



Vegetation Inventory Project

War in the Pacific National Historical Park

Natural Resource Report NPS/PACN/NRR—2014/807



ON THE COVER

Japanese coastal defense gun relicts at WAPA.
Photograph by: National Park Service.

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Executive Summary

War in the Pacific National Historical Park (WAPA) encompasses approximately 803 ha (1984 ac) on the western side of the island of Guam in the Pacific Ocean. Numerous historic sites and remnant bunkers, pill boxes, gun emplacements and Japanese fortifications are protected throughout the seven discontinuous units. WAPA supports over 390 vascular plants (Yoshioka 2008) and examples of coastal vegetation, lowland rainforest, and freshwater marsh plant species. The landscape of WAPA endured extensive degradation during World War II and as a result many of the communities are dominated by non-native species. For example, savannas dominated by non-native species burn every few years, further degrading soil and inhibiting succession into secondary forests. Frequent tropical storms and typhoons also impact the vegetation influencing canopy height and species composition across communities. All of the vegetation communities within WAPA are disturbed and support a mix of native and non-native species. To better understand the distribution of the plant assemblages located on this site, the National Park Service Pacific Island Network (PACN) Inventory and Monitoring Program started a vegetation inventory effort at WAPA in 2009.

A three-year, four phase program was initiated to complete the task of mapping and classifying the vegetation at WAPA. Phase one conducted by PACN staff in 2009 collected 40 field plots and 34 observation points. In phase two, NatureServe's Western Regional Office used these field data to classify 13 new plant associations for WAPA based on the revised U.S. National Vegetation Classification (USNVC). Phase three, directed by Cogan Technology Inc. (CTI) produced a digital vegetation map and supporting accuracy assessment (AA) materials. In the final phase, PACN staff collected 150 accuracy assessment points in 2010 to check and finalize the map.

To produce the spatial database and map layer, 0.6-meter, 4-band Quickbird satellite imagery from 2005 was provided by PACN. By comparing the signatures on the imagery to field and ground data 43 map classes (25 vegetated, three barren, and 15 land-use / land-cover) were developed and directly crosswalked or matched to their corresponding USNVC plant associations. The interpreted and remotely sensed data were converted to Geographic Information System (GIS) databases and maps were printed, field tested, reviewed, and revised. The final map layer was accessed for thematic accuracy by overlaying 150 independent accuracy assessment points. The final overall accuracy of the map layer was determined to be 84% with a Kappa value of 88%.

Products developed for WAPA are described and presented in this report, as well as stored on the accompanying DVD. These include:

A final report that includes keys to the vegetation and imagery signatures, AA information, and all of the project methods and results;

- A spatial GIS database containing spatial data for the vegetation, plots, and AA points;
- Digital photos from the field sampling efforts;
- Metadata for all spatial data (Federal Geographic Data Committee -compliant);

- Vegetation descriptions and photo signature key to the map classes and associations/alliances.

Please access the following website for posting of this information:

<http://science.nature.nps.gov/im/inventory/veg/products.cfm>

Acknowledgments

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

We are grateful to the staff at War in the Pacific National Historical Park, specifically Michael Gawel and Jenny Coffman, who went out of their way to assist with field checking, assisting the field crews and providing expert advice. They were very professional and extremely helpful throughout the process.

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Introduction

National Vegetation Inventory Program

The National Vegetation Inventory Program (NVIP) was joined as a cooperative effort between the National Park Service (NPS) and the United States Geological Survey (USGS) to classify, describe, and map existing vegetation communities in more than 270 national parks across the United States. The primary objective of the NVIP is to produce high-quality plant community classifications, standardized maps and associated data sets of the vegetation currently occurring within the parks. This information fills data gaps and complements a wide variety of resource assessments, park management, and conservation needs. Among its many uses, the NVIP products have helped park managers better identify and conserve plant biodiversity; manage non-native and rare species, monitor insect and disease effects; and provide a baseline to examine wildlife habitat relationships and the effects of wildland fires.

In 1999, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation's natural heritage through science, natural resource inventories, and expanded resource monitoring. The Natural Resource Challenge provided funding for 12 baseline inventories to be completed in each of 270 parks with significant natural resources. The vegetation mapping inventory is considered one of these 12 baseline inventories.

NVIP follows well-established procedures that are compatible with other agencies and organizations. The inventory uses the United States National Vegetation Classification (USNVC), a system that is integrated with the major scientific efforts in the taxonomic classification of vegetation, and is a Federal Geographic Data Committee (FGDC) standard. In addition, stringent quality control procedures ensure the reliability of these vegetation data and encourage the use of resulting maps, reports, and databases at multiple scales.

A complete vegetation mapping project for a park includes the following products:

- Detailed vegetation report
- Digital vegetation map
- Vegetation plot data
- Accuracy assessment data and analysis
- Dichotomous vegetation key
- Photo-interpretation key

Maps are produced in the World Geodetic System datum 1984 (WGS84) and projected using a Universal Traverse Mercator (UTM) zone 55 N specific to Guam and Saipan. Maps are 1:24,000 with a minimum mapping unit (MMU) of 0.5 ha (1.2 ac). The vegetation maps must meet the National Map Accuracy Standards for positional accuracy, and the minimum class accuracy goal across all vegetation and land cover classes of 80 percent.

National Vegetation Classification Standard

In 1994, NPS formed the NVIP to inventory and map the vegetation in the United States National Parks. Shortly thereafter, the USGS joined into a partnership, which continues to operate today. The goals of this program are to provide baseline ecological data for park resource managers, obtain data that can be examined in a regional and national context, and provide opportunities for future inventory, monitoring, and research activities. In the same year, the NVIP also adopted the U.S. National Vegetation Classification (USNVC) (Grossman et al. 1998) as a basis for the *a priori* definition of vegetation units to be inventoried. The USNVC has since been revised by NatureServe and a number of Federal agency partners, and in 2008 the FGDC formally endorsed the revised U.S. National Vegetation Classification Standard (USNVCS) (FGDC 2008).

Use of a standardized vegetation classification system, such as the USNVC helps ensure data compatibility throughout the NPS and other agencies (FGDC 2008). This is critical for a systematic inventory and classification of the nation's biological resources. The USNVC is being used for vegetation classification and mapping projects at War in the Pacific (WAPA) and other Pacific Island Inventory and Monitoring Network (PACN) parks. It evolved from the original USNVC, which was developed jointly by The Nature Conservancy (TNC), NatureServe, and the Natural Heritage Program network over more than two decades (TNC and ESRI 1994a, Grossman et al. 1998) and adopted in part by the FGDC (1997).

The USNVC is a hierarchical system that allows for vegetation classification at multiple scales (FGDC 2008). There are eight levels with specific criteria set for each level (Table 1). The upper three levels are based on climate and physiognomic characteristics that reflect geographically widespread (global) topographic and edaphic factors. The middle three levels focus largely on broad sets of diagnostic plant species and habitat factors along regional-to-continental topographic, edaphic, and disturbance gradients. These middle levels have been drafted and are undergoing peer review. The lower two levels, as in the original USNVC, are the alliance and association and are distinguished by differences in local floristic composition. The broader alliances are physiognomically distinct groups of plant associations sharing one or more differential or diagnostic species (Mueller-Dombois and Ellenberg 1974). These are commonly the dominant(s) found in the uppermost strata of vegetation. The plant association is the fundamental base unit of the classification, and following the International Botanical Congress of 1910, is defined as a community of definite floristic composition (i.e., a repeating assemblage of species), uniform physiognomy and habitat conditions (Mueller-Dombois and Ellenberg 1974).

