.21. Fixed and rotational plot locations for the rocky substrate coastal sampling frame at KALA. Alternate locations are provided in case any of the fixed or rotational plots are rejected in the field.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)
1	Fixed	253	712502.5	2344998.5
2	Fixed	192	711915.8	2345853.3
3	Fixed	208	712819.6	2344461.0
4	Fixed	104	712654.7	2344642.0
5	Fixed	108	712109.0	2345537.1
6	Fixed	278	712480.9	2344933.5
7	Fixed	5	711967.8	2345751.4
8	Fixed	273	711911.2	2345807.0
9	Fixed	293	712867.8	2344278.9
10	Fixed	255	711871.0	2345947.7
11	Rotational	16	712604.5	2344826.3
12	Rotational	149	711938.3	2346090.4
13	Rotational	310	712433.7	2345084.0
14	Rotational	284	712709.9	2344514.7
15	Rotational	134	711933.8	2345970.8
A1	Alternate	346	711910.5	2345895.1
A2	Alternate	313	712764.2	2344400.0
A3	Alternate	20	712600.2	2344688.6
A4	Alternate	341	712777.2	2344505.7
A5	Alternate	131	712568.9	2344885.7
A6	Alternate	188	712008.9	2345622.3
A7	Alternate	276	711868.1	2345861.5
A8	Alternate	19	712654.1	2344588.3
A9	Alternate	213	712155.6	2345437.9
A10	Alternate	168	712911.2	2344148.3

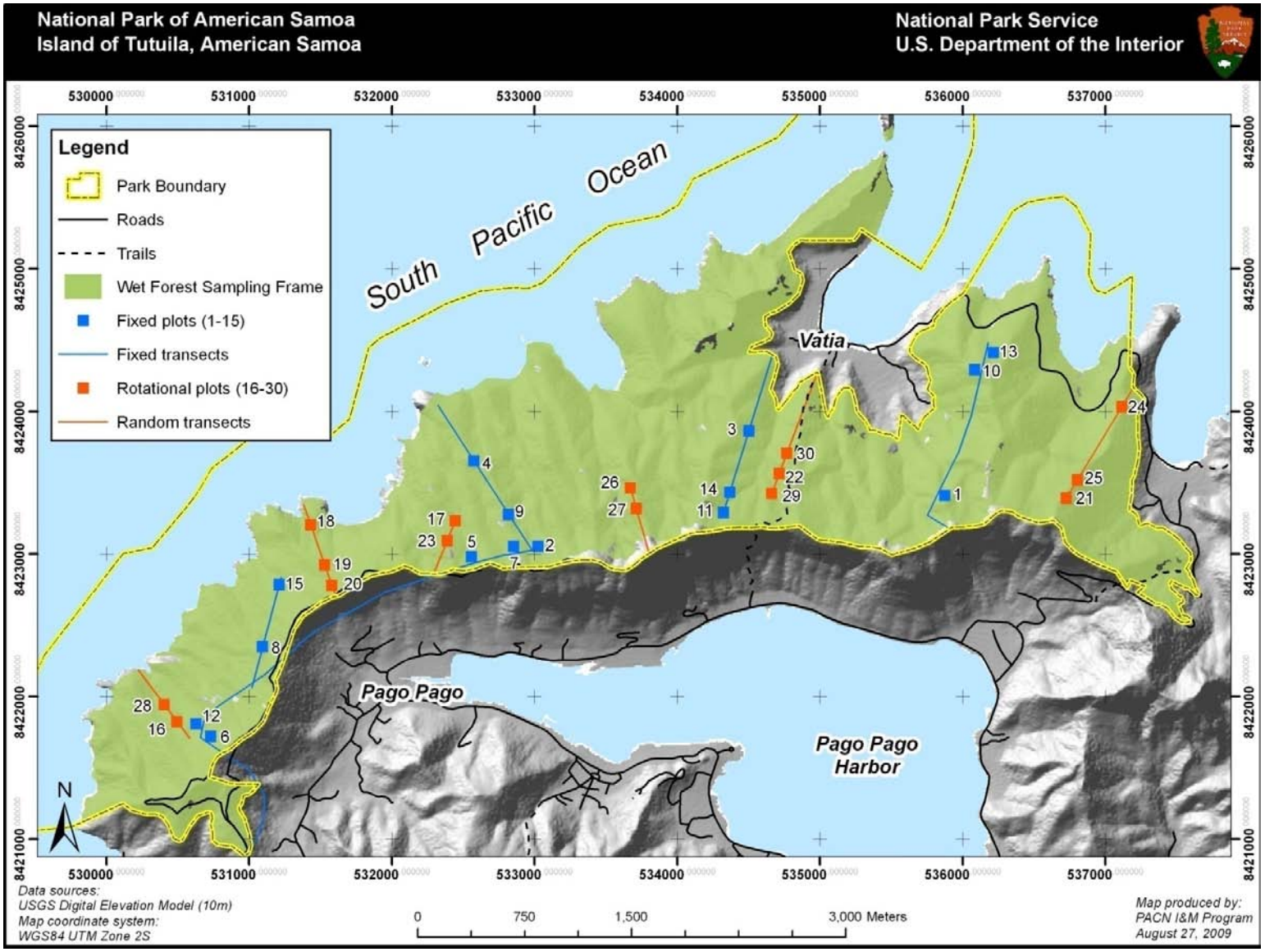

Figure A.7. Map of fixed and rotational plot locations in the Tutuila wet forest sampling frame at NPSA.

Table A.10. Fixed plot locations for the Tutuila wet forest sampling frame at NPSA. Alternate locations are provided in case any of the 15 fixed plots are rejected in the field. Transect locations and numbers coincide with transects from the Landbird Protocol.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Plot Placement[1]	Collocation with Landbirds[2]
1	Fixed	286	535875.8	8423412.6	R	Yes
2	Fixed	335	533023.6	8423054.6	R	No
3	Fixed	11	534501.9	8423863.5	On	No
4	Fixed	288	532573.5	8423654.2	On	No
5	Fixed	273	532557.2	8422982.1	L	Yes
6	Fixed	44	530731.9	8421720.9	R	Yes
7	Fixed	59	532853.9	8423054.2	L	Yes
8	Fixed	155	531094.3	8422351.5	On	No
9	Fixed	106	532818.4	8423276.7	On	No
10	Fixed	348	536083.2	8424292.8	L	Yes
11	Fixed	303	534325.5	8423290.0	On	No
12	Fixed	239	530628.0	8421809.4	L	Yes
13	Fixed	140	536214.6	8424413.9	R	No
14	Fixed	203	534369.6	8423433.4	On	Yes
15	Fixed	94	531209.4	8422786.5	On	No
A1	Alternate	204	535921.2	8423726.3	L	Yes
A2	Alternate	142	530855.4	8422043.1	L	Yes
A3	Alternate	85	535723.4	8423324.7	L	Yes
A4	Alternate	98	536063.4	8423828.8	R	Yes
A5	Alternate	50	532328.6	8424031.7	On	No
A6	Alternate	26	534546.0	8424006.8	On	No
A7	Alternate	205	534634.3	8424293.6	On	No
A8	Alternate	208	536049.7	8424147.9	L	Yes
A9	Alternate	74	532410.2	8423905.9	On	No
A10	Alternate	26	531171.1	8422641.5	On	No

[1] Plot placement may be on the transect (On), or to the left (L) or right (R) of the transect by 50 meters. For plots along legacy bird survey routes, plot center points have been shifted to the left or right (randomly chosen) of the transect by 50 meters to avoid potential “transect” effects. For newly generated transects, which should not have any “transect” effects, plots centroids lie on the transect.

[2] The fixed plots used in this protocol were selected from two sources: (a) Landbirds fixed transects, and (b) three Landbirds rotational transects from the first sample cycle. However, those located along rotational transects are not considered collated as Landbird sampling will only occur there once.

Table A.11. Rotational plot locations for the Tutuila wet forest sampling frame at NPSA. Alternate locations are provided in case any of the rotational plots are rejected in the field. Transect locations and numbers coincide with transects from the Landbird Protocol.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Rotational Transect
16	Rotational	206	530494.7	8421823.8	2
17	Rotational	1	532444.4	8423232.3	4
18	Rotational	126	531430.4	8423206.2	3
19	Rotational	34	531529.5	8422923.0	3
20	Rotational	262	531579.1	8422781.4	3
21	Rotational	38	536726.8	8423392.4	8
22	Rotational	205	534714.9	8423565.5	7
23	Rotational	213	532387.6	8423093.5	4
24	Rotational	248	537115.9	8424033.6	8
25	Rotational	267	536804.6	8423520.6	8
26	Rotational	125	533672.1	8423463.7	9
27	Rotational	40	533713.0	8423319.4	9
28	Rotational	239	530405.0	8421944.0	2
29	Rotational	127	534661.9	8423425.2	7
30	Rotational	44	534768.0	8423705.9	7
A1	Alternate	193	534821.0	8423846.2	7
A2	Alternate	142	533753.9	8423175.1	9
A3	Alternate	43	536960.2	8423777.1	8
A4	Alternate	351	531480.0	8423064.6	3
A5	Alternate	309	537038.1	8423905.3	8
A6	Alternate	76	536882.4	8423648.9	8
A7	Alternate	285	530584.4	8421703.6	2
A8	Alternate	17	530315.3	8422064.3	2
A9	Alternate	90	532330.8	8422954.6	4
A10	Alternate	154	534874.0	8423986.5	7

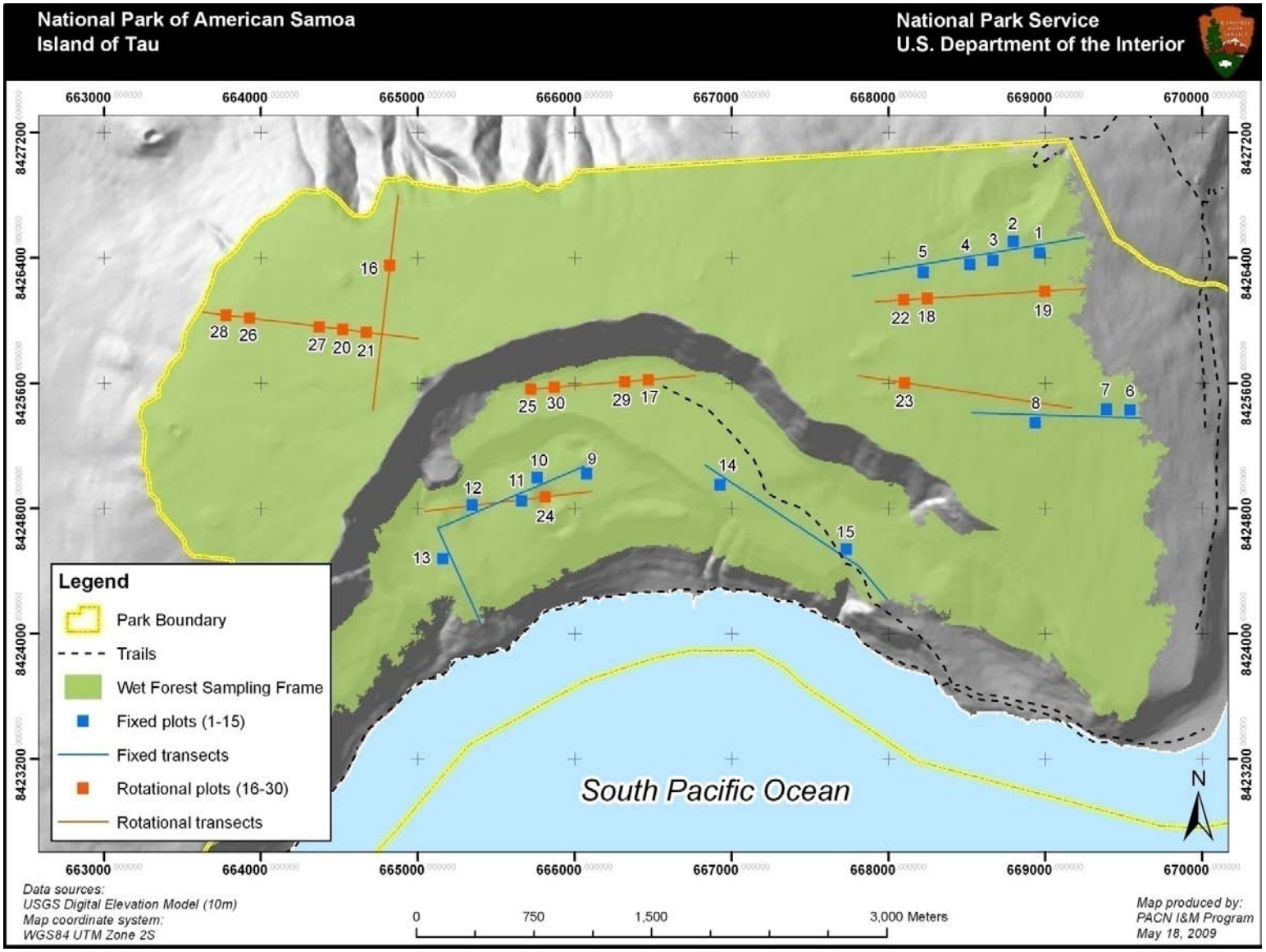

Figure A.8. Map of fixed and rotational plots for the Tau wet forest sampling frame at NPSA.

Table A.12. Fixed plot locations for the wet forest sampling frame on the island of Tau at NPSA. All plots with slopes greater than 100% were excluded. Alternate locations are provided in case any of the original fixed sites are rejected in the field. Transect locations and numbers coincide with transects from the Landbird Protocol.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Fixed Transect	Plot Placement[1]
1	Fixed	253	668962.4	8426434.0	5	L
2	Fixed	192	668797.1	8426507.5	5	R
3	Fixed	208	668666.6	8426384.2	5	L
4	Fixed	104	668518.6	8426359.3	5	L
5	Fixed	108	668222.8	8426309.5	5	L
6	Fixed	278	669539.6	8425431.2	6	R
7	Fixed	5	669389.7	8425435.7	6	R
8	Fixed	273	668936.4	8425349.3	6	L
9	Fixed	293	666076.8	8425023.1	7	L
10	Fixed	255	665761.6	8424997.9	7	R
11	Fixed	16	665662.6	8424847.2	7	L
12	Fixed	149	665347.4	8424822.1	7	R
13	Fixed	134	665158.9	8424481.1	7	R
14	Fixed	20	666927.5	8424953.3	8	R
15	Fixed	131	667732.9	8424541.0	8	L
A1	Alternate	284	665097.4	8424618.0	7	R
A2	Alternate	310	665209.3	8424763.5	7	R
A3	Alternate	313	666802.4	8425036.0	8	R
A4	Alternate	341	667357.4	8424789.1	8	L
A5	Alternate	346	665311.8	8424385.0	7	L
A6	Alternate	208	667761.7	8426333.2	5	R
A7	Alternate	192	668636.5	8425358.3	6	L
A8	Alternate	253	667428.1	8424622.5	8	R

[1] To mitigate transect effects, plot placement is either 50 meters to the left (L) or right (R) of an existing transect.

Table A.13. Rotational plot locations for the wet forest sampling frame on the island of Tau at NPSA. Alternate locations are provided in case any of the original rotational sites are rejected in the field. Transect locations and numbers coincide with transects from the Landbird Protocol.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Rotational Transect
16	Rotational	145	664821.3	8426352.6	2
17	Rotational	266	666468.6	8425622.8	3
18	Rotational	57	668248.3	8426142.1	6
19	Rotational	105	668996.9	8426188.1	6
20	Rotational	281	664521.5	8425943.7	1
21	Rotational	117	664670.4	8425925.3	1
22	Rotational	112	668098.6	8426132.9	6
23	Rotational	108	668101.9	8425603.0	5
24	Rotational	314	665812.8	8424874.7	4
25	Rotational	306	665721.0	8425562.5	3
26	Rotational	68	663926.0	8426017.2	1
27	Rotational	269	664372.6	8425962.0	1
28	Rotational	115	663777.2	8426035.5	1
29	Rotational	65	666319.0	8425610.8	3
30	Rotational	223	665870.5	8425574.6	3
A1	Alternate	86	668697.5	8426169.7	6
A2	Alternate	246	664856.3	8426650.5	2
A3	Alternate	71	667805.2	8425647.3	5
A4	Alternate	137	666020.0	8425586.6	3
A5	Alternate	76	665068.1	8424786.0	4
A6	Alternate	195	668695.4	8425514.6	5
A7	Alternate	98	664968.1	8425888.5	1
A8	Alternate	178	668547.0	8425536.7	5

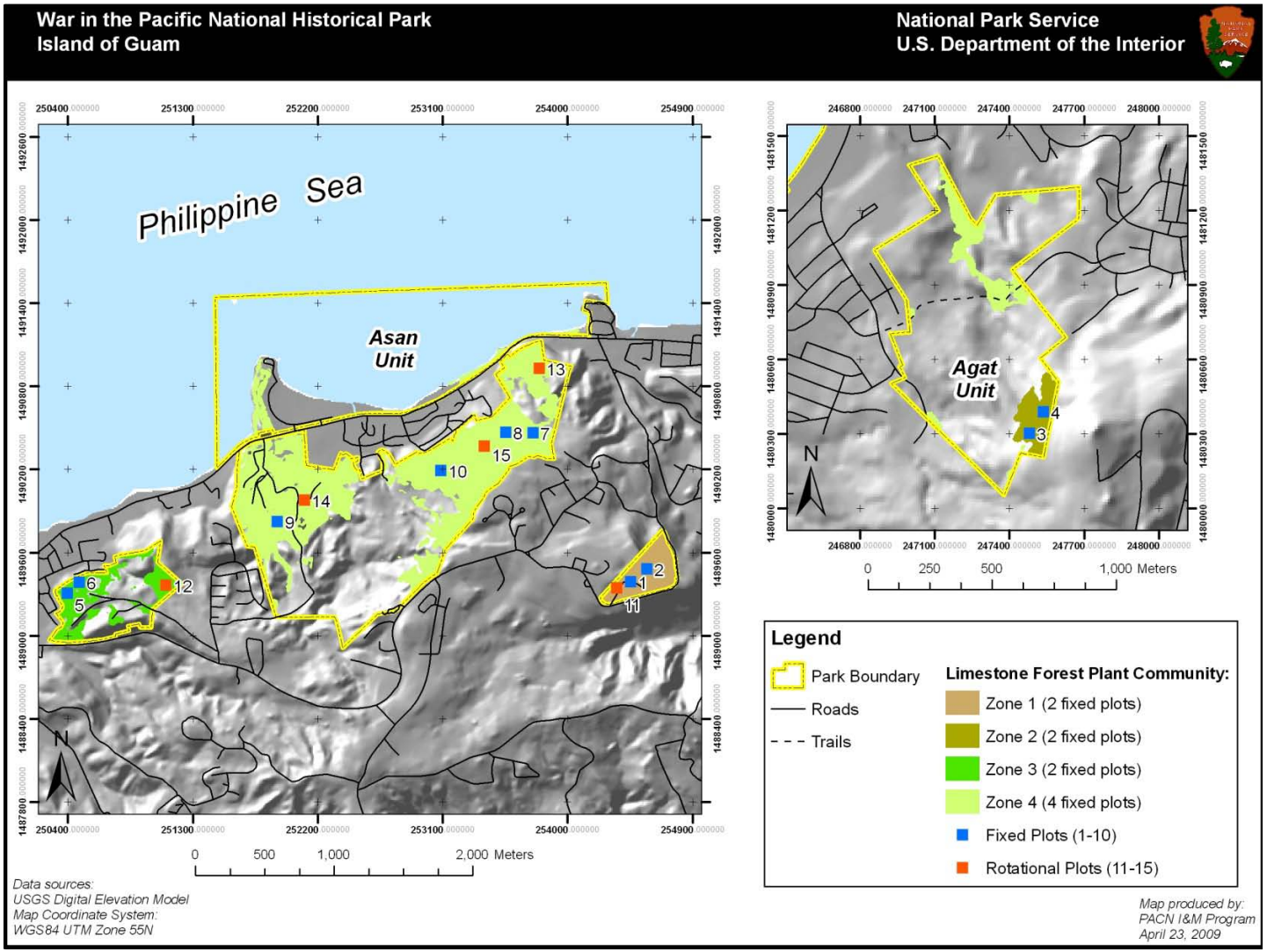

Figure A.14. Map of fixed and rotational plot locations in the limestone forest sampling frame at WAPA. The sampling frame is divided into 4 disjointed geographical zones. To ensure well-interspersed plots across the entire sampling frame, plots are located within each zone in proportion to each zone's area. Zone 2 was too small to accommodate a rotational plot without violating plot buffer constraints; thus an additional rotational plot was located in zone 4 (the largest zone). All plot data will be analyzed together.

Table A.22. Fixed and rotational plot locations for the limestone forest sampling frame at WAPA. The fixed, rotational, and alternate plots are located across 4 geographical zones in proportion to the area of each zone. Alternate locations will be used as backup in case some of the fixed or rotational plots are rejected in the field.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)	Zone
1	Fixed	346	254458.5	1489387.5	1
2	Fixed	134	254572.8	1489480.1	1
3	Fixed	108	247481.5	1480302.2	2
4	Fixed	192	247536.6	1480388.5	2
5	Fixed	296	250400.7	1489305.3	3
6	Fixed	284	250485.4	1489383.4	3
7	Fixed	352	253755.3	1490461.8	4
8	Fixed	87	253558.3	1490466.1	4
9	Fixed	192	251913.3	1489822.3	4
10	Fixed	38	253091.1	1490190.9	4
11	Rotational	16	254356.8	1489343.0	1
12	Rotational	341	251109.1	1489363.3	3
13	Rotational	253	253797.8	1490926.3	4
14	Rotational	243	252106.8	1489975.9	4
15	Rotational	5	253402.4	1490364.7	4
A1	Alternate	310	254687.0	1489553.2	1
A2	Alternate	255	254613.9	1489348.7	1
A3	Alternate	81	250445.1	1489170.7	3
A4	Alternate	250	251019.7	1489407.8	3
A5	Alternate	207	253338.8	1490215.1	4
A6	Alternate	36	252903.4	1490230.2	4
A7	Alternate	37	251665.4	1490015.0	4
A8	Alternate	287	252309.9	1490158.3	4
A9	Alternate	102	253494.6	1490195.7	4
A10	Alternate	16	253194.4	1490357.2	4

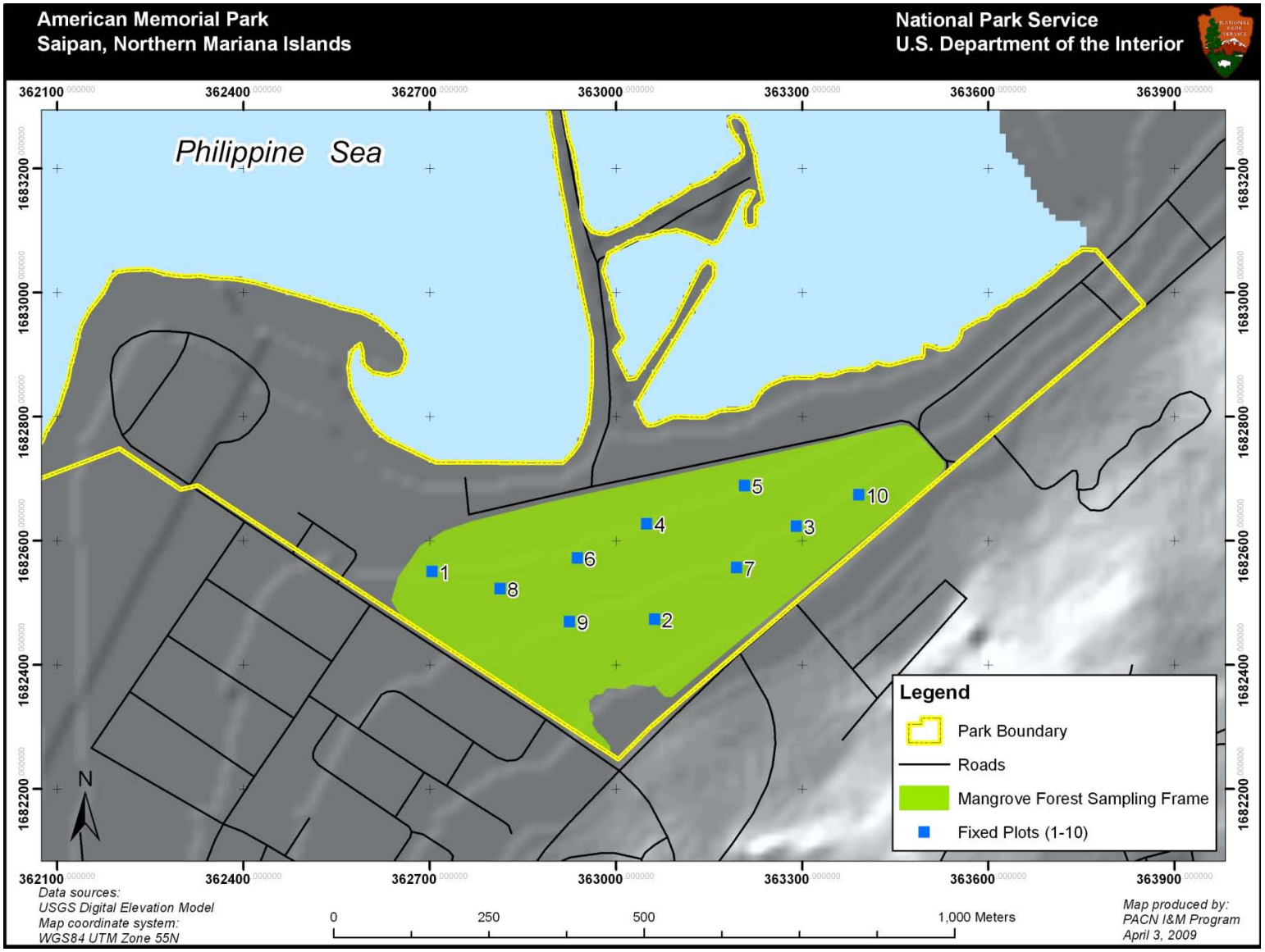

Figure A.15. Map of fixed plot locations in the mangrove forest sampling frame at AMME. Since the total area of fixed plots approaches 5% of the sampling frame area, rotational plots are not necessary in this frame.

Table A.23. Fixed and alternate plot locations for the mangrove forest sampling frame at AMME. Alternate locations are provided in the unlikely event that one of the fixed plots is rejected in the field. Since the total area of fixed plots approaches 5% of the sampling frame area, rotational plots are not necessary in this frame.

Centroid Number	Plot Type	Plot Azimuth	X (Centroid)	Y (Centroid)
1	Fixed	34	362703.5	1682550.9
2	Fixed	329	363061.9	1682473.9
3	Fixed	45	363290.8	1682624.0
4	Fixed	207	363049.4	1682627.7
5	Fixed	269	363206.9	1682689.0
6	Fixed	212	362937.7	1682572.6
7	Fixed	170	363194.6	1682556.8
8	Fixed	14	362813.1	1682523.2
9	Fixed	65	362925.0	1682469.7
10	Fixed	339	363391.5	1682674.5
A1	Alternate	288	362874.0	1682382.7
A2	Alternate	103	362981.5	1682397.3
A3	Alternate	73	362860.7	1682620.3

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Appendix B: Vegetation Monitoring in PACN Park Units

Plant inventories and vegetation relevés exist for portions of each PACN park (table B.1). Vegetation inventories are listed by author and year of report or data collection, with a brief description. Descriptions indicate the scope of the inventory and whether it was conducted in connection with a mapping project. Inventories differ from monitoring studies as sampling occurs only once and no trend analysis can be performed on inventory data. Few vegetation monitoring studies have been conducted in the identified focal plant communities of the PACN park units (table B.2). No community vegetation studies were available for the coastal community of KAHO, wetlands of AMME, or limestone forest of WAPA.

Table B.1. Vegetation inventories conducted in PACN parks.

Park	Vegetation Inventories	Description
AMME		
	(Falanruw et al. 1989)	AMME vegetation map
	(Raulerson and Rinehart 1989)	Wetland vegetation map
	(Raulerson and Witteman In prep.)	Wetland plant inventory
HALE		
	(Lamoureux 1967)	Kipahulu Valley vascular plant inventory
	(Lamoureux and Stemmerman 1976)	Kipahulu Valley vascular plant inventory
	(Canfield and Stemmerman 1980)	Lower Kipahulu Valley plant inventory
	(Smith et al. 1985)	Kipahulu Valley vegetation map
	(Higashino et al. 1988)	Kipahulu Valley vascular plant inventory
	(Jacobi 1989)	HALE vegetation maps
	(Medeiros et al. 1998)	HALE checklist
HAVO		
	(Fagerlund and Mitchell 1944)	HAVO vascular plants inventory
	(Stone 1959)	Kalapana vascular plant inventory
	(Doty and Mueller-Dombois 1966)	HAVO vegetation maps
	(Fosberg 1966)	HAVO vascular plant inventory
	(Fosberg 1975)	HAVO vascular plant inventory
	(Herat and Herat 1975)	HAVO fern and fern allies inventory
	(Higashino et al. 1988)	HAVO vascular plant inventory
	(Belfield 1989)	East Rift plant inventory
	(Jacobi 1989)	Big Island vegetation maps
	(Pratt 1998a)	HAVO vascular plant inventory
	(Benitez et al. 2007)	Kahuku vascular plant inventory
KAHO		
	(Canfield 1990b)	KAHO vegetation map
	(Pratt and Abbott 1996a)	KAHO plant inventory

Table B.1. Vegetation inventories conducted in PACN parks. (Continued)

Park	Vegetation Inventories	Description
KAHO (Continued)		
	(Nagel 2001)	KAHO rare plant census
KALA		
	(Kepler and Kepler 1981)	Pu‘u Ali‘i NAR plant and bird survey
	(Jacobi 1989)	Pu‘u Ali‘i NAR vegetation map
	(Asherman et al. 1990)	KALA vascular plant inventory
	(Canfield 1990a)	Coastal spray zone plant inventory
	(NARS 1991)	Pu‘u Ali‘i NAR 1989 plant inventory
	(LeGrande 2002)	Kūka‘iwa‘a peninsula plant inventory
	(Wood and LeGrande 2002)	Offshore islets plant inventory
	(Wood and LeGrande 2003)	Offshore islets plant inventory
	(Hughes et al. 2005)	Pu‘u Ali‘i NAR plant inventory
	(Wysong and Hughes 2008)	KALA herbarium collection
NPSA		
	(Amerson et al. 1982)	Samoan plant inventory
	(Cole et al. 1988)	USFS plant inventory
	(Whistler 1992a)	Tau vegetation map
	(Whistler 1992b)	Samoan vegetation
	(Whistler 1994)	Tutuila vegetation map
	(Heggie and Cairns 2001)	Tutuila forest type classifications
	(Whistler 2002)	Samoan vegetation guide
	(Whistler 2004)	Samoan rainforest trees
PUHE		
	(Macneil and Hemmes 1977)	PUHE plant inventory
	(Pratt and Abbott 1996c)	PUHE plant inventory
	(Pratt 1998b)	PUHE plant inventory
PUHO		
	(Yen 1971)	PUHO ethnobotanical survey
	(Leishmann 1986)	PUHO vegetation map
	(Smith et al. 1986)	PUHO plant inventory
	(Pratt and Abbott 1996b)	PUHO plant inventory
WAPA		
	(Rodda and Dean-Bradley 2001)	Guam reptile inventory and plants
	(Donnegan et al. 2002)	Guam vegetation map
	(Yoshioka 2008)	WAPA botanical survey

Table B.2. Vegetation monitoring studies previously conducted in focal communities of the PACN parks. To date, no known plant community studies have been conducted in the coastal community of KAHO, wetlands of AMME, or limestone forest of WAPA.

Park	Vegetation Monitoring Project	Community	Description
KALA			
	(Medeiros 1997)*	coastal	Coastal community monitoring in and adjacent to ungulate exclosure
	(Trainer et al. 2001)*	coastal	Coastal community monitoring in sand and crushed coral
NPSA			
	(Whistler 1994)	wet forest	Tutuila plotless tree sampling to determine relative dominance
	(Whistler 1995)	wet forest	Tutuila and Tau plots monitoring tree structure
	(Webb et al. 1999)	wet forest	Tutuila plots monitoring trees along ridges, slopes, and valleys
	(Webb and Fa'aumu 1999)	wet forest	Tutuila plots monitoring trees in talus and non-talus substrate
	(Donnegan et al. 2001)	wet forest	Tutuila and Tau USFS-FIA plots monitoring trees
	(Webb et al. 2006)	wet forest	Tau plots monitoring trees in coastal and lowland forests
HALE			
	(Yoshinaga 1977)	wet forest	HALE monitoring changes following ungulate removal
	(Anderson et al. 1992)	wet forest	Kipahulu Valley vegetation monitoring plots
	(Anderson 2006)*	wet forest	Kipahulu Valley vegetation monitoring koa defoliation
HAVO			
	(Mueller-Dombois 1977)	wet forest	‘Ōla‘a vegetation associates with *Metrosideros* dieback areas
	(Cuddihy et al. 1986)	wet forest	East Rift and Thurston vegetation monitoring
	(Loh 1994)*	wet forest	‘Ōla‘a vegetation inside and outside of pig exclosures in the Koa unit
	(Loh 1997)*	wet forest	‘Ōla‘a vegetation monitoring in the Pu‘u unit
	(Loh and Tunison 1998)*	subalpine	Vegetation community change in response to ungulate removal in upper Mauna Loa
	(Loh and Tunison 1999)	wet forest	‘Ōla‘a changes in the vegetation following pig removal in the Koa unit
	(Pratt et al. 1999)	wet forest	East Rift vegetation above a feral pig barrier
	(Ainsworth 2007)	wet forest	East Rift vegetation recovery following wildfires

* unpublished data

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Appendix C: Precision, Power and Sample Size

This appendix provides supplemental details and calculations for precision, statistical power and sample size. These three entities are closely related to one another. Increased precision of the mean, which depends on both sampling design and sample size, results in increased statistical power, or an increased probability of detecting change. All things being equal, larger sample sizes can increase precision which in turn increases statistical power. Ideally increases in precision and power result from efficient sampling design (which concentrates variance within plots not between plots) rather than from increases in sample size.

Annual Precision

High precision is desirable since it results in status estimates with narrower confidence intervals and improves the statistical power to detect trends over time. Unlike accuracy, which describes the closeness of measured values to true values, precision describes the closeness of repeated measurements of the same quantity. The sample standard deviation or variance provides a measure of precision or repeatability (Elzinga et al. 2001). High precision occurs when sample standard deviations or coefficients of variation are low (i.e., when measured values between plots are similar). Precision is high when independent samples taken from the same population yield similar sample means. Alternatively, precision is low when independent samples taken from the same population yield vastly different means.

Precision in the estimations of variables is affected by multiple sources of variation, including spatial, temporal, and analytical. Increasing precision is obtained by increasing replication, especially within the largest component of variation. Equation C.1 shows precision of the estimate (E) as a function of variability in the sample design (Skalski 2005). Precision in estimating community vegetation parameters is affected by up to three (if the parameter is measured within a subplot) sources of variability:

- at the level of the site - Coefficient of Variation$_1$ (CV_1)
- at the level of the sampling plot within a site - Coefficient of Variation$_2$ (CV_2)
- at the level of the sampling subplot within a plot - Coefficient of Variation$_3$ (CV_3)

Annual precision is estimated using

$$\mathrm{E} = Z_{1-\alpha/2}\sqrt{\frac{(1-f_1)CV_1^2}{n} + \frac{(1-f_2)CV_2^2}{nm} + \frac{(1-f_3)CV_3^2}{nmk}} \qquad \textbf{Equation C.1}$$

where f_1 = fraction of area sampled by sites (Assume that 1-f_1 = 1)
f_2 = fraction of area sampled by sampling plots within a site (Assume that 1-f_2 = 1)
f_3 = fraction of area sampled by sampling subplots within a plot (Assume that 1-f_3 = 1)
n = number of sites (primary units) within a park
m = number of sampling plots (second-stage units) within a site
k = number of sampling subplots (third-stage units) within a plot, and
$Z_{1-\alpha/2}$ = distribution value for selected confidence interval

Precision expresses the desire to have a relative error in the estimate of the population mean $(\bar{X})$ less than E for (1 - α) percent of the time (Skalski 2005):

$$P\left[\left(\frac{\hat{\bar{X}}-\bar{X}}{\bar{X}}\right)<\mathrm{E}\right]=1-\alpha \qquad \textbf{Equation C.2}$$

For example, the equation

$$P\left[\left(\frac{\hat{\bar{X}}-\bar{X}}{\bar{X}}\right)<.20\right]=.90 \qquad \textbf{Equation C.3}$$

expresses the desire to be within 20% of the true value 90% of the time. As illustrated in equation C.1, greater precision (i.e., lower relative error values and lower values for E) can be achieved with greater replication (Skalski 2005). While high values of precision (E <10%) are preferred, the variability of plant community parameters makes this level of precision difficult to achieve for many parameters.

Existing estimates of expected variation

Precision estimates were calculated for community vegetation parameters (Table C.1) using data from previous wet forest studies (Table C.2) in the ʻŌlaʻa (Loh 1994, 1997, Loh and Tunison 1999) and East Rift (Cuddihy et al. 1986, Ainsworth 2007) wet forests at HAVO and from wet forest on Tutuila Island at NPSA (Whistler 1995). Previous studies at KALA (Medeiros 1997, Trainer et al. 2001) were the basis for precision estimates for coastal community parameters (Table C.3). From this point forward, all studies are referred to by their site and sample year rather than author and publication year in an effort to reduce confusion and provide useful background information (Tables C.2 and C.3). Precision estimates for each community vegetation parameter were calculated using the following criteria:

$Z_{1-\alpha/2}$ = 1.645 = distribution value for "90% of the time"
n = 1 = number of sites (primary units) within a park
m = number of sampling plots (second-stage units) within a site
k = 1 (large trees and richness), 6 (saplings and tree seedlings), and 12 (cover estimates)
NOTE: values for k only apply to data from East Rift 2004

In each of the wet forest studies the calculated precision of the mean for native, nonnative, and total species richness was relatively high (E <25.9%; Table C.1). Precision estimates for native, nonnative, and total understory cover varied more widely ranging from high precision (E = 6.7%) to low precision (E = 54.7%), while woody density precision estimates exhibited the greatest range (E = 6.2 - 79.4%). The cited studies were conducted with specific monitoring objectives, and thus plot size, sampling techniques, and replication differed among studies (Table C.2). As expected, precision was higher on average in studies with greater replication (e.g., Loh 1997 and Loh and Tunison 1999) and lower in studies with fewer replicates (Cuddihy et al. 1986 and Whistler 1995).

Table C.1. Calculated percent precision (E) of the mean for plant community parameters using wet forest data gathered from various sources in HAVO and NPSA. The details for each study are summarized in Table C.2.

PARK	SITE	YR	MEAN	VAR	CV	N	E	PARK	SITE	YR	MEAN	VAR	CV	N	E
			Native Species Richness								**Native Understory Cover**				
HAVO	ʻŌlaʻa	1994	18.4	5.4	0.13	10	6.6	HAVO	ʻŌlaʻa	1994	92.5	2779	0.57	10	29.7
	ʻŌlaʻa	1997	24.1	22.6	0.20	24	6.6		ʻŌlaʻa	1997	104.3	1253	0.34	24	11.4
	ʻŌlaʻa	1998	22.2	12.3	0.16	16	6.5		ʻŌlaʻa	1998	53.9	743.4	0.51	20	18.6
	E. Rift	1986	56	66.7	0.15	4	12.0		E. Rift	1986	26.7	246.2	0.59	4	48.3
	E. Rift	2004	12.7	31.4	0.44	40	11.5		E.Rift	2004	24.8	978.3	1.26	40	32.8
			Nonnative Species Richness								**Nonnative Understory Cover**				
HAVO	ʻŌlaʻa	1994	3.7	1.6	0.34	10	17.6	HAVO	ʻŌlaʻa	1994	18.2	83.1	0.50	10	26.1
	ʻŌlaʻa	1997	3.3	5.9	0.74	24	25.0		ʻŌlaʻa	1997	11.9	292.1	1.43	24	48.2
	ʻŌlaʻa	1998	4.3	2.5	0.37	16	15.2		ʻŌlaʻa	1998	29.6	717.5	0.90	20	33.3
	E. Rift	1986	19.5	37.7	0.31	4	25.9		E. Rift	1986	2	1.8	0.66	4	54.7
	E. Rift	2004	7.7	24.0	0.64	40	16.6		E. Rift	2004	40.8	1453	0.93	40	24.3
			Total Species Richness								**Total Understory Cover**				
HAVO	ʻŌlaʻa	1994	22.1	7.4	0.12	10	6.4	HAVO	ʻŌlaʻa	1994	49.6	153.2	0.25	10	13.0
	ʻŌlaʻa	1997	27.3	38.2	0.23	24	7.6		ʻŌlaʻa	1997	55.4	122.2	0.20	24	6.7
	ʻŌlaʻa	1998	26.4	14.3	0.14	16	5.9		ʻŌlaʻa	1998	42.8	134.6	0.27	20	10.0
	E. Rift	1986	75.5	13.7	0.05	4	4.0		E. Rift	1986	28.7	232.0	0.53	4	43.6
	E. Rift	2004	20.4	65.4	0.40	40	10.3		E. Rift	2004	65.7	981.9	0.48	40	12.4
NPSA	Tutuila	1995	72.4	237.1	0.21	8	12.4	NPSA	Tutuila	1995	54.9	767.9	0.50	7	31.4
			Native Tree Seedling Density								**Native Tree Sapling Density**				
HAVO	ʻŌlaʻa	1994	1.2	1.5	1.02	10	53.3	HAVO	ʻŌlaʻa	1994	4.8	18.8	0.90	10	47.1
	ʻŌlaʻa	1997	92.4	4297	0.71	18	27.5		ʻŌlaʻa	1997	33	350.8	0.57	25	18.7
	ʻŌlaʻa	1998	77.3	4855	0.90	20	33.2		ʻŌlaʻa	1998	17.3	8.6	0.17	20	6.2
	E. Rift	1986	90.5	7617	0.96	4	79.4		E. Rift	1986	14.8	26.7	0.35	4	28.7
	E. Rift	2004	0.62	3.1	2.84	40	73.8		E. Rift	2004	1.4	5.3	1.64	40	42.7
			Native Large Tree Density												
HAVO	ʻŌlaʻa	1994	2.5	6.5	1.02	10	53.1								
	ʻŌlaʻa	1997	7.3	22.1	0.64	25	21.1								
	ʻŌlaʻa	1998	10.8	64.4	0.75	20	27.5								
	E. Rift	1986	5.7	19.1	0.76	4	62.8								
	E. Rift	2004	21.6	523.4	1.06	40	27.5								
NPSA	Tutuila	1995	60.4	1774	0.70	8	40.6								

However, studies in extremely heterogeneous areas (e.g., studies that included sites recently disturbed by pigs and/or fire in combination with undisturbed sites) tended to have lower precision despite high sample sizes. For example, the East Rift 2004 study (Ainsworth et al. 2007) which had 40 plots including one-year old burned plots and unburned plots in both mesic and wet forests, had very low precision for some parameters (E = 73.4%). Also sampled in disturbed areas, the ʻŌlaʻa 1994 (Loh 1994) study included plots where feral pigs were present as well as those where they had been removed.

The remaining studies, ʻŌlaʻa 1997 (Loh 1997) and ʻŌlaʻa 1998 (Loh and Tunison 1999), tended to have higher percent precision estimates for several vegetation parameters (E <10%), implying that the sampling effort (plot size and number of replicates) may have been greater than necessary for some but not all parameters. However, these two ʻŌlaʻa studies were conducted

with specific monitoring questions in mind in relatively homogeneous sites as compared to the large wet forest sampling frames being proposed for sampling.

Table C.2. General information for each study used to estimate the precision values in Table C.1 (Cuddihy et al. 1986, Loh 1994, Whistler 1995, Loh 1997, Loh and Tunison 1999, Ainsworth 2007). Note that not all studies listed in Appendix B contain appropriate data for precision calculations.

Study	Loh 1994	Loh 1997	Loh and Tunison 1999	Cuddihy et al. 1986	Ainsworth 2007	Whistler 1995
Park	HAVO	HAVO	HAVO	HAVO	HAVO	NPSA
Site	ʻŌlaʻa	ʻŌlaʻa	ʻŌlaʻa	East Rift	East Rift	Tutuila
Sample Year	1994	1997	1998	1986	2004	1995
Sample Size*	10	18-25	16-20	4	40	7-8
Richness	10 x 10 m	10 x 10 m	10 x 10 m	100 x 100 m	20 x 50 m	20 x 50 m
Cover *Method & Sample Unit*	point-intercept 250 points	point-intercept 250 points	point-intercept, 250 points	point-intercept, 250 points	ocular estimate, 12 - 1x1 m	ocular estimate, 5 - 2x2 m
Density	*Metrosideros*	Native trees	Native trees	All trees	*Metrosideros*	All trees
Seedlings *Size & Plot Dimensions*	<1 cm bd** 10 x 10 m	<1 cm bd 10 x 10 m	<1 cm bd >10 cm ht 10 x 10 m	<1 cm bd 20 x 50 m	<1.4 m ht 6 – 1 x 5 m	NA
Saplings *Size & Plot Dimensions*	1 - 10 cm bd 10 x 10 m	1 – 10 cm bd 10 x 10 m	1 – 5 cm bd 10 x 10 m	1 – 5 cm bd 10 x 10 m	>1.4 m ht & <10 cm dbh 6 – 2 x1 0 m	NA
Large Trees *Size & Plot Dimensions*	10 – 20 cm bd 10 x 10 m	10 – 20 cm bd 10 x 10 m	>5 cm bd 10 x 10 m	10 – 20 cm bd 10 x 10 m	>10 cm dbh 20 x 50 m	>10 cm dbh 20 x 50 m

* Studies with ranges listed have different sample sizes for different parameters.
** Basal diameter (bd) was recorded for some studies.

Disturbance events are expected to occur over time at varying frequencies within focal plant communities resulting in a reasonable level of heterogeneity among plots. In addition, precision for individual species within the community will likely be lower than the conglomerate parameters presented. Given the project's targeting of select species and potentially high heterogeneity across large communities, a need for greater replication ($n \geq 30$) is anticipated in the wet forest, subalpine shrubland, limestone forest, and mangrove forest than was used in past wet forest studies. Replication will be addressed further in the next two sections of this appendix.

In the coastal strand at KALA, precision estimates differed between data collected during the 1997 and 2001 studies (Table C.3). These studies were conducted in dissimilar sites within the coastal vegetation that differed in their primary substrate and dominant species cover. In the 1997 study, precision of the mean for most measured parameters was generally high (E <25%), but in the 2001 study, estimates were less precise presumably due to greater site heterogeneity and lower sample size. Stratifying the sampling between these two vegetation types in the

Table C.3. Calculated percent precision (E) of the mean for community vegetation parameters for two studies conducted in the coastal community of KALA (Medeiros 1997, Trainer et al. 2001). These studies were conducted at different sites that vary in substrate and species composition.

Study	Medeiros 1997					Trainer et al. 2001				
PARAMETER	**MEAN**	**VAR**	**CV**	**N**	**E**	**MEAN**	**VAR**	**CV**	**N**	**E**
Richness										
Native	3.7	0.2	0.12	9	6.6	7.2	1.1	0.15	5	10.9
Nonnative	3.6	0.3	0.16	9	8.6	6.4	4.8	0.34	5	25.1
Total	7.2	0.1	0.04	9	2.1	13.6	8.2	0.21	5	15.5
Cover (%)										
Native	55.6	52.6	0.13	9	7.2	20.9	97.4	0.47	5	34.8
Nonnative	23.1	46.7	0.30	9	16.3	11.5	132.6	1.00	5	73.4
Rock	13.6	116.1	0.79	9	43.6	14.5	140.9	0.82	5	60.2
Bare Ground	7.5	22.8	0.64	9	35.1	34.4	798.9	0.82	5	60.5
Fimbristylis	29.9	47.1	0.23	9	12.6	-	-	-	-	-
Digitaria	17.5	26.2	0.29	9	16.0	-	-	-	-	-
Cynodon	3.8	12.8	0.93	9	51.2	4.2	11.5	0.81	5	59.7
Scaevola	-	-	-	-	-	8.5	40.1	0.74	5	54.7
Portulaca	-	-	-	-	-	4.2	55.5	1.76	5	129.5

proposed coastal sampling for KALA is recommended because they differ in primary substrate, dominant vegetation and cover. In order to estimate status precisely and to detect changes in composition over time adequately 15 plots should be monitored in each stratum, 10 fixed and 5 rotational plots. Refer to Appendix D “Allocation of Sampling Units to Panel Members” for additional details on the ratio of fixed to temporary plots.

In previous studies of both wet forest and coastal communities, many vegetation community parameters are sufficiently precise (E <25%). However, in order to achieve precise estimates for most individual species, more samples are required because individual species parameters tend to be highly variable across the landscape resulting in less precise estimates. Generally, coefficients of variation are higher for individual species cover than for species richness (Table C.3), especially for the more uncommon and scattered species such as *Cynodon* (Bermuda grass). Larger sample sizes may address this issue, supporting the recommendation of 30 plots per sampling frame.

The recommended sample size of 30 plots per sampling frame is based on the maximum of what I&M and the parks can feasibly survey during a sampling year due to logistical and financial constraints. The wet forest communities (HAVO, HALE, KALA, NPSA), subalpine shrublands (HAVO and HALE), and coastal community (KALA) will have 30 plots per sampling frame; however the KALA coastal community will split those 30 plots between two strata. For the coastal community at KAHO and the limestone forest at WAPA, 15 plots (10 fixed and 5 rotational) will be established similar to the coastal strata sample design at KALA. For the mangrove forest community, which covers a very small area, 10 fixed plots are recommended because this number of plots will cover the sampling frame adequately. Additional plots in this sampling frame probably would create spatial autocorrelation issues.

Statistical Power Estimation

High values of statistical power correspond to a high probability of detecting change and a low risk of missed-change (Type II) errors (Elzinga et al. 2001). In general, statistical power can be increased by reducing standard deviation or increasing precision through efficient sampling designs (such as choosing an appropriate plot size, shape, and orientation) or through increased sample size.

Data collected in twenty 10 x 10 m plots from 1991 to 1998 in the ‘Ōla‘a wet forest at HAVO (Loh and Tunison 1999) were used to calculate the natural variance in the annual response (σ_θ^2) and the average annual error variance associated with estimating parameters ($\overline{\mathrm{Var}(\hat{\theta}|\theta)}$) for each of the following community vegetation parameters: native species richness, nonnative species richness, total species richness, native understory % cover, nonnative understory % cover, total understory % cover, tree seedlings, tree saplings, and large native trees. These estimates of variance were input into the noncentrality parameter equation (Skalski 2005):

$$\Phi_{1,m-2} = \frac{1}{\sqrt{2}} \frac{\left|\frac{\theta_0 \Delta}{m-1}\right|}{\sqrt{\frac{\sigma_\theta^2 + \overline{\mathrm{Var}\left(\hat{\theta}|\theta\right)}}{\sum_{i=1}^{m}\left(t_i - \bar{t}\right)^2}}}$$

Equation C.4

where Δ = total *m*-year change in response interested in detecting,
m = number of annual responses in the regression analysis,
σ_θ^2 = natural variance in the annual response of θ,
$\overline{\mathrm{Var}\left(\hat{\theta}|\theta\right)}$ = average annual error variance in the annual response of θ,
t_i = annual indicator of time (e.g., t_i = 0, 1, 2, 3, 4 for a 5-year study), and
θ_0 = initial condition of parameter at beginning of study

From Skalski’s (2005) tables, the computed noncentrality parameter (Φ) with 1 and m-2 degrees of freedom was then used to determine the prospective power to detect 10%, 25% and 50% changes in each vegetation parameter at α = 0.20, two-tailed distribution, for monitoring durations of 5, 10, 15, 20 and 25 years (Table C.4).

Based on these calculations, the power to detect a moderate change (25%) in all vegetation parameters over all time periods was less than the targeted 80% (Table C.4). The power to detect a large change (50%) over the longer time periods was greater than 80% for native species richness, total species richness and total understory cover. For most parameters, the power to detect change over time for these data is low. Small plot size and lack of adequate replication in this study are likely responsible for the observed low power to detect change. Repeated sampling data were not available for the coastal community, subalpine shrubland, limestone forest, and mangrove forest therefore power estimates for detecting future changes in these communities were not calculated.

Statistical power for this monitoring protocol is expected to be higher than the values calculated above because both plot size (20 x 50 m) and sample size (n = 30) will be larger than in above study, and variance among sampling years across each focal community should be lower except

when large disturbance events occur (e.g. wildfire, hurricane, tsunami). Additionally, power estimates will be improved over time because approximately 50% of the plots will be re-sampled (Appendix D), allowing for the refinement of parameter estimates using multiple years of data.

Table C.4. Statistical power for a two-tailed *F* distribution at α = 0.20 for detecting relative changes of 10%, 25%, and 50% in selected vegetation parameters. Data were collected in twenty 10 x 10 m plots (except species richness where n = 16).

	Relative Change						Relative Change				
α = 0.2	**5 yr**	**10 yr**	**15 yr**	**20 yr**	**25 yr**	**α = 0.2**	**5 yr**	**10 yr**	**15 yr**	**20 yr**	**25 yr**
Native Species Richness						**Native Understory Cover** (# hits)					
10%	0.217	0.233	0.247	0.262	0.276	10%	0.164	0.204	0.207	0.209	0.211
25%	0.299	0.385	0.456	0.521	0.578	25%	0.214	0.227	0.238	0.251	0.262
50%	0.532	0.734	0.844	0.912	0.950	50%	0.253	0.302	0.344	0.385	0.423
Nonnative Species Richness						**Nonnative Understory Cover** (# hits)					
10%	0.157	0.202	0.206	0.208	0.210	10%	0.073	0.094	0.112	0.127	0.140
25%	0.213	0.225	0.235	0.247	0.258	25%	0.184	0.206	0.209	0.211	0.214
50%	0.249	0.294	0.334	0.373	0.408	50%	0.211	0.222	0.232	0.241	0.251
Total Species Richness						**Total Understory Cover** (# hits)					
10%	0.219	0.236	0.253	0.269	0.285	10%	0.213	0.226	0.236	0.248	0.259
25%	0.311	0.406	0.483	0.553	0.613	25%	0.277	0.347	0.405	0.460	0.510
50%	0.564	0.771	0.878	0.936	0.999	50%	0.470	0.655	0.769	0.850	0.902
Tree Seedlings (>10 cm ht, <1 cm basal diam)						**Tree Saplings** (1-5 cm basal diam)					
10%	0.108	0.138	0.164	0.186	0.204	10%	0.137	0.175	0.204	0.206	0.208
25%	0.207	0.212	0.217	0.223	0.228	25%	0.210	0.219	0.228	0.235	0.244
50%	0.224	0.246	0.265	0.286	0.305	50%	0.238	0.272	0.302	0.333	0.362
Native Tree Density (>5 cm basal diam)											
10%	0.103	0.132	0.157	0.178	0.197						
25%	0.206	0.212	0.216	0.221	0.226						
50%	0.222	0.242	0.260	0.279	0.297						

These methods have been used to significantly increase statistical power in other monitoring programs (Skalski 2005). The true power of this design will need to be revisited after 15 to 20 years of consecutive sampling, and the sample sizes adjusted accordingly.

Sample Size Calculations

While the precision calculations above describe the repeatability of measurements and power analysis examines the probability of detecting a given level of change, neither one directly addresses the sample size required to detect specific levels of change. The following equation from Elzinga et al. (2001) provides an estimate of the sample size required to detect a given level of change between two sample means when using paired or fixed plots:

$$n = \frac{\left(s_{diff}\right)^2 \left(Z_\alpha + Z_\beta\right)^2}{\left(MDC\right)^2}$$

Equation C.5

where n = sample size,

sdiff = standard deviation of the differences between paired samples,
Z_α = Z-coefficient for the false-change (Type I) error rate,
Z_β = Z-coefficient for the missed-change (Type II) error rate, and
MDC = minimum detectable change size (in absolute terms).

Table C.5. Sample size estimates to detect a 20% and 30% change in vegetation parameters with 80% power in the ‘Ōla‘a wet forest unit based on data from Loh (1998).

Vegetation Parameter	Sample Size (n)	Mean 1991	Mean 1998	s_{diff}*	Plots to detect 20% change	Plots to detect 30% change
Native Richness	16	13.5	22.2	3.0	7	3
Nonnative Richness	16	3.1	4.25	1.6	34	15
Total Richness	16	16.6	26.4	3.8	7	3
Native Understory Cover	20	28.3	53.85	22.9	79	35
Nonnative Understory Cover	20	10.3	29.55	26.6	797	354
Total Understory Cover	20	25.3	42.8	13.0	32	14
Density of						
Native Woody Spp. (dbh<1 cm & height<10 cm)	20	107.4	78.3	163.5	278	124
Native Woody Spp. (dbh<1 cm & height>10 cm)	20	25.3	77.25	60.2	678	302
Native Woody Spp. (dbh 1-5 cm)	20	18.3	17.25	11.8	51	23
Native Woody Spp. (dbh>5 cm)	20	12.45	10.75	4.95	19	9
M. polymorpha (dbh<1 cm & height<10 cm)	20	12.7	26.6	44.8	1494	664
M. polymorpha (dbh<1 cm & height>10 cm)	20	11.45	16.0	17.35	275	123
M. polymorpha (dbh 1-5 cm)	20	2.45	1.15	3.15	198	88
M. polymorpha (dbh>5 cm)	20	0.8	0.5	1.7	515	229
Cibotium and *Sadleria* tree fern (dbh>5 cm)	19	32.70	34.11	7.74	7	3

* s_{diff} = standard deviation of the differences between paired samples

Based on plant community data collected in 1991 and 1998 in the ‘Ōla‘a wet forest unit (Loh 1998) the sample size required to detect two levels of change, 20% and 30%, can be estimated. The last two columns of Table C.5 show the number of plots required to detect a 20% and 30% change respectively, assuming 80% statistical power and a two-tailed alpha of .20. While the sample size values are generally low for species richness, most of the cover and density parameters require very large sample sizes in order to detect a 30% change. For the current protocol, which should produce lower variance values than the Loh (1998) study due to design factors (e.g., larger rectangular plots), a need for smaller sample sizes than those computed in Table C.5 is anticipated; however, 30 or more plots will likely be necessary to detect changes of 20-30%, especially for parameters related to individual species. Thus, since logistical and financial constraints prevent the use of sample sizes larger than 30 per sampling frame, a sample size of 30 plots for the larger sampling frames is recommended. This number of plots will maximize the likelihood of achieving the desired detection objectives for as many parameters as

possible. For the smaller sampling frames, such as the KAHO coastal community, fewer plots should be used to avoid issues with spatial autocorrelation.

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Appendix D: Allocation of Sampling Units to Panel Members

This monitoring effort samples for both status and trends, with a tradeoff existing between the ability to detect spatial (i.e., status) and temporal (i.e., trends) changes. The split panel design selected for this protocol uses fixed plots to increase the statistical power to detect temporal trends, while using rotational plots to increase the spatial replication (McDonald 2003). The optimal proportion of fixed to rotating panels can be estimated from the correlation (r) between years within sites with the equation D.1 (p. 347 in Cochran 1977):

$$\text{Proportion of fixed to rotating panels} = \frac{\sqrt{1-r^2}}{1+\sqrt{1-r^2}} \qquad \text{(Eq. D.1)}$$

As the correlation between sampling years increases, fewer fixed panels are needed and more sites can be allocated to the rotating panel. Past data from repeated sampling events was only available for one section of the ʻŌlaʻa wet forest at HAVO, surveyed in 1991, 1993 and 1998 (Loh and Tunison 1999). Only one parameter, native tree density, is highly correlated (r >0.80) among sampling events, resulting in a fixed to rotating panel ratio of 33% (Table D.1). Seedling densities of native trees and the dominant species *Metrosideros polymorpha* are also quite correlated (>0.60) during this study as the number of seedlings produced and surviving each year appears reasonably consistent. For *M. polymorpha*, sapling and tree densities exhibit less correlation among years than do seedling densities, as mortality influences density in the larger size classes.

In general, most measured parameters have much lower inter-sampling correlations (r <0.40) resulting in a proportion of fixed to random sites between 45% and 50% (Loh 1998). Therefore, a conservative design (i.e., one that does not require high correlation values) has been selected in which 50% of the panels are fixed and 50% are rotating. Furthermore this conservative approach has the benefit of minimizing expenses and access issues that arise in surveying the rotational panel. Equal allocation of effort among fixed and rotating panels when both status and trend are of interest is considered a reasonable compromise (McDonald 2003).There are obvious limitations to applying these correlations to other park units and community types; however, this ratio serves as a starting point until further data are available.

Table D.1. Average correlation values (r) of vegetation parameters from one year to the next (using data from 1991, 1993 and 1998) in the ‘Ōla‘a wet forest unit at HAVO. Data obtained from HAVO Resource Management (Loh 1998).

Parameter	r	Proportion Fixed:Rotating
Species Richness		
native	0.01	0.50
nonnative	0.55	0.45
total	0.32	0.49
Understory Cover		
native hits	0.58	0.45
nonnative hits	0.70	0.42
total % cover	0.36	0.48
Native Tree Density		
seedlings	0.68	0.42
saplings	0.19	0.50
trees	0.87	0.33
Metrosideros polymorpha Density		
seedlings	0.63	0.44
saplings	0.37	0.48
trees	0.21	0.49

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Appendix E: Data Forms for Recording Field Data

This appendix contains all the data forms required to record vegetation attributes in each plot and subplot. Field staff should record data in the most efficient order. Some data forms appear on multiple pages, while others are combined on a single page. The data forms appear in the following order:

Form 1. Plot location (all communities)
Form 2. Photographic record (all communities)
Form 3. Species list (all communities)
Form 4. Understory cover (forest and shrublands: 20 x 50 m plot)
Form 5. Understory cover (coastal: 10 x 20 m plot)
Form 6. Large tree density (forest: 20 x 50 m plot)
Form 7. Canopy tree height (forest: 20 x 50 m plot)
Form 8. Tree fern density (wet forest only: 10 x 25 m subplot)
Form 9. Small tree density (forest:10 x 25 m subplot)
Form 10. Seedling, shrub and small tree fern (wet forest only) density (2 x 50 m subplot)
Form 11. Small and large tree density (shrubland: 2 x 50 m subplot)
Form 12. Seedling density (2 x 50 m subplot; subalpine shrubland)
Form 13. Shrub density (2 x 50 m subplot; subalpine shrubland)
Form 14. Large tree density (coastal: 10 x 20 m subplot)
Form 15. Small tree density (coastal: 2 – 2 x 20 m subplots)
Form 16. Seedling density (coastal: 2 – 2 x 20 m subplots)
Form 17. Shrub density (coastal: 2 – 2 x 20 m subplots)
Form 18. Coarse woody debris (all communities)

Form 1. Plot Location **Vegetation Community Protocol**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Plot Azimuth: _____ Declination: 9.5 deg E Start UTME (x): _____ End UTME (x): _____

GPS Unit: _____ GPS Datum: NAD83 Start UTMN (y): _____ End UTMN (y): _____

Slope (%) along center transect azimuth: _____ Error Start (m): _____ Error End (m): _____

Slope (%) along hillside: _____

Aspect: Elevation: Stake offset distance (cm): Stake offset direction (deg):

1. Road and trail used to travel to the plot:

2. Location where field crew leaves access road/trail & azimuth to plot:

3. Describe the route to the plot including hand drawn maps. Include plot layout and reference features:

4. Problems encountered, changes, comments:

Form 2. Photographic Record **Vegetation Community Protocol**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Camera Used: Ricoh GPS Other:_____

***Rotational plots require only T2 Start/End, Center-Canopy & Community (4) photos**

Checkmark if taken	Subject	Time	Description
	Origin0mT2-Center25mT2		
	Origin0mT2-Center25mT2		T2 start post perspective -only for fixed plots
	0mT1-25mT1		
	25mT1-Center25mT2		
	50mT1-25mT1		
	50mT2-Center25mT2		
	50mT2-Center25mT2		T2 end post perspective -only for fixed plots
	50mT3-25mT3		
	25mT3-Center25mT2		
	0mT3-25mT3		
	Center25mT2-canopy		
	Community1		
	Community2		
	Community3		
	Community4		
	Photosheet		

Form 3. Presence / Absence **Vegetation Community Protocol**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Fl = Flowering; Fr = Fruiting; Indicate presence with a checkmark or neither with a "-" through the box

Species	Fl/Fr	Species	Fl/Fr

Form 4. Understory Cover (20x50m Plot) **Vegetation Community Protocol (p.1 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Substrate types: S=soil; L=litter; TT=tree trunk; B=bryophyte; LIC=lichen; TF=tree fern trunk; sand; cinder; gravel; rock; etc.

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
1	1	0.5			
2	1	1			
3	1	1.5			
4	1	2			
5	1	2.5			
6	1	3			
7	1	3.5			
8	1	4			
9	1	4.5			
10	1	5			
11	1	5.5			
12	1	6			
13	1	6.5			
14	1	7			
15	1	7.5			
16	1	8			
17	1	8.5			
18	1	9			
19	1	9.5			
20	1	10			
21	1	10.5			
22	1	11			
23	1	11.5			
24	1	12			
25	1	12.5			
26	1	13			
27	1	13.5			
28	1	14			
29	1	14.5			
30	1	15			
31	1	15.5			
32	1	16			
33	1	16.5			
34	1	17			
35	1	17.5			
36	1	18			
37	1	18.5			
38	1	19			
39	1	19.5			
40	1	20			
41	1	20.5			
42	1	21			
43	1	21.5			
44	1	22			
45	1	22.5			
46	1	23			
47	1	23.5			
48	1	24			
49	1	24.5			
50	1	25			

Form 4. Understory Cover (20x50m Plot) **Vegetation Community Protocol (p.2 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Substrate types: S=soil; L=litter; TT=tree trunk; B=bryophyte; LIC=lichen; TF=tree fern trunk; sand; cinder; gravel; rock; etc.

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
51	1	25.5			
52	1	26			
53	1	26.5			
54	1	27			
55	1	27.5			
56	1	28			
57	1	28.5			
58	1	29			
59	1	29.5			
60	1	30			
61	1	30.5			
62	1	31			
63	1	31.5			
64	1	32			
65	1	32.5			
66	1	33			
67	1	33.5			
68	1	34			
69	1	34.5			
70	1	35			
71	1	35.5			
72	1	36			
73	1	36.5			
74	1	37			
75	1	37.5			
76	1	38			
77	1	38.5			
78	1	39			
79	1	39.5			
80	1	40			
81	1	40.5			
82	1	41			
83	1	41.5			
84	1	42			
85	1	42.5			
86	1	43			
87	1	43.5			
88	1	44			
89	1	44.5			
90	1	45			
91	1	45.5			
92	1	46			
93	1	46.5			
94	1	47			
95	1	47.5			
96	1	48			
97	1	48.5			
98	1	49			
99	1	49.5			
100	1	50			

Form 4. Understory Cover (20x50m Plot) **Vegetation Community Protocol (p.3 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Substrate types: S=soil; L=litter; TT=tree trunk; B=bryophyte; LIC=lichen; TF=tree fern trunk; sand; cinder; gravel; rock; etc.

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
101	2	0.5			
102	2	1			
103	2	1.5			
104	2	2			
105	2	2.5			
106	2	3			
107	2	3.5			
108	2	4			
109	2	4.5			
110	2	5			
111	2	5.5			
112	2	6			
113	2	6.5			
114	2	7			
115	2	7.5			
116	2	8			
117	2	8.5			
118	2	9			
119	2	9.5			
120	2	10			
121	2	10.5			
122	2	11			
123	2	11.5			
124	2	12			
125	2	12.5			
126	2	13			
127	2	13.5			
128	2	14			
129	2	14.5			
130	2	15			
131	2	15.5			
132	2	16			
133	2	16.5			
134	2	17			
135	2	17.5			
136	2	18			
137	2	18.5			
138	2	19			
139	2	19.5			
140	2	20			
141	2	20.5			
142	2	21			
143	2	21.5			
144	2	22			
145	2	22.5			
146	2	23			
147	2	23.5			
148	2	24			
149	2	24.5			
150	2	25			

Form 4. Understory Cover (20x50m Plot) **Vegetation Community Protocol (p.4 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Substrate types: S=soil; L=litter; TT=tree trunk; B=bryophyte; LIC=lichen; TF=tree fern trunk; sand; cinder; gravel; rock; etc.

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
151	2	25.5			
152	2	26			
153	2	26.5			
154	2	27			
155	2	27.5			
156	2	28			
157	2	28.5			
158	2	29			
159	2	29.5			
160	2	30			
161	2	30.5			
162	2	31			
163	2	31.5			
164	2	32			
165	2	32.5			
166	2	33			
167	2	33.5			
168	2	34			
169	2	34.5			
170	2	35			
171	2	35.5			
172	2	36			
173	2	36.5			
174	2	37			
175	2	37.5			
176	2	38			
177	2	38.5			
178	2	39			
179	2	39.5			
180	2	40			
181	2	40.5			
182	2	41			
183	2	41.5			
184	2	42			
185	2	42.5			
186	2	43			
187	2	43.5			
188	2	44			
189	2	44.5			
190	2	45			
191	2	45.5			
192	2	46			
193	2	46.5			
194	2	47			
195	2	47.5			
196	2	48			
197	2	48.5			
198	2	49			
199	2	49.5			
200	2	50			

Form 4. Understory Cover (20x50m Plot) **Vegetation Community Protocol (p.5 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Substrate types: S=soil; L=litter; TT=tree trunk; B=bryophyte; LIC=lichen; TF=tree fern trunk; sand; cinder; gravel; rock; etc.

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
201	3	0.5			
202	3	1			
203	3	1.5			
204	3	2			
205	3	2.5			
206	3	3			
207	3	3.5			
208	3	4			
209	3	4.5			
210	3	5			
211	3	5.5			
212	3	6			
213	3	6.5			
214	3	7			
215	3	7.5			
216	3	8			
217	3	8.5			
218	3	9			
219	3	9.5			
220	3	10			
221	3	10.5			
222	3	11			
223	3	11.5			
224	3	12			
225	3	12.5			
226	3	13			
227	3	13.5			
228	3	14			
229	3	14.5			
230	3	15			
231	3	15.5			
232	3	16			
233	3	16.5			
234	3	17			
235	3	17.5			
236	3	18			
237	3	18.5			
238	3	19			
239	3	19.5			
240	3	20			
241	3	20.5			
242	3	21			
243	3	21.5			
244	3	22			
245	3	22.5			
246	3	23			
247	3	23.5			
248	3	24			
249	3	24.5			
250	3	25			

Form 4. Understory Cover (20x50m Plot) **Vegetation Community Protocol (p.6 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Substrate types: S=soil; L=litter; TT=tree trunk; B=bryophyte; LIC=lichen; TF=tree fern trunk; sand; cinder; gravel; rock; etc.

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
251	3	25.5			
252	3	26			
253	3	26.5			
254	3	27			
255	3	27.5			
256	3	28			
257	3	28.5			
258	3	29			
259	3	29.5			
260	3	30			
261	3	30.5			
262	3	31			
263	3	31.5			
264	3	32			
265	3	32.5			
266	3	33			
267	3	33.5			
268	3	34			
269	3	34.5			
270	3	35			
271	3	35.5			
272	3	36			
273	3	36.5			
274	3	37			
275	3	37.5			
276	3	38			
277	3	38.5			
278	3	39			
279	3	39.5			
280	3	40			
281	3	40.5			
282	3	41			
283	3	41.5			
284	3	42			
285	3	42.5			
286	3	43			
287	3	43.5			
288	3	44			
289	3	44.5			
290	3	45			
291	3	45.5			
292	3	46			
293	3	46.5			
294	3	47			
295	3	47.5			
296	3	48			
297	3	48.5			
298	3	49			
299	3	49.5			
300	3	50			

Form 5. Understory Cover (10x20m Plot) **Vegetation Community Protocol (p.1 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
1	1	0.2			
2	1	0.4			
3	1	0.6			
4	1	0.8			
5	1	1			
6	1	1.2			
7	1	1.4			
8	1	1.6			
9	1	1.8			
10	1	2			
11	1	2.2			
12	1	2.4			
13	1	2.6			
14	1	2.8			
15	1	3			
16	1	3.2			
17	1	3.4			
18	1	3.6			
19	1	3.8			
20	1	4			
21	1	4.2			
22	1	4.4			
23	1	4.6			
24	1	4.8			
25	1	5			
26	1	5.2			
27	1	5.4			
28	1	5.6			
29	1	5.8			
30	1	6			
31	1	6.2			
32	1	6.4			
33	1	6.6			
34	1	6.8			
35	1	7			
36	1	7.2			
37	1	7.4			
38	1	7.6			
39	1	7.8			
40	1	8			
41	1	8.2			
42	1	8.4			
43	1	8.6			
44	1	8.8			
45	1	9			
46	1	9.2			
47	1	9.4			
48	1	9.6			
49	1	9.8			
50	1	10			

Form 5. Understory Cover (10x20m Plot) **Vegetation Community Protocol (p.2 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
51	1	10.2			
52	1	10.4			
53	1	10.6			
54	1	10.8			
55	1	11			
56	1	11.2			
57	1	11.4			
58	1	11.6			
59	1	11.8			
60	1	12			
61	1	12.2			
62	1	12.4			
63	1	12.6			
64	1	12.8			
65	1	13			
66	1	13.2			
67	1	13.4			
68	1	13.6			
69	1	13.8			
70	1	14			
71	1	14.2			
72	1	14.4			
73	1	14.6			
74	1	14.8			
75	1	15			
76	1	15.2			
77	1	15.4			
78	1	15.6			
79	1	15.8			
80	1	16			
81	1	16.2			
82	1	16.4			
83	1	16.6			
84	1	16.8			
85	1	17			
86	1	17.2			
87	1	17.4			
88	1	17.6			
89	1	17.8			
90	1	18			
91	1	18.2			
92	1	18.4			
93	1	18.6			
94	1	18.8			
95	1	19			
96	1	19.2			
97	1	19.4			
98	1	19.6			
99	1	19.8			
100	1	20			

Form 5. Understory Cover (10x20m Plot) **Vegetation Community Protocol (p.3 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
101	2	0.2			
102	2	0.4			
103	2	0.6			
104	2	0.8			
105	2	1			
106	2	1.2			
107	2	1.4			
108	2	1.6			
109	2	1.8			
110	2	2			
111	2	2.2			
112	2	2.4			
113	2	2.6			
114	2	2.8			
115	2	3			
116	2	3.2			
117	2	3.4			
118	2	3.6			
119	2	3.8			
120	2	4			
121	2	4.2			
122	2	4.4			
123	2	4.6			
124	2	4.8			
125	2	5			
126	2	5.2			
127	2	5.4			
128	2	5.6			
129	2	5.8			
130	2	6			
131	2	6.2			
132	2	6.4			
133	2	6.6			
134	2	6.8			
135	2	7			
136	2	7.2			
137	2	7.4			
138	2	7.6			
139	2	7.8			
140	2	8			
141	2	8.2			
142	2	8.4			
143	2	8.6			
144	2	8.8			
145	2	9			
146	2	9.2			
147	2	9.4			
148	2	9.6			
149	2	9.8			
150	2	10			

Form 5. Understory Cover (10x20m Plot) **Vegetation Community Protocol (p.4 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
151	2	10.2			
152	2	10.4			
153	2	10.6			
154	2	10.8			
155	2	11			
156	2	11.2			
157	2	11.4			
158	2	11.6			
159	2	11.8			
160	2	12			
161	2	12.2			
162	2	12.4			
163	2	12.6			
164	2	12.8			
165	2	13			
166	2	13.2			
167	2	13.4			
168	2	13.6			
169	2	13.8			
170	2	14			
171	2	14.2			
172	2	14.4			
173	2	14.6			
174	2	14.8			
175	2	15			
176	2	15.2			
177	2	15.4			
178	2	15.6			
179	2	15.8			
180	2	16			
181	2	16.2			
182	2	16.4			
183	2	16.6			
184	2	16.8			
185	2	17			
186	2	17.2			
187	2	17.4			
188	2	17.6			
189	2	17.8			
190	2	18			
191	2	18.2			
192	2	18.4			
193	2	18.6			
194	2	18.8			
195	2	19			
196	2	19.2			
197	2	19.4			
198	2	19.6			
199	2	19.8			
200	2	20			

Form 5. Understory Cover (10x20m Plot) **Vegetation Community Protocol (p.5 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
201	3	0.2			
202	3	0.4			
203	3	0.6			
204	3	0.8			
205	3	1			
206	3	1.2			
207	3	1.4			
208	3	1.6			
209	3	1.8			
210	3	2			
211	3	2.2			
212	3	2.4			
213	3	2.6			
214	3	2.8			
215	3	3			
216	3	3.2			
217	3	3.4			
218	3	3.6			
219	3	3.8			
220	3	4			
221	3	4.2			
222	3	4.4			
223	3	4.6			
224	3	4.8			
225	3	5			
226	3	5.2			
227	3	5.4			
228	3	5.6			
229	3	5.8			
230	3	6			
231	3	6.2			
232	3	6.4			
233	3	6.6			
234	3	6.8			
235	3	7			
236	3	7.2			
237	3	7.4			
238	3	7.6			
239	3	7.8			
240	3	8			
241	3	8.2			
242	3	8.4			
243	3	8.6			
244	3	8.8			
245	3	9			
246	3	9.2			
247	3	9.4			
248	3	9.6			
249	3	9.8			
250	3	10			

Form 5. Understory Cover (10x20m) **Vegetation Community Protocol (p.6 of 6)**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Pt	Trans	Tape	Substrate	<1m Species (list across row)	1 - 2m Species
251	3	10.2			
252	3	10.4			
253	3	10.6			
254	3	10.8			
255	3	11			
256	3	11.2			
257	3	11.4			
258	3	11.6			
259	3	11.8			
260	3	12			
261	3	12.2			
262	3	12.4			
263	3	12.6			
264	3	12.8			
265	3	13			
266	3	13.2			
267	3	13.4			
268	3	13.6			
269	3	13.8			
270	3	14			
271	3	14.2			
272	3	14.4			
273	3	14.6			
274	3	14.8			
275	3	15			
276	3	15.2			
277	3	15.4			
278	3	15.6			
279	3	15.8			
280	3	16			
281	3	16.2			
282	3	16.4			
283	3	16.6			
284	3	16.8			
285	3	17			
286	3	17.2			
287	3	17.4			
288	3	17.6			
289	3	17.8			
290	3	18			
291	3	18.2			
292	3	18.4			
293	3	18.6			
294	3	18.8			
295	3	19			
296	3	19.2			
297	3	19.4			
298	3	19.6			
299	3	19.8			
300	3	20			

Form 6. Large Tree Density (20x50m) **Vegetation Community Protocol**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Large Trees: ≥ 10 cm DBH	**Rooting Ht Class**: **R1** = ground; **R2** < 0.5 m;
Fl = Flowering**; Fr =** Fruiting	**R3** = 0.5 < 2 m dead; **R4** = 0.5 < 2 m live; **R5=** 2 m +

Vigor Class	
V1	Healthy crown and foliage; < 10% of branches dead or without leaves
V2	Crown partially defoliated; 10-50% of branches dead or without leaves
V3	Unhealthy crown; >50% branches dead or without live leaves
V4	Plant recently dead; many fine branches remain
V5	Old dead; few fine branches (record basal diam. and length in Comments)

Species	Quad #	Live	DBH	#Boles	Vigor	√ Fl/Fr	Root-ing	Comments

Form 7. Canopy Tree Height (20x50 m) **Vegetation Community Protocol**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

ID	Species	Quad	Live	Method	DBH	Top %	Base %	Ht up base (m)	Distance (m)	Comments
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Form 8. Tree Fern Density (10x25m) **Vegetation Community Protocol**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Large Tree Ferns: ≥ 10 cm DBH
Diameter: Measured to nearest millimeter
Stem Length: Measured to nearest decimeter

Rooting Ht Class: **R1** = ground; **R2** < 0.5 m;
R3 = 0.5 < 2 m dead; **R4** = 0.5 < 2 m live; **R5** = 2 m +
Foliar Height Classes:
F1 = 0.5 < 1 m; **F2** = 1 < 2 m; **F3 =** 2 < 5 m, **F4** = 5 m +

Tree Fern Species	Live	Diameter	Rooting	Foliar	Stem Length	Comments

Form 9. Small Tree Density (10x25m Plot) **Vegetation Community Protocol**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

		Rooting Height Class									
Small Tree Species < 10 cm DBH	**DBH <5cm or 5-10 cm**	**LIVE**					**DEAD**				
		ground	**< 0.5m**	**0.5<2m dead**	**0.5<2m live**	**2m +**	**ground**	**< 0.5m**	**0.5<2m dead**	**0.5<2m live**	**2m +**

Form 10. **Seedling, Shrub, and Small Tree Fern, Density (2x50m)** **Vegetation Community Protocol**

PACN Park

Plot # (Fixed or Rotational?)

Plant Community

Date

Location (Sampling Frame / Zone)

Observers

Species Name	*Live unless noted "Dead"			
	Foliar Height Class			Rooting
≥ 0.5 m ht/length	0.5 < 1 m	1 < 2 m	2m +	Ht Class
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +

Species Name	*Live unless noted "Dead"			
	Foliar Height Class			Rooting
≥ 0.5 m ht/length	0.5 < 1 m	1 < 2 m	2m +	Ht Class
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +
				ground
				< 0.5 m
				0.5<2 dead
				0.5<2 live
				2m +

Form 11. Small & Large Tree Density (20x50m) **Vegetation Community Protocol**
Subalpine Shrubland

PACN Park	**Plot # (Fixed or Rotational?)**
Plant Community	**Date**
Location (Sampling Frame / Zone)	**Observers**

Small Trees: < 10 cm DBH **Fl =** Flowering**; Fr =** Fruiting
Large Trees: ≥ 10 cm DBH

Vigor Class	
V1	Healthy crown and foliage; >75% of branches with leaves
V2	Crown partially defoliated; 25 - 50% of branches dead or without leaves
V3	Unhealthy crown; >75% branches dead or without live leaves
V4	Plant recently dead; many fine branches remain
V5	Old dead; few fine branches (record basal diam. and length in Comments)

Species	Live	DBH	# Boles	Vigor	Fl/Fr	Comments

Form 12. Seedling Density (2x50m)
Subalpine Shrubland

Vegetation Community Protocol

PACN Park

Plot # (Fixed or Rotational?)

Plant Community

Date

Location (Sampling Frame / Zone)

Observers

	Foliar Height Class					
Seedling Species	**LIVE**			**DEAD**		
≥ 0.5 m length	0.5-1 m	> 1-2 m	≥ 2 m	0.5-1 m	> 1-2 m	≥ 2 m

Form 13. Shrub Density (2x50m)
Subalpine Shrubland

Vegetation Community Protocol

PACN Park

Plot # (Fixed or Rotational?)

Plant Community

Date

Location (Sampling Frame / Zone)

Observers

	Foliar Height Class					
Shrub Species	**LIVE**			**DEAD**		
≥ 0.5 m length	0.5-1 m	> 1-2 m	≥ 2 m	0.5-1 m	> 1-2 m	≥ 2 m

Form 14. Large Tree Density (10x20m) **Vegetation Community Protocol**

Coastal

PACN Park	**Plot # (Fixed or Rotational?)**
Plant Community	**Date**
Location (Sampling Frame / Zone)	**Observers**

Large Trees: ≥ 10 cm DBH
Fl = Flowering**; Fr =** Fruiting

Vigor Class	
V1	Healthy crown and foliage; >75% of branches with leaves
V2	Crown partially defoliated; 25 - 50% of branches dead or without leaves
V3	Unhealthy crown; most >75% branches dead or without live leaves
V4	Plant recently dead; many fine branches remain
V5	Old dead; few fine branches (record basal diam. and length in Comments)

Species	Live	DBH	# Boles	Vigor	Fl/Fr	Comments

Form 15. Small Tree Density (2-2x20m) Coastal **Vegetation Community Protocol**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

	Foliar Height Class					
Small Tree Species	**LIVE**			**DEAD**		
< 10 cm DBH	0.5-1 m	> 1-2 m	≥ 2 m	0.5-1 m	> 1-2 m	≥ 2 m

Form 16. Seedling Density (2-2x20m) Coastal **Vegetation Community Protocol**

PACN Park **Plot # (Fixed or Rotational?)**

Plant Community **Date**

Location (Sampling Frame / Zone) **Observers**

Seedling Species	**LIVE**			**DEAD**		
≥ 0.5 m length	0.5-1 m	> 1-2 m	≥ 2 m	0.5-1 m	> 1-2 m	≥ 2 m

Form 17. Shrub Density (2-2x20m) Coastal

Vegetation Community Protocol

PACN Park

Plot # (Fixed or Rotational?)

Plant Community

Date

Location (Sampling Frame / Zone)

Observers

	Foliar Height Class					
Shrub Species	**LIVE**			**DEAD**		
≥ 0.5 m length	0.5-1 m	> 1-2 m	≥ 2 m	0.5-1 m	> 1-2 m	≥ 2 m

Form 18. Coarse Woody Debris **Vegetation Community Protocol**

PACN Park	**Plot # (Fixed or Rotational?)**
Plant Community	**Date**
Location (Sampling Frame / Zone)	**Observers**

CWD: Dead downed wood (and tree fern logs) with diameter ≥ 7.6 cm at the point of planar intersection.

Transect	Length	Azimuth	Slope (degrees)	Comments
2	50 / 20			
4	20 / 10			
6	20 / 10			

Decay Class	Structural Integrity	Texture of Rotten Portions	Color of Wood	Invading Roots	Branches and Twigs
1	Sound, freshly fallen, intact logs	Intact, no rot; conks of stem decay absent	Original color	Absent	If branches are present, fine twigs are still attached and have tight bark
2	Sound	Mostly intact; sapwood partly soft (starting to decay) but can't be pulled apart by hand	Original color	Absent	If branches are present, many fine twigs are gone and remaining fine twigs have peeling bark
3	Heartwood sound; piece supports its own weight	Hard, large pieces; sapwood can be pulled apart by hand or sapwood absent	Reddish-brown or original color	Sapwood only	Branch stubs will not pull out
4	Heartwood rotten; piece does not support its own weight, but maintains its	Soft, small blocky pieces; a metal pin can be pushed into heartwood	Reddish or light brown	Through-out	Branch stubs will pull out
5	None, piece no longer maintains its shape, it spreads out on ground	Soft; powdery when dry	Red-brown to dark brown	Through-out	Branch stubbs and pitch pockets have usually rotted down

TR	Woody/ Tree Fern	Diam. (cm)	Decay Class	Comments	TR	Woody/ Tree Fern	Diam. (cm)	Decay Class	Comments

Appendix F: Database Documentation

The database for this project consists of three 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.

The database includes the following standard tables:

tbl_Sites	Sample sites – location aggregates, i.e. individual parks.
tbl_Locations	Sampling frame locations – sampling areas within the parks.
tbl_Plot	Sampling frame plot locations.
tbl_Events	Data collection event for a given location.
tbl_QA_Results	Quality assurance query results for the working data set.
tbl_Edit_Log	Edit log for changes made to data after certification.
tbl_Images	Plot photo information linked to a sampling event.