The USNVC is maintained by NatureServe and the network of affiliated Natural Heritage Programs and Conservation Data Centers for use by government agencies and the public (Faber-Langendoen et al. 2009). The USNVC database allows for tracking of vegetation at all scales and provides narrative descriptions of many alliances and associations (Faber-Langendoen et al. 2009). Descriptions of Macrogroups and Groups are being written in three phases, and are undergoing a formal peer-review process; currently Macrogroup descriptions are being drafted and sent out for peer-review (Faber-Langerndoen et al. 2009, Faber-Langendoen et al. 2010-2013, Franklin et al. 2012). The content of this database is available to the public and is regularly updated through NatureServe Explorer (<http://www.natureserve.org/explorer>).

Table 1. Summary of USNVC Hierarchy Levels and Criteria for Natural Vegetation.

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

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

These USNVC associations and alliances are commonly used for vegetation inventory projects. Their use within the NVIP facilitates effective resource stewardship by ensuring compatibility and widespread use of the information throughout the NPS as well as by other federal and state agencies. These vegetation maps and associated information support a wide variety of resource assessment, park management, and planning needs. In addition they can be used to provide a

structure for framing and answering critical scientific questions about vegetation communities and their relationship to environmental conditions and ecological processes across the landscape.

Pacific Island Network, Inventory and Monitoring Program

PACN was established to provide an efficient means of carrying out expanded natural resource inventory and monitoring activities for 10 national parks within the Pacific Ocean (Figure 1). The World War II Valor in the Pacific National Monument (VALR) is sometimes considered part of the PACN although there are no significant natural resources and thus no PACN activity. Currently, PACN contains a mixture of both small and large parks including Ala Kahakai National Historic Trail (ALKA), American Memorial Park (AMME), Haleakalā National Park (HALE), Hawai‘i Volcanoes National Park (HAVO), Kalaupapa National Historical Park (KALA), Kaloko-Honokōhau National Historical Park (KAHO), National Park of American Samoa (NPSA), Pu‘uhonua o Hōnaunau National Historical Park (PUHO), Pu‘ukoholā Heiau National Historic Site (PUHE), and War in the Pacific National Historical Park (WAPA). The larger parks, HAVO, HALE, and KALA are located on the islands of Hawai‘i, Maui, and Moloka‘i, respectively and VALR (formally the USS Arizona Memorial) is located on the island of O‘ahu. NPSA spans three American Samoa Islands and the smaller parks KAHO, PUHE, and PUHO along with the ALKA are located on the island of Hawai‘i. AMME is located on the island of Saipan, and WAPA is located on Guam. All of the parks in the PACN occur on remote islands ranging from approximately 4,000 to 10,000 km (2,500 to 6,200 mi) west and southwest of the United States mainland.

PACN personnel are involved in numerous activities including organizing and cataloging data, data analysis and synthesis, modeling, providing data and expertise to national park planners, providing data and expertise for resource assessments and resource stewardship strategies, and contributing to performance reporting. The Inventory and Monitoring (I&M) program is a key source and supplier of reliable, organized, and retrievable information about the Pacific island parks. The program’s primary responsibilities include facilitating baseline inventories, collecting, managing, analyzing and reporting long-term data on vital signs (indicators of resource condition), and effective delivery of data and information on resource condition to park managers, planners, interpreters, and other key audiences. Data and reports for PACN program projects can be accessed online at: <http://science.nature.nps.gov/im/units/pacn/index.cfm>.

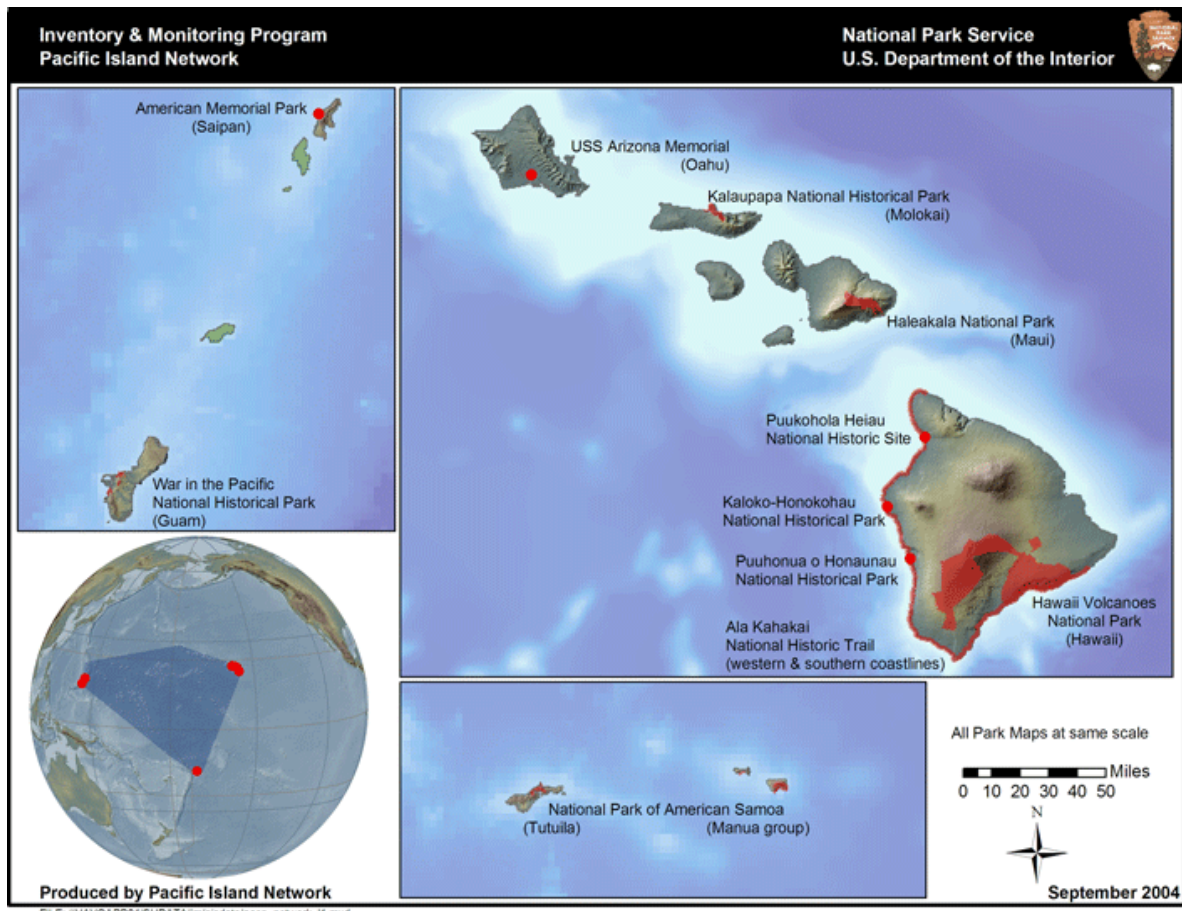


Figure 1. The 11 national parks included within the Pacific Island Network.