The following are project-specific data tables:

tbl_Basal_Sprout	Sprout size data collected in recently disturbed sites for individuals that have been top killed and are alive only by basal sprouts.
tbl_Debris_Species	Individual species of dead downed wood and tree fern logs with a diameter >=7.6 cm at the point of planar intersection.
tbl_Lg_Woody_Individual	Tree density information collected for small trees (subalpine), large trees (forest, coastal, subalpine), and large tree ferns (forest).
tbl_Multiple_Boles	Bole DBH for trees that have multiple boles.
tbl_Presence	List of species present within plot.
tbl_Segment_Slope	Slope values for the different segments of a plot transect.
tbl_Sm_Woody_Tally	Foliar and rooting height class data tallied for seedlings and shrubs (forest, coastal, subalpine), small trees (forest, coastal), and small tree ferns (forest).
tbl_Tree_Canopy_Height	Tree canopy height data.
tbl_Understory_Cover	Understory cover species and substrate data along transects in coastal and forest communities.
tbl_Woody_Debris	Transect information on dead downed wood and tree fern logs with a diameter >=7.6 at the point of planar intersection.

The following are standard lookup tables:

tlu_Contacts	Contact data for project-related personnel.
tlu_Enumerations	Enumerated lookup table.
tlu_Species	Lookup table of plant species.
tlu_Points_Coastal	Point identification table for coastal plots.
tlu_Points_Forest	Point identification table for forest plots.

The following are cross reference tables:

xref_Understory_High	Cross reference table between tbl_Understory and tlu_Species. Records at which points species less than 1 m tall were found.
xref_Understory_Low	Cross reference table between tbl_Understory and tlu_Species. Records at which points species 1 - 2 m tall were found.
xref_Event_Contacts	Cross-reference table between events and contacts.
xref_Park_Species_Nativity	Cross-reference table between parks and nativity of a species.

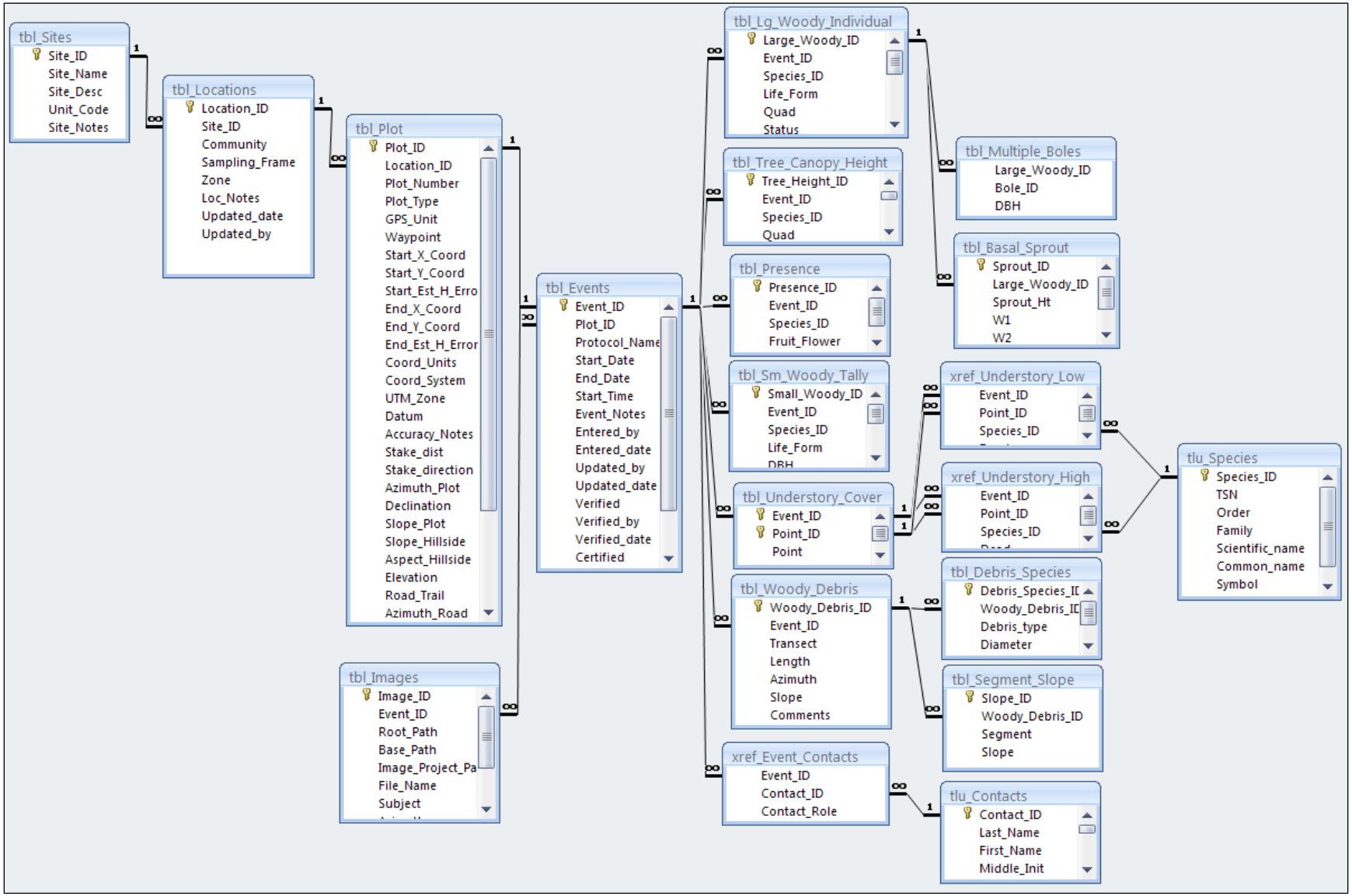

Figure F.1. Entity Relationship Diagram of the project database.

Database Tables

tbl_Basal_Sprout

Sprout size data collected in recently disturbed sites for individuals that have been top killed and are alive only by basal sprouts.

Field	*Primary?*	*Data Type*	*Size*	*Description*
Sprout_ID	Yes	Text	50	Unique record identifier
Area	No	Double	8	Sprout elliptical crown area calculated from W1 and W2 distances
Large_Woody_ID	No	Text	50	Link to tbl_Lg_Woody_Individual
Sprout_Ht	No	Long Integer	4	The longest basal sprout per tree (cm) measured from the base to the apical meristem
Volume	No	Double	8	Sprout crown volume (cm3) calculated by multiplying the height of the tallest sprout by the elliptical crown area.
W1	No	Long Integer	4	Widest horizontal distance (cm) or maximum diameter across the sprout crown
W2	No	Long Integer	4	Perpendicular diameter to W1 horizontal distance (cm) across the sprouts

tbl_Debris_Species

Individual species of dead downed wood and tree fern logs with a diameter >=7.6 cm at the point of planar intersection.

Field	*Primary?*	*Data Type*	*Size*	*Description*
Debris_Species_ID	Yes	Text	50	Unique record identifier
Comments	No	Memo	0	Comments about debris species.
Debris_type	No	Text	10	Debris type, i.e. wood or tree fern.
Decay_Class	No	Text	6	Decay class of the woody debris, i.e. sound or rotten.
Diameter	No	Double	8	Diameter of woody debris
Woody_Debris_ID	No	Text	50	Link to tbl_Woody_Debris

tbl_Edit_Log

Edit log for changes made to data after certification.

Field	*Primary?*	*Data Type*	*Size*	*Description*
Data_edit_ID	Yes	Text	50	Unique identifier for each data edit record
Data_edit_notes	No	Memo	0	Comments about the data edits
Edit_date	No	Date/Time	8	Date on which the edits took place
Edit_reason	No	Text	100	Brief description of the reason for edits
Edit_type	No	Text	12	Type of edits made: deletion, update, append, reformat, tbl design

Fields_affected	No	Text	200	Description of the fields affected
Records_affected	No	Text	200	Description of the records affected
Table_affected	No	Text	50	Table affected by edits
User_name	No	Text	50	Name of the person making data edits

tbl_Events — Data collection event for a given location.

Field	*Primary?*	*Data Type*	*Size*	*Description*
Event_ID	Yes	Text	50	Unique record identifier
Certified	No	Boolean	1	If the data is certified
Certified_by	No	Text	50	Who certified the data
Certified_date	No	Date/Time	8	When the data was certified
End_Date	No	Date/Time	8	Ending date for the event
Entered_by	No	Text	50	Who entered the data
Entered_date	No	Date/Time	8	When the data was entered
Event_Notes	No	Memo	0	Notes about the sampling event
Plot_ID	No	Text	50	Link to tbl_Plots
Protocol_Name	No	Text	100	The name or code of the protocol governing the event
QA_notes	No	Memo	0	Notes about the quality assurance procedure
Start_Date	No	Date/Time	8	Starting date for the event
Start_Time	No	Date/Time	8	Starting time for the event
Updated_by	No	Text	50	Who updated the data
Updated_date	No	Date/Time	8	When the data was updated
Verified	No	Boolean	1	If the data is verified
Verified_by	No	Text	50	Who verified the data
Verified_date	No	Date/Time	8	When the data was verified

tbl_Images — Plot photo information linked to a sampling event.

Field	*Primary?*	*Data Type*	*Size*	*Description*
Image_ID	Yes	Text	50	Unique record identifier for image records
Azimuth	No	Long Integer	4	The azimuth from the plot origin that the photo was taken
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.

Camera_Type	No	Text	50	The camera type used to take photo
Comments	No	Memo	0	Any additional information about the photo, i.e. camera type, lens, ASA.
Event_ID	No	Text	50	Link to tbl_Events
File_Name	No	Text	50	The file name
Image_Project_Path	No	Text	255	Location of the image from the main project folder or image library
Root_Path	No	Text	255	The root path for the linked image file. This will change upon re-linking of database.
Subject	No	Text	50	The subject of the photo
Time	No	Date/Time	8	The time the photo was taken

tbl_Lg_Woody_Individual **Tree density information collected for small trees (subalpine), large trees (forest, coastal, subalpine), and large tree ferns (forest).**

Field	*Primary?*	*Data Type*	*Size*	*Description*
Large_Woody_ID	Yes	Text	50	Unique record identifier
Boles	No	Long Integer	4	The number of tree trunks
Comments	No	Memo	0	Any additional comments about the species
DBH	No	Double	8	The diameter of the tree measured to the nearest tenth of a centimeter, or the total DBH of multiple boles.
Event_ID	No	Text	50	Link to tbl_Events
Foliar	No	Text	2	The foliar height class
Fruit_Flower	No	Boolean	1	Is the plant fruiting or flowering?
Height	No	Double	8	Height of the tree, only populated for dead trees (snags)
Life_Form	No	Text	15	The life form of the species; i.e. seedling, shrub, small tree, etc.
Quad	No	Text	255	The quad number the species was found in.
Rooting	No	Text	2	The rooting height class of the tree
Species_ID	No	Text	50	Link to tlu_Species
Status	No	Text	4	Is the tree live or dead?
Stem_Length	No	Double	8	The stem length measured to the nearest tenth of a meter
Vigor	No	Text	2	The vigor class of the tree

tbl_Locations — Sampling frame locations – sampling areas within the parks.

Field	*Primary?*	*Data Type*	*Size*	*Description*
Location_ID	Yes	Text	50	Unique record identifier
Community	No	Text	50	Focal community type; i.e. wet forest, subalpine shrubland, coastal, limestone forest, mangrove wetland
Loc_Notes	No	Memo	0	General notes on the location
Sampling_Frame	No	Text	100	Name of the sampling frame
Site_ID	No	Text	50	Link to tbl_Sites
Updated_by	No	Text	50	Who updated the Location information
Updated_date	No	Date/Time	8	Date of entry or last change
Zone	No	Text	50	Name of the zone if applicable

tbl_Multiple_Boles — Bole DBH for trees that have multiple boles.

Field	*Primary?*	*Data Type*	*Size*	*Description*
Bole_ID	No	Text	50	The identification of the bole (1, 2, top, etc.)
DBH	No	Double	8	The diameter of the bole measured to the nearest tenth of a centimeter.
Large_Woody_ID	No	Text	50	Link to tbl_Lg_Woody_Individual

tbl_Plot — Sampling frame plot locations.

Field	*Primary?*	*Data Type*	*Size*	*Description*
Plot_ID	Yes	Text	50	Unique record identifier
Accuracy_Notes	No	Text	255	Positional accuracy notes
Aspect_Hillside	No	Text	50	Direction the hillside is facing
Azimuth_Plot	No	Long Integer	4	Azimuth of the plot origin
Azimuth_Road	No	Text	50	Azimuth where road and trail is left to access plot
Coord_System	No	Text	50	Coordinate system
Coord_Units	No	Text	50	Coordinate distance units
Datum	No	Text	5	Datum of mapping ellipsoid
Declination	No	Double	8	Declination of the plot origin
Elevation	No	Long Integer	4	Elevation of the plot origin
End_Est_H_Error	No	Single	4	Estimated horizontal accuracy for ending coordinates
End_X_Coord	No	Double	8	The X coordinate for the end of the plot
End_Y_Coord	No	Double	8	The Y coordinate for the end of the plot

GPS_Unit	No	Text	255	What GPS unit was used to collect the plot coordinates
Location_ID	No	Text	50	Link to tbl_Locations
Plot_created_date	No	Date/Time	8	Time stamp for record creation
Plot_discontinued	No	Date/Time	8	Date the plot was discontinued
Plot_established	No	Date/Time	8	Date the plot was established
Plot_Notes	No	Memo	0	Any additional information about the plot; i.e problems encountered, changes, etc.
Plot_Number	No	Long Integer	4	Plot identification number
Plot_Type	No	Text	50	What type of plot it is, i.e. fixed or rotational
Plot_updated	No	Date/Time	8	Date of the last update to this record
Plot_updated_by	No	Text	50	Person who made the most recent edits
Road_Trail	No	Text	255	Road and trail used to travel to the plot
Route	No	Memo	0	The route to the plot. Includes plot layout and any reference features used to access the plot
Slope_Hillside	No	Long Integer	4	Percent slope along hillside
Slope_Plot	No	Long Integer	4	Percent slope along center transect azimuth
Stake_direction	No	Long Integer	4	Stake offset direction in degrees
Stake_dist	No	Long Integer	4	Stake offset distance in centimeters
Start_Est_H_Error	No	Single	4	Estimated horizontal accuracy for starting coordinates
Start_X_Coord	No	Double	8	The X coordinate for the start of the plot
Start_Y_Coord	No	Double	8	The Y coordinate for the start of the plot
UTM_Zone	No	Text	50	UTM Zone
Waypoint	No	Text	50	GPS waypoint

tbl_Presence List of species present within plot.

Field	*Primary?*	*Data Type*	*Size*	*Description*
Presence_ID	Yes	Text	50	Unique record identifier
Comments	No	Memo	0	Any additional comments about the species
Event_ID	No	Text	50	Link to tbl_Events
Fruit_Flower	No	Boolean	1	Is the plant fruiting or flowering?
Species_ID	No	Text	50	Link to tlu_Species

tbl_QA_Results — Quality assurance query results for the working data set

Field	Primary?	Data Type	Size	Description
Is_done	No	Boolean	1	No description
QA_user	No	Text	50	Name of the person doing quality assurance
Query_description	No	Memo	0	Description of the query
Query_expression	No	Memo	0	Evaluation expression built into the query
Query_name	No	Text	100	Name of the quality assurance query
Query_result	No	Text	50	Query result as the number of records returned the last time the query was run
Query_run_time	No	Date/Time	8	Run time of the query results
Query_type	No	Text	20	Severity of data errors being trapped: 1=critical, 2=warning, 3=information
Remedy_date	No	Date/Time	8	When the remedy description was last edited
Remedy_desc	No	Memo	0	Details about actions taken and/or not taken to resolve errors
Time_frame	No	Text	30	Field season year or range of dates for the data being passed through quality assurance checks

tbl_Segment_Slope — Slope values for the different segments of a plot transect.

Field	Primary?	Data Type	Size	Description
Slope_ID	Yes	Text	50	Unique record identifier
Segment	No	Text	255	Slope segment length
Slope	No	Long Integer	4	Slope of the segment
Woody_Debris_ID	No	Text	255	Link to tbl_Woody_Debris

tbl_Sites — Sample sites – location aggregates, i.e. individual parks.

Field	Primary?	Data Type	Size	Description
Site_ID	Yes	Text	50	Unique record identifier
Site_Desc	No	Text	255	Description for a site
Site_Name	No	Text	100	Unique name or code for a site
Site_Notes	No	Memo	0	General notes on the site
Unit_Code	No	Text	12	Park, Monument or Network code

tbl_Sm_Woody_Tally — Foliar and rooting height class data tallied for seedlings and shrubs (forest, coastal, subalpine), small trees (forest, coastal), and small tree ferns (forest).

Field	Primary?	Data Type	Size	Description
Small_Woody_ID	Yes	Text	50	Unique record identifier

Comments	No	Memo	0	Any additional comments about the species
Count	No	Long Integer	4	The count of the species observed for the height class
DBH	No	Text	10	The DBH class of small trees.
Event_ID	No	Text	50	Link to tbl_Events
Foliar	No	Text	2	The foliar height class
Life_Form	No	Text	15	The life form of the species; i.e. seedling, shrub, small tree, etc.
Rooting	No	Text	2	The rooting height class of the tree
Species_ID	No	Text	50	Link to tbl_Species
Status	No	Text	4	Is the tree live or dead?

tbl_Tree_Canopy_Height Tree canopy height data.

Field	*Primary?*	*Data Type*	*Size*	*Description*
Tree_Height_ID	Yes	Text	50	Unique record identifier
Base	No	Long Integer	4	Base percent, used to calculate canopy height if clinometer is used
Base_ht	No	Double	8	The height of the base of the tree (meters) that is used for the canpoy height calculation
Comments	No	Memo	0	Any additional comments about the tree canopy height
DBH	No	Double	8	Diameter basal height
Distance	No	Double	8	Distance, used to calculate canopy height if clinometer is used
Event_ID	No	Text	50	Link to tbl_Events
Height	No	Double	8	Height of the canopy
Method	No	Text	50	Method used to record canopy height; i.e. measuring rod, clinometer, ocular estimate, other
Quad	No	Text	255	The quad number the species was found in.
Species_ID	No	Text	50	Link to tlu_Species
Status	No	Text	4	Is the tree live or dead?
Top	No	Long Integer	4	Top percent, used to calculate canopy height if clinometer is used

tbl_Understory_Cover Understory cover species and substrate data along transects in coastal and forest communities.

Field	*Primary?*	*Data Type*	*Size*	*Description*
Point_ID	Yes	Text	50	Link to tlu_Points
Event_ID	No	Text	50	Link to tbl_Events
Point	No	Long Integer	4	The point where the understory was observed
Substrate	No	Text	50	The substrate that the understory is growing on

tbl_Woody_Debris **Transect information on dead downed wood and tree fern logs with a diameter >=7.6 at the point of planar intersection.**

Field	*Primary?*	*Data Type*	*Size*	*Description*
Woody_Debris_ID	Yes	Text	50	Unique record identifier
Azimuth	No	Long Integer	4	Azimuth of the transect
Comments	No	Memo	0	Comments on the woody debris transect
Event_ID	No	Text	50	Link to tbl_Events
Length	No	Text	255	Length of the transect. For all forest and shrubland plots, will be either 50 or 20 meters. For coastal plots, will be either 20 or 10 meters.
Slope	No	Long Integer	4	Slope of the transect
Transect	No	Text	2	Transect number

tlu_Contacts **Contact data for project-related personnel.**

Field	*Primary?*	*Data Type*	*Size*	*Description*
Contact_ID	Yes	Text	50	Unique record identifier
Active	No	Boolean	1	Allows users to choose which names show up in the drop down list
Address	No	Text	50	Street address
Address_Type	No	Text	50	Address (mailing, physical, both) type
Address2	No	Text	50	Address line 2, suite, apartment number
Cell_Phone	No	Text	50	Cell phone number
City	No	Text	50	City or town
Contact_created	No	Text	50	Date the contact record was created
Contact_Location	No	Text	255	Contact's work location
Contact_Notes	No	Memo	0	Contact notes
Contact_updated	No	Date/Time	8	Date the contact record was updated
Country	No	Text	50	Country
Email_Address	No	Text	50	E-mail address
Fax_Number	No	Text	50	Fax number
First_Name	No	Text	50	First name
Initials	No	Text	50	Three letter initials of observer
Last_Name	No	Text	50	Last name
Middle_Init	No	Text	4	Middle initial
Organization	No	Text	50	Organization or employer
Position_Title	No	Text	50	Title or position description
State_Code	No	Text	8	State or province
Work_Extension	No	Text	50	Phone extension

Work_Phone	No	Text	50	Phone number
Zip_Code	No	Text	50	Zip code

tlu_Enumerations **Enumerated lookup table.**

Field	*Primary?*	*Data Type*	*Size*	*Description*
Enum_Group	Yes	Text	50	Category for lookup value
Enum_Code	No	Text	50	Code for lookup values
Enum_Description	No	Memo	0	Lookup value description
Sort_Order	No	Integer	2	Order in which to sort lookup values

tlu_Points_Coastal **Point identification table for coastal plots.**

Field	*Primary?*	*Data Type*	*Size*	*Description*
Point_ID	Yes	Text	50	Unique record identifier
Point	No	Long Integer	4	Point identification
Tape	No	Text	50	Distance in meters from the start of the transect
Transect	No	Long Integer	4	Transect identification

tlu_Points_Forest **Point identification table for forest plots.**

Field	*Primary?*	*Data Type*	*Size*	*Description*
Point_ID	Yes	Text	50	Unique record identifier
Point	No	Long Integer	4	Point identification
Tape	No	Text	50	Distance in meters from the start of the transect
Transect	No	Long Integer	4	Transect identification

tlu_Species **Master look-up table for plant species names and taxonomic information. Derived from NPSpecies.**

Field	*Primary?*	*Data Type*	*Size*	*Description*
Species_ID	Yes	Text	50	No description
Code	No	Text	255	6 letter code to identify the plant species. First 3 letters of genus and the first 3 letters of species.
Common_name	No	Text	255	No description
Family	No	Text	255	No description
Order	No	Text	255	No description
Scientific_name	No	Text	255	No description
Symbol	No	Text	255	No description
TSN	No	Double	8	No description

xref_Event_Contacts **Cross-reference table between events and contacts.**

Field	*Primary?*	*Data Type*	*Size*	*Description*
Contact_ID	No	Text	50	Link to tlu_Contacts
Contact_Role	No	Text	50	The contact's role in the protocol

Event_ID	No	Text	50	Link to tbl_Events

xref_Understory_High **Cross reference table between tbl_Understory and tlu_Species. Records at which points species less than 1 m tall were found.**

Field	*Primary?*	*Data Type*	*Size*	*Description*
Dead	No	Boolean	1	Is the species dead?
Event_ID	No	Text	50	Together with Point_ID, a link to tbl_Understory
Point_ID	No	Text	50	Together with Event_ID, a link to tbl_Understory
Species_ID	No	Text	50	Link to tlu_Species

xref_Understory_Low **Cross reference table between tbl_Understory and tlu_Species. Records at which points species 1 - 2 m tall were found.**

Field	*Primary?*	*Data Type*	*Size*	*Description*
Dead	No	Boolean	1	Is the species dead?
Event_ID	No	Text	50	Together with Point_ID, a link to tbl_Understory
Point_ID	No	Text	50	Together with Event_ID, a link to tbl_Understory
Species_ID	No	Text	50	Link to tlu_Species

xref_Park_Species_Nativity **Cross-reference table between parks and nativity of a species.**

Field	*Primary?*	*Data Type*	*Size*	*Description*
Nativity	No	Text	255	Nativity of the species
Park	No	Text	255	4 letter park abbreviation
TSN	No	Double	8	Taxonomic serial number of the species

Appendix G: 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 G.1. Yearly Project Task List for Focal Terrestrial Plant Communities Monitoring Protocol.

Project Stage	Task Description	Responsibility	Timing
Preparation	Notify data manager and/or GIS specialist of needs (field maps, Global Positioning System [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 at each park	Project Lead, Data Manager and 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	GIS Specialist	by Apr 1
	Provide database/GPS training as needed	Data Manager and GIS Specialist	by Apr 1
	Train field crew in species identification, equipment usage, and field sampling protocols	Field Leader, Project Lead, Park Botanists	by Apr 1
	Verification of field observer qualifications	Field Leader	by Apr 1
Data acquisition	Collect monitoring data and GPS data in the field	Field Leader, Field Technicians	Apr-Oct (varies by park)
	Review data forms after each day and identify any unknown species	Field Leader, Field Technicians	daily
	Regular review of field forms for completeness and accuracy	Field Leader	bi-weekly
Data entry & processing	Download GPS data and email files to GIS specialist for correction	Field Leader, GIS Specialist	ASAP, after each tour
	Enter data into working copy of the database	Field Leader, Field Technicians	ASAP, after each tour
	Verification of accurate transcription as data are entered	Field Leader, Field Technicians	ASAP, after each tour
	GPS data correction	GIS Specialist	ASAP, after each tour
	Periodic review of GPS location data and database entries for completeness and accuracy	Field Leader	bi-weekly
	Upload processed and verified coordinates to database	GIS Specialist	Oct
Product development	Complete field season report	Field Leader	Nov 30
Product delivery	Send field season report to project lead and data manager	Field Leader	by Dec 1

Table G.1. Yearly Project Task List for Focal Terrestrial Plant Communities Monitoring Protocol.

(Continued)

Project Stage	Task Description	Responsibility	Timing
Quality review	Quality review and data validation using database tools	Project Lead	Dec
	Prepare coordinate summaries and/or GIS layers and data sets as needed for spatial data review	GIS Specialist	by Nov 15
	Joint quality review of GIS data	Project Lead and GIS Specialist	Nov-Dec
Metadata	Identify any sensitive information contained in the data set	Project Lead	Oct-Dec
	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 [1]	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 [1]	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 2 or more years of data is available for a park	Project Lead and Statistician (as consultant only)	Feb
	Export analysis results into database	Project Lead	Feb
Product development	Export automated reports from database	Project Lead	Feb
	Produce park-wide and area-specific maps for archives	GIS Specialist	Jan-Feb
	Generate quality maps for reports	GIS Specialist	Jan-Feb
	Acquire the proper report template from the NPS website, create annual report	Project Lead	Mar-Apr
	Screen all reports and data products for sensitive information	Project Lead	Mar-Apr
Product delivery	Submit draft report to program manager and initial peer reviewers 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
	Revise manuscript and complete NRPM checklist. Resubmit to program manager.	Project Lead	upon approval
	Submit manuscript and documentation to	Program Manager	upon

Table G.1. Yearly Project Task List for Focal Terrestrial Plant Communities Monitoring Protocol.

Project Stage	Task Description	Responsibility	Timing
(Continued)	Regional I&M coordinator		approval
	Assign a Peer Review Manager to review the manuscript for content, formatting and organization.	Regional I&M Coordinator	upon approval
	Contacts project lead and schedules review. Determines if reviewer comments were addressed and if additional reviews are necessary. Approves report for publication.	Peer Review Manager	upon approval
	Submits draft for formatting review and requests report numbers from NRPC	Project Lead	upon approval
	Produce PDF and email submittal form to NRPC.	Project Lead	upon approval
	Upload completed report and other products to PACN Digital Library[1], notify data manager.	Project Lead	upon completion
Posting & distribution	Submit metadata to Natural Resource Information Portal [2]	Data Manager	by Mar 15
	Post reports to Natural Resource Information Portal [2]	Data Manager	upon receipt
	Update Natural Resource Information Portal [2] records according to data observations	Data Manager	Dec-Mar
	Submit certified data and GIS data sets to Natural Resource Information Portal [2]	Data Manager	by June of the second year
Archival & records management	Store finished products in PACN Digital Library [1]	Data Manager	upon receipt
	Review, clean up and store and/or dispose of project files according to NPS Director's Order #19 [3]	Project Lead	Jan
Season close-out	Meet to discuss the recent field season, and document any needed changes to field sampling protocols 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

[1] The PACN Digital Library is a hierarchical digital filing system stored on the PACN file server. Network users have read-only access to these files, except where information sensitivity may preclude general access.
[2] The Natural Resource Information Portal is a clearinghouse for natural resource data, metadata, bibliographic records, and park species information (http://nrinfo/Home.mvc/showWelcomePage). Only non-sensitive information is posted to the Natural Resource Information Portal. Refer to the protocol section on sensitive information for details.
3 NPS Director's Order 19 provides a schedule indicating the amount of time that the various kinds of records should be retained. Available at: http://data2.itc.nps.gov/npspolicy/DOrders.cfm

Literature Cited

National Park Service (NPS). 2001. Director's Orders and Related Documents website. http://home.nps.gov/applications/npspolicy/DOrders.cfm (accessed 1 Oct 2007).

National Park Service (NPS). 2011. National Resource Information Portal website. https://nrinfo.nps.gov/Home.mvc/showWelcomePage (accessed on 26 April 2011).

Standard Operating Procedure (SOP) #1

Before the Field Season

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP outlines the steps to prepare for a field season and ensures that the proper equipment is available prior to the start of Pacific Island Network (PACN) focal terrestrial plant communities monitoring.

Procedures

Prior to conducting fieldwork, all field crew members are required to review the entire Focal Plant Communities Monitoring Protocol, including SOPs. Review of plant identification is particularly important as misidentification of a species is one of the most serious errors crew members can make during vegetation monitoring. This SOP includes a brief description of how plant community monitoring should be scheduled at PACN park units. Preseason planning facilitates the completion of scheduled work. All of the equipment and supplies listed in this SOP should be organized and made ready for the field season. Copies of the field data forms in Appendix E should be made using water resistant paper.

General Preparation and Review

Notebooks

Notebooks and reports from previous surveys should be reviewed if available to identify any unique events that may be encountered. These items will be stored in file cabinets at the PACN I&M vegetation office. A field notebook for the survey year should be prepared with pages for entry of sampling schedules, names of field crew members, field hours and unique happenings that may influence how the data are reported.

Compile Species Lists

Prior knowledge of species most likely to be encountered in a park will aid the field crew in preparing for the vegetation monitoring season. Therefore, species lists from previous efforts in a park or local area should be compiled and compared in order to reference manuals to identify species not yet recorded which have a probability of being recorded. Copies of these combined species list should be carried into the field as quick references in helping to identify unknown plants.

Load Waypoints

Waypoints for each monitoring plot must be loaded onto the GPS unit prior to the start of the field season. Waypoints are the X and Y coordinates of the center point of each monitoring plot which can be used to navigate to the plot location. SOP #5 contains information on preparing maps, images and sampling point locations. SOP #6 describes how to use GPS units, including uploading and navigating to waypoints. Copies of waypoint lists should be carried into the field to ensure that each plot is located; this is especially relevant for permanent plots.

Scheduling Field Work

Sampling Dates

Focal terrestrial plant surveys will begin in April and end approximately six months later depending upon the park, focal community and year. This allows for approximately 180 days (or 130 weekdays) in a typical field season. Inclement weather and personnel workloads will preclude the scheduling of sampling events to specific annual dates. Sampling dates should be scheduled and logistics organized prior to the start of each field season.

Crew

Monitoring within each PACN park will require two-person or four-person field crews depending on the focal community being sampled.

Timing and Collection

The amount of time required to survey a plot will vary by park, plant community and plot. A single plot may require up to two days to complete in wet forest and as little as two hours in coastal areas. Access issues and logistics will play a major role in scheduling and timing, as helicopter support and coordination with PACN I&M landbirds monitoring efforts will be required for transects shared between programs. Some areas will require multiple day field trips in order to complete the work efficiently and cost effectively. Monitoring of plots separated by the least amount of distance should be scheduled together when possible.

Organizing Supplies and Equipment

Review Equipment Lists

All equipment required for monitoring should be compiled, organized, and made ready prior to the field season. Time to make needed repairs and order equipment should be allocated before the fieldwork starts; at least two months advance preparation is recommended.

*Equipment Required to Establish and Survey One Permanent Plot**

The following list presents the field equipment required to establish and survey one permanent plot in the wet forest focal community. Coastal plots which do not have nested subplots require slightly less and/or different equipment; these differences are noted in parentheses below. To mark multiple plots, the number of required pins, flags, tags, rods and PVC pipes should be multiplied by the number of plots being established. The other monitoring equipment will be used for all plots surveyed. Equipment is stored at HAVO in either the rainshed or the PACN I&M vegetation office.

1. 3 - 50 m tapes (coastal: 3 - 20 m tapes)
2. 2 - 20 m tapes (coastal: 2 - 10 m tapes)
3. 1 - 10 m tape (forest and shrubland plots only)
4. 2 - 1 x 50 cm stainless steel threaded rods per plot (to mark the center transect origin and endpoint)
5. 2 white PVC pipes per plot (inner diameter of 1 cm)
6. Fast-setting two-part epoxy and latex gloves
7. 1 - 5 lb. sledgehammer
8. 8 blue pin flags (plot and subplot corners)
9. 6 aluminum tags (centerline endpoints and plot corners)
10. Blue flagging (arctic heavy duty)
11. Digital camera and accessories (charger, cables for uploading, batteries, etc.)
12. 2 compasses
13. 2 GPS units and extra batteries
14. Dry erase board and pen (for writing plot # and placing in lower right of photos)
15. Waterproof data forms, multiple pencils, 2 clipboards
16. 1 PDA (if data will be collected digitally), 1 waterproof casing, 2 SD memory cards (type may depend on PDA model), extra batteries
17. 2 Clinometers
18. Plant species lists and reference books
19. Maps of the survey area and plots
20. Two 2 m diameter tapes
21. 2 - 2 m poles (6 mm or ¼ inch diameter with the 0.1, 0.5, 1, 1.5 and 2 m intervals marked)
22. 2 carpenter tapes (5 m)

Many items (e.g., the pins, flags, and PVC pipes) apply only to the first year of sampling. In subsequent sampling events, re-establishing permanent plots should only involve replacing lost or damaged equipment. Also, while temporary plots require marking, pins or blue flags do not need to be left permanently and can be reused multiple times, thus reducing the amount of equipment required.

Miscellaneous Equipment

1. 4WD vehicle
2. Personal protective equipment for helicopter flights (flight suits, helmet, etc. for remote sites)
3. First aid kits (see SOP #3 “Safety”)
4. Sunscreen
5. Swiss army knife

6. Duct tape
7. Protective clothing (e.g., warm and waterproof layers for montane wet forest)
8. Sturdy boots
9. Wrist watch
10. Gallon Ziploc® bags (to keep data forms dry)
11. Field radios and/or cell phones (see SOP #3 “Safety”)
12. Personal survival kits (see SOP #3 “Safety)
13. Materials for collecting and vouchering (see SOP #10 “Collecting and Vouchering”).
14. Water for full day in field
15. Food for full day in field

Field Data Forms

Copies of the field data forms should be made on water resistant paper. Field forms can be found in Appendix E.

Standard Operating Procedure (SOP) #2

Training Field Crew Members

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP outlines the steps to train field crew members to identify native and nonnative plant species within the Pacific Island Network (PACN) parks and to become familiar with methods used to collect field data on focal terrestrial plant communities. Skill in plant identification is particularly important as misidentification of a species is one of the most serious errors crew members can make during vegetation monitoring.

Procedures

Prior to initiating monitoring all field crew members should review the entire monitoring protocol, including SOPs. Additionally, time should be spent learning or reviewing field identification characteristics for plant species that may be observed during the field season as well as practicing field collection methods.

Species Identification

The ability to identify both native and nonnative plant species is essential to the collection of credible, high-quality plant community data. Recognizing that a species is unknown and collecting a voucher specimen is equally as crucial. It is important that each member of the field crew has a basic understanding of field botany as well as plant anatomy. field leaders will have a more advanced understanding of field botany and ability to identify plant species; however, there will be times when an unknown plant is encountered and cannot be identified to the desired taxonomic level. In these cases, a voucher specimen must be collected and assigned a temporary name to be recorded in the field records until a proper determination can be made for that specimen (see SOP #10 “Collecting and Vouchering”).

Species identification training (or refresher training) will be conducted prior to the initiation of data collection in the field. Training will involve reviewing species lists for each sampling area and becoming proficient with field identification of most of the species that could be encountered. In order to become familiar with the flora of an intended sampling frame, field crew members will examine books, reports, journal publications, web sites, photographs, and herbarium collections that contain examples of all of the plant species that are expected to be encountered during the monitoring effort that coming year. A list of references is provided in the Suggested Reading section of this SOP. Copies of most of these resources should be available at each park so they can be used to assist with field identifications as needed.

Field Sampling Methodology

A detailed description of the methods used to monitor focal plant communities is provided in SOP #8. Additional procedures used during monitoring are described in SOP #6 "Using GPS to Navigate and Mark Waypoints," SOP #7 "Establishing and Marking Permanent Plots," and SOP #9 "Using a Clinometer to Measure Height and Slope". These techniques are based on standard vegetation sampling procedures that are described in several of the references listed in the Bibliography. During the training period prior to each field season, the entire crew should establish at least one practice sampling plot and review all data collection and recording procedures that will be required in the field.

Suggested Reading

Field Sampling Methods

Elzinga, C. L., D. W. Salzer, J. W. Willoughby and J. Gibbs. 2001. Monitoring Plant and Animal Populations. Blackwell Science Ltd., Denver, CO.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York, NY.

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Standard Operating Procedure (SOP) #3

Safety Protocol

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP explains safety procedures that all field crew members should follow to ensure optimum safety when working in the field to monitor Pacific Island Network (PACN) focal terrestrial plant communities. Part of this SOP covers material found in Pacific Cooperative Studies Unit (PCSU) field operation SOPs (2010), while other parts cover material from a Wilderness Hiking and Backpacking Training workshop for PACN Inventory and Monitoring employees held in January 2007.

PCSU Procedures

The PCSU is part of the national network of Cooperative Ecosystem Studies Units established to provide technical assistance and research to environmental and resource managers at organizations such as the NPS. Field personnel should examine the following procedures before working in the field to ensure all safety procedures are understood and followed. These field safety rules and regulations are meant to ensure the safety and well-being of all field workers.

Field Personnel Rules and Regulations

1. Only staff and approved field crew are allowed to assist with field work. Friends, pets and children are prohibited from accompanying field teams. Employees of state and federal agencies on official business connected with the project may accompany people working in the field. The project lead should always be consulted if there are uncertainties regarding someone's eligibility to accompany the field crew.
2. Field work will be planned ahead of departure and discussed with a supervisor. On a daily basis, park personnel will be notified of the itinerary and destination (including plot location

where appropriate) of the field crew and the estimated return time. A contact person should be chosen at the park that will be responsible for notifying a Safety Officer if a field person is injured.

3. Field crew members must avoid working alone and should never traverse difficult terrain without another crew member. If travel by vehicle alone during working hours is needed, the crew member will notify a park contact person or supervisor. Whatever the case, the individual must ensure that someone knows of their location and expected return time. A radio or cellular phone is required when working off the road or in a remote area.
4. When working in the sun, members of the field crew should wear a hat and a pair of sunglasses to protect themselves from harmful ultraviolet rays. Sunscreen should be applied to exposed skin.
5. Be aware of weather forecasts and changes in the weather, and be prepared to alter field work and clothing accordingly.
6. Learn how to lift heavy objects properly. Ask for help when lifting heavy objects.
7. In areas concerning safety of field personnel, the on-site supervisor's decision is final. However, an individual still may refuse to engage in what they believe is an unsafe operation.
8. It is the employee's responsibility to notify the supervisor regarding any health problems that might put the employee at additional risk of injury in the field. Such problems include fever, aches, fatigue, colds or other ill health, as well as allergies and other long-term and chronic health concerns.
9. Any injury incurred on the job will be reported to the supervisor IMMEDIATELY. Failure to report injury may result in the denial of workers compensation claims and/or disciplinary action.
10. Vehicles must be operated safely and in a manner consistent with Standard Operating Procedures for Vehicles for the agency whose vehicle is being utilized. A supervisor should be asked for a briefing on the procedures before any field crew members operate the vehicle for the first time.
11. Know the Emergency Action Plan.

Emergency Action Plan

1. The contact person is responsible for making sure that an emergency alert and/or process is initiated if field personnel do not return when scheduled or no radio or cell phone contact is received from the field at the expected call-in time.
2. Thirty minutes after call-in time, an alert is issued. The contact person or another person should stay near the phone in case field personnel call.
3. One hour from call-in time, search procedures should begin. Note: Prior to going into the field, the field leader and park contact person should agree on a time when search procedures should begin, as it may be more appropriate to set an alternate time to begin search procedures.
4. One person should remain near the phone, and one person familiar with the field area should begin tracking the scheduled route.

5. Tracking person should have a radio and/or cell phone and call back to the office every 20 minutes to see if field personnel have made contact.
6. Tracking continues until the person is found or word is received that the field personnel are safe.

Emergency Response Plan

If an emergency arises and a call must be placed to 911, be sure to give the following information: name, location of emergency, type of emergency and type of help required. Notify any supervisory personnel and provide them with the same information. Notify the local park manager for the relevant national park.

Safety Clothing and Equipment

1. Field personnel shall wear sturdy boots that provide ankle support and traction. Sturdy sneakers may be allowed if terrain is not very rugged. Bare feet, other shoes, and slippers are not allowed.
2. Rain gear and outerwear (i.e., sweater or jacket) shall be carried in the field at all times in wet forests or other locations. Rain gear includes rain pants and rain jacket. The combination of clothing must be adequate to keep the worker warm and reasonably dry until returning from the field or reaching field shelters, or for surviving an unplanned overnight stay in the field.
3. Each field person shall carry water with them in canteens or other suitable containers. Sufficient water shall be carried for unplanned, extended emergency stays overnight in the field.
4. Each field person shall carry a First Aid Kit while in the field. Additionally, each vehicle should carry a fully stocked first aid kit and a survival kit.
5. There shall be at least one individual per field crew with current Standard First Aid and CPR certificates.
6. Each person working in the field should have a box of waterproof matches (kept in a sealable plastic bag or waterproof container), a space blanket, a whistle and a flashlight or headlamp in their pack.

Portable Radios

The most important thing that field crew members should know about the Bendix King R-31 (14 channel) portable radio is that it is a communication tool that helps to ensure the safety of staff in the field. Portable radios allow other staff in the park to know the location and status of crew members in the field. Because crew members often work off-trail in the park backcountry, and hike over uneven ground, slopes, and near cliff edges, the radios are especially important as a means of communication in the event that injuries are incurred. The radios also provide an invaluable tool for communicating scientific observations if field crew members are some distance apart. Field crew members should have a working knowledge of the protocols for communicating with the radios, and a basic understanding of how to use them. Procedures for using radios effectively and appropriately are listed below. Note that some of the procedures below relate specifically to HAVO, and may require some modifications when working in other parks. Thus before entering the field in other parks, be sure to discuss current radio SOPs with park personnel.

1. Read and review the user guide, if available. Also review the radio call numbers and radio channels. Field crew members should photocopy the list of radio call numbers and take it with them into the field as a reference.
2. Whenever the portable radio is not in use (i.e., when crew members are back at the office or base yard), make sure that the unit is turned off (with the on/off volume control dial turned as far counterclockwise as possible) and charging in a battery charger. Chargers are available in the I&M office, and should be assigned to field crew members at the beginning of the season.
3. Before going into the field, take an extra battery from a charging unit.
4. Before traveling into the field, park dispatch must be notified. The field leader will inform Dispatch of the field plans and the estimated time of arrival (ETA) back at the departure point. For example within HAVO, you might contact the **Pacific Area Communications Center (808-985-6170)**, tell them you are working at HAVO on Mauna Loa and provide your ETA as 1700 hr at HAVO Visitor's Center. This is important because it provides the dispatch station with your general location in the event of an emergency. Follow the procedures listed below for HAVO:
   - Turn on the radio by turning the on/off volume control dial clockwise, until it is facing about 11 o'clock. The LED indicator should show a green light, indicating that the battery is charged and the unit is on.
   - There are four channels used on the HAVO radio system:
     - **Channel 1** – This is a direct channel, used for short, line of sight distances. It is used for talking to another field crew member close by. Employees in other areas of the park do not hear their conversations using Channel 1.
     - **Channel 2** – The repeater for Channel 2 is located at the Summit of Mauna Loa. This channel is used to reach all areas of HAVO except for some areas located at the Kahuku Ranch portion of the park. Channel 2 is the channel to use most of the time you are using the radio,
     - **Channel 3** – The repeater for Channel 3 is located at the South Point on the Big Island. This channel is used for the Kahuku Ranch area, as well as along the coastal areas of HAVO.
     - **Channel 4** – The repeater for this channel is located on Kulani Cone. This channel is used by field personnel working in remote forests of HAVO.
   - Press and firmly hold down the push-to-talk (PTT) button, and speak into the microphone. The LED indicator will show a red light, indicating that the speaker's communications are being broadcast through the radio.
   - Inform the dispatcher of travel plans and ETA back at departure point.
5. While in the field, keep the radio on with the volume loud enough to hear and respond to any communications directed at the designated radio call number (TBD).
6. In most situations, it will not be necessary to communicate with anyone while monitoring plant communities. If arrival off-trail will be later than the previously stated ETA, inform dispatch of the revised ETA as soon as possible.
7. If work requires that two paired field crew members to be separated by physical distance, the channel selector dial should be turned to Channel 1 so crew members can freely

communicate with one another, while leaving the regular airwaves of Channels 2, 3 and 4 open for park-wide use. Return to Channel 2 when crew members are together.