War in the Pacific National Historical Park

WAPA was established in 1978 to commemorate the Pacific theater campaigns during World War II (WWII). WAPA encompasses 803 ha (1984 ac) in southwestern Guam, an unincorporated territory of the United States. Terrestrial systems are represented by 400 ha (989 ac) while the remaining 403 ha (995 ac) protects marine communities. WAPA is comprised of seven discontinuous units ranging from sea level to nearly 300 m (984 ft) in elevation and spanning across numerous vegetation communities. From north to south, the units are Asan Beach, Asan Inland, Fonte Plateau, Piti Guns, Agat, Mount Chachao-Mount Tenjo and Mount Alifan (Figure 2; Yoshioka 2008, Whistler 2009, Evans-Hatch and Associates, Inc. 2004).

Asan Beach is comprised of 32 ha (79 ac) of land on the ocean-side of Marine Corps Drive and 175 ha (433 ac) of offshore waters. The Liberator's Memorial, Asan Memorial beach, private homes and businesses occupy much of the terrestrial land of this unit which spans from Asan Point (west) to Adelup Point (east). The Matgue River empties into the ocean on the western side of Asan Beach while the Asan River empties in the center of Asan Bay (Yoshioka 2008, Whistler 2009, Evans-Hatch and Associates, Inc. 2004, <http://www.nps.gov/wapa/planyourvisit/asan-beach-unit.htm>).

Asan Inland is the largest park unit, composed of 220 ha (545 ac) ranging from near sea level to 150 m (492 ft). The coastal highway Route 1 and Asan village border the western boundary of

the park, while the eastern and southern boundaries are accessible from Route 6. Remnant Japanese defense fortifications (pill boxes and gun installations) reside within this unit along with bronze statues that depict the events on Guam during Japanese occupation in 1941-1944 (Yoshioka 2008, Whistler 2009, Evans-Hatch and Associates, Inc. 2004, <http://www.nps.gov/wapa/planyourvisit/asan-bay-overlook.htm>).

Fonte Plateau, located along Route 8, protects 14 ha (35 ac) on Nimitz (named Fonte Plateau prior to WWII) and overlooks Asan Beach. The Japanese occupied a cave which was used as a command post in WWII. Elevation ranges from 140-195 m (459-640 ft); much of the land is an unvegetated quarry (Yoshioka 2008, Whistler 2009, Evans-Hatch and Associates, Inc. 2004, <http://www.nps.gov/wapa/planyourvisit/fonte-plateau-unit.htm>).

Piti Guns encompasses 39 ha (96 ac) of hilly terrain above the village of Piti. The unit spans from 12-104 m (39- 341 ft) and a small section of the Taguag River runs through the eastern side. This site encompasses some of an experimental agricultural station that was in use from 1909-1932. The unfired Japanese cannons draw in many visitors to this unit (Yoshioka 2008, Whistler 2009, Evans-Hatch and Associates, Inc. 2004, <http://www.nps.gov/wapa/planyourvisit/piti-guns.htm>).

The Agat unit encompasses 14 ha (35 ac) land area and 228 ha (562 ac) of coastal water including 2 km (1.2 mi) of shoreline and three subunits ranging from sea level to 10 m (33 ft). Apaca Point subunit lies north of the Namu River mouth and includes the Pelagi Islets. Ga'an Point is a large lawn area by the mouth of Salinas River. The United States forces included Ga'a point as part of a southern landing site during WWII. Bangu Point subunit is on the shore adjacent to Inaso Maso Village. The small islets of Alutomm, Yona, and Bangi are included in the Bangu Point subunit (Yoshioka 2008, Whistler 2009, Evans-Hatch and Associates, Inc. 2004, <http://www.nps.gov/wapa/planyourvisit/gaan-point.htm>).

Mt. Chachao-Mt. Tenjo runs along a narrow ridge corridor between the two peaks. Japanese forces used this high, 18 ha (45 ac) vantage point during WWII to view Apra Harbor and Orote Point. This unit spans from 268-318 m, (879-1043 ft) to the summit of Mt. Chachao (Yoshioka, 2008, Whistler 2009, Evans-Hatch and Associates, Inc. 2004, <http://www.nps.gov/wapa/planyourvisit/chachaotenjo.htm>).

Mt. Alifan unit lies on the western slopes of Mt. Alifan (265 m, 869 ft) above the village of Agat, adjacent to and west of the village of Santa Rita. This unit encompasses 62 ha (154 ac) and ranges from 10-180 m (32-600 ft) in elevation. It was the site of a Japanese command post, including remnant fox holes, trenches, and bomb craters from numerous battles during WWII (Yoshioka 2008, Whistler 2009, Evans-Hatch and Associates, Inc. 2004, <http://www.nps.gov/wapa/planyourvisit/alifan-unit.htm>).

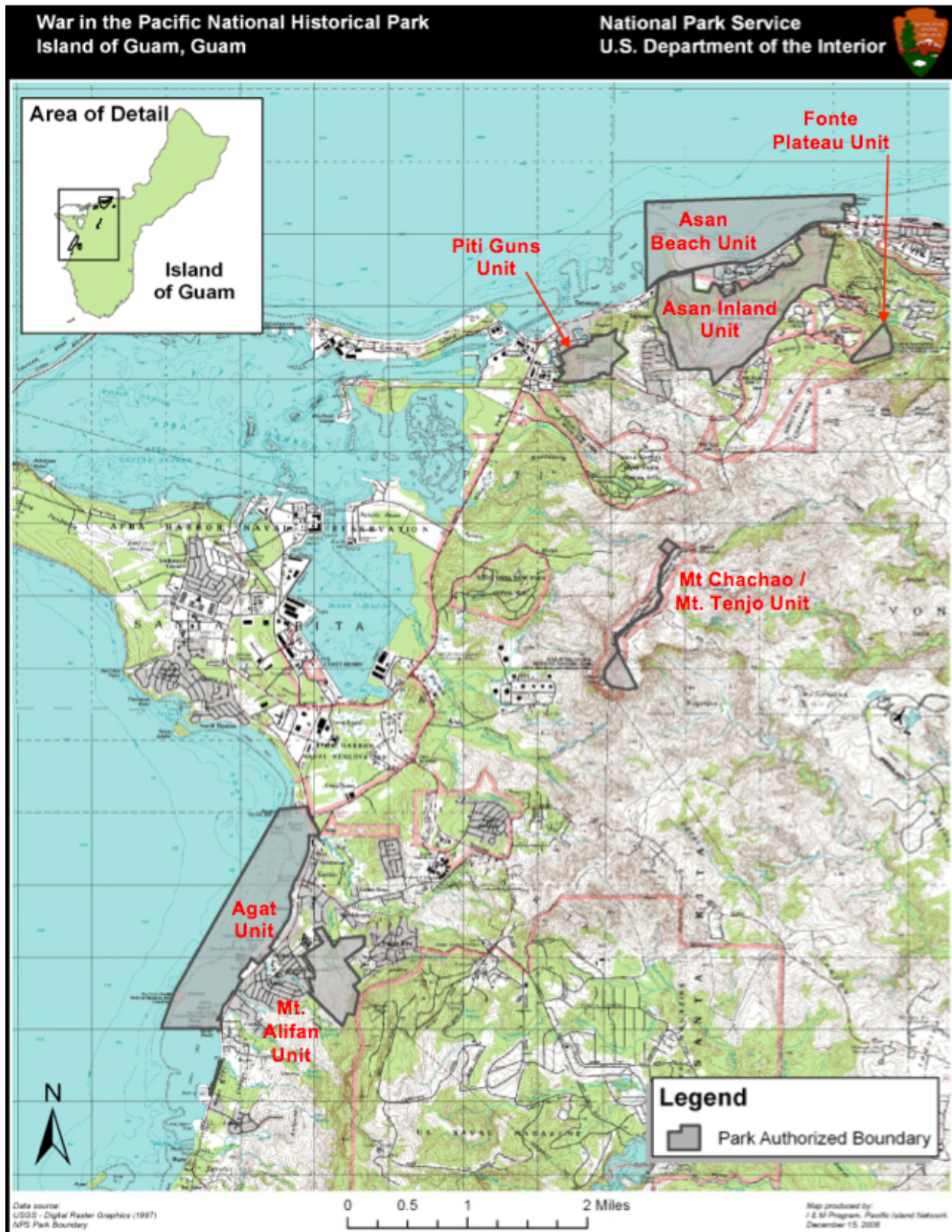


Figure 2. NPS War in the Pacific National Historical Park map.

Natural Setting

WAPA has a warm, tropical climate with an average daily temperature of 27°C (80°F) and 81% humidity (NPS 1997). Temperature and humidity are lowest during the dry season (December-June) when the westerly trade winds are persistent (average daily wind 7.9 knots; NPS 1997). Guam receives 2000-2750 mm (80-110 in) of rain annually, over half of which falls during the wet season (July-November; Whistler 2009). Guam is annually affected by tropical storms and/or typhoons, which can develop within 72 hours in the northwest Pacific Ocean during any time of the year (NPS 1997). This weather cycle marked by heavy wind and rainfall strongly influences species composition, growth habit, and patterns of succession.

Guam is the largest and southernmost island of the Mariana archipelago. Southern Guam is composed of old volcanic rock with few limestone deposits, while the northern portion of Guam is entirely uplifted limestone plateau, set upon a submerged volcanic base. Topographically, southern Guam is composed of mountainous and rugged terrain with steep slopes dropping to low-lying plains and valleys. Elevation varies from sea level to 318 m (1043 ft; Whistler 2009). Much of WAPA's substrate is volcanic in origin and composed of shallow, acidic, purple, red or yellow clay. Argillaceous limestone soil is common in the inland park units, while marshes and valley bottoms have deep, alluvial soil and clay rich in organic matter (Mueller-Dombois and Fosberg 1998).

Vegetation

The flora of Guam has been previously documented, dating back to floral collections made by the Spanish in the 1700's. The only floral survey work specific to WAPA was conducted by Yoshioka (2008) which reported 392 vascular plants in WAPA. Native species comprise 44% (173) of all species in WAPA and of these native plants, 8.7% (15) are endemic and 91.3% (158) are indigenous to Guam (Yoshioka 2008).

Fosberg's *Vegetation of Micronesia* (1960) described nine vegetation types for Guam; while more recent work by Mueller-Dombois and Fosberg (1998) classified six vegetation types specific to Guam. This work has been used as an ancillary classification in subsequent work completed by Stone (1970), Liu and Fischer (2005), and Yoshioka (2008). Whistler (2009) summarized all previous work and describes seven vegetation communities within WAPA. In this project, the terrestrial vegetation of WAPA can be classified into five basic life zones: limestone forest, ravine forest, beach and coastal strand, savanna complex, marshland and swampland (Figure 5). One or more of these representative community types is found in each of the seven management units (Figure 3,4).

Both limestone and ravine forest communities have seen varying degrees of degradation and were much more extensive prior to human occupation with only remnant pockets of forest remaining. Today these communities occur in valleys, gulches (ravine forest), steep slopes and ridge tops (limestone forest) across varying substrates of volcanic clay and limestone soil and rock within Asan Inland, Fonte Plateau, Piti Guns, Mt Chachao-Mt Tenjo and Mt. Alifan units at WAPA (Figure 5). Non-native tangan-tangan (*Leucaena leucocephala*), palma brava (*Heterospathe elata*), limeberry (*Triphasia trifolia*), and native gagu (*Casuarina equisetifolia*), lada (*Morinda citrifolia*), gasoso (*Colubrina asiatica*), hau (*Hibiscus tiliaceus*), and kafu (*Pandanus tectorius*) are common associates in limestone and ravine forest communities. Trees are often short-statured due to heavy winds generated by frequent typhoons and tropical storms.

Many plantations and planted ornamentals have been abandoned and have established semi-natural forests within WAPA. Forests of broad-leaved mahogany (*Swietenia macrophylla*), mango (*Mangifera indica*) and smallflower chastetree (*Vitex parviflora*) are remnant plantations with various understory woody and herbaceous species. African tulip tree (*Spathodea campanulata*) and piao palaoana (*Bambusa vulgaris*) are often planted near homes as ornamentals and have spread in some localized areas within several inland units of WAPA.

Coastal strand communities exist within Agat and Asan Beach units (Figure 5) as near shore, low slope environments with sandy, rocky, or limestone substrates. Like all communities within WAPA, native and non-native herbaceous and woody species intermix. Non-native species; tangan-tangan, Bermuda grass (*Cynodon dactylon*) and native species; gagu, tronkon niyok (*Cocos nucifera*), hau, milo (*Thespesia populnea*), and nanaso (*Scaevola taccada*) are typical coastal vegetation components. Areas surrounding shorelines, parking lots, and buildings are manicured lawns of native inifuk (*Chrysopogon aciculatus*) and non-native grasses such as Australian beardgrass (*Bothriochloa bladhii*).