8. When returning from the field, contact dispatch again to let them know the field crew is safe: for example, “Dispatch, off trail at 2100 hours.”
9. After signing off with dispatch, return the radio to the charger unit, and make sure the radio is turned off while charging. Return the extra battery to the battery charger.
10. Follow the protocols listed below as general guidelines for appropriate use of the radio:
    - Each division within HAVO has a series of Call Numbers. Each employee is assigned a Call Number from the series of the Division they are working in. Example: Maintenance employees call numbers all start with 200, 201, 202, etc.
    - When communicating with the radio, always begin by stating the call number of the person you are trying to reach, followed by your own. For example, state: “505, 301”, or “Volcano Dispatch, 301.” Then the dispatcher will come on the radio and say “301, this is dispatch.” Then let the dispatcher know the reason for the radio transmission.
    - After keying the radio, wait a second before speaking into the radio. This prevents the start of the radio communication from being cut off.
    - Be brief and concise when communicating with the radio. This keeps the airwaves clear and saves battery power.
    - Speak clearly into the radio’s microphone, and press the PTT button firmly while speaking.
    - Think about what needs to be relayed before calling on the radio.
    - If your transmission is longer than 30 seconds, you must take a “break”, which means you must say “break”, take a breath, listen for any other traffic and then resume your transmission to dispatch if there is no other traffic. The “break” allows for someone else to interrupt the transmission is there is an emergency.
    - Securing the Radio Channel: During park emergencies or certain incidents, the dispatch office will “SECURE THE RADIO FREQUENCY.” When this happens, the only traffic on the radio should relate to the ongoing incident. If there is an emergency that happens during an ongoing incident, then use the radio for that. Otherwise, there should be no radio traffic until the original incident is done and then the dispatchers will “RELEASE THE FREQUENCY TO NORMAL TRAFFIC.” If you have not been listening to the radio, you might not know there is a situation going on in the park. So, when turning on the radio, give a minute of time to listen for any ongoing radio traffic.
11. Be careful about carrying your radio in your back pack or wearing it while using the seatbelt in a vehicle. The radio key could be activated by the pressure of your seat belt or something in your back pack that will not allow anyone else to use the radio. Also, everyone in the park with a radio on can hear what you might be talking about or other noises related to what you are doing. Having the radio key activated will keep the system out of use for other traffic, including emergencies.
12. Protect radios from moisture, dust and hard impacts.

Travel on Foot

1. Wear proper clothing and footwear.

2. Always carry a first aid kit, radio and water.
3. Be sure that equipment and supplies are carried in a manner consistent with safe travel over rough terrain. Backpacks should be in good repair and fit properly. DO NOT OVERESTIMATE YOUR LOAD CAPACITY.
4. Always be aware of what's around you (on ground and overhead).
5. Be conscious of surroundings – when disoriented, familiar objects can set you on track. Even if you have a GPS, carry a compass, and an area (field) map showing locations of pertinent transects, plots, roads, trails, and other landmarks. These items may prove invaluable especially in fog, rain or darkness.
6. Always be sure someone at the park knows where you are and when you are expected to return.
7. Never overextend your capabilities.
8. Be sure permission is GRANTED before entering private property.
9. Report accidents immediately to your supervisor.
10. Use common sense.
11. If you do get lost or become disoriented STAY WHERE YOU ARE. You may be overcome by panic. Sit down and quietly organize your thoughts on where you are. A few moments of recollection may clarify your situation. If not, find a comfortable place to rest. Use your whistle or other means to attract the attention of anyone around you. Do not try to leave the area if there are no signs of where to go. Do not follow a stream downhill, as it will almost certainly go over a waterfall at some time. Do not travel at night.

Hiking and Backpacking Techniques

Worker injuries, in addition to causing physical harm, directly impact projects by reducing personnel and funds available for project research. Although most workers possess a reasonable degree of wilderness hiking knowledge and experience, the hazards of wilderness hiking or backpacking should not be taken for granted. A large number of injuries result from slips, trips, and falls while hiking. Just like any other work activity, hazards must be identified, safe procedures and techniques must be developed, and workers must be trained to perform tasks safely.

The general training material below (taken from the January 2007 training course on Wilderness Hiking and Backpacking) is designed to insure that workers are aware of the hazards, and knowledgeable of the procedures and techniques for safely hiking and backpacking in wilderness areas.

Section 1: Individual levels of physical conditioning, knowledge, and experience for wilderness hiking and backpacking

- Years of experience
- Types of terrain and elevation changes
- Climate and environmental conditions
- Length and duration of hikes
- Types of gear and/or work equipment utilized

- Amount of weight carried
- Types of physical conditioning
- Types of wilderness activities
- Participation in hiking/climbing organizations
- Training and/or certifications from hiking/climbing organizations and/or employers
- Involvement in wilderness work activities requiring hiking (i.e. Resource Management, Hunting, Surveying)

Section 2: Hazards involved in hiking and backpacking activities

- Lack of physical conditioning
- Improper footwear
- Carrying backpacks
- Carrying hand tools and equipment
- Improper protective eyewear
- Slips, trips and falls due to uneven terrain
- Ascending, descending, or traversing hillsides
- Abrupt ledges and cliffs
- Grass or brush-concealed rocks, holes, roots, forest debris, drop-offs
- Brush and other low-growing vegetation
- Lava tubes and tree molds (Hawai'i)
- Broken, jagged lava flows (Hawai'i)
- Logs
- Slippery mud
- Loose rocks
- Footing conditions while hiking alongside or crossing streams
- Flash flood hazards while hiking alongside or crossing streams
- Falling limbs and trees in windy conditions
- Extreme weather to include: Lightening, Heavy Rain, Windstorm, Misty /Foggy Conditions
- Fatigue and heat stress
- Dehydration
- Disorientation
- Hypothermia
- Over-confidence
- Lack of communication and a daily check-in procedure
- Poor time management resulting in a rushed schedule or return in darkness
- Being unprepared as far as needed gear, and mental readiness for the daily challenges and unplanned circumstances

Section 3: Procedures and techniques to mitigate hiking and backpacking hazards

- Physical conditioning is the key critical element in performing hiking tasks, especially when additional weight, such as backpacks, tools, or equipment is to be carried, and the terrain is steep. Lack of conditioning may lead to fatigue and poor judgment in executing safe hiking procedures.
- "Buddy System" – Always work in the field with a buddy.
- Always be prepared for the day's tasks, mentally, physically, and with the proper equipment. At a minimum, all staff should have first aid kits, field maps, cell phone, pager, radio, raingear, lunch, and water.
- Always conduct a hiking hazard safety briefing with crews prior to starting the hike.
- High-visibility bright colored clothing is required for all field operations to more readily locate workers in the wilderness. Long and short-sleeved shirts may be provided for all workers by their project unit.
- Good footwear is essential for hiking safely. Proper footwear will provide good traction, firm ankle and arch support, protection from sharp tools, and general comfort. For hiking in steep, muddy, wet, or loose terrain, lace-up boots that are a minimum 8" (20 cm) high with lug soles are required. It is important that footwear fit properly, be worn with appropriate socks, and be "broken in" to prevent blisters. Footwear must be maintained in good condition, and periodically inspected, especially the soles, to maintain skid resistance.
- Backpack fit and comfort improve hiking safety. An ill-fitting pack can result in short and long term back pain and injury. For a good fit follow these tips:
    - Use a pack with wide, padded shoulder straps.
    - Make sure the straps are long enough.
    - Ensure that the pack properly fits your torso and stays contoured correctly along your back.
    - Never put more weight in a pack than you can comfortably carry. (Never exceed one third of your body weight.)
    - Position your pack low on your back. Wearing your pack too high can increase shoulder and neck pain.
    - Adjust the hip-belt correctly. Your pack should rest right above your hip bones. For smaller packs, the hip-belt serves to reduce bouncing. It helps keep the pack comfortably in place. For larger packs, the hip-belt also helps distribute the weight load more evenly.
    - Use both straps to carry your pack.
    - Typically, if you are able to stand up straight and comfortably when using your pack, you have a good fit.
    - Use a sternum strap to position shoulder straps in the correct position.
- Knowing how to pack your backpack can also improve comfort and safety.

  Follow these packing tips:
    - Distribute the weight throughout your pack.
    - Most heavy items do best toward the middle of your pack, closest to your back, or toward the bottom for a lower center of gravity.

    - With too many heavy objects toward the top or outside of your pack, your posture will shift to accommodate the added burden.
    - Pad bulky items (i.e., tools and equipment) well so they do not stick out and irritate your back.
    - Secure the hip-belt to help distribute weight more evenly.
- Always carry tools and equipment on the downhill side of the body. Tools should be sheathed while walking, unless they are needed for clearing vegetation (e.g., pruning saw). Never carry loads that require use of both hands; instead have two persons carry them or use a backpack or pack frame. Long pieces of equipment, are best carried by two persons.
- Wear tempered sunglasses, safety glasses, or goggles whenever there is a chance of eye injury. The project provides safety glasses for eye protection which is required in areas with thick vegetation and in dusty environments.
- Maintain safe walking and working distance between people (10-foot minimum) to avoid being struck by branches and tools. Stagger spacing when on slopes such that people are not directly below other personnel higher on the slope. Be sure other workers in the vicinity know where you are. If something comes loose from a slope, warn others by yelling "ROCK!!!"
- The majority of injuries involve slips, trips and falls. When negotiating the hazards of uneven terrain and hidden ground surface hazards, either on or off designated trails, watching where you step is most critical as this can prevent 99% of slip, trip and fall incidents. If work tasks require observation of items or areas other than the path you are walking, make periodic stops to conduct your observations, and then resume your travel with a focus on the path in front of you. Never look at the forest canopy while walking.
- Always examine the ground ahead of where you are walking, and test and use secure footing. Plan ahead, select safe routes, and be alert to changes in ground surface, slick spots, or unusual hazards. Select each stepping spot carefully, and do not shift body weight until you are sure the spot is solid.
- In heavy undergrowth, lift your knees high to clear obstacles. Slow down and exaggerate steps in the area of exposed roots to keep from catching your toes.
- Watch for and avoid lava tubes, earth cracks, and tree molds when walking through forest, shrubland, and grassland. Walk slowly and test footing. Uluhe, a native fern, is very effective at concealing holes and cracks, so be especially careful when walking in areas covered by uluhe.
- Avoid walking on logs because they can be deceptively slippery. Step over small logs. If you must cross a large log, sit on it and swing your legs over one at a time. If stepping on a log is unavoidable, test the footing first before shifting your full weight to the log. Walk slowly.
- When contouring a steep slope, do not lean into the hill. This tends to loosen footing. Erect posture, or slightly leaning out, gives more secure footing.
- When moving uphill or in sandy soils, lean slightly forward, turn feet outward, shorten stride, and use as much of the inside of the foot as possible. Another technique is to toe into the slope by kicking your toe in and creating a step

- On slippery, loose ground, or going downhill, keep most of your weight on your heels. Shorten your stride, keep knees bent, and lean slightly backward. Make sure of secure footing and safe working positions. Walk - never run down slopes.
- Rocky slopes, especially loose rock and steep country, are treacherous. Have one hand free, preferably on the uphill side, for protection against falls or obstructions. Always carry tools on your downhill side.
- When slipping, lean into the slope and grasp for things to help arrest your descent. Do not lean out away from the slope, as this may result in a head over heels tumble.
- If you feel yourself slipping, pick a landing spot. Even before this, as you traverse a steep area, survey the area and look for good landing spots.
- Know how to fall to avoid hard impacts. Keep flexible with knees slightly bent. This helps your legs act as a shock absorber. Sit down if you begin to slide, or roll with the fall.
- Carry webbing for use when hiking or working in steep environments. Be conservative when deciding to use webbing. Remember, it is always easier to go up, than down.
- Do not stick your arms out to break a fall from a log or on level ground. Keep your arms slightly bent in front of your head. Protect you head and back.
- "Curse your fall." This means shout out an exclamation as you fall. This ensures you exhale as you land, which in turn releases air from your lungs. This can help minimize damage to your internal organs.
- When crossing streams, scout the area to determine a safe spot to ford the stream. Avoid crossing where the water is knee high or higher. Do not cross on logs that span the stream. Do not attempt crossing during heavy rainfall or if upslope thunder has been noted. Walk slowly and deliberately to allow for proper evaluation of upcoming terrain in order to avoid any potentially dangerous obstacles. Place your feet carefully in firm footholds. Avoid loose rocks, high water flow, slippery rocks, and overly steep or muddy terrain. When climbing rocks or crossing rocky areas attempt to have three points of contact at all times and keep your center of gravity low. A wading pole is required to aid in balance and exploring for drop offs. Appropriate footwear with traction (tabies, or shoes with a felt or nylon sole, lace-on oversoles, or bonded carpeting sole) should be used for stream work. If wearing a non-quick release backpack, slip off the upstream shoulder strap so the pack can be discarded in an emergency situation.
- Reliable weather reports should be obtained for the areas that influence the streams or river beds in areas where work will be conducted, prior to leaving for the field. Avoid working in flooded areas or where water is moving swiftly. Cancel work activities during or following storm events that would compromise the safety of such activities. Be aware of quick weather changes, especially upslope of stream sites (excessive rain, although it may be sunny at the site). Be alert and listen for signs of a flash flood. Any sudden increase of debris, muddy water, or a low roar of thunder are indicators of a possible flash flood. Leave yourself with exit routes in the event of flash flooding.
- Always be on guard against injury from falling trees, snags, limbs, rolling logs or rocks. Never run blindly if a rolling rock, log, or tree is heard. Try to determine the direction of fall, and then move out of the path.

- Do not enter the forest during a lightning storm. If a lightning storm is heard approaching, leave the forest and get into the vehicle. If a lightning storm is occurring while you are still in the forest do the following:
  - Put down all tools.
  - Do not use the cell phone or radio.
  - Do not lean against a tree.
  - Get off of ridges and hilltops, and avoid open spaces, ledges, outcrops of rock, and other exposed locations.
  - If you feel your hair standing on end or your skin tingling, lightning may be about to strike you. Squat down immediately, keeping the soles of your feet flat on the ground and curl into the smallest ball possible.
- Avoid fatigue and heat-stress. Plan long-distance foot travel for the cooler hours of the day. Stop for frequent rest periods of at least 15 minutes to cool down and drink water, especially if carrying heavy loads. Keep hydrated and include in meals and snacks potassium-rich foods, such as bananas and citrus fruits. Avoid high-protein foods (meats) which increase metabolic heat production and water loss. Wear lightweight, light-colored, loose clothing. During periods of continued extreme temperatures, monitor each other and watch for signs of heat-stress disorders.
- Prevent dehydration. Carry 2-4 liters of water for the day – more if the day is going to be hot. Take drinks regularly so that normal urination patterns are maintained. Keep a reserve quart in the vehicle for use on the return to base. Do not drink stream or ponded water without first filtering and treating to eliminate harmful organisms, including *Giardia lamblia* and *Leptospira interrogans*.
- Avoid disorientation. Always remain within verbal hailing distance of another crewmember. Always carry and know how to use a compass and a site map that shows true and magnetic north relative to the study area and the location of the parked vehicle. Orient yourself at the parking area and at intervals as you walk through and work in the forest. Trust your compass. Turn on, carry, and periodically test operability of field radios among crewmembers. Check in with Base at lunch, and at the end of the day. Carry charged replacement batteries. Stay put if lost, and protect yourself from hypothermia by keeping warm and dry. Wear high visibility clothing.
- Prevent hypothermia. Hypothermia results in a subnormal core body temperature and is a medical emergency. Carry in your pack a long-sleeve shirt or jacket. If you feel chilled, put it on. Always carry a full set of rain gear and put it on when rain starts falling. Each crewmember must carry the supplied emergency space blankets. Crewmembers must know the symptoms and treatment of hypothermia.
- Know Your Limits! When you start as a new worker in the field, you may not be sure of your limits, and should explore and expand them slowly, at your own pace. When working with an experienced staff member whose limits are beyond yours, do not feel obligated to push yourself to follow them onto a ledge or across a steep slope unless you feel comfortable doing so. Forcing yourself to go beyond your limits may increase the chance of an accident.

Travel in Vehicles

Follow the guidelines below for vehicle use:

1. You must have a valid driver's license before driving any vehicle whether on the road or off-road.
2. Persons not experienced in 4-wheel driving may require training in off-road driving.
3. Always carry emergency equipment (i.e., first aid and basic survival kit and car jack).
4. Always be sure someone in the park knows where you are going and when you are expected to return.
5. On private land the owners and their workers have the right of way. Drive slowly so as not to kick up dust.
6. Any vehicle being used to reach sampling sites should be inspected prior to use.
7. Report any vehicle problem immediately to the supervisor and maintenance.
8. Report accidents to your supervisor immediately.
9. Use common sense.
10. Obey the rules of the road even when driving off-road.
11. Driving safety policies are listed in NPS Reference Manual 50B, Section 6.0 Motor Vehicles

Travel in Helicopters and on Commercial Flights

If you will be flying in helicopters for work related activities, you are required to take the Basic Aviation Safety Training. See your supervisor for details about participating in the Aviation Safety Program. The NPS Aviation Departmental Manual, RM 60 provides additional information regarding safety and flying regulations (NPS 2003). If you will be flying on commercial airlines, you are not permitted to take any fuel for cook stoves or have it packed in your luggage. All fuel must be purchased at your destination. It is also prohibited to fly commercially with any fuel containers (even if they are empty) or stoves using fuel containers that have previously contained fuel. You can be fined and/or arrested for attempting to bring these items on commercial airlines. For a listing of what is not allowed on commercial airlines, visit the Federal Aviation Administration (FAA 2010) or the Transportation Security Administration (TSA 2010) websites.

Health Concerns

An open cut may become infected easily under field conditions; therefore all scratches and cuts should be given appropriate attention, such as disinfecting and bandaging, and any injury should be monitored. Antibacterial cream, such as Neosporin, may be applied to reduce the chances of infection. Persons with serious injuries should seek professional medical attention as soon as possible.

Leptospirosis

There is a known risk of contracting leptospirosis in Hawai'i and American Samoa. This is a disease caused by bacteria (*Leptospira interrogans*) that are transmitted from animals to humans. The bacteria can survive long periods of time in fresh water and mud and can enter the body through the eyes, nose, mouth and broken skin. It is inadvisable to drink or swim in potentially contaminated water (i.e., streams and ponds). The last outbreak in American Samoa was reported

in 2004, which appeared to be related to contamination of streams from pig farms (Goldberg 2010). Avoid entering freshwater if you have breaks in the skin.

If 2 to 20 days after working in or around a stream, you experience flu-like symptoms that persist for more than two days, consult a physician and inform him/her that you may have been exposed to *L. interrogans* bacteria. If you come down with any severe fever or disease, ask your doctor to consider whether there are any unusual diagnoses that should be considered because of your fieldwork.

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Federal Aviation Administration (FAA). 2010. Hazardous Materials Information for Passengers. Available at http://www.faa.gov/about/office_org/headquarters_offices/ash/ash_programs/hazmat/passenger_info/ (accessed 27 Apr 2010).

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Standard Operating Procedure (SOP) #4

Sanitation Protocol

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP explains the sanitation procedures that all field crews performing Pacific Island Network (PACN) focal terrestrial plant communities monitoring should implement to ensure that invasive plant and animal species are not spread by field crews working near, in, and around invasive species populations or in areas that are native-dominated. Sanitation, in this context, is best defined as the removal and destruction of invasive species, plant parts or propagules through the decontamination of vehicles, tools, equipment, supplies, clothes, and hands to prevent the spread of invasive plants, animals, or pathogens. The required sanitation procedures should be implemented by all agencies and organizations that work in natural areas of high ecological value, as one of the major dispersal mechanisms of invasive species into these areas is through human actions (i.e., on field staff, vehicles, helicopters, pack animals, equipment and supplies). Before working in any park, review all sanitation guidelines for that park, and then implement whichever sanitation protocol (this protocol or the park's protocol) is more stringent. In all cases, field crews are responsible for understanding and implementing sanitation guidelines before, during, and after monitoring events.

Pre-survey Procedures

Field Clothes and Gear

- Use only clean gear and clothes for field work. Launder clothes prior to field work and preferably dry clothes in high heat.

- Scrub shoes, packs, and pack contents and inspect them for any hitchhiking seeds, organisms, and soil. Take special care to check boot tongues and tread, pack, seams, pockets, radio harnesses, etc. A small brush should be used to clean boots, equipment and gear.
- Use designated, specially marked clothing, shoes, and gear when working in areas with highly dispersible invasive species. Use this set of clothes and gear exclusively for work with specific invasive plants. Keep this set of clothes separate from personal, non-work clothes or field clothes used for native natural areas.
- Suggestion: Pack extra clothes to change into to prevent transport of invasive species.

Equipment and Supplies

- Wash all equipment and supplies prior to field work to ensure all soil, plant parts, and organisms are removed.
- Treat monitoring supplies (e.g., PVC poles, stakes) and transport equipment (e.g., helicopter sling nets) that have been stored outside or in unmonitored storage areas with a mild bleach or appropriate cleaning solution to kill hitchhiking organisms such as spiders, slugs, ants, cockroaches, and other species.
- If work is planned in a pristine natural area, inspect all gear and supplies before packing them. Store the gear and supplies in a pest free environment before taking them into the field (e.g., indoors or in plastic trash bags). It may be necessary to freeze gear overnight (or at least 12 hrs) at or below 26°F and pack camp food in covered plastic buckets or action-packers to prevent accidental introductions of unwanted pests and to make freezing and cleaning easier. Refer to the park guidelines for more details on these procedures.

Vehicles

- Clean vehicle exteriors (especially wheel wells, bumpers, grill, fenders, and underneath) by washing with soap and strong spray, preferably using a high pressure hose.
- Clean vehicle interiors to remove soil, invasive plants and plant parts. A vacuum is suggested. Use an air compressor to blow the insides clean, if needed.
- Do not allow vehicles to move from one area to another without first being cleaned and inspected.
- Utilize the vehicle air conditioning to prevent seeds from entering the vehicle interior.

Survey Procedures

- If possible, strategically plan field work to move from weed-free areas to weedy areas. If working over long distances, this often means walking from higher elevation sites that tend to be more pristine to lower elevation sites that tend to be weedier. If possible, limit field work to times when invasive plants of concern are not seeding.
- Pack out everything. Food scraps including orange peels and apple cores potentially introduce new organisms, and are food for rats and other animals. Seeds of fruit may germinate in the field as well. All field crews should adopt a “leave no trace” policy.
- If it is possible, camp or arrange breaks in plant or animal pest-free sites to prevent transporting invasive species.

- When surveying along transects or clearing trails, limit the amount of ground disturbance and foliage removal, which may create suitable substrate and light conditions for weeds to become established.
- Report sightings of invasive species populations observed in the course of field work. Use the example form provided below. Reporting incipient populations allows managers to eradicate populations before they become widespread.
- Inspect clothes and gear and take a few moments to clean them before heading to a new work area or leaving the field.
- Refrain from eating certain fruit to avoid becoming a dispersal agent. Eating the fruit of invasive species while in the field (e.g., blackberry) or eating fruit while at home (e.g., tomatoes) has resulted in their introduction to remote sites. If these items are eaten, bury waste at least 12 inches.

Post-survey Procedures

- Clean gear and vehicles promptly with the understanding that transported frogs, insects, and plant seeds do not remain in one place for very long.
- Dispose of invasive plant seeds and plant parts that are removed from clothing. Appropriate disposal techniques include microwaving the seeds, grinding them in a food processor, using a pestle and mortar, or incinerating them. Often, it is not appropriate to throw them in the trash, which could result in their establishment at the refuse dump.
- Clean gear in a designated site at home or office so that the area can be continually monitored for invasive species.

Sample Invasive Plant Reporting Form

Below is a generalized version of the invasive species report form used by Resource Management at HALE. A similar form may be adapted for other agencies and organizations utilizing this protocol. Ensure the codes for each field (see fig. 1) are provided with the form, preferably copied to the back of each form.

Park-Specific Sanitation Protocols

Most parks have their own protocols for biological sanitation. Field crews should always review these park-specific protocols before any monitoring occurs. For instance, in HAVO no pack animals may be used in upper elevation Kahuku (e.g. above the cattle pastures) until protocols for preventing movement of weeds by pack animals can be developed. HAVO also has coqui frog and ant sanitation protocols. All vehicles going above the 5,000 foot elevation level in Kahuku must be sanitized for ants to prevent ants from getting established above the Kāʻu Forest Reserve. After reviewing park-specific sanitation guidelines, field crews should implement whatever protocol is most rigorous for that area.

Invasive Species Observations (Vegetation Community Protocol)

Park:_____

Date:_____ Time:_____ AM PM Observation was: seen heard saw evidence (e.g. nest)

Species:_____ Number Observed: _____ Within Park Boundary? Yes No Unsure

Observer: _____ Confidence: positive fairly confident somewhat confident unsure

Location: _____ Elevation: _____ ft m

Location Determined by: (GPS, map, etc.) _____ If GPS was used, please provide:

Coordinates: _____ Datum: _____ Accuracy: _____

Details Size:_____ Color: _____

ID Marks: _____ Track/Sign: _____

Use Codes- see other side of sheet

Terrain: _____ Habitat: _____ Slope: _____ Behavior: _____ Precipitation: _____ Wind: _____

Circle one

Age: Adult SubAdult Juvenile Other_____ Gender: Male Female Unknown

Additional Notes

Codes

Habitat:
- 0 = open water
- 1 = wetland/march
- 2 = meadow
- 3 = shrub thicket
- 4 = woodland
- 5 = unvegetated
- 6 = agriculture

Terrain
- 0 = floodplain
- 1 = hillside
- 2 = ridge top
- 3 = river/stream
- 4 = pond/lake
- 5 = marine
- 6 = brackish

Precipitation:
- 0 = clear
- 1 = partly cloudy
- 2 = overcast
- 3 = foggy/drizzly
- 4 = raining
- 5 = snow
- 6 = other- decribe

Slope:
- 0 = nearly level (0-3%)
- 1 = gently sloping (1-8%)
- 2 = strongly sloping (4-16%)
- 3 = moderately steep (10-30%)
- 4 = steep (20-60%)
- 5 = very steep (>45%)

Note- in parentheses are lower and upper percent slope gradient limits

Behavior:
- 0 = dead
- 1 = feeding
- 2 = flying
- 3 = mating
- 4 = nesting
- 5 = resting/basking/sleeping
- 6 = standing
- 7 = swimming
- 8 = walking/ running
- 9 = unknown
- 10 = other- please describe

Wind:
- 0 = Calm- smoke rises vertically, below 1 mph
- 1 = Light air- smoke drifts, leaves barely move, 1-3 mph
- 2 = Light breeze- leaves rustle, wind can be felt, 4-7 mph
- 3 = Gentle breeze, leaves and twigs move, debris and dust raised from ground, 8-12 mph
- 4 = Moderage breeze- small branches move, debris and dust raised from ground, 13-18 mph
- 5 = Fresh breeze, small trees sway and large branches in motion, dust clouds raised, 19-24 mph
- 6 = Strong breeze- large branches continuously move, wind whistles, 25-31 mph
- 7 = Moderate gale- large trees sway, difficulty walking, 32-38 mph
- 8 = Fresh gale- twigs and small branches break, walking very difficult, 39-46 mph
- 9 = Strong gale- slight damage to buildings, 47-54 mph
- 10 = Whole gale- large trees uprooted, heavy building damage, 55-63 mph
- 11 = Storm- widespread damage, 64-72 mph
- 12 = Hurricane, above 73 mph

Figure 1. Generalized form for recording invasive species observations in PACN parks, adapted from the HALE Resource Management form.

Standard Operating Procedure (SOP) #5

Generating Sampling Point Locations with GIS

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Partially based on: Camp, R. J. 2006. Standard Operating Procedure (SOP) #3 "Preparing Maps, Images, and Sampling Point Location Tables From GIS," Version 1.00. *in* Camp, R. J., T. K. Pratt, C. Bailey, and D. Hu. 2011. Landbirds vital sign monitoring protocol – Pacific Island Network. Natural Resources Report NPS/PACN/NRR—2011/402. National Park Service, Fort Collins, Colorado.

Purpose

This SOP explains how to use ArcGIS™ and the Hawth's Tools extension to generate random sampling points for Pacific Island Network (PACN) terrestrial plant community monitoring. This SOP describes two methods for generating sampling points: (1) random point generation within sampling frame boundaries, applicable to all communities except the wet forest, and (2) random point generation along transects in the wet forest plant community. Once sampling points have been generated, SOP #7 describes how to install rectangular plots around each sampling point.

Procedures

Sampling points are generated in ArcMap® 9.3 using the "Random Point Generation" tool within Hawth's Tools. Alternate points are generated simultaneously in case any of the initial locations are unsafe, unrepresentative or infeasible to sample. For the first year of sampling in each frame, all fixed and rotational plots (including alternates) have been generated. On an ongoing basis, additional rotational plots need to be generated starting with the second round of sampling for each frame (except for the mangrove forest frame which has only fixed plots). For the remainder of this SOP, it is implied that alternate plots will be generated whenever rotational plots are generated. The I&M GIS staff has the necessary ArcMap® documents and base layers

(park boundaries, streams, roads, etc.) to generate the required rotational plots for subsequent sampling cycles, as described below.

Simple Random Point Generation in ArcGIS™

This method for generating random plots within a sampling frame applies to four plant communities: subalpine shrubland, coastal communities, limestone forest and mangrove forest. Note that no additional plots need to be generated for the mangrove forest, as only the initial fixed plots need be sampled in this frame. Within these plant communities, sampling plots are generated randomly using a simple random sampling strategy outlined below.

1. Open ArcMap®, and load the park specific map document and associated layers including park boundaries, coastlines, roads, trails, elevation grids and slope grids.
2. The criteria for generating random points are listed below. For all 20 x 50 m plots each centroid must be:
   - within the sampling frame.
   - greater than 47 m from sampling frame boundaries, roads, trails, streams, coastlines, cultural features or other unrepresentative features, ensuring that plot edges are ≥20 m from these features (Figure 1).
   - greater than 104 m from fixed plot centroids and other sampling points, ensuring a 50 m buffer between the adjacent plots.
   - in a location with a slope less than 100% (45°).

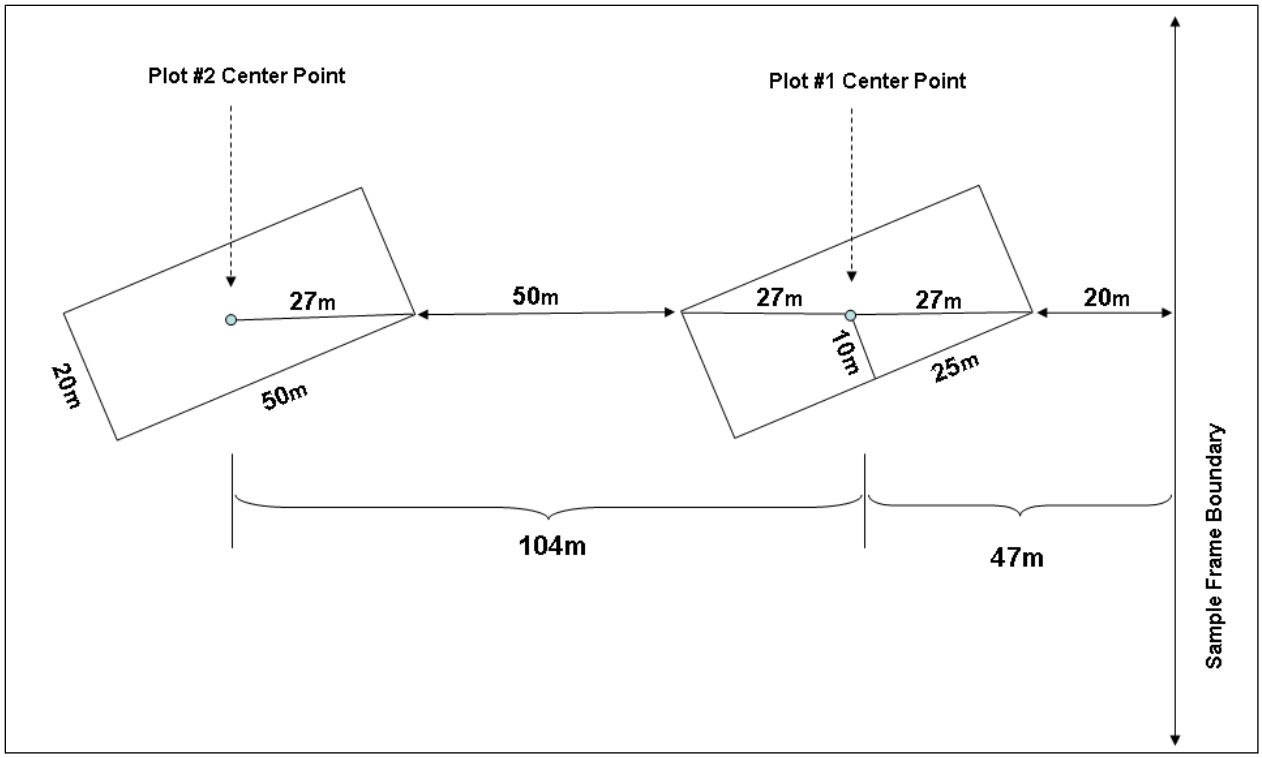

Figure 1. The minimum distance between plot center points and either frame boundaries or unrepresentative features (47 m), as well as adjacent plot center points (104 m) for 20 x 50 m plots. Note that these distances ensure plot edges greater than 20 m from frame boundaries or unrepresentative features and greater than 50 m from other plots. These values apply to all 20 x 50 m plots.

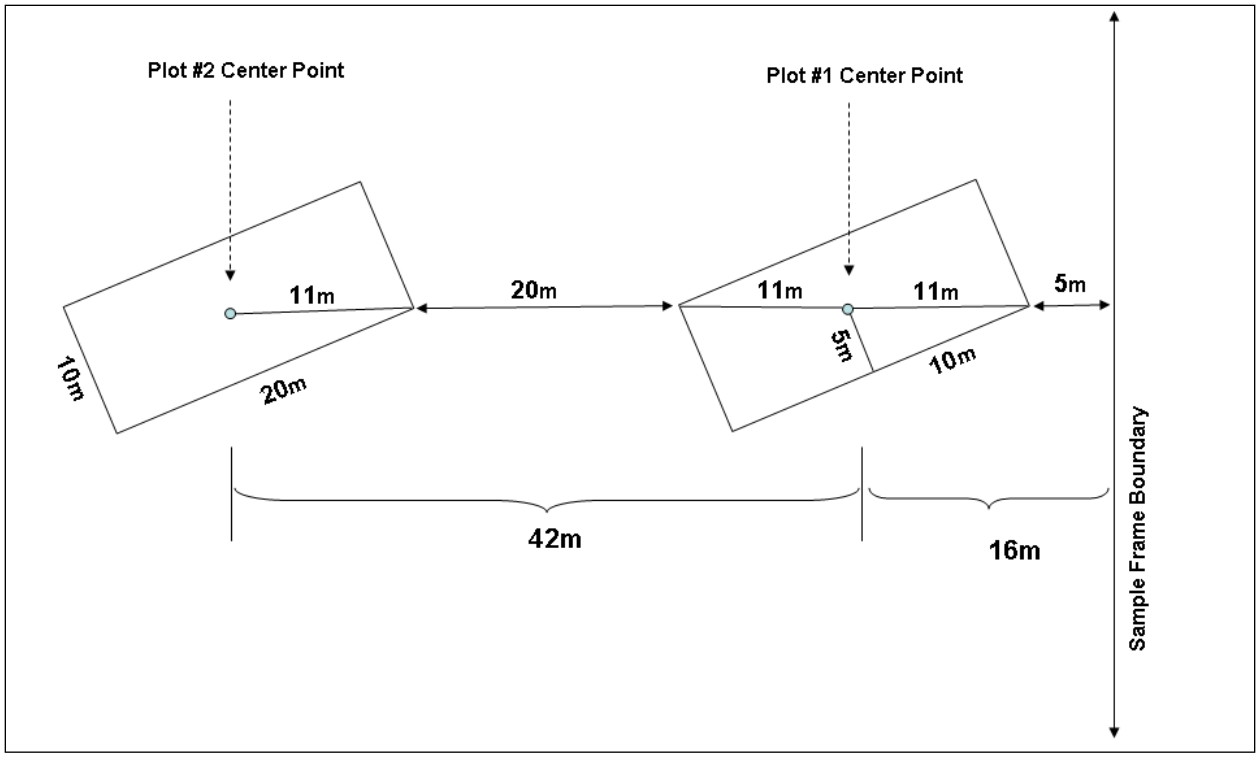

Figure 2. The minimum distance between plot center points and either frame boundaries or unrepresentative features (16 m), as well as between adjacent plot center points (42 m) for 10 x 20 m plots. Note that these distances ensure plot edges greater than 5 m from frame boundaries or unrepresentative features, and greater than 20 m from other plots. For the 10 x 20 m plots at KAHO, these buffer requirements are slightly more lenient (see text).

For the 10 x 20 m coastal plots at KALA, each sampling point must be:

- within the sampling frame.
- greater than 16 m from sampling frame boundaries, roads, trails, streams, coastlines, cultural features or other unrepresentative features, ensuring that plot edges are ≥5 m from these features (Figure 2).
- greater than 42 m from fixed plot centroids and other sampling points, ensuring a 20 m buffer between adjacent plots.
- in a location with a slope less than 100% (45°).

Finally for the small coastal strand community at KAHO the 10 x 20 m plots require more lenient buffer requirements than KALA. At KAHO, each sampling point must be:

- within the sampling frame.
- greater than 11 m from sampling frame boundaries, roads, trails, streams, coastlines, cultural features or other unrepresentative features, ensuring that plot edges do not touch any of these features.

- greater than 32 m from fixed plot centroids and other sampling points, ensuring a 10 m buffer between adjacent plots.
- in a location with a slope less than 100% (45°).

3. Generate buffers around all unrepresentative features such as roads, boundaries, trails, etc. These buffer zones represent areas that cannot contain plot center points; otherwise portions of the plot may lie too close to unrepresentative features or beyond sampling frame boundaries. Procedurally it may be easier to combine all unrepresentative features into one layer before generating buffers.
4. Use Hawth's Analysis Tools for ArcGIS™ to generate a list of potential sampling locations and coordinates. Table A.1 lists the number of fixed and rotational plots generated for the first cycle of sampling in each frame. On an ongoing basis, I&M staff need to generate only rotational plots. Since some points may be discarded in the next step, generate approximately 50% more points than required to ensure that enough rotational plots are created:
   - from the Hawth's Tools pull-down menu under the "Sampling Tools" option, open the "Generate Random Points" tool.
   - within the dialog box (Figure 3), enter the name of the sampling frame polygon, the excluded buffer area, the minimum distance between points and the number of points.
   - after all the points have been generated, use the "Table Tools – Add XY to Table (Points)" option from within Hawth's Tools to create X and Y values for each point.
5. Discard any point with a slope of greater than 100% (45º).
   - based on the highest resolution digital elevation model (DEM) available, create a slope raster using the "Surface Tools" in Spatial Analyst. If a DEM already exists in the I&M GIS database, this step may be skipped.
   - Run the "Extract Values to Points" tool located within the "Extraction" subfolder of the Spatial Analyst Toolset. This tool uses the slope raster to compute slope for each random sampling point.
   - Based on the interpolated slope values, discard all points that do not meet the slope criteria. Furthermore, if a plot location lies next to dangerous slopes that could fall within or on the edge of plot boundaries, eliminate this point as well. In general, only the wet forests of KALA, NPSA and HALE have large areas with slopes greater than 100%. In the other sampling frames, extreme slopes are distributed more sparsely (if at all) across the frame.
6. From the remaining feasible points, use the "Create Random Selection" tool from Hawth's Tools to select the appropriate number of rotational plots (see table A.1 for the required number of rotational plots). After generating the required number of plots, any extra points can be discarded.

After permanent plots have been established and surveyed in the first year, buffer areas should be created around them and merged with the other buffer areas to prevent future rotational plots from being located too close to fixed plots. An alternative strategy to buffering unrepresentative features and creating exclusion zones around them is to generate random points throughout the sampling frame and then manually exclude any infeasible points at the end. This approach works

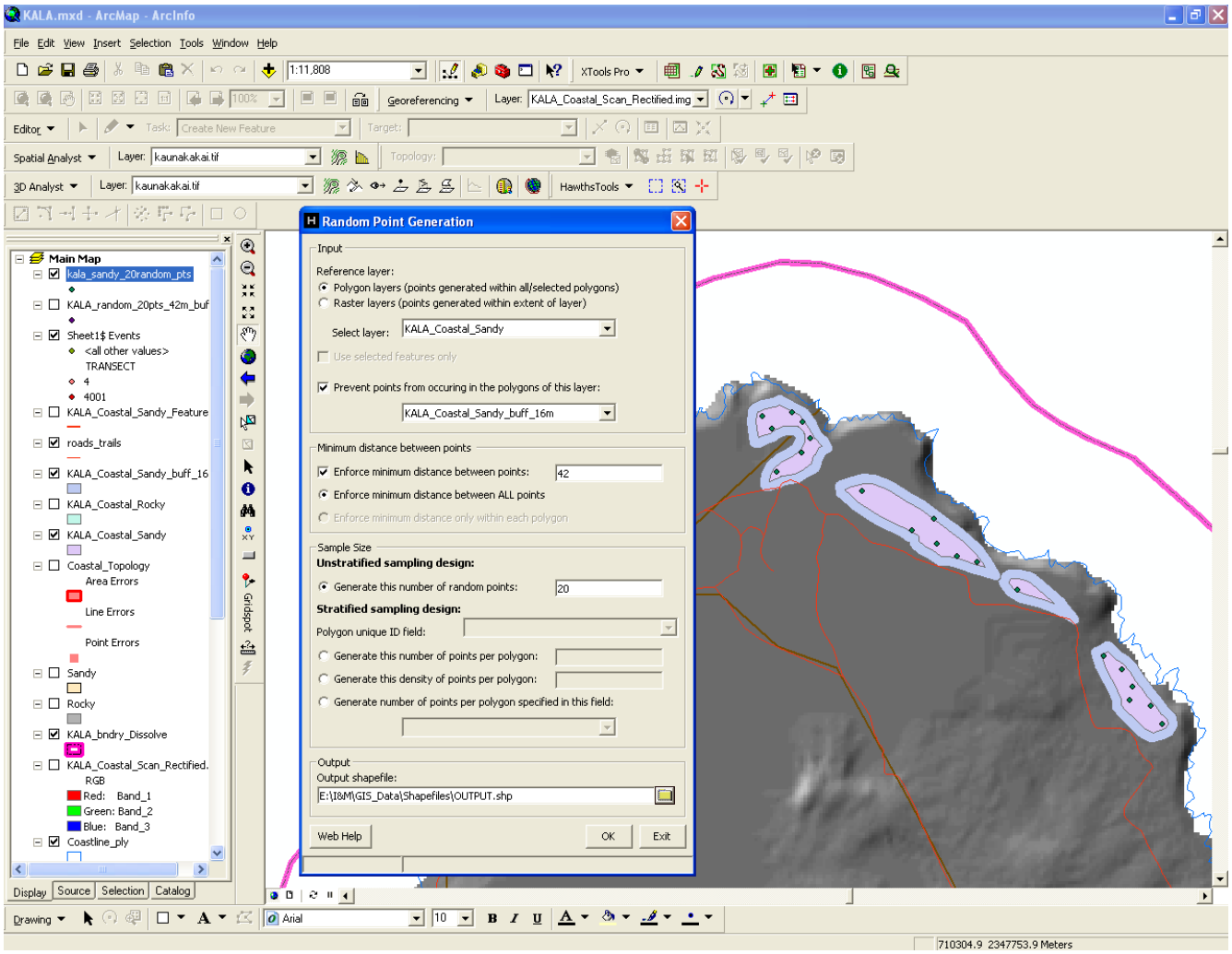

Figure 3. Dialog box for the "Random Point Generation" tool in Hawth's Tools. Note relevant options (a) to prevent points from occurring in selected polygons and (b) to enforce minimum distances between points.

reasonably well in the larger sampling frames with few unrepresentative areas/features but will be more time-consuming in smaller, more restricted sampling frames.