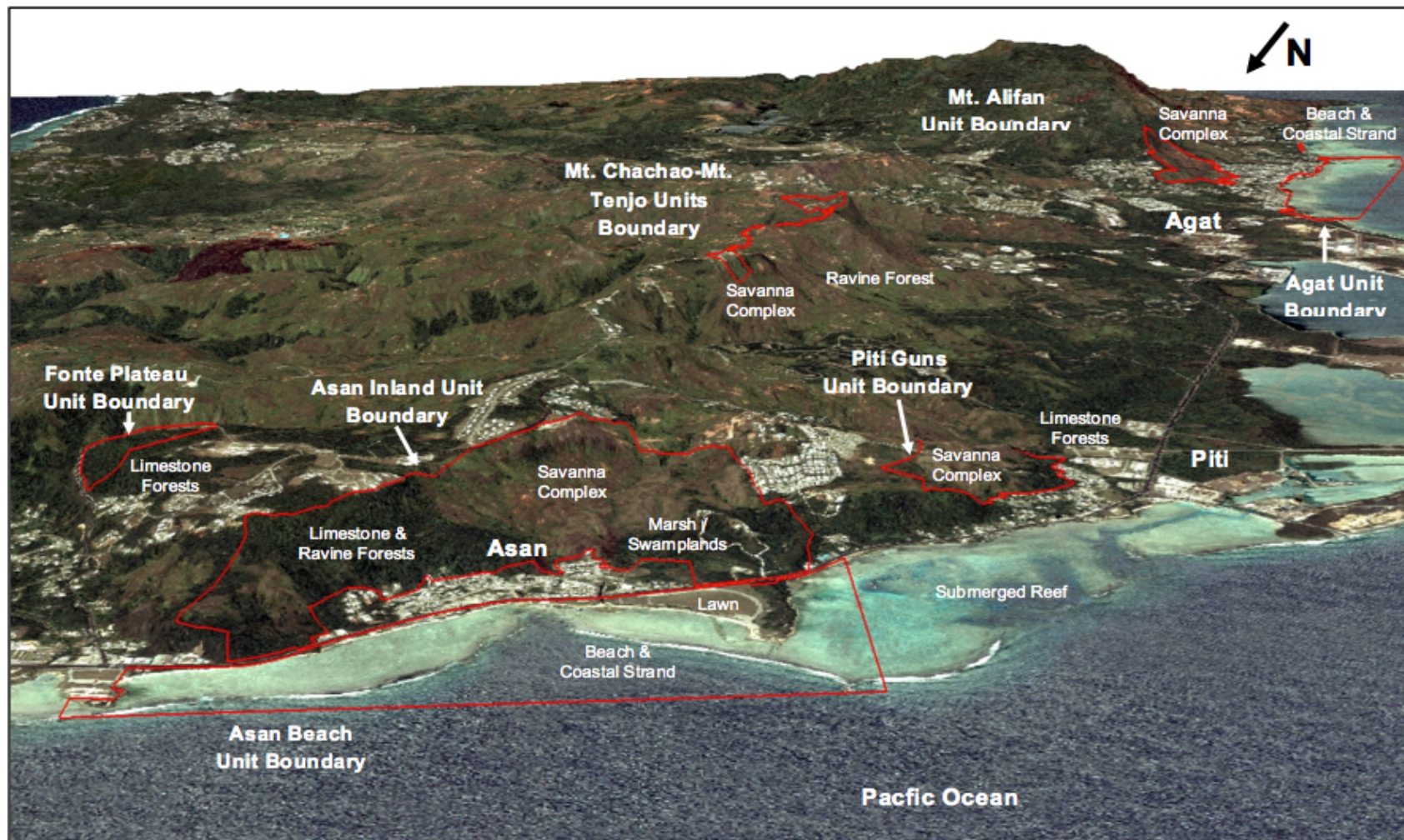
Savanna complexes are common within WAPA and can be found in four units: Mt. Chachao-Mt. Tenjo, Asan Inland, Piti Guns and Mt. Alifan (Figure 5; Yoshioka 2008). Through land conversion and the establishment of fire-tolerant (pyrophytes) grasses, fire regimes have become a regular successional component to savanna communities (Mueller-Dombois and Fosberg 1998 and Whistler 2009). Deliberate fires have perpetuated fire frequency and thus strongly fire tolerant grass species dominate. Today, savanna communities are dominated by a mix of both non-native and native herbs such as mission grass (*Cenchrus polystachios*; non-native), and neti (*Miscanthus floridulus*; native), and native woody species such as gagu.

Freshwater marshes and swamplands occupying low-lying, saturated substrates have herbaceous plants including both non-native and native dominated communities. Communities of non-native species are dominated by chain-of-love (*Antigonon leptopus*) and guinea grass (*Urochloa maxima*) with various native herbs present. Native freshwater marsh communities are found in the Asan, Fonte Plateau Agat and Mt. Alifan units and are dominated by the herbs karriso (*Phragmites karka*), alalag-tasi (*Ipomoea pes-caprae*) and neti (Figure 5).

Much of the vegetation of WAPA has been degraded through both anthropogenic and natural pressures. Non-native species represent 55% of the vegetation found within WAPA, (Yoshioka 2008) and pose a threat to native flora and communities. Although the number of native species varies across WAPA's units; today there are no units consisting of greater than 75% native species cover. Yoshioka (2008) recorded the percent of native species by unit and found Mt Chachao-Mt. Tenjo had the highest percent of native species (54%); while Piti Guns had the lowest (34%).

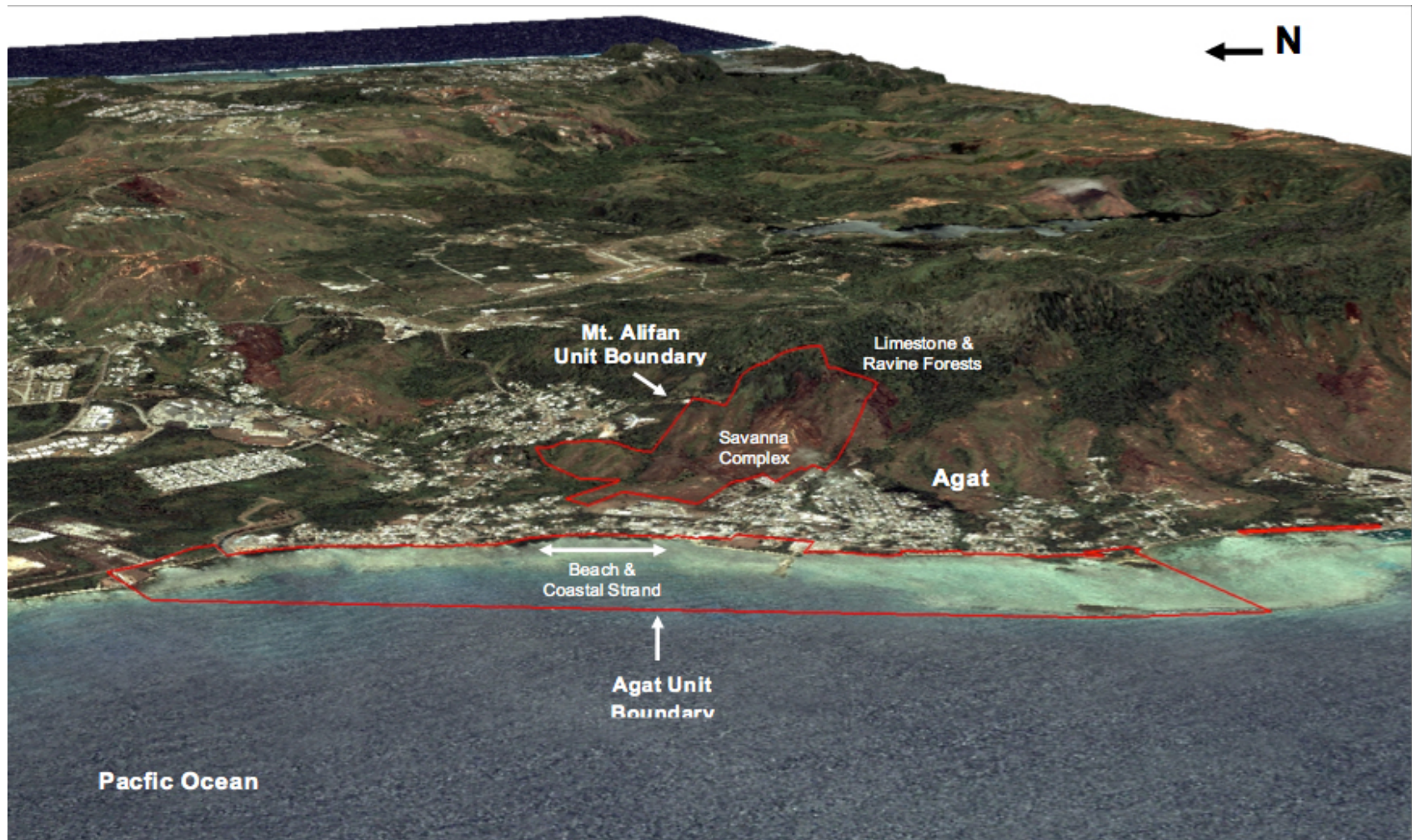
Although restoration efforts at WAPA have been limited, the recent infestation of the coconut rhinoceros beetle (CRB; *Oryctes rhinoceros*) has received some control efforts. The CRB was first recorded in Guam in 2007 and has since spread into WAPA (Moore 2008). The CRB can kill a tronkon niyok tree within a year, and thus poses an immediate threat to coastal strand communities within WAPA and Guam. According to Mike Gawel (personal communication, October 30, 2012), in 2013, several CRB infested tronkon niyok trees were removed from the Asan Beach unit due to the safety hazard imposed by trees shedding dead plant material. In

addition to tronkon niyok, the CRB is known to attack *Pandanus* spp. and some agricultural species (Moore 2008). All units at WAPA are in the CRB infestation area, and with a high potential to spread and inflict environmental and economic damage (Moore 2008). Future control efforts of the CRB will likely alter the landscape of WAPA, particularly along the beach strand where tronkon niyok is landscaped.



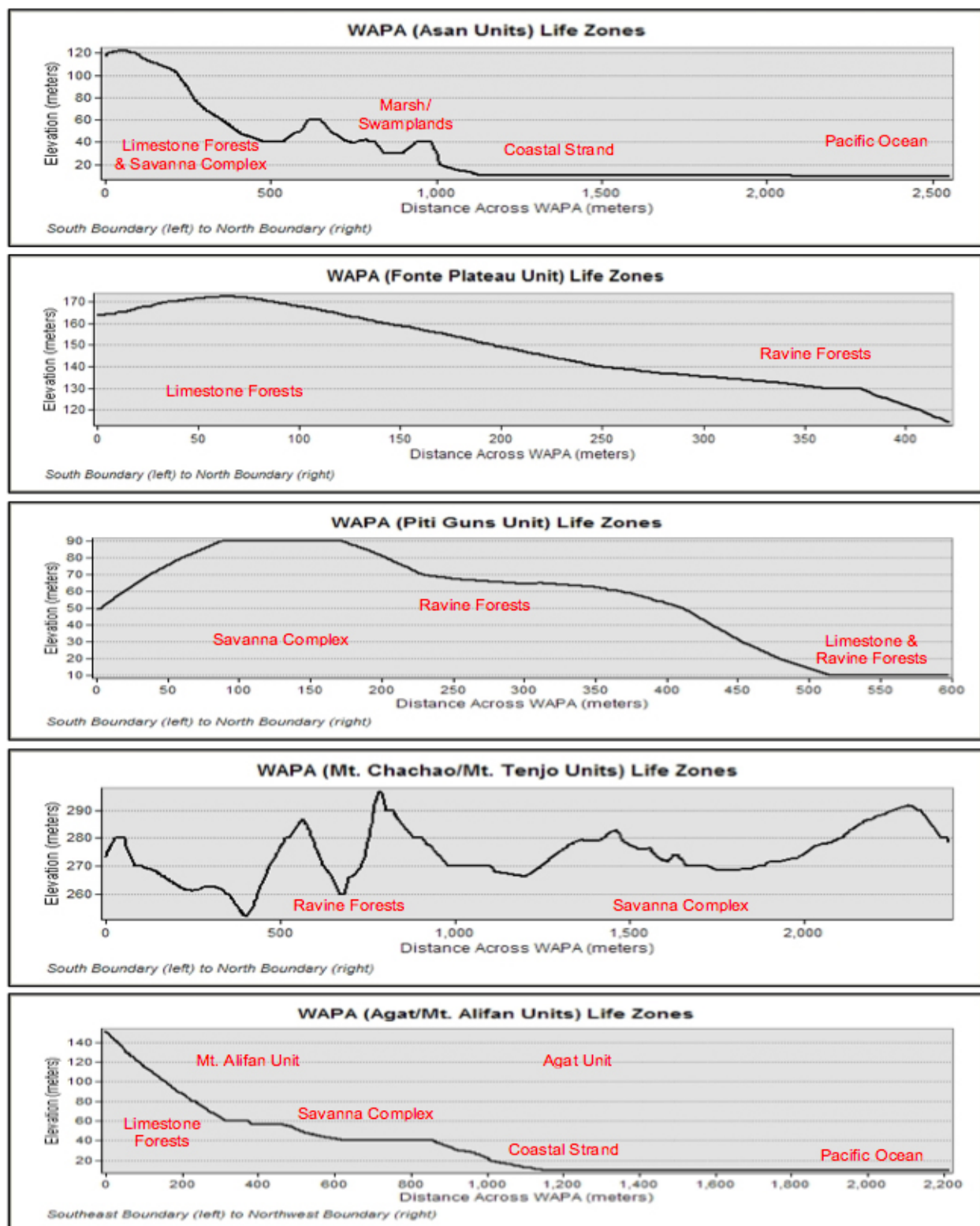
Source: CTI, USGS 10-meter DEM, and 2005 Digital Globe Imagery

Figure 3. 3D overview image from the north of WAPA and surrounding areas showing vegetation patterns and landscape features.



Source: CTI, USGS 10-meter DEM, and 2005 Digital Globe Imagery

Figure 4. 3D overview image from the west of WAPA and surrounding areas showing vegetation patterns and landscape features.



Source: CTI and USGS 10-meter DEM

Figure 5. Representative cross-sections of WAPA topography showing life zones.



Ipomoea coastal strand (front) with tangan-tangan shrubland (back) in Apaca Point



Maintained lawns in Apaca Point



Ravine forest (overview) on Mt. Tenjo



Tronkon niyok, hau, and tangan-tangan woodland in Alifan



Mixed savanna on Mt. Chachao



Mixed Limestone forest on Mt. Alifan

Figure 6. Common vegetation types at WAPA.