Point Generation Along Transects in ArcGIS™

This method applies only to the wet forest sampling frame where logistics and risks dictate that sampling must occur along transects. Fixed plot locations are randomly located along fixed transects and rotational plots are randomly located along rotational transects. The fixed plots have been generated (see Appendix A "Target Populations and Sampling Frames") and should not need to be modified again. The rotational plots have also been generated for the first cycle of sampling (Appendix A), but additional plots need to be generated prior to each subsequent sampling cycle. This process involves generating new rotational transects and selecting a random set of points along these rotational transects. To the greatest extent possible this protocol will share rotational transects with the Landbirds Protocol (Camp et al. 2011). Table A.1 lists the

required number of rotational plots for each frame. The following steps describe in detail the procedure to generate rotational transects and rotational plots.

1. Generate a series of random transects. The criteria for transect establishment is identical to the Landbirds Protocol enabling the I&M GIS staff to create one set of transects for both protocols where applicable. The procedure to create rotational transects is as follows:
   - using Hawth's Tools select 20 random points from within the sampling frame for use as potential transect starting points.
   - beginning with the first random point, assign a random azimuth (either by computer or using the random number table in SOP #7). Draw a 1500 m transect (or shorter if the transect reaches a park boundary, coastline, or impassable section) in the direction of that azimuth. If the transect is less than 600 m long (i.e., the equivalent of five landbirds monitoring stations spaced 150 m apart), then discard the transect since it is not practical to access and sample isolated plots. Rotational transects and legacy transects may cross one another.
   - continue generating transects from each random starting point until the combined length of new transects equals the total length of rotational transects from year 1. The I&M GIS staff has this transect information in their geodatabases. In general, this length corresponds to 7500 m (7.5 km) or approximately 50 landbirds monitoring stations (located on five to eight transects). However, the total length of transects varies between frames; so the safest approach is to match the length of new rotational transects to the length of rotational transects generated in year 1. To ensure compatibility with the Landbirds Protocol, consult with the Landbirds project lead to verify that the new transects meet their protocol requirements.
2. Using the "Divide" tool in the ArcGIS® editor, create sampling stations at 150 meter intervals along each of the newly created rotational transects. In addition to serving as landbirds sampling stations, these stations act as a pool from which we will select our sampling points.
3. Before selecting specific points, discard any points that are potentially unsafe or that may contain features such as human structures or disturbance corridors making the plot unrepresentative of the main surrounding. Since this protocol requires the placement of 20 x 50 m plots around each sampling point, we may have to discard some points that are acceptable to the Landbirds Protocol.
4. Table A.1 lists the required number of rotational (15) and alternate plots (number varies). The required number of plots will match the number of plots generated in year 1 of sampling. Using the "Create Random Selection" tool from Hawth's Tools, select and partition the appropriate number of rotational and alternate plots from the pool of acceptable plots.
5. After all the sampling points have been generated, assign plot numbers to each plot. Since fixed plots are numbered 1–15 in each wet forest frame, rotational plots will be numbered 16–30 in year 1 of sampling, 31–45 in year 2, 46–60 in year 3, and so on. Alternate plot numbering begins with "A1" and continues until each alternate plot has a number (e.g., A1–A15).
6. Use the "Table Tools – Add XY to Table (Points)" option within Hawth's Tools to create X and Y values for each plot.

7. Since we do not anticipate any “transect” effects on rotational transects, rotational plots do not need to be shifted off transect by 50 m.

Printing Coordinates and Maps

1. Print out the X and Y coordinates for all plots.
2. To maximize efficiency in the field, the list should include information on the proximity of plots to each other, as well as the recommended order of sampling.
3. Print out the GIS maps showing each transect and plot location relative to each other.
4. Laminate the tables and map (two-sided: map on one side, list on the other) for field use.
5. Coordinates should be in Universal Transverse Mercator (UTM) format.
6. Enter the X and Y coordinates and unique plot numbers into GPS units (see SOP #6) before entering the field.

Defining Plots from Random Sampling Points

Using the random sampling points generated above, follow SOP #6 to locate these points in the field, and SOP #7 to establish and mark rectangular plots around these points.

Literature Cited

Camp, R. J., T. K. Pratt, C. Bailey, and D. Hu. 2011. Landbirds vital sign monitoring protocol – Pacific Island Network. Natural Resources Report NPS/PACN/NRR—2011/402. National Park Service, Fort Collins, Colorado.

Standard Operating Procedure (SOP) #6

Using GPS to Navigate to and Mark Waypoints

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Based on: Camp, R.J. 2006. Standard Operating Procedure (SOP) #4 "Using GPS to Navigate and Mark Waypoints," Version 1.00. *in* Camp, R. J., T. K. Pratt, C. Bailey, and D. Hu. 2011. Landbirds vital sign monitoring protocol – Pacific Island Network. Natural Resources Report NPS/PACN/NRR—2011/402. National Park Service, Fort Collins, Colorado.

Purpose

This SOP explains how to use an autonomous, non-differential Garmin GPS receiver and GPS transfer software for Pacific Island Network (PACN) focal terrestrial plant communities monitoring. This protocol may be used for any Garmin GPS that can average a waypoint and store tracklogs. The GPS transfer process uses DNRGarmin Version 5.1.1. and GIS software. DNRGarmin software can be updated for free via the State of Minnesota Department of Natural Resources website (MN-DNR 2010).

Pre-Field Preparation

Garmin GPS Preparation

1. Load fresh batteries and have extra, charged sets available. Extra batteries should be placed in a water tight "dry bag" or a re-sealable plastic bag.
2. Initialize and download a fresh almanac into a Garmin™ if more than one week has passed since last collection or if the GPS unit has moved more than a straight-line distance of 150 miles. Downloading the almanac takes roughly 20 minutes in open areas - away from buildings, canopy, and obstructions.

3. Delete old waypoints and tracks from memory (download and save data elsewhere if appropriate).
4. Turn off active tracklog. Set “Tracklog” to the preferred collection method (“Time” is recommended) and an appropriate logging rate for the data collection (“five seconds” is recommended for most walking collection, but keep in mind the total storage capacity of the GPS).
5. Ensure Simulator Mode is not ON when collecting data.
6. If necessary, transfer data (e.g. background maps) to the GPS unit using DNR Garmin software. See below for DNR Garmin instructions.
7. Set Time and Date on the GPS Unit (note that no PACN parks use daylight savings time, rather the entire PACN is always in ‘standard’ time).
8. Make sure that “Interface Protocol” is set to Garmin.
9. Make sure that WAAS is enabled.
10. Set the Coordinate System (UTM or LAT/LONG) and Datum to ensure compatibility with any written coordinates needed for navigation or mapping. Recommended settings are:
    - State of Hawai‘i: NAD83 UTM
    - Guam, Saipan, and American Samoa: WGS84 UTM
11. Set Heading to Magnetic or True, and make sure your compass is set the same way. Setting your GPS and compass inconsistently will make accurate navigation unnecessarily challenging at best.
12. If needed, use Trimble Planning Software (Trimble Navigation Limited 2010) to ensure best time of day for GPS data collection.
13. Prior to fieldwork, ensure the GPS has been placed in a “dry bag” with a desiccant pack.

GPS Transfer Software for DNR Garmin

1. Uninstall any previous versions of DNR Garmin
2. As of Spring 2006, download and install Version 5.1.1 to any computer that will receive GPS data from the Garmin. DNR Garmin can be downloaded from the State of Minnesota Department of Natural Resources (DNR) website (MN-DNR 2010).
3. In DNR Garmin, set projection to ensure compatibility with data stored in GIS.
    - Hawai‘i Island: ESRI (or EPSG) POSC code of 26905 (NAD83 UTM zone_5N).
    - Maui Island: ESRI (or EPSG) POSC code of 26904 (NAD83 UTM zone_4N).
    - Molokai Island: ESRI (or EPSG) POSC code of 26904 (NAD83 UTM zone_4N).
    - Oahu Island: ESRI (or EPSG) POSC code of 26904 (NAD83 UTM zone_4N).
    - Guam: ESRI (or EPSG) POSC code of 32602 (WGS 84 UTM zone_55N).
    - Saipan: ESRI (or EPSG) POSC code of 32602 (WGS 84 UTM zone_55N).
    - American Samoa: ESRI (or EPSG) POSC code of 32775 (WGS 84 UTM zone_2S).
4. In ESRI ArcMap®, ensure that Data Frames are set to the appropriate projection.
    - State of Hawai‘i: UTM, NAD83
    - Guam: UTM, WGS84

- Saipan: UTM, WGS84
- American Samoa: UTM, WGS84

GPS Field Procedures

Data Collection

Data collection is not anticipated to be a frequent task. Initially, actual data collection locations will need to be documented, relative to sample design specifications. Other data collection needs are not anticipated.

1. Hold GPS unit or antenna at or above your head. Use an external antenna to free hands.
2. Electronically store all data (waypoints and tracks). Write down positions for backup.
3. Note that a Garmin™ will collect data no matter what the GPS positioning quality is, so it will be necessary to monitor the GPS Satellite Page continuously for anomalies and accuracy. Collect only when "3D GPS" or "3D Differential" is shown. Do not collect data in 2D unless absolutely necessary. 2D Differential should not be used either.
4. Waypoints:
   - Collect all waypoints in "Averaged Position" mode if you are standing still. Obtain a minimum of 10 position points per site, or record for a maximum of 20 minutes at that site. Somewhere in between is enough to generate a quality position in most cases.
   - Name points for each monitoring plot following a consistent naming convention including site abbreviation (e.g., O = Olaa, ER = East Rift), plot number, and location within plot (e.g., S = start, E = end, C = center). For example the origin or start of plot 12 in Olaa wet forest is labeled in the field as "O12S."
   - Collect instantaneous waypoints only when moving.
5. TrackLogs:
   - Use "Stop when Full" or "Fill" Record Mode to prevent overwriting TrackLog points when Active TrackLog becomes full.
   - Begin collecting Active TrackLog once the desired destination is known and immediately begin moving when TrackLog begins collecting.
   - Stop Active TrackLog when stopped.
   - Always stop Active TrackLog when nearing the beginning point of a polygon area you want closed. A line between the last track point and the initial point will automatically be generated in order to close the polygon.
   - Always turn Active TrackLog to OFF when finished collecting. If TrackLogs are turned ON when you are in the office, ugly data will result.
   - NEVER 'store' or 'save' an active Tracklog unless you need to save space, rather choose to 'stop' an active TrackLog. Garmin III+ receivers remove the Active TrackLog, while modern Garmins merely make a copy of the Active TrackLog. In any case, saved tracklogs degrade original data, whereas a 'stopped' TrackLog retains data quality.

Back in the Office

1. Connect GPS to PC with cable and place GPS in Simulator Mode.
2. Check that TrackLog is OFF! Again, do not save Track!
3. Open DNR Garmin from the desktop (for ArcGIS™ users) or from within ArcView® by loading the extension.
4. Check Projection in DNR Garmin one more time. This will define the projection the GPS file will be stored in.
5. Download Waypoints and Tracks and save to Shapefile (if in ArcGIS™) or if saving a shapefile from the desktop DNR Garmin, save to projected shapefile. Use naming conventions as below.
   - The file-naming convention is to indicate the GPSModel, type of data (Waypoint or Tracks), projection and datum, and date (YYYYMMDD) separated by an underscore (_). For example, a set of waypoints collected with a Garmin™ GPS76c, using UTM and WGS84 as the projection and datum, on Christmas Day 2005, would be named "GPS76c_waypt_UTMWGS84_20051225."
   - If additional notes about GPS collection exist, such as data collected in '2D' mode; create a simple *text* file with an identical filename in the same location which contains this information, with a .text filename extension.
6. Delete all Waypoints and Tracks for the next mapping mission.
7. Turn off the GPS and disconnect cables, returning equipment to its proper storage location.
8. Recharge batteries if appropriate.

Options to Consider

- External antennae, with long cable and pole in order to extend the antennae above a thick vegetated canopy.
- An external beacon, such as the Thales Mobile Mapper Beacon®, for DGPS (Differential GPS). This will improve the accuracy of your GPS location.
- Averaging will improve your GPS locations, if and only if, the satellite geometry improves during point collection. Otherwise, averaging can sometimes result in a less accurate position.

Literature Cited

Minnesota Department of Natural Resources (MN-DNR). 2010. DNR Garmin Application. Available at http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html (accessed 14 Jun 2010).

Trimble Navigation Limited. 2010. Trimble Planning Software Download. Available at http://www.trimble.com/planningsoftware_ts.asp?Nav=Collection-8425 (accessed on 14 June 2010).

Standard Operating Procedure (SOP) #7

Establishing and Marking Permanent Vegetation Monitoring Plots

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP describes how to establish and mark plots for Pacific Island Network (PACN) focal terrestrial plant communities monitoring in the wet forest, subalpine shrubland, limestone forest, mangrove forest, and coastal community types. For the forest and shrubland communities vegetation is sampled in large 20 x 50 m plots and nested subplots (10 x 25 m and 2 x 50 m). In coastal communities, vegetation is sampled in smaller plots (10 x 20 m) and nested subplots (2 x 20 m) because these communities are smaller in size and linearly constrained. All sample plots are established using the same methodology with measuring tapes, but only the fixed plots are marked for future sampling.

A master equipment list for the entire Focal Terrestrial Community Monitoring Protocol is in SOP #1 “Before the Field Season.” The master equipment list should be updated as needed if this SOP is revised.

Establishing Monitoring Plots

Methods for establishing fixed panel and rotational panel plots are the same for all communities with two exceptions: (1) rejection criteria and (2) new plot selection criteria in cases where initial plots are rejected. A plot location should be rejected by the field leader if the site does not meet *a priori* community specific criteria. Details on rejection criteria for each community are provided below. If a plot location is rejected, the field leader attempts to establish the plot using a new random azimuth or in a new location. Procedures differ among community types, and within the wet forest community between fixed and rotational plots. For most communities (subalpine

shrubland, limestone forest, mangrove forest, and coastal) plot locations are randomly generated for each sampling frame using a simple random sampling technique (see SOP #5 "Generating Sampling Point Locations with GIS"). In the wet forest communities, where access, logistics, and concerns over nonnative species introductions constitute dominant issues, random points are generated along rotational and fixed transects only.

Plot locations are navigated to in the field using procedures described in SOP #6 "Using GPS to Navigate and Mark Waypoints." For the first cycle of sampling, Appendix A lists center points and random azimuths for all fixed and rotational plots. During subsequent sampling events, if random azimuths are not determined prior to sampling, a random azimuth (from 1 to 360 degrees) is chosen from Table 1. To use this random number table, start at an arbitrary point and read from left to right. The plot origin (Fig. 1) is then navigated to from the center point by measuring half the length of the plot (forest and shrub: 25 m; coastal: 10 m) in the opposite direction of the plot azimuth (i.e., the back azimuth). If the plot is accepted by the field leader, then the measuring tape is extended to complete the plot centerline (i.e., the line from the origin to the midpoint of the opposite side, also known as transect 2).

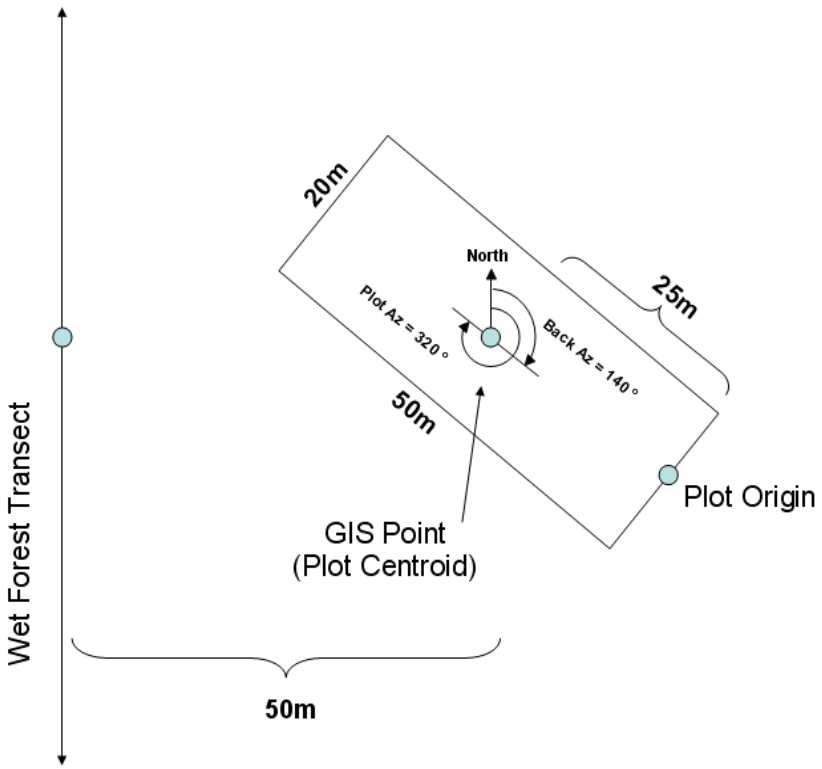

Figure 1. Example of the spatial relationship between the pre-selected GIS point, plot origin, plot azimuth and back azimuth in the context of the wet forest community. Note that the GIS point is 50 m from the transect in a direction perpendicular to the transect line. In this case, the field crew obtains a random plot azimuth of 320º (from true north) from the random number table. To reach the proposed plot origin from the plot centroid, they travel along a bearing of 140º (back azimuth of 320º) for 25 m. If the plot origin is acceptable, then the field team will establish the plot from this origin using the azimuth of 320º as the plot azimuth. The resulting

plot centerline will connect the plot origin, the GIS point (or centroid), and the center of the opposite edge.

Table 1. Random number table for selecting a random azimuth from 1 to 360 degrees.

Row/Col	1	2	3	4	5	6	7	8	9	10
1	162	278	348	343	275	44	234	99	238	48
2	41	81	119	302	207	158	159	164	41	3
3	8	135	145	222	31	130	346	101	107	140
4	69	88	306	19	225	26	216	85	299	24
5	72	77	158	306	123	15	167	149	71	91
6	89	307	71	233	170	50	55	108	309	322
7	347	224	354	65	89	217	65	181	315	55
8	255	345	69	176	231	19	130	96	289	2
9	315	96	177	261	168	167	136	274	197	125
10	156	173	184	31	134	252	105	176	349	161
11	264	156	191	228	115	300	318	180	177	90
12	249	24	130	196	113	226	331	52	197	249
13	79	57	359	190	28	66	20	128	42	229
14	276	207	293	69	250	37	272	233	222	225
15	72	91	177	66	171	350	339	347	124	331
16	346	255	103	234	230	245	77	349	20	42
17	188	93	136	92	309	316	188	82	2	188
18	119	20	239	252	151	303	278	284	313	273
19	266	227	184	170	222	118	317	231	276	155
20	279	217	117	151	164	61	239	178	123	192
21	175	88	265	85	48	87	256	312	101	268
22	309	201	82	292	86	267	230	252	300	333
23	249	95	56	265	63	30	177	114	255	211
24	238	103	178	121	36	324	93	147	232	235
25	69	316	11	207	288	231	232	165	254	191
26	204	109	340	188	5	237	299	336	239	356
27	162	204	85	360	265	226	121	270	42	51
28	277	158	341	256	50	179	290	338	62	24
29	240	327	286	338	164	93	188	258	208	284
30	263	311	225	216	27	142	162	220	101	144
31	310	113	13	190	358	136	79	338	65	58
32	188	257	313	266	325	330	238	51	50	27
33	1	313	213	100	257	77	66	2	92	62
34	315	165	255	231	238	282	332	157	59	232
35	328	301	264	341	32	9	313	218	139	283
36	122	340	152	113	290	172	40	53	123	116
37	68	90	23	288	85	321	19	235	9	289
38	320	343	340	6	14	129	334	66	213	139
39	297	115	134	189	256	53	18	139	191	247
40	195	197	78	143	328	129	76	241	85	55
41	226	55	115	59	113	52	155	57	340	105
42	134	166	321	232	302	267	329	76	128	15
43	300	289	129	320	125	120	191	355	106	217
44	159	244	11	64	19	147	345	130	207	245
45	249	212	56	288	250	345	84	53	53	127
46	83	88	223	288	136	278	205	222	233	90
47	196	301	196	250	63	5	179	271	352	167
48	234	318	15	63	132	341	69	188	22	138
49	226	100	58	219	7	294	270	330	52	199
50	225	60	243	271	266	11	287	56	99	360

Four field crew members are recommended to install forest and shrubland plots and two field crew members are recommended to install plots in coastal communities. To establish each monitoring plot at least two field staff will have declinated compasses. It is important to walk to the side of each transect while establishing the plot to minimize trampling since vegetation cover data are collected along the centerline and each long edge of the rectangular plot. The centerline is laid from the origin along the plot azimuth. Three tapes are installed perpendicular to the centerline at the plot origin, center, and end point (forest and shrub: 20 m; coastal: 10 m). These three short tapes are oriented in the same direction from left to right when standing at the plot origin facing the plot. The rectangle is completed by installing two edge tapes parallel to the centerline and oriented in the same direction (i.e. the zero ends of each tape are near the zero end of the centerline tape). It is necessary to stake the end of each measuring tape in order to prevent slack and subsequent inaccuracies in data collection. Stakes and markers are placed 0.1 m beyond the endpoint of the centerline and two parallel edge lines (e.g., at 50.1 m instead of 50.0 m for a forest or shrubland plot) because understory cover data are collected at these end points. Stake offset distance is recorded on the plot data form, as this distance may vary if rocks are encountered at the preferred marker site (50.1 m). The tapes measure slope distance rather than horizontal distance when the plot encompasses variable slopes (e.g., ravine) because this represents the ground area of the site more accurately (NPS 2003). All tapes should be laid as close to the ground as practical (i.e., below vegetation).

Rejection Criteria

For the wet forest, subalpine shrubland, limestone forest, and mangrove forest communities, plots are rejected if slopes are greater than 100% (45º) or plots are within 20 m of streams (wider than 1 m), roads, trails, fencelines, coastlines, or park boundaries. Additionally, plots may be rejected if surface lava flows have covered the area recently. As described in SOP #5 many of these rejected areas will be filtered out using GIS, but because maps do not always reflect ground conditions, the field leader may need to reject plots that are unsafe (e.g. cliff face).

For the coastal community, the field leader should reject plot establishment if the plot boundaries occur within 5 m of any of the following features: airport runways, coastal roads, high tide line, major fences, cliff faces, large archeological features such as house sites, or any other feature that may cause the plot to be unrepresentative (eg. recent surface lava flows or inclusion of human disturbance or structures), unsafe, or potentially damaging to cultural resources. For the coastal community at KAHO, the narrow and convoluted sampling frame requires relaxed buffer requirements between adjacent plots and the sampling frame boundaries (see SOP #5 “Generating Sampling Point Locations with GIS").

Replacement Plot Procedures When a Plot is Rejected

For all community types, if a pre-selected plot location is rejected the field crew attempts to establish a new plot in a series of other possible locations as described below. The procedures for establishing new plot locations differ among communities and within the wet forest community between fixed and rotational plots. Differences in replacement plot procedures are due to differences in random sampling techniques among communities, and within the wet forest community due to differences in “use” between fixed and random transects.

The following steps provide details for selecting a plot within each community. If all six potential plot locations are rejected the field leader selects and navigates to the next alternate plot location.

Wet forest:

Fixed plots:

1. Pre-selected plot location (offset 50 m from transect) with original random azimuth.
2. Pre-selected plot location (offset 50 m from transect) with alternate random azimuth and same plot centroid.
3. Opposite side of transect (offset 50 m from transect and 100 m from original pre-selected plot location) with original azimuth.
4. Opposite side of transect (offset 50 m from transect and 100 m from original pre-selected plot location) with alternate azimuth.
5. Opposite side of transect (offset 100 m from transect and 150 m from original pre-selected plot location) with original azimuth.
6. Opposite side of transect (offset 100 m from transect and 150 m from original pre-selected plot location) with alternate azimuth.

Rotational plots:

1. Pre-selected plot location (no offset) with original random azimuth.
2. Pre-selected plot location (no offset) with alternate random azimuth and same plot centroid.
3. Random side of transect (offset 50 m from transect) with original azimuth.
4. Same random side of transect (offset 50 m from transect) with alternate azimuth.
5. Opposite side of transect (offset 50 m from transect) with original azimuth.
6. Same opposite side of transect (offset 50 m from transect) with alternate azimuth.

Subalpine shrubland, limestone forest, mangrove forest and coastal communities:

Fixed and rotational plots:

1. Pre-selected plot location (no offset) with original random azimuth.
2. Pre-selected plot location (no offset) with alternate random azimuth and same plot centroid.
3. 50 m in a random direction with original azimuth.
4. 50 m in the same random direction with alternate azimuth.
5. 50 m in a new random direction from the original pre-selected plot location with original azimuth.
6. 50 m in the same new random direction from the original pre-selected plot location with alternate azimuth.

Plot Layout

For the majority of focal plant communities (wet forest, subalpine shrubland, limestone forest, and mangrove forest) vegetation is measured within 20 x 50 m rectangular plots (fig. 2). Three 50 m tapes (centerline and perimeter) are laid 10 m apart in the same direction with their zero ends closest to the origin. When standing at the origin, the 0 m ends of three 20 m tapes (center

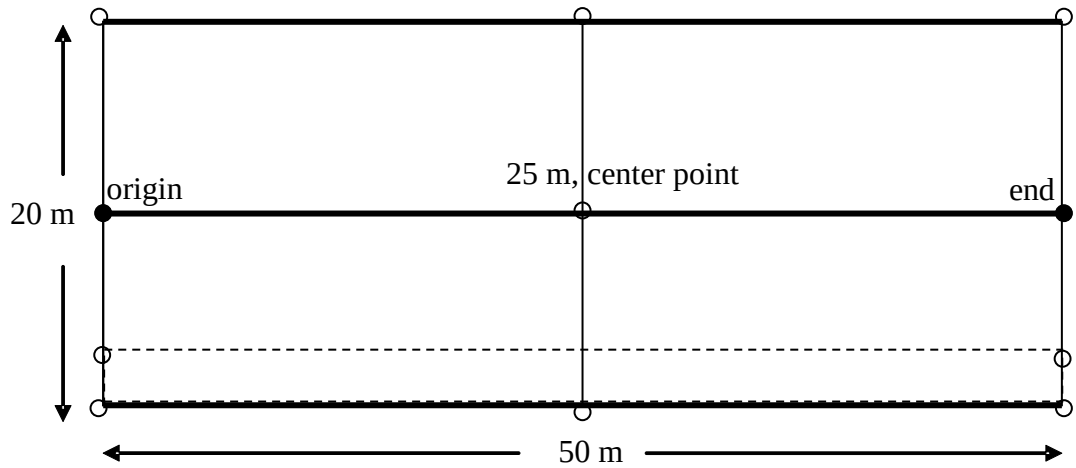

Figure 2. Plot used to quantify vegetation composition and structure in wet forest, subalpine shrubland, limestone forest, and mangrove forest communities. Plot installed using three 50 m tapes and three 20 m tapes to define the plot boundaries and centerlines. For fixed plots, stainless steel threaded rods (covered with PVC pipe) at the origin and 0.5 m beyond the end of the centerline are depicted by solid circles. The plot and 10 x 25 m subplot corners are marked with blue pin flags and flagging. Dashed lines indicate the 2 x 50 m subplot to be read using a 2 m pole; therefore tapes are not needed. Rotational plots utilize tapes and temporary pin flags only.

and edges) are laid to the left of and perpendicular to the centerline. No additional tapes are needed to establish the 10 x 25 m subplot in the right corner closest to the origin. A 2 x 50 m subplot overlaps the 10 x 25 m subplot and runs along the inside of the right long edge of the large plot, but a tape is not laid. Instead, a 2 m pole is used to walk along this subplot. These additional plot divisions increase sampling efficiency by enabling trees of different size classes to be sampled in different sized plots.

For the coastal communities, vegetation is measured within 10 x 20 m rectangular plots (fig. 3). Six tapes, three 20 m and three 10 m, are required for this plot layout. The 0 m end of the 10 m transects should be placed on TR1. Although two 2 x 20 m subplots are nested within the larger plot along the inside of the two long edges, tapes are not laid. Instead, a 2 m pole is used to walk along these plots.

Marking Permanent Monitoring Plots

The permanent plot boundaries and dissecting transects are defined with stainless steel threaded rods covered with PVC pipes, pin flags and flagging (fig. 2 and fig. 3). The 0.01 m x 0.5 m stainless steel rods are buried at the origin and 0.1 m beyond the end point of the centerline, with at least 0.3 m of the rod above ground. In rocky substrates, setting the rod may require a 5 lb sledgehammer and a fast-setting two-part epoxy (e.g., Power-Fast™) to keep the marker vertical. White PVC pipe (inner diameter of 0.01 m) is slid over the stainless steel threaded rod and secured with epoxy to increase marker visibility. Labeled brass and aluminum tags are attached to the rods with the inventory and monitoring vegetation identifier (I&MV), “FTPCP” (to

distinguish which protocol is being implemented) and plot number, year and month of plot installation, appropriate transect and meter mark (e.g., 0 m, 20 m, 50 m), and plot azimuth (fig.

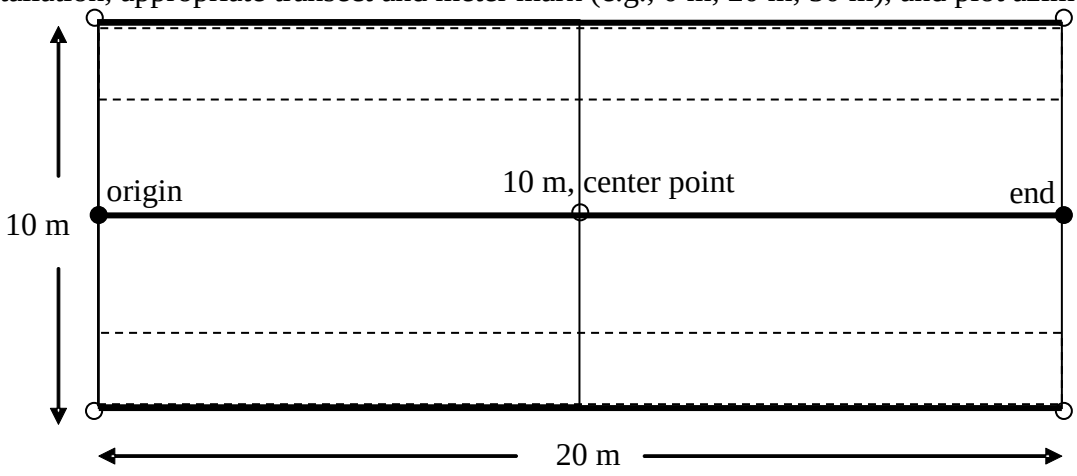

Figure 3. Coastal community plot used to quantify vegetation composition and structure. Plot installed using three 20 m tapes and three perpendicular 10 m tapes. For fixed plots, stainless steel threaded rods (covered with PVC pipe) at the origin and 0.5 m beyond the end of the centerline are depicted by solid circles. The four plot corners and edge midpoints (10 m) are marked with blue pin flags and flagging. Dashed lines indicate the 2 x 20 m subplots read using a 2 m PVC pole; therefore tapes are not needed. Rotational plots utilize tapes and temporary pin flags only.

I&MV	Plot 7
FTPCP	TR 1
200909	Start 0m 250°

Figure 4. Label example for marking centerline starts and ends include: Inventory and Monitoring vegetation identifier and plot number, year and month of plot installation, appropriate meter mark, and plot azimuth.

4). The four corners of the plot are marked with blue pin flags and arctic blue flagging tied to a visible nearby tree or shrub.

Note that some areas (e.g., KAHO coastal strand community) may have sensitive archaeological features present within the sampling frame. It is the responsibility of the project lead to protect these resources and ensure compliance with the National Historic Preservation Act. Burying of stainless steel rods may be prohibited under some circumstances, and field crew workers should do their best at all times to avoid negative impacts to any known or suspected cultural resource sites. The project lead will consult with the local park staff regarding cultural resources issues prior to monitoring. If detailed archeological surveys exist, then culturally sensitive sites can be

buffered and excluded from the sampling frame to ensure that no sampling plots coincide with important cultural resources (refer to SOP #5 “Generating Sampling Point Locations with GIS”).

Photographing the Plot

Once all tapes are installed, a minimum of eleven photographs are taken in each fixed plot: four from the midpoints of each side to the plot center point, four from the plot corners looking down

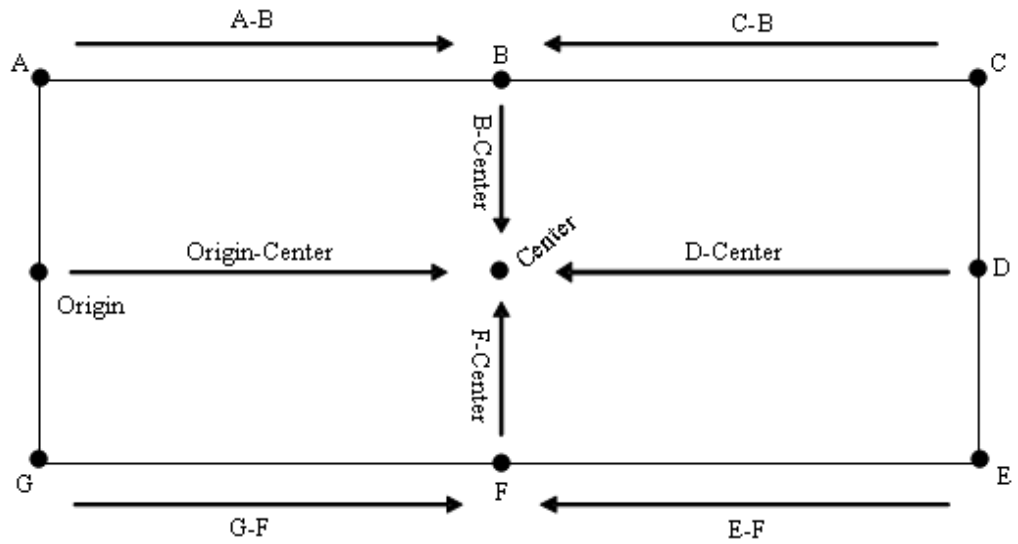

Figure 5. Schematic of the plot showing the eight horizontal photo points for fixed plots. Each arrow represents one photo and is labeled according the location of the photographer and the location of the subject (or photo target). For example, arrow “A-B” represents a photo taken from point A in the direction of point B. For rotational plots, only 3 photos need to be taken: Origin-Center, D-Center, and Canopy.

the long edge of each plot, one of the canopy taken from the plot center point, and one photo each for the centerline posts (fig. 5). Photographs of random plots are taken from the ends of the centerline toward the center and of the canopy at plot center. For only the center canopy photo, the photographer may move tree fern fronds if they are blocking the view of the tree canopy. Photo points are patterned after the photo points in the NPS Fire Monitoring Handbook (2003). Additional photographs capturing the community overall, staff while working, and disturbance should be taken as opportunity permits.

Photos provide qualitative information that can aide in communicating patterns of vegetation change to a wide audience. Plot photographs are taken prior to sampling vegetation. If the camera used does not offer digital memos or labeling, a clipboard with the plot identification code and date is placed in the lower right hand corner of each photograph. All photos should be taken with the camera at a height of 1.4 m. To the extent possible, the same type of camera and lens is used each time the plot is photographed. Permanent plots are revisited during the same time of day and phenological season. When revisiting permanent plots, field members should bring laminated copies of previous photos to ensure that all nonstandard photographs (those beyond the required eleven photographs) can be duplicated. All photographs are recorded on the Photographic Record data form (Appendix E: “Data Forms for Recording Field Data”).

Mapping Permanent Plot Locations

Field maps are created or updated for all fixed plots during each sampling event to ensure future field crews are able to locate the site. GPS coordinates of the plot as well as access transects and reference points are recorded on the Plot Location data form (Appendix E: "Data Forms for Recording Field Data"). In addition, the field leader constructs a hand drawn map complete with distances and direction from reference points (e.g., road sign, large rock outcrop) to the permanent markers at each end of TR2 (figs. 2 and 3). It is essential that clear text be included for locating and installing plots so that the plot can be reread even if some markers are missing. Lastly, after a fixed plot is installed the field leader and the GIS specialist create a map of the plot using GIS software and print out a copy complete with elevation and reference feature information. On return visits to fixed plots, the field crew updates previous maps, GPS points, descriptions and reference information as needed.

Literature cited

National Park Service (NPS). 2003. Fire Monitoring Handbook. Fire Management Program Center, National Interagency Fire Center, Boise, ID. Available at http://www.nps.gov/fire/download/fir_eco_FEMHandbook2003.pdf (accessed 22 Sept 2010).

Standard Operating Procedure (SOP) #8

Conducting Community Vegetation Surveys

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP describes how to collect Pacific Island Network (PACN) focal terrestrial plant communities monitoring data in order to quantify plant composition and structure. Data on different plant life forms are collected in different sized plots to maximize the efficiency of field sampling. A master equipment list for the entire Focal Terrestrial Plant Communities Monitoring Protocol can be found in SOP #1 "Before the Field Season." The master equipment list should be updated as needed if this SOP is revised.

Definitions

Coarse Woody Debris (CWD): Down dead wood consisting of fallen trees, large dead branches and large fragments of wood found on the ground or elevated off the ground up to 45°, but no longer supported by roots. CWD does not include live material, standing dead trees (> 45°), or the part of the bole below the root collar.

Diameter at Breast Height (DBH): The diameter of a tree 1.4 m up the trunk from the root crown. Specific instructions regarding this subject can be found under the Measuring Woody Species Density section of this SOP.

Frond Height: Vertical measurement from the ground to the top of a tree fern's canopy. This measurement does not include horizontal stem length because it is intended to provide information on where a tree fern stands within the forest's vertical profile as opposed to the age class as measured by stem length.

Root Collar: The location above the root crown where the base of the tree is no longer splayed out.

Root Crown: The location where the plant has rooted into the ground.

Rooting Height: The vertical distance between the ground and the point at which a plant has rooted (root crown). This measurement is used to investigate epiphytic stratification.

Surface substrate: The top layer of the substrate or the first ground layer the pole hits when sampling cover (e.g., litter as opposed to rock if leaves are overlaying rocks).

Tree Ferns: Ferns which develop an elongated trunk including species in the *Cibotium*, *Sadleria*, and *Sphaeropteris* genera.

Tree Fern Stem or Trunk Length: Stem length provides an estimate of tree fern age class and biomass and is measured from where the rhizome ("trunk") emerges from the ground to the terminal end (where the fiddleheads originate). The stem length measurement contours to the shape of the trunk.

Vigor: A rating of plant vegetative health. Table 1 displays how class ratings are delineated.

Woody Species: All species with ligneous tissue growth on the main stem of the plant.

Woody Stem Height: Measurement of an individual's stem from where it is rooted to the height or length at which the plant branches or displays caespitose growth. This measurement will apply to both standing and fallen woody species.

Table 1. Plant vigor classes and descriptions adapted from Jacobi et al. (1983).

Vigor Class	Description
V1	Healthy crown and foliage; >90% of branches with leaves
V2	Crown partially defoliated; 10 - 50 % of branches dead or without leaves
V3	Unhealthy crown; >50% of branches dead or without live leaves
V4	Plant recently dead; many fine branches remain
V5	Old dead; few fine branches remain and some bark loss

Sampling Plot Design and Vegetation Parameters

Wet forest, subalpine shrubland, limestone forest, and mangrove forest communities
All plots established in wet forest, subalpine shrubland, limestone forest, and mangrove forest communities have 20 x 50 m dimensions (fig. 1). Species presence and large tree and large snag density are recorded within the entire plot. Understory vegetation cover and surface substrate type are read along three transects: two of which make up the long sides of the plot, and one

centerline that runs parallel to the long sides. Within each 20 x 50 m plot, lie a nested 10 x 25 m subplot and 2 x 50 m subplot. Small tree, small snag, and large tree fern densities are read within

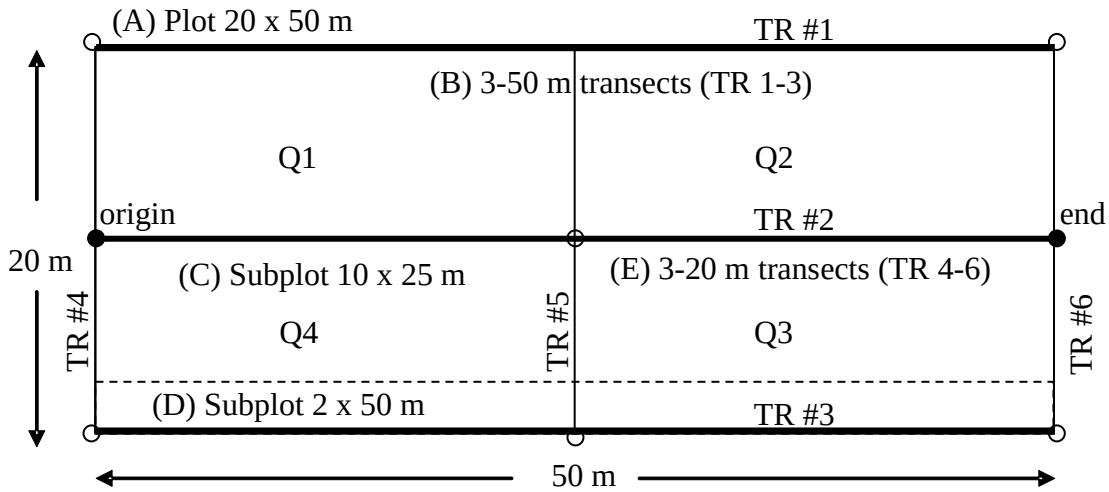

Figure 1. Wet forest, subalpine shrubland, limestone forest, and mangrove forest sampling plot layout used to quantify vegetation composition and structure. (A) Species presence and large tree species density are read in the 20 x 50 m plot. (B) Plant species cover is recorded in two height layers (<1 m and 1-2 m) every 0.5 m along three 50 m transects. When standing at the origin facing the plot, TR 1 (points 1-100) is located to the left forming the outer edges of quadrants 1 and 2 (Q1, Q2), TR 2 (points 101-200) in the center, and TR 3 (points 201-300) to the right forming the outer edges of quadrants 3 and 4 (Q3, Q4). (C) Small tree and large tree fern density are measured in the 10 x 25 m subplot (quadrant 4) which lies between TRs 2 and 3 from the 0 m mark to the 25 m mark. (D) Tree seedling and small tree fern densities are recorded in the 2 x 50 m subplot which is read along the inside of Transect 3 from the 0 m mark to the 50 m mark including portions of quadrants 3 and 4. (E) Dead downed wood and tree fern logs (≥7.6 cm) are quantified along the 50 m centerline (TR 2) and two 20 m end lines (TR 4 and TR 6).

4 (10 x 25 m subplot) while live and dead tree seedling, small tree fern, and shrub density are read within the 2 x 50 m subplot. Large coarse woody debris (CWD, ≥7.6 cm) are counted along the center 50 m transect and two outer 20 m transects using the planar intercept technique. Large dead tree ferns (≥7.6 cm) with no distinguishable terminal end (i.e., where the fiddleheads originate) are recorded with CWD.

Coastal Communities

All plots established in the coastal community measure 10 x 20 m (fig. 2). Species presence and large tree and snag density are recorded within the entire plot. Understory vegetation cover and surface substrate are read along three transects: two of which make up the long sides of the plot, and one centerline that runs parallel to the long sides. Within each 10 x 20 m plot, lie two nested 2 x 20 m subplots. Live and dead small tree, tree seedling, and shrub densities are read within both 2 x 20 m subplots. Large CWD (≥7.6 cm) are counted along the 20 m centerline and two 10 m transects using the planar intercept technique.

Documenting Species Presence

Species presence data are recorded in each sample plot within the wet forest, subalpine shrubland, limestone forest, mangrove forest, and coastal communities. Once plot installation is complete, the field crew surveys the entire plot. A thorough survey can be accomplished by walking through the plot at least three times within a reasonable amount of time (i.e., 30 minutes or less for a four-person field team). Although the plot lengths will be marked beyond 50 m

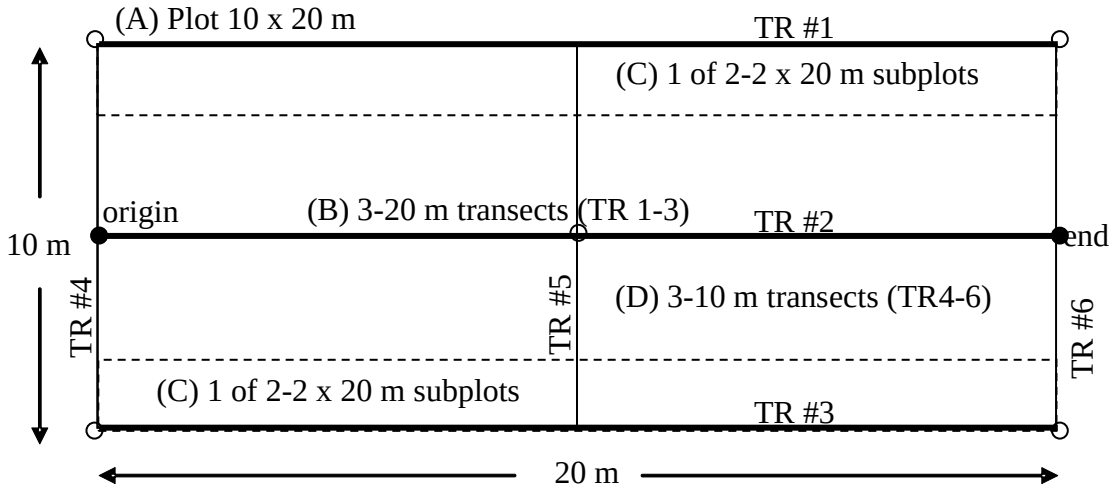

Figure 2. Coastal communities sampling plot layout used to quantify vegetation composition and structure. (A) Species presence and large tree density will be recorded in the entire 10 x 20 m plot. (B) Plant species cover will be recorded in two height layers (<1 m and 1-2 m) every 0.2 m along three 20 m transects. When standing at the origin facing the plot, TR 1 (points 1-100) is located to the left, TR 2 (points 101-200) in the center, and TR 3 (points 201-300) to the right. (C) Small tree, tree seedling, and shrub densities are read within two 2 x 20 m subplots which lie along the inside lengths of TRs 1 and 3 from 0 m to 20 m. (D) Dead downed wood (≥7.6 cm) is quantified along the 20 m centerline (TR 2) and the two 10 m end lines (TR 4 and TR 6).

(forest) or 20 m (coastal) to prevent reading cover on permanent markers, the field crew will record species presence as those species rooted within the actual plot boundaries (forest and shrub: 20 x 50 m; coastal: 10 x 20 m) and not to the offset markers. The field crew constructs a checklist of all species present and records whether the plants show any sign of reproduction, new or old, using the Species Presence data form (Appendix E: "Data Forms for Recording Field Data"). Any additional species found within the plot during this sampling event are added to the Species Presence data form. Data are reported as species richness or the number of species per plot and are used for examining the frequency of occurrence of a species across a community. Species presence and richness do not provide any information on species abundance.

Conducting Vegetation Cover Surveys

Understory plant cover data are recorded in each sample plot along three transects using the pole intercept method, which is a variation on the point-intercept method (Mueller-Dombois and Ellenberg 1974, Elzinga et al. 2001). In the wet forest, subalpine shrubland, limestone forest and mangrove forest communities, transects are 50 m long, and point data are recorded every 0.5 m along each transect starting at 0.5 m and ending at 50 m, totaling 100 points per transect and 300 points per plot (fig. 1). In the coastal community, transects are 20 m long and point data are

recorded every 0.2 m along each transect starting at 0.2 m and ending at 20 m, totaling 100 points per transect and 300 points per plot (fig. 2). The left long edge of the plot rectangle when standing at the origin includes points 1 – 100. The centerline includes points 101 – 200, and the right long edge of the rectangle includes points 201 – 300.

At each point along the transect, a 2 m long pole (8.5 mm or 1/3 inch diameter) is held plumb to the ground on the right hand side of the tape. On a slope, a plumb pole is not perpendicular to the surface. If the pole hits a large tree fern or large tree trunk with the bottom ≥50 cm off the ground, then the line of the pole is extended to the ground, and cover species and substrate are recorded from the ground up, essentially removing the gap. If the gap below the tree fern or tree trunk is <50 cm, then the line of the pole is not extended to the ground, and cover species and surface substrate will be read from on top of the individual.

All plant species in contact with any point on the pole are recorded for two defined layers, <1 m and 1-2 m (fig. 3). For each hit, the upper-most surface substrate type (e.g., rock, sand, soil, litter, tree trunk, tree fern trunk, bryophytes, etc) and all plant species touching the pole are listed by layer. In each level a species is recorded only once even if multiple individuals of the same species or multiple sections of the same plant are in contact with the pole. For example, if species A is only in contact with the pole below 1 m it is recorded as one hit in the lower strata. If species B is in contact with the pole both below 1 m and between 1 m and 2 m, it is recorded as one hit for each stratum. The maximum number of hits for any particular species within one stratum of a sample plot is 300, as there are a total of 300 points. Dead plant parts in contact with the pole are recorded as live if they are attached to live plants and recorded as dead if the entire

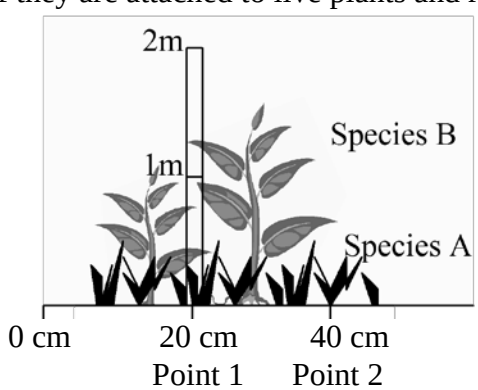

Figure 3. Plant cover recorded in a coastal plot in two strata (<1 m and 1-2 m) along each transect. Species A is only in contact with the pole below 1 m and is recorded as one hit for Point 1 (20 cm) in the lower strata. Species B is in contact with the pole in both strata at Point 1 and is recorded as one hit in each strata.

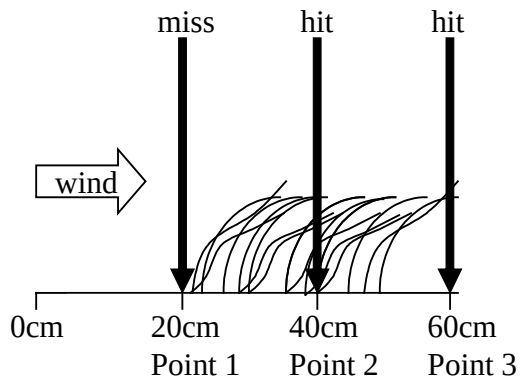

Figure 4. Regular winds such as the trade winds in the coastal community frequently result in angled vegetation structure. Plant species are recorded as a hit if they are in contact with the pole (e.g., Points 2 and 3), even if the contact is the result of wind direction. No plant species are recorded as a hit at Point 1.

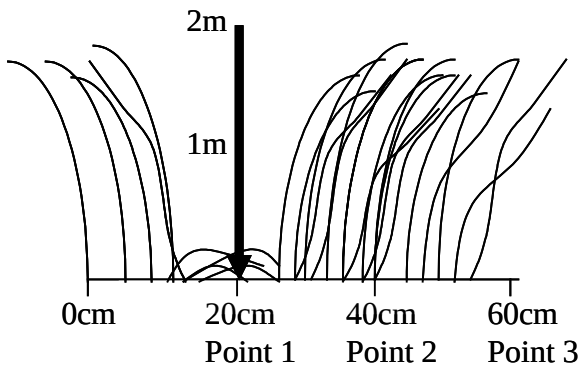

Figure 5. Cover is recreated when the absence of a plant hit is clearly due to trampling during the current sampling event. For example, if the tall grass along a transect was obviously trampled at Point 1 during plot installation then cover is recreated at this point and the grass is recorded as a hit in both strata (<1 m and 1-2 m).

plant is dead and remains where it originally rooted. In windy areas, particularly the coastal community, species that are in contact with the pole should be recorded as a hit even if the contact is the result of wind direction and speed because this represents average conditions at the site (fig. 4). Alternatively, if species are in contact or not in contact with the pole due to trampling effects from the current sampling period then cover should be recreated (e.g., lift up matted grass and count as a hit) as in Figure 5.

For quality control and measurement error assessment, 20% of the plots are re-read for understory percent cover data (applies to first sampling year only). If measurement error appears insignificant during the first year of sampling at each site, then the project lead may choose to discontinue this quality control measure in future years.

Conducting Woody Vegetation and Tree Fern Density Counts

Density counts are conducted for all live and standing dead woody plants and tree fern species at least 0.5 m tall or long if prostrate. Woody species and tree ferns are separated into size categories (Large Trees, Small Trees, Tree Seedlings, Large Tree Ferns, Small Tree Ferns, and Shrubs) and sampled in different sized plots and subplots among communities to increase field sampling efficiency (fig. 1 and fig. 2). Trees are divided among size classes based on diameter at breast height (DBH) measured at 1.4 m above the root collar on the uphill side of the tree. Large Trees have a DBH greater than or equal to 10 cm. Small Trees have a measureable DBH of at least 1 cm and less than 10 cm. Tree Seedlings are defined as individuals with a DBH less than 1 cm or no DBH and a height or length of at least 0.5 m; tree seedlings below this height/ length are not counted. Large Tree Ferns have a stem diameter greater than or equal to 10 cm, while Small Tree Ferns have a stem diameter less than 10 cm and a height (including stem and frond canopy) of at least 0.5 m; tree ferns below this height are not counted. To be included in a plot or subplot, woody species must have more than 50% of their bole (or stem mass) rooted within the boundary. Tree ferns must have more than 50% of their terminal end (i.e. where the fiddleheads originate) within the boundary.

There are cases where measuring DBH is not as straight forward as measuring the diameter at 1.4 m on the uphill side of the tree. If buttressed roots are present the diameter should be measured 1.4 m above the root crown along the stem. Measurements will also differ for forked trees depending on where the fork originates. In order to qualify as a fork, the stem in question must be at least one third the size of the main stem or at least 10 cm. For those individuals that are visibly forked below 1.4 m, each stem that is at least one third the size of the main stem will be measured and recorded as boles from the same individual. If there is doubt as to the connection between stems, count each stem as an individual. If irregularities (e.g., swellings, depressions, branches) occur at 1.4 m, the diameter immediately above or below if necessary the irregularity where it does not affect normal stem form should be measured and the height from the ground where the measurement was taken recorded in the comments. If a tree is missing wood or bark, DBH should not be reconstructed; instead, DBH will be measured as is unless the missing bark or wood is a localized anomaly in which case DBH should be measured immediately above as previously described and noted on the recording sheet. The diameter of live horizontal trees (i.e., wind thrown) will be measured 1.4 m from the root collar along the length of the stem. If a fallen, live tree has tree-form branches growing vertically from the main bole, and the main bole is above the litter/duff layer, use the rules specified for a forked tree. Alternatively, if the main bole is in the duff/litter layer treat each vertical branch as a separate tree.

Wet Forest, Limestone Forest, and Mangrove Forest Communities

Density count data collected in each forest community differ among plant life form and size class (table 2). Detailed descriptions of quantitative and qualitative data collected for each plant life form size class are provided below.

Table 2. Data to be collected in wet forest, limestone forest, and mangrove forest according to vegetation sample group.

Plot Size (m)	Sample Group	Tally Count	Living Status	Diam.	No. of Boles	Vigor Class	Flr/ Frt	Rooting Height Class	Foliar Height Class	Stem Length
20 x 50	Large Trees (≥10 cm DBH)	X	X	X	X	X	X	X		
10 x 25	Large Tree Ferns (≥10 cm Diam.)	X	X	X				X	X	X
10 x 25	Small Trees (1<10 cm DBH)	X	X					X		
2 x 50	Small Tree Ferns (≥0.5 m ht. & <10 cm Diam.)	X	X					X	X	
2 x 50	Tree Seedlings (0<1 cm DBH, ≥0.5 m length)	X	X					X	X	
2 x 50	Shrubs (≥0.5 m length)	X	X					X	X	

Table 3. Rooting height classes and descriptions for woody species and tree ferns. Rooting height indicates if an individual is epiphytic and is recorded as the measured distance (height) class between the root crown and the ground.

Class	Height	Type	Description
R1	ground	Terrestrial	Rooted in the ground
R2	<0.5 m	Low Epiphytes	Rooted on a low log or tree
R3	0.5<2 m	Medium Epiphytes (dead)	Rooted on dead wood or tree ferns
R4	0.5<2 m	Medium Epiphytes (live)	Rooted on live wood or tree ferns
R5	≥2 m	High Epiphytes	Rooted greater than 2 m above the surface

Table 4. Frond height classes for large tree ferns and stem height/ length classes or small tree ferns, shrubs, and seedlings. Frond height is an indication of where the individual is within the forest vertical profile and is measured as the vertical distance from the ground to an individual's canopy or the tallest live piece (not necessarily following the stem). Alternatively, stem height/ length class does follow the stem and is an indication of the individual's age.

Class	Frond Height	Class	Stem Height/Length
F1	0.5<1 m	S1	0.5<1 m
F2	1<2 m	S2	1<2 m
F3	2<5 m	S3	2<5 m
F4	≥5 m	S4	≥5 m

Large Trees: Live and dead Large Trees (DBH ≥10 cm) are counted within the entire 20 x 50 m plot and recorded by quadrant number. Quantitative measures recorded for each individual include: species, living status (live or dead), DBH, number of boles, vigor class (table 1), reproductive status, and rooting height class (table 3). Additionally, for all dead Large Trees, quadrant height is recorded. The number of boles corresponds to how many stems have recorded DBHs for an individual tree. Vigor is recorded as one of five classes ranging from healthy live to old dead based on criteria defined in Table 1. Dead trees or snags and stumps are tallied including diameter and height as long as they are standing (even if leaning) and have an intact bole that is at least 0.5 m tall. Reproductive status is recorded for all live individuals with any evidence of flowering or fruiting. Rooting height indicates if an individual is epiphytic and is recorded as the measured distance class (0, >0 – <0.5 m, 0.5 m – <2 m, or ≥2 m) between the root crown and the ground (table 3). Individuals with stilt roots and root crowns between 0.5 and 2 m off the ground are recorded as R3 (rooted on dead wood or tree ferns) with a comment that the log is decomposed.

In areas that have burned, additional measurements are taken on Large Trees. Sprouting at the base or along the trunk indicates the tree is still alive and should be taken into account when assigning vigor class. When root sprouts are present, record 1) height of the tallest sprout, 2) width of the entire sprout complex at the broadest point, and 3) width perpendicular to the axis of the broadest point. These three measurements allow volume to be calculated for the root sprouts. Canopy height is recorded within each plot by measuring the height of five canopy trees per plot that represent the average canopy height within the plot; these are selected subjectively. The height of up to five scattered emergent trees if present, above the average canopy are also measured. Height is measured to the nearest tenth of a meter from the ground or a measured distance up the tree that is visible to the top of the tree using a clinometers and meter tapes (SOP #9 “Using a Clinometer to Measure Height and Slope”). For each tree, living status, DBH, and quadrant number are also recorded.

Large Tree Ferns: Live and dead Large Tree Ferns (stem diameter ≥10 cm) in the wet forest community are counted within the 10 x 25 m nested subplot (quadrant 4). Quantitative measures recorded for each individual include: species, living status (live or dead), stem diameter, rooting height (table 3), frond height class (table 4), and stem length. Tree ferns are recorded as live if any portion of the individual is alive including fiddleheads. To be counted as dead, the terminal end of the Large Tree Fern must be distinguishable and dead. The measurement for diameter is taken 0.2 m below the terminal end and is to 0.1 cm. If the stem width is not more or less uniform, then a second diameter measurement is taken at the base of the trunk, and the two measurements are averaged. Rooting height is recorded as the measured distance class (0, >0 – <0.5 m, 0.5 m – <2 m, or ≥2 m) between the base of the individual and the ground (table 3). In order to characterize the role of tree ferns within the community profile, frond height class and stem length are also recorded. Frond height class (0.5 – <1 m, 1 – <2 m, 2 – <5 m, ≥5 m) indicates where an individual is within the forest vertical profile (table 4). For epiphytic individuals, frond height is the vertical distance between the base of the stem and the highest live frond. Stem length provides an estimate of tree fern age and biomass and is measured from where the rhizome emerges from the ground to the terminal end. The stem length measurement is recorded in meters and should contour the shape of the trunk and round to the nearest tenth of a meter.

Small Trees: Live and dead Small Trees and exceptionally large shrubs with a tree-like growth form (DBH 1<10 cm) are counted within the 10 x 25 m nested subplot (quadrant 4). Individuals are tallied in two diameter groups (DBH 1<5 cm and DBH ≥5 cm) by species, living status, and rooting height class (table 3). Forked small trees are tallied based on the diameter of the largest stem. Similar to sampling large trees, if there is doubt about whether stems are from the same individual tally as separate individuals.

Small Tree Ferns: Live and dead Small Tree Ferns with a height/ length ≥0.5 m and stem diameter <10 cm are counted within the 2 x 50 m nested subplot. Individuals are tallied by species, living status, rooting height class (table 3), and height/ length class (table 4). Height/ length class includes the trunk and the frond height for small tree fern individuals.

Tree Seedlings: Live and dead Tree Seedlings (DBH < 1 cm) are counted within the 2 x 50 m nested subplot. Individuals are tallied by species, living status, rooting height class (table 3), and height/ length class (table 4). Height/ length class for woody species is measured from the base of the stem to the growing tip and provides data on size and/or age structure for small woody individuals.

Shrubs: Live and dead shrub species that are not recorded in the Small Tree category are counted within the 2 x 50 m subplot. Individuals are tallied by species, living status, rooting height class (table 3), and height/ length class (table 4). Species with a vine-like growth form (e.g. *Frecinetia arborea*) are also included in the shrub belt as they are not captured well by any other measurement.

Subalpine Shrubland Community

Similar to the forest communities, vegetation is measured within a 20 x 50 m plot in the subalpine shrubland community. However, subplot sizes vary to account for differences in community structure (i.e., fewer trees). Details on each sampled parameter by plant life form and size class are provided below (table 5).

Large Trees: Live and dead Large Trees (DBH ≥10 cm) are counted within the 20 x 50 m plot and tallied by species, living status, DBH, number of boles, vigor class (table 1), and reproductive status. Parameter descriptions were detailed in the previous forest sampling section. Rooting height class is not recorded for this community because epiphytic growth is very rare in these drier high elevation areas.

Small Trees: Live and dead Small Trees and exceptionally large shrubs with a tree-like growth form (DBH 1<10 cm) are also counted within the 20 x 50 m plot. Similar to the Large Trees, individuals are tallied by species, living status, DBH, number of boles, vigor class (table 1), and reproductive status within each quadrant. Larger sample plots are required to capture smaller woody individuals in this community as compared to the forest communities because trees are sparse.

Tree Seedlings: Live and dead Tree Seedlings (DBH < 1 cm) are counted within the 2 x 50 m subplot and are recorded by species, living status, and height/ length class (table 4).

Shrubs: Live and dead Shrubs that are not counted in the Small Trees category are counted in the 2 x 50 m subplot and tallied by species, living status, and height/ length class (table 4).

Coastal Community

Vegetation is measured within a 10 x 20 m plot in the coastal community. Plot and subplot sizes differ from the forest and shrubland communities due to the restricted linear nature of this community. Details on each sampled parameter by plant life form and size class are provided below (table 6).

Table 5. Data to be collected in subalpine shrubland according to vegetation sample group.

Plot Size (m)	Sample Group	Tally Count	Living Status	Diam.	No. of Boles	Vigor Class	Flr/ Frt	Height Class
20 x 50	Large Trees (≥10 cm DBH)	X	X	X	X	X	X	
20 x 50	Small Trees (1<10 cm DBH)	X	X	X	X	X	X	
2 x 50	Tree Seedlings (0<1 cm DBH, ≥0.5 m length)	X	X					X
2 x 50	Shrubs (≥0.5 m length)	X	X					X

Table 6. Data to be collected in coastal communities according to vegetation sample group.

Plot Size (m)	Sample Group	Tally Count	Living Status	Diam.	No. of Boles	Vigor Class	Flr/ Frt	Height Class
10 x 20	Large Trees (≥10 cm DBH)	X	X	X	X	X	X	
2 - 2 x 20	Small Trees (1<10 cm DBH)	X	X					X
2 - 2 x 20	Tree Seedlings (0<1 cm DBH, ≥0.5 m length)	X	X					X
2 - 2 x 20	Shrubs (≥0.5 m length)	X	X					X

Large Trees: Live and dead Large Trees (DBH ≥10 cm) are counted within the 10 x 20 m plot in a similar manner as those in the shrubland communities. Individuals are tallied by species, living status, DBH, number of boles, vigor class (table 1), and reproductive status.

Small Trees: Live and dead Small Trees and exceptionally large shrubs with a tree-like growth form (DBH 1<10 cm) are counted within two 2 x 20 m subplots. Individuals are tallied in two

diameter groups (DBH <5 cm and DBH ≥5 cm) by species, living status, and height/ length class (table 4).

Tree Seedlings: Live and dead Tree Seedlings (no measureable DBH) found in coastal community plots are also recorded within two 2 x 20 m subplots. Similar to Small Trees, individuals are tallied by species, living status, and height/ length class (table 4).

Shrubs: Live and dead Shrubs that are not counted in the Small Trees category are counted in the same two 2 x 20 m subplots used for recording Small Trees and Tree Seedlings. Individuals in the shrub sample group are tallied by species, living status, and height/ length class (table 4).

Quantifying Coarse Woody Debris

Coarse woody debris or downed wood and downed tree ferns with no distinguishable terminal end are tallied along the centerline (TR2) and the two short transects forming the plot border (TR4 and TR6) for each plot (fig. 1) using a planar intercept technique. The transect azimuth and slope are recorded for the three sample transects (TR2, TR4 and TR6) from the zero end of each transect. If the entire transect length is not visible due to vegetation, slope can be calculated for each 10 m section and then averaged. Particles of large CWD (≥7.6 cm) that are within 2 m of the ground and that intersect the transect using the planar intercept technique will be reported. The diameter (cm) of the particle will be taken perpendicular to the point where the tape crosses the central axis of the debris and will be recorded. Additionally each particle will be assigned one of five decay classes (table 7). Wood must be downed and dead to be counted. Stems and branches attached to standing shrubs or trees are not included. If the transect intersects a curved piece more than once, each intersection is tallied. Uprooted stumps are tallied, but undisturbed stumps are not. For rotten logs that have fallen apart, the cylinder containing rotten material is visually reconstructed in order to estimate its diameter. Only leaning (>45 degrees from vertical and <2 m from the ground) dead trees are tallied.

Table 7. Decay classes for logs with diameters ≥7.6 cm (USDA Forest Service 2005). To apply to tree ferns, primarily use structural integrity.

Decay Class	Structural Integrity	Wood Texture	Color of Wood	Branches and Twigs	Invading Roots
1	sound, freshly fallen, intact logs	intact, hard, decay absent	original color	twigs present; bark tight	none
2	sound	mostly intact; sapwood partly soft (starting to decay) but cannot be pulled apart by hand, heartwood is mostly sound	original color	fine twigs gone; bark peeling	none
3	heartwood sound; piece supports its own weight	hard, large pieces, partly decaying; sapwood can be pulled apart by hand or sapwood absent	reddish-brown or original color	branch stubs will not pull out	sapwood
4	heartwood rotten; piece does not support its own weight, but maintains its shape	small, blocky pieces; a metal pin can be pushed into heartwood	reddish or light brown	branch stubs will pull out	heartwood
5	piece no longer maintains its shape, spreads out on ground	many small pieces, soft portions; powdery when dry	red-brown to dark brown	branch stubs and pitch pockets have rotted down	heartwood

Tree fern stems or logs are only counted along with CWD when the individual is dead and the terminal end is not distinguishable (i.e., no obvious end where the fiddleheads originated). Stem diameter and decay class are recorded for each tree fern log (with no distinguishable live or dead head) intersecting the transect plane. Three decay classes are used for tree fern logs with numbering generally consistent with CWD (1) freshly fallen, (3) sound, intact, and supports its own weight, and (5) old dead, decomposing and difficult to tell from a mound of soil on the ground.

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Standard Operating Procedure (SOP) #9

Using a Clinometer to Measure Height and Slope

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP outlines the procedure to measure plant height and ground slope with a clinometers as part of Pacific Island Network (PACN) focal terrestrial plant communities monitoring. For the most part this procedure follows the concepts and steps described in the Suunto Clinometer Instructions (2001). This SOP is not intended as an endorsement of the products mentioned, but simply as description of the procedure to collect height and slope data.

Procedures

Most brands of clinometer will work sufficiently well for this protocol. We will present instructions for the Suunto clinometer as an example of the procedure. To measure tree height with a Suunto clinometer, follow these general steps taken verbatim from the instruction manual.

1. Measure the horizontal distance from the *base of the tree* (or the *position directly beneath the required point*) to a position where the required point on the tree (e.g., tree tip) can be seen.
2. Sight at the required point on the tree:
   - Using one eye: Close one eye and simultaneously look through the Suunto at the scale and ‘beside’ the Suunto at the tree. Judge where the horizontal line on the Suunto scale would cross the tree.
   - Both eyes: With one eye looking at the Suunto scale and the other looking at the tree, allow the images to appear to be superimposed on each other. Note: If you suffer from astigmatism, use the one eye approach.

3. Read from the percent scale and multiple this percentage by the horizontal distance measured in step 1.
4. Site to the base of the tree and repeat steps 2-3.
5. Combine the heights from steps 3 and 4 to determine total tree height:
   - Add the 2 heights together if you looked up to the required point in step 2 and down to the base of the tree in step 4.
   - Subtract the height to the base of the tree from the height to the required point if you are on sloping ground and had to look up to both the required point and the base of the tree.
6. Check all readings and calculations.

Tree Height Example

The example below, which is a condensed and paraphrased version of the Suunto Clinometer instructions, provides a more concrete example of how to measure tree height, as defined as the distance from the ground to the upper most point of the tree.

Measure a horizontal distance of 20 meters from the tree to a position where both the top and bottom of the tree are visible. You may need to alter this distance as needed to find a suitable location for taking measurements. Be sure your final position allows you to see both the very top and bottom of the tree (i.e., walk around the tree first before choosing a final position).

Once in a suitable position, hold the clinometer as shown in the right side of Figure 1.

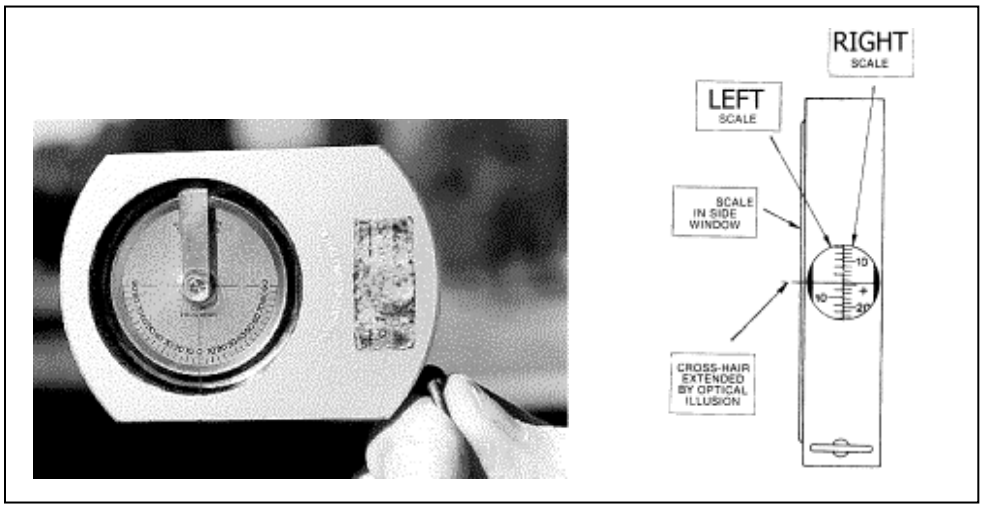

Figure 1. Suunto clinometer and scale.

Use the Percent scale, which as you look through the side “peep” hole, will probably be on the left side (it should be labeled on the exposed side). When you look through the “peep” hole, keep BOTH eyes open at all times. This will produce an optical effect that transposes the cross hair onto the tree in question. If you tilt the clinometer up and down as you look through the “peep” hole you will notice the scales have both positive (+) and negative (-) numbers. Always note whether the number is positive or negative.

With both eyes open tilt the clinometer until you superimpose the cross hair on the very top of the tree. Then read the proper scale and sign. This will be your upper reading. Then tilt the clinometer down until you get the number that coincides with where the tree meets the ground. Assuming a distance of 20 meters, use the equation below to get the tree height:

Total height (meters) = (Top measurement – bottom measurement) * 0.20

For example, suppose the top measurement (to the highest point on the tree) is +100 and the bottom measurement (to the base of the tree) is -10 (see Figure 2). To compute tree height substitute the percent values into the equation as follows:

Total height (m) = (100 – (-10)) * 0.20 = 110 * 0.20 = 22 meters

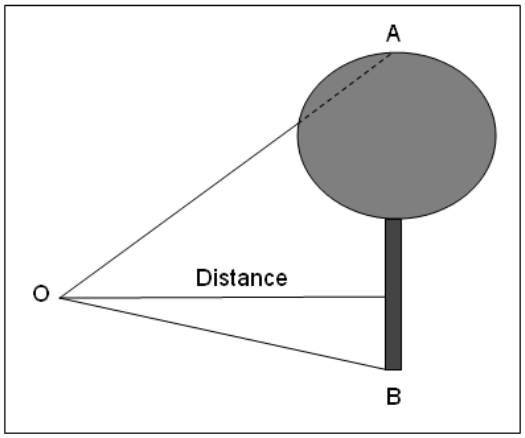

Figure 2. Schematic diagram of the measurements from a field crew member ("O") to the highest ("A") and lowest ("B") points on a tree. According to the Suunto manual, the most common mistake in measuring height is not using the true tree top. If side branches are mistaken for the top, an overestimate of height will occur. Note how the above angle measurement to the top of the tree ("A") sights through the crown of the tree.

If you use a different distance than 20 m then the total height equation changes accordingly. For example, if you use a horizontal distance of 50 m then the total height equation becomes:

Total height (m) = (Top measurement – bottom measurement) * 0.50

The general form for the total height equation is:

Total height (m) = (Top measurement – bottom measurement) * (Distance /100)

Measuring Slope

Plot slope and centerline slope are general characteristics noted on the "Plot Location" data form in Appendix E. To measure slope accurately, look through the clinometer and locate an upslope object or person that is the same height as your eye level. Read and record the angle using the technique described above. This angle is the slope of the surface.

Literature Cited

Suunto. 2001. Suunto Clinometer Instructions. Vantaa, Finland.

Standard Operating Procedure (SOP) #10

Collecting and Vouchering

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Based on: Williams, A., S. O'Neil, E. Speith, and J. Rodgers. 2007. Standard Operating Procedure (SOP) 4 "Plant Collecting and Vouchering," Version 1.0. *In* Early Detection Monitoring of Invasive Plant Species in the San Francisco Bay Area Network: A Volunteer-Based Approach. Department of the Interior, National Park Service, Pacific West Regional Office, Oakland, CA.

Only PARK STAFF are allowed to collect without a permit.

Purpose

This SOP describes how to collect voucher specimens in the process of Pacific Island Network (PACN) focal terrestrial plant communities monitoring. Having a physical voucher of a plant, especially a potentially new record in a park, is still the preferred method of proving an observation. Specimens, even non-natives, should not be collected by non-staff unless the individual has the proper Scientific Research and Collecting Permit. Volunteers and inexperienced field crew members should only take photographic vouchers of any unknown species. More experienced staff may field-key or choose to voucher for expert identification, or to record a new species for the park plant list or significant range expansion for an invasive species (e.g., the first record in the county), but should also photograph the plant *in situ* to capture characteristics that may be lost during pressing. Contact park vegetation staff for a list of plants that lack voucher evidence of their presence in the park.

In the field

Collecting ethics and regulations

Only collect native individuals if the plant's population will not be seriously affected by the taking: generally, if there are over 20 individuals in the vicinity. If the population is small, but you must collect, take only enough to key without destroying the plant (e.g., a flower and stem without roots) and consider photo-vouchering. If native plants are or are suspected to be rare, consider carefully whether or not to collect. Hawaii Plant Extinction Prevention program (State of Hawaii 2011), state and federally listed species should not be collected without consultation with the park supervisory botanist and the appropriate permits. Nonnative individuals can be collected regardless of population size, but if there is any uncertainty as to whether a rare individual is native or not it should not be collected.

Collecting tips

Plants are best keyed fresh, so field-key when possible. Tiny-flowered plants are especially difficult to key when wilted or pressed. If field-keying is unsuccessful, press some of the plant, and store the rest in a plastic bag or container. Blow the bag up with air and keep the plant moist (a small piece of wet paper in the bag helps); refrigeration will help keep the specimen fresh. Label the bagged and the pressed plants!

If you decide to collect with the intent of creating a pressed and mounted specimen:

- Collect a representative example of the species, not the largest or smallest. Try to capture any phenotypic variation.
- Collect enough of the plant to make pressing worthwhile. If the plants are tiny, collect enough to fill about half an herbarium sheet. Take enough to make a good voucher, plus a little extra for keying if necessary.
- Collect as much of the individual plant as possible, including roots (or a portion if rhizomatous), bulbs, vegetative and flowering/fruiting matter.
- Collect as many phenological stages as possible (flowering and fruiting), since many keys use characteristics of fruit and flower. If necessary, snip flowers or fruits off an additional plant to complete the collection.
- Press carefully; the standard plant press is the same size as a standard herbarium sheet (11"x17"). How you place the plant in the press will generally be how it will look mounted. If a plant is large, fold it or cut it to fit, keeping branchings and general form intact. Note original dimensions and photograph if possible. Plants may occasionally require more than one sheet for proper representation.
- Take copious notes, including the following information (see field descriptions from NPSpecies below): date; collector; exact location in Lat/Long or UTM (if GPS is used, specify datum such as NAD83); descriptive location (do not use "local" nicknames not on any map!); habitat description (dominant species); associated species; characteristics that may be lost in pressing (*e.g.* smells, flower color, habit, etc.); study name and number/plot number if applicable. Some information (elevation, sensitivity) may be filled in at the office. Many specimens are eventually discarded due to a lack of collection information.

- Wash as much dirt as possible from the roots and pat dry before pressing.
- If flowers are large enough, cut one or two open and press flat so the interior/cross-section can be seen. Do the same for fruits. Turn over at least one leaf so the underside will be visible in the final mounting.
- When photo-vouchering, many of the above guidelines still apply. For key characteristics such as flowers and fruits, be sure to get close-ups from several angles. Also photograph the whole plant including an object for scale.

Date: 03/31/03	Collector: Andrea Williams		Collection #: AW-03-03
Binomial: *Allium triquetrum*	Authority:	L.	
Family: Liliaceae	Common Name: three corner leek		
Distinctive Features: Onion odor, triangular stem, sl succulent, bracted umbel of 5-15 6-tepalled fls; perianth white with grn midvein			
Habitat: disturbed areas			
Assoc sp.: *Rubus discolor, Achillea millefolia* plus weedy grasses			
Location Description: Freshwater Lagoon Spit			
Numeric Location: Orick Quad, T10N R1E S6			
Slope: 0%	Aspect: N/A	Elevation: ~30 ft	
Comments: New to list; weedy and a potential problem			

Figure 1. Sample collection label. Remember to specify units and give any useful details.

Table 1. NPSpecies field descriptions.

Field Name	Description
ParkCode	4-Character park code (Hawai'i Volcanoes National Park = HAVO)
LatinName	Accepted scientific name of specimen.
ParkAdminUnit	Administrative Unit for Park (i.e., Alcatraz Island, Mori Point)
Sensitivity	Security level: 0=sensitive; 1=park only; 2=NPS only; 3=public
DocLatinName	Documented scientific name of species in the original records when it was observed
Date	Date of observation or collection (mm/dd/yy)
EndDate	Companion to Date; allows date ranges (mm/dd/yy)
Time	Time of observation or collection (24-hour clock, hh:mm)
Observer	Name of observer or collector
ObserverNumber	Field collection number provided by collector, if available.
Habitat	Concise description of habitat where observation or collection was made
Elevation	Estimated elevation in feet or meters where observation or collection was made
ElevationUnits	Units for elevation (feet or meters)
SpecimenID	Repository identification number of voucher specimen.
SpecimenLocation	Acronym, name and address of herbarium, museum or other location of specimen
Location	Concise description of collection site within the park or location from specimen label
LocalLocCode	An optional code for a permanently recognized local location.
Latitude	Latitude in decimal degrees
Longitude	Longitude in decimal degrees
UtmX	UTM X coordinate (northing)
UtmY	UTM Y coordinate (easting)
UtmZone	UTM zone
Datum	DATUM for location (e.g., NAD27, NAD83)
LocationError	Estimated location error in meters. How close are the coordinates to the true location?
DataSource	Source of voucher data (e.g. database name, file name, etc.)
Comments	Comments
FromPark	Collected within park boundary - yes or no.
VoucherType	Specimen, audio recording, image, or other.

VoucherTypeDetails	Concise description of voucher type.

Post-collection processing

Identify the specimen

Do your best to identify the plant to species level; it may be a good idea to confirm this identification by asking a local expert and comparing to an existing herbarium specimen or online photo.

Determining formal accession of specimen into the herbarium collection

If the specimen meets any of the following criteria, you should consider accessioning it, if it does not then you may consider adding it to a field collection (an informal notebook or set of specimens that can be used in the field for reference) or you may discard it once you are finished identifying it for whatever purpose you had.

- Is the species under-represented (less than 5 specimens) in the herbarium?
- Does specimen display a unique feature?
- Is this a unique voucher associated with a study or monitoring project?
- Is the specimen exceptional in some other way?
- Is there complete collection information associated with the specimen? Plants that lack location, habitat, collector and/or identifier information should not be accessioned.

Independent verification

If plants will be verified, do not accession until they are returned. This makes loan paperwork unnecessary. A receipt for property is sufficient.

Whether or not to verify: If the specimen is to be formally accessioned, independent verification of the specimen's identity should be considered when one or more of the following conditions are met:

- There are no preexisting specimens of the same species in the collection;
- The collection represents a new species to the park;
- Designated park staff are unable to confirm its identification with certainty;
- The specimen is otherwise unique or problematic.

Where to get them verified: If independent verification is desired for a quantity of specimens, the herbarium manager or curator should arrange for a contract through a recognized herbarium; current options include informal assistance from the Bishop Museum in Honolulu or Smithsonian Institute in Washington DC. Independent verification can pose a problem, because many herbaria want to keep specimens or duplicate specimens after identification, but NPS property guidelines will only allow for "permanent loans" which may not suffice in the eyes of some herbaria. Be sure to discuss with local or regional NPS curation staff that has experience with natural resource collections.

Documenting and packing specimens for shipping: Include proper documentation including a spreadsheet listing the specimens with collection numbers. Place a label with each specimen. See Figure 2 for an example of a label that can be used.

- Dry and press, but do not mount them. This facilitates identification.
- Place them in folded, numbered sheets of newsprint, occasionally layered between cardboard, and tie the entire bundle with string to facilitate removal from the box.
- Pack the box tightly to prevent anything from moving around within it.
- Send it via a reputable carrier (FedEx, UPS, USPS), insured. If feasible, hand carry.

Date Collector Collection # Binomial Authority Family Common name *Please do not make notations in this space, as these labels will not be included with the specimens once cataloged. You can make additional notations on the reverse of this temporary label, or on separate archival paper, with the collection number noted.*	*Please make all of your notations anywhere in this space. This portion will be cut off and affixed to the actual herbarium sheet, with the official label.* Det: Margriet Wetherwax Date:

Figure 2. Temporary label to be attached to specimens sent off for verification.

Accessioning the specimen into the formal herbarium collection

A collection of dried plants to be added to the parks' herbarium needs an accession number, as a group, and individual catalog numbers for each specimen. Obtain these from the museum curator. Specimens collected as part of a study should be accessioned together, clearly indicating relevant study information. Researchers who have collected specimens under a Scientific Research and Collecting Permit must provide cataloging data in the form specified by the museum curator in the permit. Catalogued specimens must be entered into the ANCS+ database. Contact the herbarium manager or museum curator for procedures and permit requirements if applicable. Remember that in entering the specimen you should be preserving the process as well as the final identification, so original identifications and identifiers should be recorded even if incorrect. Information needed for ANCS+ includes the data from the sheet above, as well as the date of any subsequent identifications and the name of the person identifying (verifying) the specimen.

SPECIMENS MUST INCLUDE LOCATION, HABITAT AND COLLECTION DATA TO BE ACCESSIONED AND INCLUDED IN NPSPECIES.

Adding the specimen into NPSpecies

Currently, some duplication of data exists between park herbaria and NPSpecies. Researchers who have collected specimens under a Scientific Research and Collecting Permit under I&M must also provide data in electronic format suitable for upload into NPSpecies. Updates to the park species list and to NPSpecies need to be accompanied by a voucher specimen and coordinated through an NPSpecies "gatekeeper." The current coordinator for data updates is the data manager. S/he can provide you with the template with which you can record your collection information.

Mounting the specimen

Once specimens are identified and verified, they may be mounted. Mounting can take place before or after accessioning. Not all pressed material must (or should) be mounted: only the most complete plants, plus additional fertile material or leaf variations, should be adhered to a sheet—enough to show the plant's characteristics, but not so much as to crowd the page. Split into "a" and "b" sheets if necessary, and be sure to leave room for label information. Additional information is available in the NPS Museum Handbook (NPS 1990) which is a complete reference guide on how to manage, preserve, document, access and use NPS museum collections. If you are inexperienced at mounting, consult I&M or local experts and/or look into one of the references listed at the end of this document.

Glossary

Accession number: The number assigned to an object or group of objects to be added to the parks' collection.

Authority: The original publishing author for a scientific name.

Binomial: The genus and species of a scientific name. Taken here in the broad sense to include subspecies.

NPSpecies: The National Park Service catalog for natural resource inventory data.

Phenotypic: The outward expression of genetic; flowers of Scotch broom show phenotypic variation in that some are all yellow and some have red wings.

UTM: Universal Transverse Mercator (or latitude/longitude) in pinpointing a location.

Voucher: A physical representation of a plant observation; the pressed, mounted plant "vouching" that a plant was found in a given location.

Suggested Reading

Bridson, D. and Forman, L., editors. 1992. *The Herbarium Handbook*, rev. ed. Kew, Royal Botanic Gardens.