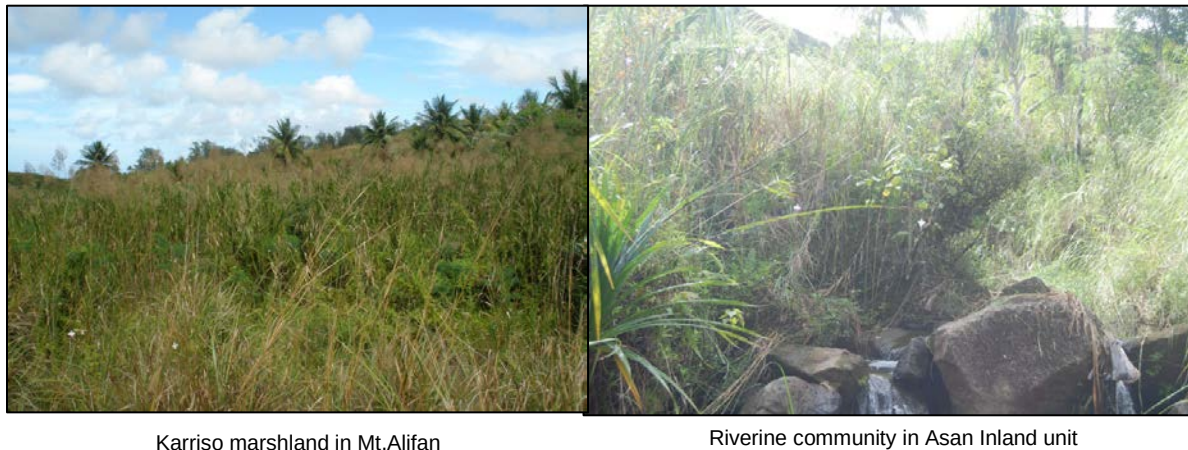


Figure 6. Common vegetation types at WAPA (continued).

Vegetation Inventory Project

The specific decision to classify and map the vegetation at WAPA was made in response to guidelines set forth by the NVIP and implemented by the Pacific Island Network. The PACN initiated a vegetation inventory for WAPA in 2009 as part of a larger effort to complete vegetation inventory maps for each of the 10 parks in the network that contain significant natural terrestrial resources (VALR was excluded).

Planning for the inventory projects began with an initial multi-year study plan developed for the PACN by Cogan Technology, Inc. (CTI) in 2007. The PACN study plan provided recommendations for completing the plant community classification, digital database, and map products for each of the 10 PACN parks. The work plan received approval from the Washington Support Office (WASO) Vegetation Inventory Program Manager in 2008.

An initial planning meeting was held at HAVO in March 2008 to discuss the project. Subsequent to this meeting, PACN staff ecologists and WAPA staff were detailed to complete the vegetation plot field data collection during the summer of 2009 and collect the accuracy assessment data in 2010 and 2011. The Western Regional Office of NatureServe was also contracted at this time to provide the preliminary and final vegetation classification including field keys and descriptions. CTI, as part of an interagency agreement through the Bureau of Reclamation, was tasked with providing the mapping and support services.

As a team, the objectives were to produce data consistent with the national program's mandates. These include the following:

Spatial Data

- Map classification based on WAPA-specific requirements;
- Map classification description and key;
- Spatial database of vegetation communities;
- Digital and hardcopy maps of vegetation communities;

- Metadata for spatial databases;
- Complete accuracy assessment of spatial data.
- Vegetation Information
- USNVC-based vegetation data;
- Dichotomous field key of vegetation associations;
- Formal description for each vegetation association;
- Ground photos of vegetation associations;
- Field data in database format.

Scope of Work

Vegetation mapping for WAPA occurred within an approximate 2551 ha (6302 ac) project boundary, encompassing both the authorized and administrative boundaries of WAPA (as provided by PACN) and some buffering in the environs. The WAPA vegetation inventory project area covers all seven individual units of WAPA including the Asan Beach, Asan Inland, Mt. Chachao/Mt. Tenjo, Agat, Piti Guns, Mt. Alifan and Fonte Plateau units and some environ areas in between (Figure 7). The final project area determination was based on management needs, financial constraints, and time limitations. A 0.40 km (0.25 mile) environs was adopted and modified to group Asan Beach, Asan Inland, Fonte Plateau and Piti Guns units into one mapping section of the project area (Asan section). Similarly the Agat and Mt. Alifan units were grouped into another mapping section (Agat section) and the third mapping section included the Mt. Chachao/Mt. Tenjo unit (Mt. Tenjo section). The final project boundary was implemented to insure completeness and capture the reef areas included in the WAPA authorized boundary.

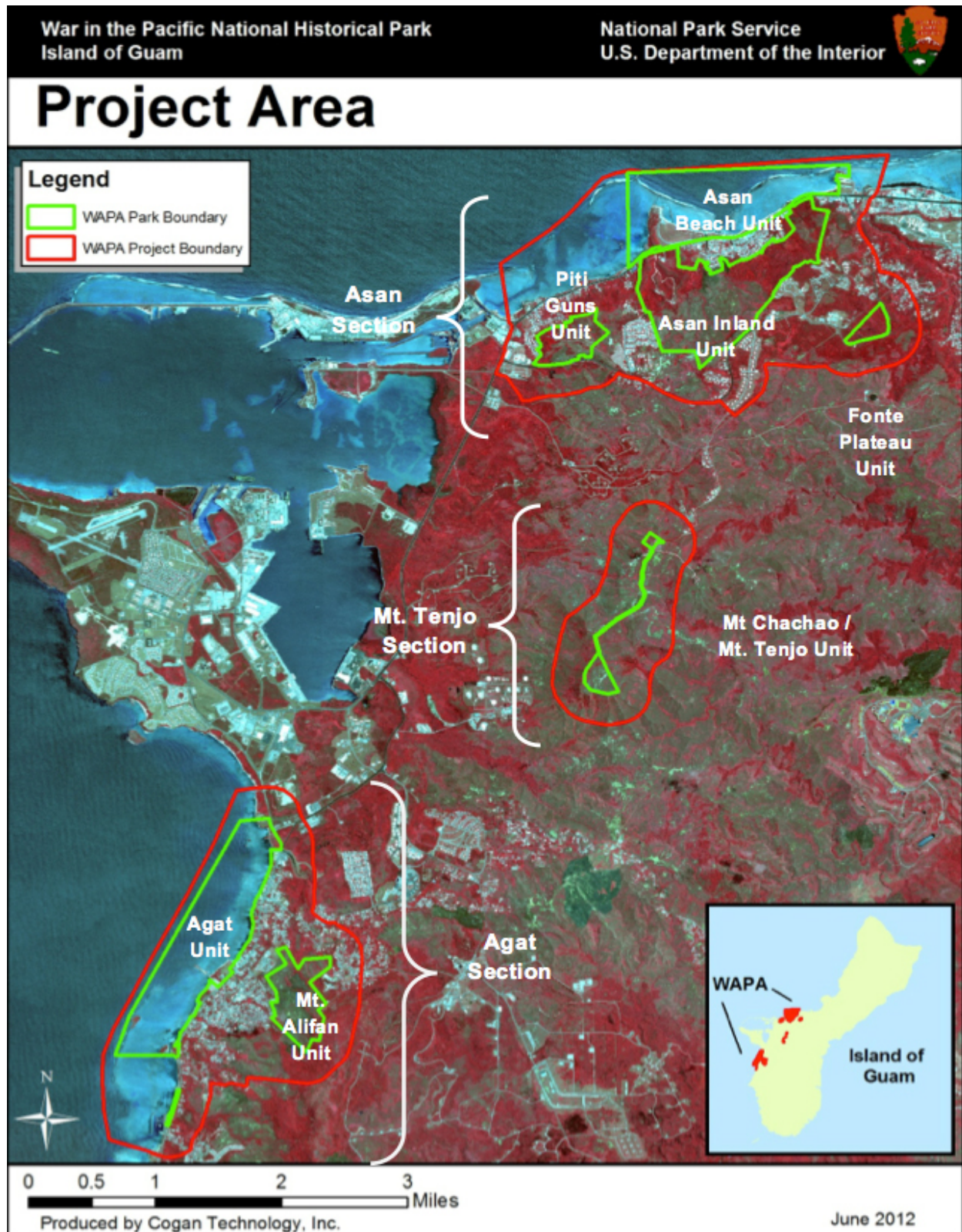


Figure 7. The vegetation mapping project boundary divided into three sections and WAPA park boundary.