National Park Service (NPS). 1990. Museum Management Handbook. Available at http://www.nps.gov/history/museum/publications/Museum%20Handbook%20with%20Quick%20Reference.pdf (accessed on 16 March 2011).

NPS Museum Management Handbook for collections

United States Department of Agriculture, Agricultural Research Service. 1971. *Preparing Herbarium Specimens of Vascular Plants*. U.S. Government Printing Office. Washington, D.C.

Literature Cited

State of Hawaii. 2011. Plant Extinction Prevention Program website. http://hawaii.gov/dlnr/dofaw/rpc/pep-program (accessed 5 May 2011).

Standard Operating Procedure (SOP) #11

After the Field Season

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP explains procedures that all field crew members should be familiar with and follow after the field season for Pacific Island Network (PACN) focal terrestrial plant communities monitoring is completed.

Procedures

The following list summarizes the procedures to follow after the field season.

1. Clean, inspect and repair all equipment prior to returning them to their proper storage areas at the PACN I&M facilities. All field equipment should also be decontaminated according to SOP #4 “Sanitation Procedure.” All references manuals should be re-shelved on their appropriate bookshelf. Other reference materials and extra data sheets need to be filed in their appropriate filing cabinet. Clean the insides and outsides of all vehicles used in the field.
2. Remove the memory card from the camera and store with the camera. Remove the camera power supply and place it in the camera battery charger. Put the camera in its case and place in cool, dry, secure storage. After the power supply is recharged, place it in the case with the camera.
3. Prepare a maintenance log that clearly identifies each piece of gear, the date serviced, and the type of maintenance performed.
4. Organize field data sheets and check that they have been filled out completely. As a rule, all data sheets need to be reviewed for completeness before the crew leaves the field. However,

because of the number of field days and crew members, some deficiencies in data recording may not be identified until all data sheets have been organized and reviewed as a group.

5. At the earliest practicable time, the field leader and crew members should enter data into the working database, validate it, and file the field season report. Conducting these tasks in a timely manner increases the odds of identifying and correcting discrepancies and inconsistencies in the data. The field leader is responsible for filing all field reports.
6. Identify and obtain ancillary data. It is of critical importance that this data be incorporated into the plant community monitoring efforts. First and foremost, knowledge of management efforts in a park for that year (i.e. ungulate control) may be used to assess the effects of these efforts on the terrestrial plant communities. Secondly, data collected by other PACN Vital Signs (e.g., habitat and vegetation data from the Landbirds Protocol, and climate data from the Climate Vital Sign) may provide additional information about the status and trends of the terrestrial plant communities monitored in this protocol.

Standard Operating Procedure (SOP) #12

Workspace Setup and Project Records Management

Version 1.0 (October 11, 2007)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP describes how to set up a project workspace on one's computer and describes the Pacific Island Network (PACN) Digital Library which is used for archival of finished PACN focal terrestrial plant communities monitoring products.

Set up project workspace

A section of the networked PACN file 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 is lost.

The recommended file structure within this workspace is shown in Figure 1. Certain folders – especially those for GPS data and images – should be retained in separate folders for each calendar year as shown in Figure 1. This will make it easier to identify and move these files to the project archives at the end of each season (see Chapter 4: Season Close-out).

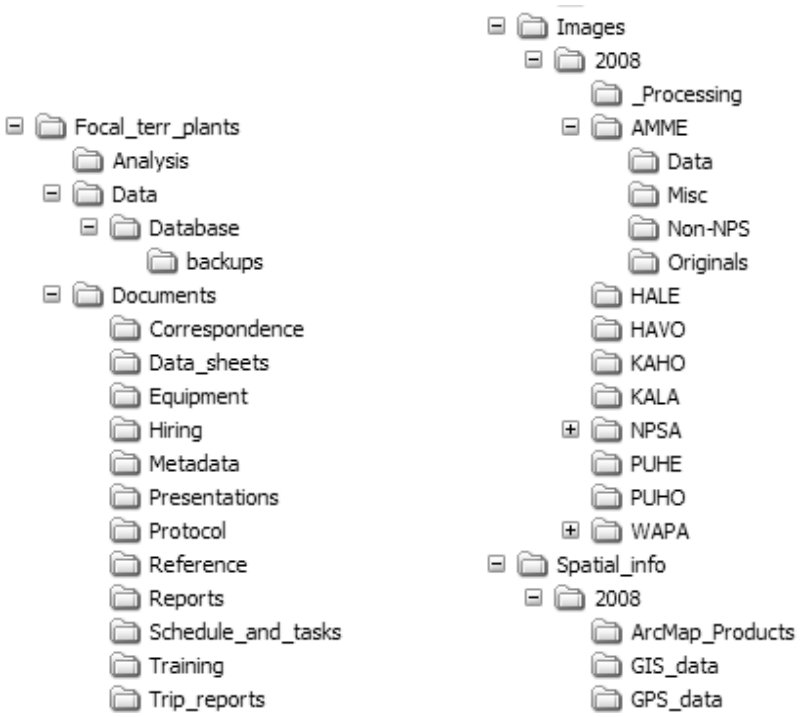

Figure 1. Recommended file structure for project workspace.

Images that are to be linked to the database have to be in the folders as designated in Figure 2. This will insure that when the images and database are moved that the links to the files will be updated in the database. The database must be in the database folder for the links to work.

Within the Database folder there should be a folder called "Database_images". Within this folder should be a folder for the current monitoring year. The year folder will have a folder for each park. Images for sampling event images that are to be linked to the database should go into the appropriate folder for the year and park. All other images should go into the image folder in the main directory.

Following these steps will ensure that the files will be re-linked to the database upon moving as long as the structure is maintained.

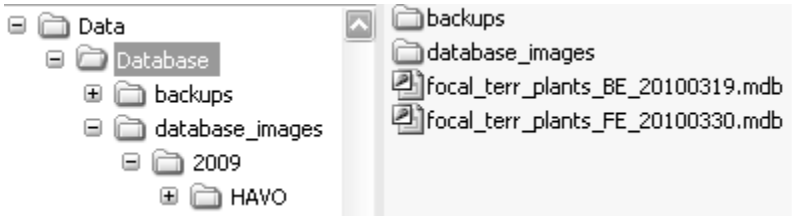

Figure 2. Required file structure for images linked to the focal terrestrial plant communities database.

Each major subfolder is described as follows:

- Analysis – Contains working files associated with data analysis.
- Data – Contains the working database file for the season. The master database for the project is stored in the PACN Digital Library.
- Documents – Contains subfolders to categorize documents as needed for various stages of project implementation.
- Images – For storing images associated with the project (refer to SOP #14 "Managing Photographic Images"). Note that this folder contains subfolders to arrange files by year.
- Spatial info – Contains files related to visualizing and interacting with GIS data.
    - ArcMap documents – Map composition files (.mxd).
    - GIS data – New working shapefiles and geodatabases specific to the project.
    - GPS data – Contains GPS data dictionaries and raw and processed GPS data files.

Naming Conventions

Folder Naming Standards

In all cases, folder names should follow these guidelines:

- No spaces or special characters in the folder name.
- Use the underbar ("_") character to separate words in folder names.
- Try to limit folder names to 20 characters or fewer.
- Dates should be formatted as YYYYMMDD.

File Naming Standards

In all cases, file names should follow these guidelines:

- No spaces or special characters in the file name.
- Use the underbar ("_") character to separate file name components.
- Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters.
- Dates should be formatted as YYYYMMDD.
- Correspondence files should be named as YYYYMMDD_AuthorName_subject.ext.

Archival and Records Management

All project files should be reviewed, cleaned, 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 (2001), which provides a schedule indicating the amount of time that the various kinds of records should be retained. Although many of the files for this project may be scheduled for permanent retention, it is important to isolate and protect these important files and not lose them in the midst of a large, disordered array of miscellaneous project files. Because this is a long-term monitoring project, good records management practices are critical for ensuring the continuity of project information. Files will be more useful to others if they are well organized, well named, and stored in a common format. In addition, it is important that files containing sensitive information be stored in a manner that will

enable quick identification. Refer to SOP #18 “Sensitive Information Procedures” for more information.

To help ensure safe and organized electronic file management, PACN has implemented a system called the PACN Digital Library, which is a hierarchical digital filing system stored on the PACN file servers. The typical arrangement is by project, then by year to facilitate easy access. Network users have read-only access to these files, except where information sensitivity may preclude general access. Submission of certified products occurs in the PACN Digital Library by uploading the certified products in the “Submissions” folder and notifying the Data Manager.

As digital products are delivered for long-term storage according to the schedule in SOP #19 “Product Delivery Specifications and Schedule,” they will be catalogued in the PACN project tracking database and filed within the PACN Digital Library by the Data Manager. The master versions of all digital files relating to the Focal Terrestrial Plant Communities protocol are stored within the PACN Digital Library, with regular file back-ups accomplished automatically. Presently, the master protocol files include the protocol narrative, the SOPs, and the Focal Terrestrial Plant Communities database files. Analog (non-digital) materials are to be handled according to current practices of the individual park collections.

Archived Data Maintenance

Any editing of archived data is accomplished jointly by the Project Lead or designee and PACN Data Manager. Prior to any major changes of a dataset, a copy is stored with the appropriate version number to allow for tracking of changes over time. Likewise, any time a revision of the protocol requires a revision to the database, a complete copy of the database will be made and stored in an archive directory. In addition to this copy in its native database format, all tables will be archived in a comma-delimited ASCII format that is platform-independent by using the Access_to_ascii.mdb utility developed by Northern Colorado Plateau Network.

Versioning of archived datasets is handled by adding a three digit number to the file name, with the first version being numbered 001 (e.g., focal_terr_plants_be_2009_validated_v001, for the first version of a back-end data file validated by the Project Lead and Data Manager at the end of the 2009 field season). The two text files generated by the Access_to_ascii.mdb utility, FieldDef.txt and TableDef.txt, will be stored in a similarly named folder (e.g., focal_terr_plants_be_2008_validated_v001_text). Each additional version is assigned a sequentially higher number. Frequent users of the data are notified of the updates, and provided with a copy of the most recently archived version.

Every change must be documented in the edit log and accompanied by an explanation that includes pre- and post-edit data descriptions. All data collected using this protocol are subject to the following three caveats:

- Only make changes that improve or update the data while maintaining data integrity.
- Once archived, document any changes made to the dataset through an edit log. At end of each fiscal year, the database manager will update the central database and will post read-only versions.

- Mistakes can be made during editing so updates must be compared with the original data form prior to validating the data.

Literature Cited

National Park Service (NPS). 2001. Director's Orders and Related Documents website. http://home.nps.gov/applications/npspolicy/DOrders.cfm (accessed 1 Oct 2007).

Standard Operating Procedure (SOP) #13

Field Form Handling Procedures

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP describes how to process field data forms from monitoring Pacific Island Network (PACN) focal terrestrial plant communities.

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. If changes to data on the forms need to be made either during or after field data acquisition, the original values should not be erased or otherwise rendered illegible. Instead, changes should be made as follows:

- Draw a horizontal line through the original value, and write the new value adjacent to the original value with the date and initials of the person making the change.
- All corrections should be accompanied by a written explanation in the appropriate notes section on the field form. These notes should also be dated and initialed.
- If possible, edits and revisions should be made in a different color ink to make it easier for subsequent viewers to be able to retrace the edit history.
- Edits should be made on the original field forms and on any photocopied forms.

These procedures should be followed throughout data entry and data revision. After each tour, data sheets are to be scanned as PDF documents placed in the project workspace folder assigned to data. See SOP #12 “Workspace Setup and Project Records Management” for more details. These digital files will be archived with the certified data according to the Product Delivery

Schedule and Specifications in SOP #19 “Project Delivery Specifications and Schedule.” The PDF files may then serve as a convenient digital reference of the original if needed.

Standard Operating Procedure (SOP) #14

Managing Photographic Images

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This Standard Operating Procedure document describes how to process photographic images collected by project staff or volunteers during the course of conducting project-related activities. Images that are acquired by other means – e.g., downloaded from a website or those taken by a cooperating researcher – are not project records and should be handled separately.

Care should be taken to distinguish data photos from incidental or opportunistic photos taken by project staff. Data photos are those taken for at least one of the following reasons:

- to document a particular feature or perspective for the purpose of site relocation
- to capture site habitat characteristics and possibly to indicate gross structural changes over time
- to document a species detection that is also recorded in the data

Data photos are linked to specific records within the database, and are stored in a manner that permits the preservation of those database links. Other photos – e.g., of field crew members at work – may also be retained but are not necessarily linked with database records.

Effectively managing hundreds of photographic images requires a consistent method for downloading, naming, editing, and documenting. The general process for managing data photos proceeds as follows:

A. File Structure Setup – Set up the file organization for images prior to acquisition

B. Image Acquisition
C. Download and Process
    - Download the files from the camera
    - Rename the image files according to convention
    - Copy and store the original, unedited versions
    - Review and edit or delete the photos
    - Move into appropriate folders for storage
D. Establish Database Links
E. Deliver Image Files for Final Storage

File Structure Setup

Prior to data collection for any given year, project staff will need to set up a new folder under the Images folder in the project workspace as follows:

[Year]	The appropriate year – 2008, 2009, etc.
_Processing	Processing workspace
[Park code]	Arrange files by park – HAVO, NPSA, etc.
Data	Data images
[Site_code]	Arranged by sampling locations, or
[Date]	by date, for images not taken at sampling locations
Miscellaneous	Non-data images taken by project staff
[Site_code]	Arranged by sampling locations, or
[Date]	by date, for images not taken at sampling locations
Originals	Renamed but otherwise unedited image file copies
[Site_code]	Arranged by sampling locations, or
[Date]	by date, for images not taken at sampling locations
Non-NPS	Images acquired from other sources

This folder structure permits data images to be stored and managed separately from non-record and miscellaneous images collected during the course of the project. It also provides separate space for image processing and storage of originals. For all images that are to be linked to the database, the image files will need to be copied to the appropriate image folder under the database folder. This will ensure that the links to the database are preserved at all times. See below for database image workspace structure. Note: For additional information about the project workspace, refer to SOP #12 “Workspace Setup and Project Records Management.”

Database
    Database_images
        [Year]
            [Park]

Folder Naming Standards

In all cases, folder names should follow these guidelines:

- No spaces or special characters in the folder name

- Use the underscore ("_") character to separate words in folder names
- Try to limit folder names to 20 characters or fewer
- Dates within folder names should be formatted as YYYYMMDD (for better sorting)

Image Acquisition

Capture images at an appropriate resolution that balances space limitations with the intended use of the images. Although photographs taken to facilitate future navigation to the site do not need to be stored at the same resolution as those that may be used to indicate gross environmental change at the site, it may be more efficient to capture all images at the same resolution initially. A recommended minimum raw resolution is 1600 x 1200 pixels (approximately two megapixels).

Download and Processing Procedures

1. Download the raw, unedited images from the camera into the appropriate "_Processing" folder.
2. Rename the images according to convention (refer to the image file naming standards section below). If image file names were noted on the field data forms, be sure to update these to reflect the new image file name prior to data entry. See SOP #13 "Field Form Handling Procedures."
3. Process the images in the "_Processing" folder. At a minimum, the following processing steps should be performed on all image files:
    - Copy the images to the "Originals" folder and set the contents as read-only by right clicking in Windows Explorer and checking the appropriate box. These originals are the image backup to be referred to in case of unintended file alteration or deletion.
    - Delete any poor quality photos, repeats, blurred or otherwise unnecessary photos. Low quality photos might be retained if the subject is highly unique, or the photo is an irreplaceable data photo.
    - Rotate the image to make the horizon level.
    - Photos of people should have 'red eye' glare removed.
    - Photos should be cropped to remove edge areas that grossly distract from the subject.
4. When finished, move the image files that are to be retained and possibly linked in the database to the appropriate folder – data images under the Data folder, other images under the Miscellaneous folder. Photos of interest to a greater audience should be copied to the PACN Digital Library\Photo Archive folder. Metadata associated with the image should be entered into the ThumbsPlus application. To minimize the chance for accidental deletion or overwriting of needed files, no stray files should remain in the processing folder between downloads.
5. Depending on the size of the files and storage limitations, contents of the Originals folder may be deleted if all desired files are accounted for after processing.

Large groups of photos acquired under sub-optimal exposure or lighting can be batch processed to enhance contrast or brightness. Batch processing can also be used to resize groups of photos for use on the web. Batch processing may be done in ThumbsPlus, Extensis Portfolio or a similar image software package.

Image File Naming Standards

In all cases, image names should follow these guidelines:

- No spaces or special characters in the file name
- Use the underscore ("_") character to separate file name components
- Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters
- Park code and year should either be included in the file name or conclusive by the directory structure

The image file name should consist of the following parts:

- The date of data capture (formatted as YYYYMMDD)
- The sampling location (if recorded at a sampling location)
- Optional: a brief descriptive word or phrase
- Optional: a sequential number if multiple images were captured
- Optional: time (formatted as HHMM)

Examples:

- 20070621_Waihanau_habitat_001.jpg: The habitat at Waihanau Valley taken on June 21, 2007
- 20070518_training_004.jpg 4th photo taken during training on May 18, 2007

In cases where there are small quantities of photos it is practical to individually rename these files. However, for larger numbers it may be useful to rename files in batches. This may be done in ThumbsPlus, Extensis Portfolio or a similar image software package. A somewhat less sophisticated alternative is to batch rename files in Windows Explorer, by first selecting the files to be renamed and then selecting File > Rename. The edits made to one file will be made to all others, although with the unpleasant side effect of often adding spaces and special characters (e.g., parentheses) which will then need to be removed manually.

Renaming photos may be most efficient as a two part event – one step performed as a batch process which inserts the date and transect number at the beginning of the photo name, and a second step in which a descriptive component is manually added to each file name.

Establish Database Links

During data entry and processing, the database application will provide the functionality required to establish a link between each database record and the appropriate image file(s). To establish the link, the database prompts the user to indicate the root project workspace directory path, the specific image folder within the project workspace, and the specific file name. This way, the entire workspace may be later moved to a different directory (i.e., the PACN Digital Library) and

the links will still be valid after changing only the root path. Refer to SOP #15 “Data Entry and Verification” for additional details on establishing these links.

Note: It is important that the files keep the same name and relative organization once these database links have been established. Users should not rename or reorganize the directory structure for linked image files without first consulting with the Data Manager.

Deliver Image Files for Final Storage

Note: Please refer to SOP #19 “Product Delivery Specifications and Schedule.”

At the end of the season, and once the year’s data are certified, data images for the year may be delivered along with the working copy of the database to the Data Manager on a CD or DVD. To do this, simply copy the folder for the appropriate year(s) and all associated subfolders and images onto the disk. These files will be loaded into the project section of the PACN Digital Library, and the database links to data images will be updated accordingly.

Prior to delivery, make sure that all processing folders are empty. Upon delivery, the delivered folders should be made read-only to prevent unintended changes.

Standard Operating Procedure (SOP) #15

Data Entry and Verification

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP describes the general procedures for entry and verification of Pacific Island Network (PACN) focal terrestrial plant communities monitoring data in the working project database. Refer to protocol sections “Overview of Database Design” and “Data Entry and Processing” for related guidance and a clarification of the distinction between the working database and the master database.

Data Entry

The following are general guidelines to keep in mind.

- Data entry will be conducted by field staff and overseen by the field leader at their duty station.
- Data entry should occur as soon after data collection as possible so that the field leader keeps current with data entry tasks, and catch any errors or problems as close to the time of data collection as possible.
- The working database application will be found in the project workspace. The project workspace may be on the user’s computer if the connection to the networked server is too slow (see SOP # 12 “Workspace Setup and Project Records Management”) with periodic uploads to the network server. If the workspace resides on the networked server, it is recommended that users copy the front-end database onto their workstation hard drives and open it there for enhanced performance. This front-end copy may be considered “disposable” because it does not contain any data, but rather acts as an interface with data residing in the back-end working database.

- Each data entry form is patterned after the layout of the field form, and has built-in quality assurance components such as pick lists and validation 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 the pre-built forms as a way of ensuring the maximum level of quality assurance.
- As data are being entered, the person entering the data should visually review each data form 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.
- After each data entry session, the field leader should upload the working copy of the database onto the networked server if the database has been stored on their computer.

Data Verification

Data verification checks that the digitized data match the source data. The following guidelines regarding data verification should be followed.

- Project leads are responsible for specifying in the project protocol one or more of the data verification methods available and ensuring proper execution. At the discretion of the project lead, additional verification methods may be applied.
- Data verification is carried out by staff thoroughly familiar with data collection and entry.
- All records (100%) should be verified against original source data. Upon completion of data entry, all records are printed and compared with the original values from the hard copy. Errors are clearly marked and corrected in the database as soon after data entry as possible. Reliability increases if someone other than the person keying the data performs the review. Alternatively, two technicians (one reading from the original data and one checking the entered data) can perform this review.
- A subset of randomly selected records (10%) should be reviewed after initial verification by the project lead. If errors are found, the entire data set should be verified again.
- A record of the verification process for each data set, including number of iterations and results, will be prepared by the project lead as part of formal metadata generation.
- Spatial data collected as part of the project will be viewed in a GIS and visually inspected for accuracy (e.g., points located outside park boundaries, upland locations occurring in water).

Database Instructions

The first action to be taken is to make sure the data entry workspace is set up properly either on a networked drive or the user's computer if networked server connections are too slow for efficient data entry. If you are unclear about where the data entry workspace should be contact the data manager see SOP #12 "Workspace Setup and Project Records Management" for more information).

- Store the back-end database file in the database folder in the project workspace. The back-end file has "_be_" as part of its name.
- The user's copy of the front-end database should also be stored in the same folder.
- If it does not already exist, also create a folder in the same folder named "backups" for storing daily backups of the back-end database file.

- Open the front-end database. The first thing it will do is to ask to update the links to the back-end database file. This will only need to be done once for each new issue of the front-end database.

Important Reminders for Daily Database Use

- A copy of the front-end will need to be copied to your workstation if the project workspace is set up on the networked server. *Do not open up and use the front-end on the network* as this 'bloats' the database file and makes it run more slowly.
- The front-end application will automatically prompt you to make a backup upon initially opening the application.
- To save drive space and network resources, backup files should be compacted by right-clicking on the backup file in Windows Explorer and selecting the option: "Add to Zip file". Older files may be deleted at the discretion of the Field Lead.
- New issues of the front-end application may be released as needed through the course of the field season. If this happens, there should be no need to move or alter the back-end file. Instead, the front-end file may be deleted and replaced with the new version, which will be named in a manner reflecting the update (e.g., Focal_terr_plants_2008_v2.mdb).
- If the front-end database gets bigger and slower, compact it periodically by selecting Tools > Database Utilities > Compact and Repair Database.

Working Database Functions

The working front-end application has the following functional components, which are accessed from the main application switchboard form that opens automatically when the application starts:

Data Entry and Review

- Data entry/edit: After verifying default settings (e.g., park, coordinate datum) the data gateway form will open. From here, data for a particular sampling date and location can be reviewed and edited if necessary. By choosing the option "Add a New Record" the data entry form will open and new data may be entered.
- Quality assurance tools – opens a form that shows the results of pre-built queries that check for data integrity, missing data, and illogical values, and allows the user to fix these problems and document the fixes. See SOP #16 "Post-season Data Quality Review and Certification".

Other Functions

- Manage lookups – opens a tool for managing the lookup values for the project data set (e.g., species list, list of project personnel, etc.)
- View database window – allows the user to view the database objects (tables, queries and forms)
- Back up data – creates a date-stamped copy of the back-end database file
- Connect back-end database – Verifies the connection to the back-end working database file, and provides the option to redirect or update that connection
- Set system defaults – user name, declination, current park, coordinate datum

- View release history – opens a form describing known bugs and changes made to the front-end database since its first release

Standard Operating Procedure (SOP) #16

Data Quality Review and Certification

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP describes the procedures for validation and certification of Pacific Island Network (PACN) focal terrestrial plant communities monitoring data in the working project database. Refer also to protocol sections in Chapter 4 (Overview of Database Design, Quality Review, and Data Certification and Delivery) for related guidance and a clarification of the distinction between the working database and the master database.

After the season's field data have been entered, verified, and processed, they need to be reviewed and certified by the project lead for quality, completeness and logical consistency. Data validation is the process of checking data for completeness, logical consistency, and structural integrity. 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 project lead may then fix these problems and document the fixes. Following this process the project lead certifies these data.

Data Quality Review

At the end of each field season, the project lead and the PACN data management staff are collectively responsible for finalizing a validated dataset for that field season. The project lead, will ensure that all data are validated. Some validation (ensuring that the data make sense) methods have been incorporated into the terrestrial focal plant communities database. Other, more specific validation routines will be worked out with the protocol developers and project lead, and incorporated into the database as appropriate.

Completing Data Certification

Data certification is a benchmark in the project information management process that indicates: 1) the data are complete for the period of record, 2) the data have undergone and passed the quality assurance checks, and 3) that the data 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. Once the data have been through the validation process and metadata have been developed for them, they are to be certified by completing the PACN Project Data Certification Form (NPS 2010). The project lead is primarily responsible for completing this form. The completed form, certified data, and updated metadata may then be delivered to the data manager according to the timeline in Appendix G: Yearly Project Task List. Refer to SOP #19 "Product Delivery Specifications and Schedule" for delivery instructions.

Literature Cited

National Park Service (NPS). 2010. Pacific Island Network: Data Management Guidance Documents website. http://science.nature.nps.gov/im/units/pacn/data/data_sop.cfm (accessed on 26 April 2011).

Standard Operating Procedure (SOP) #17

Metadata Development

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP describes the guidelines for documenting the content, quality, condition and other characteristics of Pacific Island Network (PACN) focal terrestrial plant communities monitoring data sets and how it should be accomplished.

Metadata Documentation

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. Additionally, metadata provide the means to catalog and search among data sets, thus making them available to a broad range of potential data users. Metadata for all PACN monitoring data will conform to Federal Geographic Data Committee (FGDC) guidelines and will contain all components of supporting information such that the data may be confidently manipulated, analyzed and synthesized. Initial metadata development describing individual measurements is based on the definitions and procedures described in SOP #8 “Conducting Community Vegetation Surveys.”

Updated metadata is a required deliverable that should accompany each season’s certified data. For long-term projects such as this one, metadata creation is most time consuming the first time it is developed – after which most information remains static from one year to the next. Metadata records in subsequent years then only need to be updated to reflect changes in contact information and taxonomic conventions; to include recent publications; to update data

disposition and quality descriptions; and to describe any changes in collection methods, analysis approaches, or quality assurance for the project.

Specific procedures for creating, parsing, and posting the metadata record are found in *PACN Metadata Guidelines* (NPS 2010). The general flow is as follows:

1. After the annual data quality review has been performed and the data are ready for certification, the project lead (or a designee) updates the *PACN Metadata Interview Form* (NPS 2010).
    a. The *Metadata Interview Form* greatly facilitates metadata creation by structuring the required information into a logical arrangement of 15 main questions, many with additional sub-questions.
    b. The first year, a new copy of the *Metadata Interview Form* should be downloaded. Otherwise the form from the previous year can be used as a starting point, in which case the track changes tool in Microsoft Word should be activated in order to make edits obvious to the person who will be updating the XML record.
    c. Complete the *Metadata Interview Form* and maintain it in the project workspace. Much of the interview form can be filled out by cutting and pasting material from other documents (e.g., reports, protocol narrative sections, and SOPs).
    d. The data manager can help answer questions about the *Metadata Interview Form.*
2. Deliver the completed interview form to the data manager according to SOP #19 ("Product Delivery Specifications and Schedule").
3. The data manager (or GIS specialist for spatial data) will then extract the information from the interview form and use it to create and update an FGDC- and NPS-compliant metadata record in XML format. Specific guidance for creating the XML record is contained in *PACN Metadata Guidelines*.
4. The data manager will post the record and the certified data to NR Info (NPS 2011), and maintain a local copy of the XML file for subsequent updates. NR Info has help files to guide the upload process.
5. The project lead should update the metadata interview content as changes to the protocol are made, and each year as additional data are accumulated.

Identifying sensitive information

Part of metadata development includes determining whether or not the data include any sensitive information, which is partly defined as the specific locations of rare, threatened or endangered species. Prior to completing the metadata interview form, the project lead should identify any sensitive information in the data after first consulting SOP #18 "Sensitive Information Procedures." Their findings may be documented and communicated to the data manager through the metadata interview form.

Literature Cited

National Park Service (NPS). 2007. Pacific Island Network: Data Management Guidance Documents website. http://science.nature.nps.gov/im/units/pacn/data/data_sop.cfm (accessed on 26April 2011).

National Park Service (NPS). 2011. National Resource Information Portal website. https://nrinfo.nps.gov/Home.mvc/showWelcomePage (accessed on 26 April 2011).

Standard Operating Procedure (SOP) #18

Sensitive Information Procedures

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP details how to prepare sensitive data collected through Pacific Island Network (PACN) focal terrestrial plant communities monitoring for sharing with non-agency entities. Although it is the general National Park Service (NPS) policy to share information widely, the NPS also realizes that providing information about the location of park resources may sometimes place those resources at risk of harm, theft, or destruction. This can occur, for example, with regard to caves, archeological sites, tribal information, and rare plant and animal species. Therefore, information will be withheld when the NPS foresees that disclosure would be harmful to an interest protected by an exemption under the Freedom of Information Act (FOIA). The National Parks Omnibus Management Act, Section 207, 16 U.S.C. 5937, is interpreted to prohibit the release of information regarding the "nature or specific location" of certain cultural and natural resources in the national park system. Additional details and information about the legal basis for this policy can be found in the NPS Management Policies (NPS 2006) and in Director's Order #66 (NPS 2001).

These guidelines apply to all PACN staff, cooperators, contractors, and other partners who are likely to obtain or have access to information about protected NPS resources. The project lead has primary responsibility for ensuring adequate protection of sensitive information related to this project.

The following are highlights of our strategy for protecting this information:

- *Protected resources*, in the context of the PACN Inventory and Monitoring Program, include species that have State- or Federally-listed status, and other species deemed rare or sensitive by local park taxa experts.
- *Sensitive information* is defined as information about protected resources which may reveal the "nature or specific location" of protected resources. Such information must not be shared outside the National Park Service, unless a signed confidentiality agreement is in place.
- In general, if information is withheld from one requesting party, it must be withheld from anyone else who requests it, and if information is provided to one requesting party without a confidentiality agreement, it must be provided to anyone else who requests it.
- To share information as broadly as legally possible, and to provide a consistent, tractable approach for handling sensitive information, the following shall apply if a project is likely to collect and store sensitive information:
    - Random coordinate offsets of up to 2 km for data collection locations, and
    - Removal of data fields from the released copy that are likely to contain sensitive information.

What Kinds of Information Can and Cannot Be Shared?

Do not share

Project staff and cooperators should not share any information that reveals details about the "nature or specific location" of protected resources, unless requested by NPS staff with a valid reason or outside of the NPS a confidentiality agreement is in place. Specifically, the following information should be omitted from shared copies of all data, presentations, reports, or other published forms of information.

- *Exact coordinates* – Instead, public coordinates are to be generated that include a random offset azimuth and distance. These offset coordinates can be shared freely.
- *Other descriptive location data* – Examples may include travel descriptions, location descriptions, or other fields that contain information which may reveal the specific location of the protected resource(s).
- *Protected resource observations at disclosed locations* – If specific location information has already been made publicly available, the occurrence of protected resources at that location cannot be shared outside NPS without a confidentiality agreement. For example, if the exact coordinates for a monitoring station location are posted to a website or put into a publication, then at a later point in time an endangered plant is observed at that monitoring station, that plant cannot be mentioned or referred to in any report, presentation, data set, or publication that will be shared outside NPS.

Do share

All other information about the protected resource(s) may be freely shared, so long as the information does not reveal details about the "nature or specific location" of the protected resource(s) that are not already readily available to the general public in some form (e.g., other published material). Species tallies and other types of data presentations that do not disclose the

precise locations of protected resources may be shared, unless by indicating the presence of the species the specific location is also revealed (i.e., in the case of a small park).

Details for Specific Products

Whenever products such as databases and reports are being generated, handled and stored, they should be created explicitly for one of the following purposes:

- *Public or general-use* – Intended for general distribution, sharing with cooperators, or posting to public websites. They may be derived from products that contain sensitive information so long as the sensitive information is either removed or otherwise rendered in a manner consistent with other guidance in this document.
- *Internal NPS use* – These are products that contain sensitive information and should be stored and distributed only in a manner that ensures their continued protection. These products should clearly indicate that they are solely for internal NPS use by containing the phrase: "Internal NPS Use Only – Not For Release." These products can only be shared within NPS or in cases where a confidentiality agreement is in place. They do not need to be revised in a way that conceals the location of protected resources.

Data Sets

To create a copy of a data set that will be posted or shared outside NPS:

1. Make sure the public offset coordinates have been populated for each sample or observation location in tbl_Locations.
2. Delete any database objects that may contain specific, identifying information about locations of protected resources.

The local, master copy of the database contains the exact coordinates and all data fields. The data manager and/or GIS specialist can provide technical assistance as needed to apply coordinate offsets or otherwise edit data products for sensitive information.

Maps and Other GIS Output

General use maps and other geographic representations of observation data that will be released or shared outside NPS should be rendered using offset coordinates, and should only be rendered at a scale that does not reveal their exact position (e.g., 1:100,000 maximum scale).

If a large-scale, close-up map is to be created using exact coordinates (e.g., for field crew navigation, etc.), the map should be clearly marked with the following phrase: "Internal NPS Use Only – Not For Release."

The data manager and/or GIS specialist can provide technical assistance as needed to apply coordinate offsets or otherwise edit data products for sensitive information.

Presentations and Reports

Public or general-use reports and presentations should adhere to the following guidelines:

- Do not list exact coordinates or specific location information in any text, figure, table, or graphic in the report or presentation. If a list of coordinates is necessary, use only offset

coordinates and clearly indicate that coordinates have been purposely offset to protect the resource(s) as required by law and NPS policy.

- Use only general use maps as specified in the section on maps and other GIS output.

If a report is intended for internal use only, these restrictions do not apply. However, each page of the report should be clearly marked with the following phrase: "Internal NPS Use Only – Not For Release."

Voucher Specimens

Specimens of protected taxa should only be collected as allowed by law. Labels for specimens should be clearly labeled as containing sensitive information by containing the following phrase: "Internal NPS Use Only – Not for Release." These specimens should be stored separately from other specimens to prevent unintended access by visitors. As with any sensitive information, a confidentiality agreement should be in place prior to sending these specimens to another non-NPS cooperator or collection.

Procedures for Coordinate Offsets

1. Process GPS data, upload into the database, and finalize coordinate data records.
2. Set the minimum and maximum offset distances (project-specific, typically up to 2 km).
3. Apply a random offset and random azimuth to each unique set of coordinates.
4. Coordinates may then be either rounded or truncated so the UTM values end in zeros to give a visual cue that the values are not actual coordinates.
5. Do not apply independent offsets to clustered or otherwise linked sample locations (e.g., multiple sample points along a transect). Instead, either apply a single offset to the cluster so they all remain clustered after the offset is applied, or apply an offset to only one of the points in the cluster (e.g., the transect origin) and store the result in the public coordinates for each point in that cluster.
6. These "public" coordinates are then the only ones to be shared outside NPS – including all published maps, reports, publications, presentations, and distribution copies of the data set – in the absence of a confidentiality agreement.

The following components can be used to create individual offsets rounded to the nearest 100 meters in MS Excel:

- Angle = rand() * 359
- Distance = ((Max_offset – Min_offset) * rand() + Min_offset)
- Public_UTME = Round(UTME_final + (Distance * Cos(Radians(Angle – 90))), -2)
- Public_UTMN = Round(UTMN_final + (Distance * Sin(Radians(Angle + 90))), -2)

Sharing Sensitive Information

Refer to SOP #20 "Product Posting and Distribution" for a more complete description of how to post and distribute products and to keep a log of data requests.

No sensitive information (e.g., information about the specific nature or location of protected resources) may be posted to the Natural Resource Information Portal (NPS 2011) or another

publicly-accessible website, or otherwise shared or distributed outside NPS without a confidentiality agreement between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared. Only products that are intended for public/general-use may be posted to public websites and clearinghouses – these may not contain sensitive information.

Responding to Data Requests

If requests for distribution of products containing sensitive information are initiated by the NPS, by another federal agency, or by another partner organization (e.g., a research scientist at a university), the unedited product (e.g., the full data set that includes sensitive information) may only be shared after a confidentiality agreement is established between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared. All data requests will be tracked according to procedures in SOP #20 "Product Posting and Distribution."

Once a confidentiality agreement is in place, products containing sensitive information may be shared following these guidelines:

- Always clearly indicate in accompanying correspondence that the products contain sensitive information, and specify which products contain sensitive information.
- Indicate in all correspondence that products containing sensitive information should be stored and maintained separately from non-sensitive information, and protected from accidental release or re-distribution.
- Indicate that NPS retains all distribution rights; copies of the data should not be redistributed by anyone but NPS.
- Include the following standard disclaimer in a text file with all digital media upon distribution: "The following files contain protected information. This information was provided by the National Park Service under a confidentiality agreement. It is not to be published, handled, re-distributed or used in a manner inconsistent with that agreement." The text file should also specify the file(s) containing sensitive information.
- If the products are being sent on physical media (e.g., CD or DVD), the media should be marked in such a way that clearly indicates that media contains sensitive information provided by the National Park Service.

Confidentiality Agreements

Confidentiality agreements may be created between NPS and another organization or individual to ensure that protected information is not inadvertently released. When contracts or other agreements with a non-federal partner do not include a specific provision to prevent the release of protected information, the written document must include the following standard Confidentiality Agreement:

> **Confidentiality Agreement -** I agree to keep confidential any protected information that I may develop or otherwise acquire as part of my work with the National Park Service. I understand that with regard to protected information, I am an agent of the National Park Service and must not release that information. I also understand that by law I may not share protected information with anyone through any means except as specifically authorized by the National Park Service. I understand that protected

information concerns the nature and specific location of endangered, threatened, rare, commercially valuable, mineral, paleontologic, or cultural patrimony resources such as threatened or endangered species, rare features, archeological sites, museum collections, caves, fossil sites, gemstones, and sacred ceremonial sites. Lastly, I understand that protected information must not be inadvertently disclosed through any means including websites, maps, scientific articles, presentation, and speeches.

Freedom of Information (FOIA) Requests

All official 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.

Literature Cited

National Park Service (NPS). 2001. Director's Orders and Related Documents website. http://home.nps.gov/applications/npspolicy/DOrders.cfm (accessed 1 Oct 2007).

National Park Service (NPS). 2006. Management Policies website. http://www.nps.gov/policy/mp/policies.htm (accessed 6 February, 2007).

National Park Service (NPS). 2011. National Resource Information Portal website. https://nrinfo.nps.gov/Home.mvc/showWelcomePage (accessed on 26 April 2011).

Standard Operating Procedure (SOP) #19

Product Delivery Specifications and Schedule

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP contains details on the process of submitting completed data sets, reports and other project deliverables related to Pacific Island Network (PACN) focal terrestrial plant communities monitoring. Prior to submitting digital products, files should be named according to the naming conventions appropriate to each product type (see below for general naming conventions).

All digital file submissions that are sent by email should be accompanied by a *Product Submissions Form* (NPS 2010), which briefly captures the following information about the products:

- Submission date
- Name of the person submitting the product(s)
- Name and file format of each product
- Indication of whether or not each product contains sensitive information (see SOP #18 "Sensitive Information Procedures") for more detail).

The *Product Submission Form* can be obtained from the data manager or from the PACN website (NPS 2010). Upon notification and/or receipt of the completed products, the data manager or GIS specialist will check them into the PACN project tracking application.

Delivering Certified Data and Related Materials

Data certification is a benchmark in the project information management process that indicates that: (1) the data are complete for the period of record; (2) they have undergone and passed the

quality assurance checks; and (3) that they are appropriately documented and in a condition for archiving, posting and distribution as appropriate. To ensure that only quality data are included

Table 1. Product Delivery Schedule for the Focal Terrestrial Plant Communities Monitoring Protocol.

Deliverable Product	Primary Responsibility	Target Date	Instructions
Field season report	Field Leader	October 30 of the same year	Upload digital file in MS Word format to the PACN Digital Library[1] submissions folder.
Raw Global Positioning System (GPS) data files	Field Leader	October 31 of the same year	Zip and send all digital files to the GIS specialist.
Processed GPS data files	GIS Specialist	December 31 of the same year	Zip and upload raw and processed files to the PACN Digital Library[1].
Digital photographs	Project Lead	December 31 of the same year	Organize, name and maintain photographic images in the project workspace according to SOP #12. Upload to the PACN Digital Library[1].
Certified working database	Project Lead	December 31 of the same year	Refer to the following section on delivering certified data and related materials. Data will be uploaded to the Reference service within the Natural Resource Information Portal (NR Info)[2], and stored in the PACN Digital Library[1].
Certified geospatial data	Project Lead with GIS Specialist		
Data certification report	Project Lead		
Metadata interview form	Project Lead		
Full metadata (parsed XML)	Data Manager and GIS Specialist	March 15 of the following year	Upload the parsed XML record to the Reference service within NR Info[2], and store in the PACN Digital Library[1].
Annual Inventory I&M report	Project Lead	April 30 of the following year	Refer to the following section on reports and publications. Final reports will be entered in NR Info[2], and stored in the PACN Digital Library[1].
5-year analysis report	Project Lead	Every 5 years by April 30	
Other publications	Project Lead, and possibly other project personnel	As completed	
Field data forms	Project Lead	Scan after every filed tour, upload by April 30 of the following year	Scan original, marked-up field forms as PDF files and upload these to the PACN Digital Library[1] submissions folder. Originals go to the park curator for archival.
Other records	Project Lead	Review for retention every January	Organize and send analog files to park curator for archival. Digital files that are slated for permanent retention should be uploaded to the PACN Digital Library[1]. Retain or dispose of records following NPS Director's Order #19[3].

[1] The PACN Digital Library is a hierarchical digital filing system stored on the PACN file servers. Network users have read-only access to these files, except where information sensitivity may preclude general access.
[2] NR Info (NPS 2011a) is the National Park Service's Natural Resource Information Portal. NR Info is a clearinghouse for natural resource data, metadata, bibliographic records, and park species information. Only non-sensitive information is posted to the Natural Resource Information Portal. Refer to the protocol section on sensitive information for details.
[3] NPS Director's Order 19 (NPS 2001) provides a schedule indicating the amount of time that the various kinds of records should be retained.

in reports and other project deliverables, the data certification step is an annual requirement for all tabular and spatial data. For more information refer to SOP #16 "Data Quality Review and Certification."

The following deliverables should be delivered as a package:

- *Certified working database* – Database in MS Access format containing data for the current season that has been through the quality assurance checks documented in SOP #14 "Data Quality Review and Certification."
- *Certified geospatial data* – GIS themes in Environmental Systems Research Institute (ESRI) geodatabase format.
- *Project Data Certification Form* – A brief questionnaire in MS Word that describes the certified data product(s) being submitted. A template form is available on the PACN website (NPS 2010).
- *Metadata Interview Form* – The metadata interview form is an MS Word questionnaire that greatly facilitates metadata creation. This form is available on the PACN website (NPS 2010). For more details, refer to SOP #15 "Metadata Development."

After the quality review is completed, the project lead should package the certification materials for delivery as follows:

1. Open the certified back-end database file and compact it (in Microsoft Access, Tools > Database Utilities > Compact and Repair Database). This will make the file size much smaller. Back-end files are typically indicated with the letters "_be" in the name (e.g., Plant_Communities _be_2011.mdb).
2. Rename the certified back-end file with the project name ("Plant_Communities"), the year or span of years for the data being certified, and the word "certified". For example: Plant_Communities_2011_certified.mdb.
3. Create a compressed file (using WinZip® or similar software) and add the back-end database file to that file. Note: The front-end application does not contain project data and as such should not be included in the delivery file.
4. Add the completed *Metadata Interview Form* and the *Project Data Certification Form* to the compressed file. Both files should be named in a manner consistent with the naming conventions described elsewhere in this document.
5. Add any geospatial data files that are not already in the possession of the GIS specialist. Geospatial data files should be developed and named according to PACN GIS Naming Conventions.

6. Upload the compressed file containing all certification materials to the submissions folder of the PACN Digital Library. If the project lead does not have access to the PACN Digital Library, then certification materials should be delivered as follows:
    a. If the compressed file is under 5 mb in size, it may be delivered directly to the data manager by email.
    b. If the compressed file is larger than 5 mb, it should be copied to a CD or DVD and delivered in this manner. Under no circumstances should products containing sensitive information be posted to an FTP site or other unsecured web portal (refer to SOP #18 "Sensitive Information Procedures" for more information).
7. Notify the data manager by email that the certification materials have been uploaded or otherwise sent.

Upon receiving the certification materials, the data manager will:

1. Review them for completeness and work with the project lead if there are any questions.
2. Notify the GIS specialist if any geospatial data are submitted. The GIS specialist will then review the data, and update any project GIS data sets and metadata accordingly.
3. Check in the delivered products using the PACN project tracking application.
4. Store the certified products together in the PACN Digital Library.
5. Upload the certified data to the master project database.
6. Notify the project lead that the year's data have been uploaded and processed successfully. The project lead may then proceed with data summarization, analysis and reporting.
7. Develop, parse and post the XML metadata record to the NR Info.
8. After a holding period of two years, the data manager will upload the certified data to NR Info. This holding period is to protect professional authorship priority and to provide sufficient time to catch any undetected quality assurance problems. See SOP #20 "Product Posting and Distribution."

Reports and Publications

Annual reports and trend analysis reports will use the NPS Natural Resource Publications template, a pre-formatted Microsoft Word template document based on current NPS formatting standards. Annual reports will use the Natural Resource Report (NRR) template or the Natural Resource Data Series (NRDS) template, and trend analysis and other peer-reviewed technical reports will use the Natural Resource Technical Report (NRTR) template. Templates and specific instructions for acquiring a series number and other information about NPS publication standards can be found at the NPS Natural Resources Publications website (NPS 2011b). A summary of the process for publishing in the NRR, NRTR, and NRDS series, which is described more fully in *Instructions to Authors* (NPS 2011b), is as follows:

1. Project lead prepares draft manuscript following style/formatting guidelines outlined in the *Instructions to Authors* (NPS 2011b) and makes initial determination to which series material is most appropriate. Project lead submits draft manuscript to the program manager.
2. Program manager reviews manuscript and obtains additional peer reviewers if necessary and then returns manuscript to project lead for revisions.

3. Project lead revises manuscript and resubmits draft manuscript and the *Manuscript Submittal Form and Checklist* to the program manager.
4. Program manager submits approved draft manuscript and the NRPM Manuscript Submittal Form and Checklist via email to the regional Inventory and Monitoring Program (I&M) coordinator.
5. The regional I&M coordinator assigns a Peer Review Manager (selected PWR program manager from a different network than the project lead) who then contacts the author and schedules a time for review.
6. The Peer Review Manager reviews the manuscript for content, the quality of the initial reviews, and for compliance with formatting and organization. The Key Official may determine that additional content peer review is needed and or a Management Review.
7. Once the Peer Review Manager is satisfied that reviewer comments have been adequately incorporated and the report meets the minimum standards for the series, the report is approved for publication in one of the series. The project lead or program manager then requests report numbers from the Natural Resources Program Center (NRPC) office in Fort Collins.
8. Once the report numbers are added the project lead produces a PDF (portable document format) version of the publication, uploads the file to the PACN Digital Library submissions folder, and sends a printout to each park curator.
9. The data manager or a designee creates a bibliographic record and uploads the PDF document to NR Info according to document sensitivity.

File naming conventions

In all cases, digital file names should follow these guidelines:

- No spaces or special characters in the file name
- Use the underscore ("_") character to separate file name components
- Try to limit file names to 30 characters or fewer, up to a maximum of 50 characters
- As appropriate, include the project name (e.g., "Plant_Communities"), network code ("PACN") or park code, and year in the file name.

Examples:

- PACN_Plant_Communities_2011_Annual_report.pdf

Literature Cited

National Park Service (NPS). 2001. Director's Orders and Related Documents website. http://home.nps.gov/applications/npspolicy/DOrders.cfm (accessed 1 Oct 2007).

National Park Service (NPS). 2010. Pacific Island Network: Data Management Guidance Documents website. http://science.nature.nps.gov/im/units/pacn/data/data_sop.cfm (accessed on 26 April 2011).

National Park Service (NPS). 2011a. National Resource Information Portal website. https://nrinfo.nps.gov/Home.mvc/showWelcomePage (accessed on 26 April 2011).

National Park Service (NPS). 2011b. Natural Resource Publication Management website. http://www.nature.nps.gov/publications/NRPM/ (accessed on 26 April 2011).

Standard Operating Procedure (SOP) #20

Product Posting and Distribution

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP provides details on the process of posting and otherwise distributing finalized data, reports and other project deliverables related to Pacific Island Network (PACN) focal terrestrial plant communities monitoring. For a complete list of project deliverables, refer to SOP #19 "Product Delivery Specifications and Schedule."

Product posting and distribution

Once digital products have been delivered and processed, the data manager will post the products to the Natural Resource Information Portal (NR Info). NR Info (NPS 2011) is the NPS clearinghouse for natural resource products that are available to the public. The following sets of products are available in NR Info:

1. Full metadata records and datasets will be posted to the References service within NR Info and made available to the public.
2. A record for reports and other publications will be created in the Reference service. The digital report file in PDF format will then be uploaded and linked to the reference record.
3. Species observations will be extracted from the database and entered into the Biology service which is the NPS database and application for maintaining park-specific species lists and observation data.

NR Info serves as the primary mechanism for sharing reports, data, and other project deliverables with other agencies, organizations, and the general public.

Holding period for project data

To protect professional authorship priority and to provide sufficient time to complete quality assurance measures, there is a 2-year holding period before posting or otherwise distributing finalized data. This means that certified data sets are first posted to publicly-accessible websites (i.e., NR Info) approximately 24 months after they are collected (e.g., data collected in June 2011 becomes generally available through NR Info in June 2013). In certain circumstances, and at the discretion of the project lead and park biologists, data may be shared before a full two years have elapsed.

Note: This hold only applies to raw data; all metadata, reports or other products are to be posted to NR Info in a timely manner as they are received and processed.

Responding to Data Requests

Occasionally, a park or project staff member may be contacted directly regarding a specific data request from another agency, organization, scientist, or from a member of the general public. The following points are considered when responding to data requests:

- NPS is the originator and steward of the data, and the NPS Inventory and Monitoring Program should be acknowledged in any professional publication using the data.
- NPS retains distribution rights; copies of the data should not be redistributed by anyone but NPS.
- The data that project staff members and cooperators collect using public funds are public records and as such cannot be considered personal or professional intellectual property.
- No sensitive information (e.g., information about the specific nature or location of protected resources) may be posted to NR Info or another publicly-accessible website, or otherwise shared or distributed outside NPS without a confidentiality agreement between NPS and the agency, organization, or person(s) with whom the sensitive information is to be shared. Refer to the section in this document about sensitive information and also to SOP #18 "Sensitive Information Procedures."
- For quality assurance, only the certified, finalized versions of data sets should be shared with others.

The project lead will handle all data requests as follows:

1. Discuss the request with other park biologists as necessary to make those with a need to know aware of the request and, if necessary, to work together on a response.
2. Notify the data manager of the request if s/he is needed to facilitate fulfilling the request in some manner.
3. Respond to the request in an official email or memo.
4. In the response, refer the requestor to NR Info so they may download the necessary data and/or metadata. If the request cannot be fulfilled in that manner – either because the data products have not been posted yet, or because the requested data include sensitive information – work with the data manager to discuss options for fulfilling the request directly (e.g., burning data to CD or DVD). Ordinarily, only certified data sets should be shared outside NPS.

5. If the request is for a document, it is recommended that documents be converted to PDF format prior to distributing it.
6. If the request is for data that may reveal the location of protected resources, refer to the section in this document about sensitive information and also to SOP #18 "Sensitive Information Procedures."
7. After responding, provide the following information to the data manager, who will maintain a log of all requests in the PACN Project Tracking database:
    a. Name and affiliation of requestor
    b. Request date
    c. Nature of request
    d. Responder
    e. Response date
    f. Nature of response
    g. List of specific data sets and products sent (if any)

All official 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.

Special procedures for sensitive information

Products that have been identified upon delivery by the project lead as containing sensitive information will either be revised into a form that does not disclose the locations of sensitive resources, or withheld from posting and distribution. When requests for distribution of the unedited version of products are initiated by the NPS, by another federal agency, or by another partner organization (e.g., a research scientist at a university), the unedited product (e.g., the full data set that includes protected information) may only be shared after a confidentiality agreement is established between NPS and the other organization. Refer to SOP #18 "Sensitive Information Procedures" for more information.

Literature Cited

National Park Service (NPS). 2011. National Resource Information Portal website. https://nrinfo.nps.gov/Home.mvc/showWelcomePage (accessed on 26 April 2011).

Standard Operating Procedure (SOP) #21

Data Analysis

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP describes how to analyze Pacific Island Network (PACN) focal terrestrial plant communities monitoring data for both status and trends. Status is described primary with summary statistics including means and variances, while trends are evaluated using Chi-square tests, McNemar's test of symmetry, paired t-tests, repeated measures ANOVA, or generalized linear models, depending on the type of data and its distribution.

Note that a Type I error level of 0.10 is assumed. Testing at this level may be conservative for long-term monitoring. Since a Type I error occurs when we erroneously find a trend that is not real, the consequences are to take management action to conserve the resource for which the trend was detected. The consequences of a Type II error may be more severe if native plant vigor or recruitment are decreasing without detection. The relative cost of each error make the use of a large Type I error rate reasonable for monitoring (Buhl-Mortensen 1996; Gibbs, et al. 1998; Mapstone 1995).

Status

Based on the certified data, descriptive statistics can be computed for most measured attributes. For continuous variables (e.g., percent cover, density, height, or DBH), summary statistics should include the mean, standard deviation, skewness, kurtosis, minimum and maximum values. These statistics provide information about the distribution and normality of the dataset. Normal probability plots (or quantile-quantile plots) will also be used to evaluate normality and outliers.

For categorical attributes such as presence/absence, different descriptions are appropriate. For species presence/absence, we will compute three measures of species richness (total, native, and nonnative), as well as a ratio (native richness:total species richness). For substrate type, we will display the data in a vertical bar chart showing the percent of points in each substrate type. Table 1 provides a list of recommended summary statistics based on the data collected.

For understory cover, 20% of the fixed plots will be re-read to assess measurement error. A paired t-test will be used to determine if significant measurement errors exist.

Table 1. List of recommended summary statistics and trend analysis methods, organized by vegetation attributes. Trend analysis is recommended for variables with asterisks next to them.

Vegetation Attribute	Plot Size (m)	Summary Statistics (Means & Var)	Trend Analysis
Presence/Absence	20 x 50 10 x 20	Total Species Richness* Native Species Richness* Nonnative Species Richness*Ratio (Native Richness:Total Richness)*	Chi-Square (P/A for some species) McNemar's Test (P/A for some species) Generalized Linear Model (Richness)
Understory Cover (<1 m; 1-2 m)	20 x 50 10 x 20	% cover for some species and life forms, native and nonnative (<1 m)* % cover for some species and life forms, native and nonnative (1-2 m)*	Generalized Linear Model*
Understory Cover - QC Tests	20 x 50 10 x 20	Paired t-test	N/A
Large Tree Density (DBH ≥10 cm)	20 x 50	# Trees/ha (all trees)* # Trees/ha (for some species)* # Native Trees/ha* # Nonnative Trees/ha* # Snags/ha* # Native Snags/ha* # Nonnative Snags/ha* # Boles/Tree (all trees) # Boles/Native Tree # Boles/Nonnative Tree DBH (all trees) DBH (for some species)* Percent of Trees with Damage Percent of Natives with Damage Percent of Nonnatives with Damage Percent of Trees Flowering/Fruiting Percent of Natives Flowering/Fruiting Percent of Nonnatives Flowering or Fruiting	Generalized Linear Model*
Tree Canopy Height	20 x 50	Canopy Height	none
Tree Fern Density (Diameter ≥10 cm)	10 x 25	# Tree Ferns/ha* # Tree Fern Snags/ha* Diameter	Generalized Linear Model*
Tree Fern Subcanopy Height	10 x 25	Subcanopy Height	none

Table 1. List of recommended summary statistics and trend analysis methods, organized by vegetation attributes. Trend analysis is recommended for variables with asterisks next to them.

Vegetation Attribute	Plot Size (m)	Summary Statistics (Means & Var)	Trend Analysis
Sapling Density	10 x 25	# Saplings/ha (all trees)* # Saplings/ha (for some species)* # Native Saplings/ha* # Nonnative Saplings/ha* # Dead Saplings/ha* # Dead Native Saplings/ha* # Dead Nonnative Saplings/ha* % Saplings with Damage % Native Saplings with Damage % Nonnative Saplings	Generalized Linear Model* (Continued)
Seedling Density	2 x 50	# Seedlings/ha* # Native Seedlings/ha* # Nonnative Seedlings/ha* % Seedlings in terrestrial substrate* % Native seedlings in terrestrial substrate* % Nonnative seedlings in terrestrial substrate*	Generalized Linear Model*
Shrub Density	2 x 50	# Shrubs/ha* # Native Shrubs/ha* # Nonnative Shrubs/ha* % shrubs in terrestrial substrate* % shrubs at maturity* % Native shrubs in terrestrial substrate % Native shrubs at maturity % Nonnative shrubs in terrestrial substrate % Nonnative shrubs at maturity	Generalized Linear Model*
Tree Fern Juvenile Density	2 x 50	# tree fern juveniles/ha (overall)* # tree fern juveniles/ha (some species)* % Native tree fern juveniles (if possible) % Nonnative tree fern juveniles (if possible) % tree fern juveniles in terrestrial sub. % Native tree fern juveniles in terrestrial substrate	Generalized Linear Model*
Coarse Woody Debris (CWD)	90 m of Transect; 70 m of Transect	# woody logs/ha # tree fern logs/ha Diameter woody logs Diameter tree fern logs % CWD	Generalized Linear Model*

* Generalized Linear Model encompasses repeated measures ANOVA and general linear mixed models.

Formulas for Continuous Data

In most sampling frames (except for mangrove forests) field crews will collect continuous data from both permanent and rotating plots. To compute statistics, we will use data from both plots types. Table 2 shows an excerpt of the rotational design from Skalski (2005).

Table 2. Rotational design with fixed and rotational sites.

Fixed	Rotational			
	Cycle 1	Cycle 2	. . .	Cycle C
x_{11}	y_{11}	y_{21}		y_{C1}
x_{12}	y_{12}	y_{22}		y_{C2}
x_{13}	$\vdots$	$\vdots$		$\vdots$
x_{14}	y_{1n}	y_{2n}		y_{Cn}
$\vdots$				
x_{1k}				

Using the notation above (where $x_{11},\ldots,x_{1k}$ represents data from fixed sample plots in year 1, $y_{11},\ldots,y_{1n}$ represents the rotating plots from year 1, etc.), the initial estimate of the population mean in year 1 is

$$\hat{\bar{X}}_1 = \frac{\left(\sum_{i=1}^{k} x_{1i} + \sum_{j=1}^{n} y_{1j}\right)}{(k+n)}, \qquad \textbf{Equation 1}$$

with an estimated variance of

$$\widehat{Var}\left(\hat{\bar{X}}_1\right) = \frac{\left(1-\frac{(k+n)}{N}\right) s^2_{\text{Pool}}}{k+n} \qquad \textbf{Equation 2}$$

where

$$s^2_{\text{Pool}} = \frac{\sum_{i=1}^{k}\left(x_{1i}-\hat{\bar{x}}_1\right)^2 + \sum_{j=1}^{n}\left(y_{1j}-\hat{\bar{y}}_1\right)^2}{k+n-1} \qquad \textbf{Equation 3}$$

and

$$\left(1-\frac{(k+n)}{N}\right) \qquad \textbf{Equation 4}$$

represents the finite population correction (FPC) factor (Skalski 2005). Note that the FPC factor is likely to equal one and probably can be ignored. In the second year of sampling the initial estimate of the population mean would be:

$$\hat{\bar{X}}_2 = \frac{\left(\sum_{i=1}^{k} x_{2i} + \sum_{j=1}^{n} y_{2j}\right)}{(k+n)}. \qquad \textbf{Equation 5}$$

According to Skalski (2005) the repeated measures from year 1 to year 2 can be used to improve the precision of the prior year's estimate (i.e., $\hat{\bar{X}}_1$) by regressing x_{1i} on x_{2i} (i.e., $x_{1i} = \alpha + \beta x_{2i} + \varepsilon_i$) to provide an alternative year 1 estimate:

$$\hat{\bar{X}}_1' = \hat{\alpha} + \hat{\beta}\left(\frac{\sum_{i=1}^{k} x_{2i}}{k}\right) = \hat{\alpha} + \hat{\beta}\bar{x}_2. \qquad \textbf{Equation 6}$$

With the two estimates for year 1 ($\hat{\bar{X}}_1$ and $\hat{\bar{X}}_1'$), the best year 1 estimate is a variance weighted estimate using the following Skalski (2005) formula:

$$\tilde{\bar{X}}_1 = \frac{\frac{1}{\mathrm{Var}\left(\hat{\bar{X}}_1\right)}\hat{\bar{X}}_1 + \frac{1}{\mathrm{Var}\left(\hat{\bar{X}}_1'\right)}\hat{\bar{X}}_1'}{\frac{1}{\mathrm{Var}\left(\hat{\bar{X}}_1\right)} + \frac{1}{\mathrm{Var}\left(\hat{\bar{X}}_1'\right)}}. \qquad \textbf{Equation 7}$$

As sampling continues, each year we can compute the current year's estimate, plus an adjusted estimate for the prior year.

Formulas for Discrete Data

This section applies to presence/absence (P/A) data and percent cover data in the two understory layers. Using discrete P/A values, species richness will be tabulated as the count (or number) of different species found in a given plot. Species richness is subdivided into native and nonnative species richness, and also expressed as the ratio of native species richness to total species richness. The terms below summarize this information:

$N_{total} =$ total species richness (count of total species in a plot),

$n_{native} =$ native species richness (count of native species in a plot),

$n_{nonnative} =$ nonnative species richness (count of nonnative species in a plot), and

$\frac{n_{native}}{N_{total}} =$ ratio of native species richness to total species richness.

For the two understory layers (<1 m and 1-2 m), percent cover will be computed using the point-intercept method for 300 points per plot. Based on the number of "hits" observed for a given species (or group of species, e.g., natives), percent cover will be computed as the number of "hits" observed divided by total number of "hits" possible, as described below:

$$Percent\ Cover_{species\ X} = 100\left(\frac{n_{observed}}{N_{possible}}\right), \qquad \textbf{Equation 8}$$

where $n_{observed}$ = the number of "hits" observed, and

$N_{possible} = 300$.

Aggregating Data from Multiple Sampling Frames

For plant communities with more than one sampling frame (e.g., the wet forest of HAVO and NPSA), scientists and managers often want to see the data aggregated for the entire plant community, not just a particular sampling frame within that community. In this case, the standard formulas for stratified random sampling apply where each sampling frame represents a different stratum within the plant community. For instance, data from the three wet forest sampling frames at HAVO can be combined to create overall statistics for the entire wet forest community. Following from Skalski (2005), the formula to compute the overall population mean from strata (or analogously, the plant community mean from multiple sampling frames) is:

$$\hat{\bar{X}} = \frac{\sum_{g=1}^{L} \hat{\bar{X}}_g \cdot A_g}{\sum_{g=1}^{L} A_g} = \sum_{g=1}^{L} \hat{\bar{X}}_g W_g \qquad \textbf{Equation 9}$$

where $\hat{\bar{X}}_g$ = estimate of the gth strata mean (expressed in consistent areal units such as m^2, km^2)

A_g = area of the gth stratum,

L = number of strata in the sampling frame, and

$W_g = \dfrac{A_g}{\sum_{g=1}^{L} A_g}$ = weight of the gth stratum.

The variance of $\hat{\bar{X}}$ is

$$\mathrm{Var}\left(\hat{\bar{X}}\right) = \sum_{g=1}^{L} W_g^2 \cdot \mathrm{Var}\left(\hat{\bar{X}}_g\right). \qquad \textbf{Equation 10}$$

Trends

In the framework of the rotating panel design, only monitoring data from permanent plots will be used for trend analysis. Of the attributes listed in Table 1, the ones with asterisks next to them will be analyzed for trend. The list of continuous variables includes plant community composition variables such as richness and structural variables such as percent cover and density (by layer, plant life form, size, and maturity level). Trends in categorical data (presence/absence) will be analyzed using the Chi-square goodness of fit test and McNemar's test of symmetry. These tests evaluate whether the proportion of plots with species presence changes between sampling periods. Based on initial monitoring data, the project lead will choose which species are appropriate for Chi-square and McNemar analysis.

Once two sampling periods of data exist for continuous attributes, parametric paired t-tests can be used to assess changes between sampling periods for continuous variables that meet the standard assumptions of normality and homogeneity of variance. Note that in terms of normality, it is the normality of residuals (not the normality of the raw data) that is required for significance testing (Kery and Hatfield 2003). After three or more sampling periods of data exist, repeated measures ANOVA can be used provided the standard assumptions are met. A more generally applicable method for assessing the effect of year on a response variable is to use a generalized linear model (GzLM) that can accommodate a variety of error structures.

Generalized Linear Model

Following from Schneider (2007) an initial GzLM model can be written as

$$N = \mu + \textit{Normal error} \qquad \textbf{Equation 11}$$

$$\mu = \beta_o + \beta_P \cdot P + \beta_{Yr} \cdot Yr \qquad \textbf{Equation 12}$$

where N = response variable (e.g., seedling density),

Yr = year (the categorical explanatory variable of interest), and

P = plot (the secondary explanatory variable for statistical control, also categorical).

Substituting the second equation into the first, we obtain the traditional general linear model (in this case, a two-way ANOVA) with normal error distribution. For data that meet the standard assumptions of normality and homogeneity of errors, the above model is adequate. However, when standard ANOVA assumptions are not met, the generalized linear model allows us to move from normal errors to other error distributions (e.g., negative binomial, gamma, etc.). A brief example follows (Schneider 2007).

Hypothetical response variable data for two years is presented in Table 3, while the same data reorganized for input into a GzLM routine is presented in Table 4. Both SAS and SPlus require data in the format shown in Table 4. Other statistical packages may have different input requirements.

Table 3. Sample response variable data for 20 plots after two years of monitoring.

Plot	Year 1	Year 2
1	222	171
2	125	101
3	69	57
4	92	161
5	121	792
6	97	121
7	153	119
8	609	360
9	147	93
10	135	130
11	32	73
12	113	200
13	51	48
14	62	92
15	78	105
16	26	35
17	10	6
18	5	10
19	59	62
20	87	48

Table 4. Reorganized response variable data for 20 plots after two years of monitoring.

Plot	Year	N
1	1	222
2	1	125
3	1	69
4	1	92
…	…	…
18	1	5
19	1	59
20	1	87
1	2	171
2	2	101
3	2	57
4	2	161
…	…	…
18	2	10
19	2	62
20	2	48

```
******************** GzLM with normal error structure *****************;

proc genmod data = Input_Data;
      class plot year;
      model N = plot year /
            link = identity
            dist = normal
            scale = deviance
            type1 type3;
OUTPUT out=RESPRED p=pred resraw=resraw;
run;

proc gplot data=RESPRED;            *plot residuals vs. predicted;
plot resraw*pred;
run;

proc univariate data = RESPRED normal plot;     *QQ plot, normality tests;
var resraw;
run;

******************** GzLM with gamma error structure ***********************;

proc genmod data = Input_data;
      class plot year;
      model N = plot year /
            link = identity
            dist = gamma
            scale = deviance
            type1 type3;
OUTPUT out=RESPRED2 p=pred resdev=resdev;
run;

proc gplot data=RESPRED2;           *plot deviance residuals vs. predicted;
plot resdev*pred;
run;
```

Figure 1. Sample SAS code to run a GzLM on the data in Table 3.

Based on the hypothetical data in Tables 3 and 4, Figure 1 contains the SAS commands required to run two different models, one with normal error structure and another with gamma error structure. The code also performs diagnostic tests on each model to evaluate its appropriateness. Since year has only two classes in our sample data, the first model represents a paired comparison design comparable to a paired t-test. The diagnostic tests on this model indicate that the residuals are neither normal (fig. 2), nor exhibit homogeneity of errors (fig. 3). Consequently, since the standard assumptions are violated, we cannot trust the p-values from this model.

The second model run in Figure 1 uses a gamma distribution to model the error structure, expressed in Equations 11 and 12. As a diagnostic test, scaled residuals, or deviance residuals, are plotted against the fitted values. In models with non-normal error structures, scaled residuals must be plotted instead of raw residuals. In the second model the deviance residuals are homogenous, the assumptions met, and the p-values reliable (Schneider 2007). Schneider

provides additional details on fitting models with different error structures and links (e.g., log links examine multiplicative effects while identity links examine additive effects).

Since the assumptions are met in this case, we can evaluate the null hypothesis (H_o: $\beta_{Yr1} = \beta_{Yr2}$, or alternatively expressed, H_o: Deviance$(\beta_{Yr}) = 0$) based on the analysis of deviance table. In SAS, either Type 1 or Type 3 analysis (more commonly used) can be used to evaluate the potential year effect on the response variable. Type 1 analysis provides a Chi-Square value for adding a year effect to all previous effects (intercept and plot), while Type 3 analysis evaluates the effect of removing the year effect from the complete model. In this case, the two types of analysis are identical (fig. 4). Schneider (2007) provides a more detailed interpretation of the analysis of deviance table and the GLzM output within the context of SPlus. Essentially Schneider recommends using a G-statistic to evaluate year effect, which in SAS terms corresponds to the Chi-square value. The only difference between Schneider's G-statistic and the SAS Chi-square value is that the SAS Chi-square is adjusted for the model's dispersion factor. In this example, the Chi-square value of 0.29 does not allow us to reject the null hypothesis for a year effect; consequently we must conclude that no significant year effect exists.

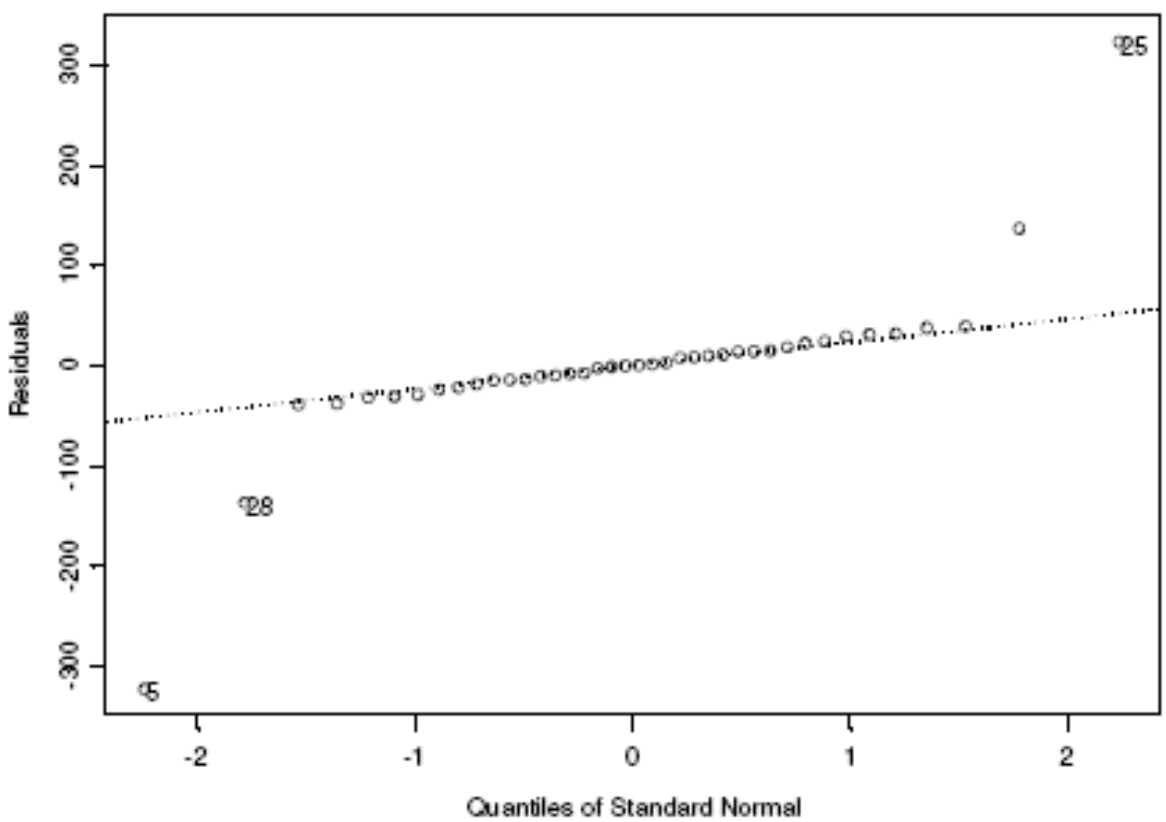

Figure 2. QQ-plot of residuals (from SPlus) for initial model with normal error structure. *Source:* Schneider 2007. Note that the residuals do not fall on a straight line and are not normal.

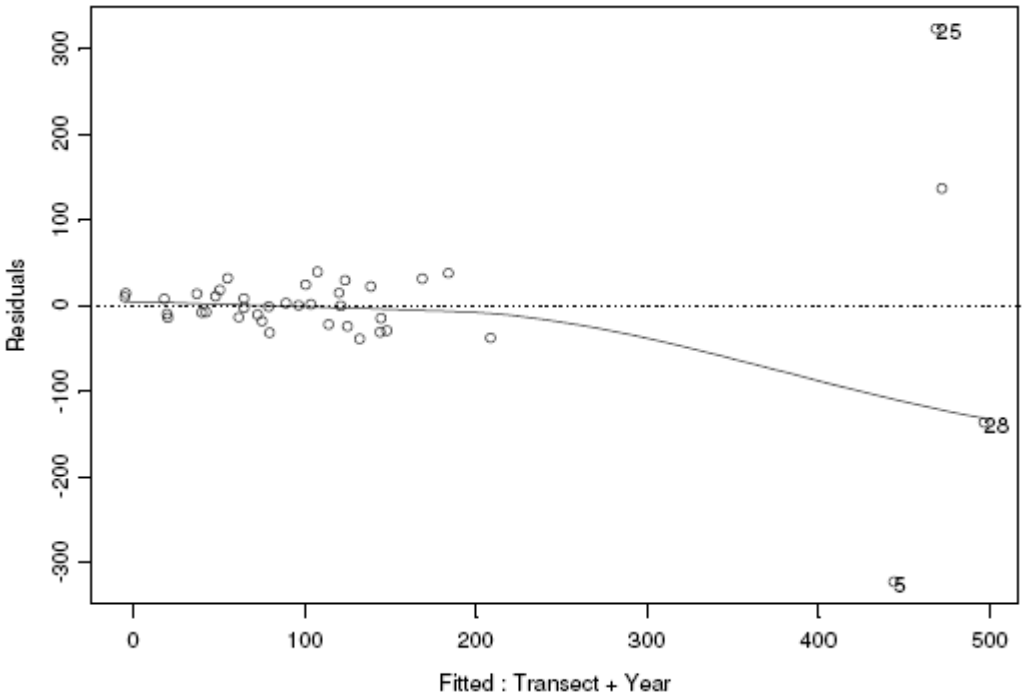

Figure 3. Plot of residuals against fitted values (from SPlus), showing increasing variance with larger fitted values. *Source:* Schneider 2007.

LR Statistics For Type 1 Analysis

Source	Deviance	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
Intercept	38.0509						
Plot	3.2793	19	19	10.77	<.0001	204.54	<.0001
Year	3.2300	1	19	0.29	0.5964	0.29	0.5901

LR Statistics For Type 3 Analysis

Source	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
Plot	19	19	10.66	<.0001	202.62	<.0001
Year	1	19	0.29	0.5964	0.29	0.5901

Figure 4. Analysis of deviance output, Type 1 analysis, and Type 3 analysis (most commonly used) for the model with gamma error, from SAS.

Literature Cited

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Standard Operating Procedure (SOP) #22

Reporting

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP provides an overview of the types of reports produced by the Pacific Island Network (PACN) Focal Terrestrial Plant Communities Monitoring Protocol. It also provides detailed information on generating the annual and 5-year monitoring reports. The purpose of the annual report is to summarize data for the current year, as well as compare the current year's data with data from previous years. The 5-year analysis report takes a more comprehensive approach, examining each year's data with respect to other plant communities, parks, the PACN network, and if possible the Pacific Region. These reports should be produced under the direction of the project lead.

Report Types

The annual and 5-year monitoring reports are part of a broad set of report categories, including (1) protocol reviews, (2) monitoring reports, (3) scientific writing and presentations, (4) management briefings, (5) website communication, and (6) interpretation and outreach. Table 1 describes these report types and their purpose, audiences, responsible parties, production frequency, and review processes.

Table 1. Summary of anticipated products from the Focal Terrestrial Plant Species Monitoring Protocol, grouped by type and frequency.

Type of Report	Purpose of Report	Targeted Audience	Initiated by	Frequency of Reporting	Review Process
1. Protocol Review					
Protocol Review Reports	Document progress made and challenges encountered, where actual procedures fall short or exceed expectations, recommend necessary changes. Document changes since last protocol review report. Document the overall quality of protocol in terms of protocol objectives and implementation, effectiveness, and data management.	Superintendents, park resource staff, I&M staff, external scientists, partners	Project Lead	Preliminary report within 1-3 years of implementation. Otherwise, at 5-year intervals after each monitoring cycle. Eventually, it may be possible to include this review in the 5-year Monitoring Report.	Peer review at network and regional level
2. Monitoring Reports					
Vital Signs Reports, Including Status and Trend Information	Document annual monitoring activities and survey effort, describe current resource status, discuss patterns and trends of monitored resources, present data analysis results. Document changes in monitoring protocol, communicate monitoring efforts to resource managers. For the 5-year report, use a more comprehensive scale of analysis including multiple plant communities, parks, networks, and regions. Also include an evaluation of sampling effort with respect to the monitoring objectives (i.e., power analysis).	Park resource staff, PACN staff, external scientists, partners	Project Lead	Annual reports compiled by April 30 each year. 5-year reports compiled by April 30 after each complete monitoring cycle.	Peer review at network level
Summary of Vital Sign Reports	Same as annual “Vital Signs Reports” above, but highlights key points for non-technical audiences. Usually this is a bulleted list.	Superintendents, NPS interpreters, public, partners	Project Lead	Annually, compiled by April 30 each year	Peer review at network level
PACN contribution to NPS-wide “State of the Parks” Report	Describes current conditions of park resources, reports interesting trends and highlights of monitoring activities, identifies resource issues of concern, explores future issues and directions	Congress, budget office, NPS leadership, Superintendents, general public	Compiled by the Washington Support Office (WASO) from data provided by networks	Annual	Peer review at national level

Table 1. Summary of anticipated products from the Focal Terrestrial Plant Species Monitoring Protocol, grouped by type and frequency. (Continued)

Type of Report	Purpose of Report	Targeted Audience	Initiated by	Frequency of Reporting	Review Process
3. Scientific Writing and Presentations					
PACN Vital Signs Monitoring Conference	Review and summarize information on this Vital Sign, help identify emerging issues and generate new ideas	Park resource staff, network staff, external scientists, partners	Project Lead, Park Scientists	Biennial	Peer review at national level
Scientific journal articles and book chapters	Document and communicate advances in knowledge, provides a broader perspective on quality assurance and peer review	External scientists, Park resource managers, and professional staff	Project Lead, Park Scientists	Variable	Peer review according to journal or book standards
Other symposia, conferences and workshops	Review and summarize information on this Vital Sign, help identify emerging issues and generate new ideas	External scientists, professional staff, Park resource managers, and other resource managers.	Project Lead, Park Scientists	Variable (e.g., Hawai‘i Conservation Conference)	Peer review at network level; for papers may also be peer reviewed
4. Management Briefings					
Executive briefings	Update Superintendents and other VIPs on park-specific findings and potential resource issues; suggest action items where appropriate	Individual Superintendents and other VIPs	Project Lead, Network Coordinator	As needed	Peer review by network and monitoring staff
5. Website Posting					
Web-based media	Centralized repository of all final reports and information to ensure products are easily accessible in commonly-used electronic formats (See SOP #20 “Product Posting and Distribution”)	Superintendents, Park resource staff, PACN staff, external scientists, partners, public	Typically Data Manager	As media is completed	Peer review at network level to NPS web standards as finalized, reviewed products
6. Interpretation and Outreach					
Science Days	Communicate main monitoring findings as well as underlying data; discuss potential significance for management, further monitoring, potential additional research needs, and for outreach	Superintendents, park resource staff, PACN staff, protocol managers, partners, public	Project Lead, Technicians, and others as needed	Variable by park, annual when possible	Meeting / presentation itself is a form of review

Table 1. Summary of anticipated products from the Focal Terrestrial Plant Species Monitoring Protocol, grouped by type and frequency. (Continued)

Type of Report	Purpose of Report	Targeted Audience	Initiated by	Frequency of Reporting	Review Process
Interpretive Conversations	Interactive conversations with park interpretive staff to discuss main monitoring findings as well as underlying data; discuss potential significance for management, further monitoring, potential additional research needs, and for outreach	Park interpretive staff, environmental educators, PACN staff	Project Lead, Technicians, and others as needed	Variable by park, annual when possible	Meeting / presentation itself is a form of review
Park Interpretive / outreach sessions	Review and summarize information on PACN Vital Signs; engage and involve greater participation in monitoring efforts	Park staff, public, partners	Project Lead, Technicians, and others as needed	Variable	Peer review by network, PICRP staff
Park staff meetings (results synthesis)	Communicate results to non-technical audiences, discuss potential significance for management, receive feedback on resource and monitoring issues in park operations	All park staff, volunteers, and partners, especially those not typically encountered in I&M program, RM, science operations	Project Lead, Technicians, and others as needed	Annually for each network park	Peer review by network

Monitoring Reports

The annual and 5-year monitoring reports are key elements in the reporting process. The list below provides information on producing these reports including minimal content requirements:

1. Reports should be written following the NPS Natural Resources Publications template, as described in SOP #19 "Product Delivery Specifications and Schedule."
2. The annual and 5-year I&M reports should be completed by April 30 in the year following the field season. See SOP #19 for the complete schedule of deliverables.
3. Report the following monitoring parameters for the current year, at a minimum:
   - List of field crew members who performed the monitoring
   - Detail of the survey effort (number of fixed and random stations sampled in each plant community and park)
   - List of species detected in each plant community and park
   - Summary statistics (i.e., richness, percent cover, density, etc.) listed in SOP # 21 "Data Analysis." If applicable, aggregate summary statistics for plant communities with more than one sampling frame (i.e., present statistics for each sampling frame and for the plant community as a whole).
   - Trend assessments for variables with asterisks next to them (see table 1, SOP #21). Trend analysis should be conducted for these parameters after two years of data is available. The project lead should conduct or supervise this analysis, in consultation with a contract statistician if necessary.
   - The current-year parameter values should be added to a table that lists similar measures for all monitored years.
4. Reports should include or be accompanied by maps of all sampling plot locations, including a table of UTM coordinates for all surveyed plots. Ideally many of the above plant community parameters should be presented in thematic maps to provide an indication of how these parameters vary spatially.
5. The 5-year report should provide the same information as the annual report, as well as:
   - Comparisons between different plant communities, parks, the PACN network as a whole, and if possible the Pacific Region (e.g., comparisons between wet forest plant community parameters at NPSA and wet forest parameters at HAVO, or a comparison of trends in native species density for all PACN parks).
   - A re-evaluation of sampling effort relative to the variability of parameters using standard power analysis to ensure that sample-size needs are sufficient to satisfy the sampling objectives. Power analysis should be used to determine if sampling effort should be adjusted to better achieve the objectives. Methods for power analysis as well as mathematical equations are provided in Appendix C of the PACN Focal Terrestrial Plant Communities Monitoring Protocol.
   - An evaluation of the operational aspects of the monitoring protocol
6. The project lead should provide a copy of the report and associated data to the PACN data manager for archiving. See SOP #19 for additional details on managing digital data and reports.

Standard Operating Procedure (SOP) #23

Revising the Protocol

Version 1.0 (January 28, 2011)

Change History

Version #	Date	Revised by	Changes	Justification

Only changes in this specific SOP will be logged here. Version numbers will be incremented by a whole number (e.g., Version 1.3 to Version 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.6 to Version 1.7) when there are minor modifications that do not affect requirements or procedures for publication in the series.

Purpose

This SOP explains how to make and document changes to the narrative and associated SOPs for the Pacific Island Network (PACN) Focal Terrestrial Plant Communities Monitoring Protocol. Anyone editing the Protocol Narrative or any one of the SOPs needs to follow this outlined procedure in order to eliminate confusion in how data is collected, managed, analyzed, or reported. All field crew members should be familiar with this SOP in order to identify and use the most current methodologies.

Procedure

The Focal Terrestrial Plant Communities Monitoring Protocol narrative and associated SOPs for the PACN represent our effort to document and employ scientifically rigorous methodologies for collecting, managing, analyzing, and reporting monitoring data and information. However, all protocols regardless of initial rigor require editing as new and different information becomes available. Required edits should be made in a timely manner and appropriate reviews undertaken. Careful documentation of changes to the protocol, and a library of previous protocol versions are essential for maintaining consistency in data collection, and for appropriate treatment of the data during data summary and analysis. The MicroSoft Access database for each monitoring component contains a field that identifies which version of the protocol was being used when the data were collected.

In this context of revising the protocol, the rationale for dividing this into a Protocol Narrative with supporting SOPs is based on the following:

- The Protocol Narrative is a general overview of the protocol that gives the history and justification for monitoring and an overview of the sampling methods, but does not provide all of the methodological details. The Protocol Narrative will only be revised if major changes are made to the protocol.
- The SOPs, in contrast, are very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the Protocol Narrative.
- When a SOP is revised, in most cases, it is not necessary to revise the Protocol Narrative to reflect the specific changes made to the SOP.
- All versions of the Protocol Narrative and SOPs will be archived in a Protocol Library.

All edits require review for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by Pacific Island Network staff (e.g. version changes by hundredths). However, if a complete or major change in methods is sought, then an outside review may be required (e.g. version changes by whole numbers). When a major change in methodology is undertaken, either to the entire protocol or individual SOP or narrative components, The Pacific West Region Inventory and Monitoring Program coordinator will be consulted to determine the appropriate level of peer review required. Typically, Regional and National staff of the NPS, and outside experts in government, private sector, and academia with familiarity in plant community monitoring in Pacific Islands will be utilized as reviewers.

1. Edits and revisions to the protocol narrative and associated SOPs will be documented by version in the Change History table that is found on the first page of each SOP and 2nd page of the protocol narrative document. Log changes in the protocol narrative or SOP being edited only. Version numbers increase incrementally by hundredths (e.g., version 1.01, version 1.02, etc.) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0, etc.). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.
2. Inform the data manager about changes to the Protocol Narrative or SOP so the new version number can be incorporated in the Metadata of the project database. The database may have to be edited by the data manager to accompany changes in the Protocol Narrative and SOPs.
3. Any changes to associated database design and organization are documented in the Metadata of the project database(s).
4. The appropriate PACN staff is notified of the changes and appropriate level review process initiated as determined in collaboration between the network staff and protocol principal investigator.
5. Once review comments are received and incorporated, post revised versions on the internet and forward copies to all individuals so they can replace previous versions of the effected Protocol Narrative or SOP. Provide a copy to the PACN data manager so it can be included in the network's protocol library.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 988/108005, June 2011

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U.S. Department of the Interior

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