Methods

The vegetation mapping project at WAPA was considered to be in the “small park” category based on the overall size of the project area (TNC and ESRI 1994b). As such, the standard methodology for sampling and mapping is to visit the entire park and select representative sites. These sites are used to characterize the vegetation types and explain their distribution across the park without having to survey each stand of vegetation. Based on this approach the assignment of responsibilities was divided into five major steps following the 12 Step Guidance for NPS Vegetation Inventories (NPS 2009), <http://science.nature.nps.gov/im/inventory/veg/index.cfm>.

Plan, gather data, and coordinate tasks;

1. Survey WAPA to understand and sample the vegetation;
2. Classify the vegetation using the field data to USNVC standard associations and alliances and crosswalk these to recognizable map classes;
3. Acquire current digital imagery and interpret the vegetation from these using the classification scheme and a map class crosswalk;
4. Assess the accuracy of the final map product.

All protocols for this project as outlined in the following sections can be found in the original program documents produced by TNC and Environmental Research Systems Institute (1994a, 1994b, and 1994c) and later revisions (Lea and Curtis 2010).

Planning, Data Gathering and Coordination

A series of planning conference calls were held throughout 2009 and attended by representative CTI, PACN, and WAPA staff. The goals of these calls were to (1) discuss the project, (2) learn about the management issues and concerns, (3) discuss availability of existing data, (4) develop a schedule, (5) discuss procedural issues and data, (6) define potential cooperators, and (7) define a project scope.

Once the boundary was finalized copies of 2005 Quickbird Imagery were obtained from the PACN. This imagery was obtained as pan-sharpened, cloud-free, 4-band, 0.6-meter resolution digital ortho-photos that covered the entire island of Guam. The specific imagery tiles covering the WAPA project area were selected, clipped and mosaiced to provide the basemap for mapping purposes. In addition to the Quickbird imagery, 1-meter, 3-band (true color) 2002 Ikonos imagery was also obtained for WAPA, but due to cloud cover and ensuing changes at WAPA since 2002 this product was only used in an ancillary role.

The remaining work responsibilities were assigned to the following participants:

NPS-PACN

- Provide oversight and project funding;
- Provide the WAPA plant list;
- Supply digital boundary files and ancillary data files;
- Assist with fieldwork and logistical considerations;
- Work with NatureServe to develop the vegetation classification;
- Provide project management;

- Coordinate the field work with WAPA;
- Collect representative plot data;
- Collect less detailed observations about the draft vegetation map;
- Collect accuracy assessment data;
- Provide a section for the final report describing the field portion of this project;
- Compile, review, and update drafts of the vegetation map, classification and report;
- Accept the final products and finalize the project.

NatureServe (Western Regional Office)

- Work with NPS to develop a vegetation classification for the study area based on the USNVC using quantitative analysis and ecological interpretation of the field data;
- Provide guidance regarding the crosswalk of vegetation types to map classes;
- Write descriptions of the vegetation types found at WAPA;
- Write a field key to the vegetation types found at WAPA;
- Write vegetation sections (classification methods, results and discussion) for final report;
- Revise field methods document and review other deliverables including database and final report.

Cogan Technology, Inc.

- Help with overall project facilitation and coordination;
- Verify vegetation and land use/land cover signatures on the imagery;
- Develop map classes linked to the USNVC;
- Provide field maps and Geographic Information System (GIS) support to the field crews;
- Interpret and delineate the final vegetation and land use types;
- Transfer and automate interpreted data to a digital spatial database;
- Produce spatial layers of plot and accuracy assessment site locations;
- Assist with the accuracy assessment by picking the stratified random target points, creating field maps, and providing GIS support;
- Provide a visual guide to the photo signatures of each map class;
- Provide a final report describing the project;
- Document FGDC-compliant metadata for all vegetation data;
- Create a DVD with reports, metadata, guides, vegetation classification, plot data, spatial data, vegetation database (map), graphics, and ground photos.

Field Surveys

The field methods used for developing the classification and conducting the accuracy assessment at WAPA followed the methodology outlined by the NVIP (TNC and ESRI 1994b) for small sized park units. Field crews were led by PACN ecologists with plant community sampling experience in the Mariana Islands and other landscapes. The list of ecological systems, vegetation alliances, and component plant associations prepared by NatureServe ecologists provided a starting point for naming the plant communities sampled in the field. The sampling goal was to collect between three and five classification plots in every plant association within the WAPA project area. However, some common associations were sampled more often and some rare types were sampled less often. An effort was made to achieve a good spatial distribution of plots across the landscape and to capture the full range of variation of each association.

When a representative stand of vegetation was located a relevé macroplot was established to record stand characteristics; transitional areas such as ecotones were usually avoided unless they exceeded the project MMU of 0.5 ha (1.2 ac). Highly disturbed areas were also avoided unless they supported a distinct plant community. Classification plots were generally located in stands exceeding the MMU; however a few plots were sampled in smaller patches if the vegetation was rare and distinctive (such as coastal strand sites). All plots were circular with a radius of 11.28 m and a plot area of 400m² which is consistent with NVIP guidelines (TNC and ESRI 1994b). Measuring tapes were used to establish the sampling area and the plot shape was adjusted as needed to sample linear bands of vegetation in drainage bottoms or other confined sites. Plot size and shape were recorded for all plots.

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

Additional species within the vegetation unit that occurred outside of sampled plots were listed separately to assist with the creation of local descriptions. Species that were not identifiable in the field were collected for later identification and specimens were typically destroyed in analysis. Species were recorded by scientific epithet familiar to researchers and a provisional vegetation type was assigned to the plot. Appendix B contains all species found within sample plots and common names used throughout the document.

Table 2. Cover classes and vegetation strata.

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

Field crews documented the vegetation plots as follows: (1) a species list was developed and recorded; (2) UTM WGS84 X-Y, field note headers (Identifiers/Locators), environmental descriptions, and elevation were recorded both manually on the plot forms and stored as waypoints in the Global Positioning System (GPS) receiver; and (3) eight representative digital photographs were acquired for each plot. Four photos were captured facing each of the cardinal directions (N, E, S, and W), one photo was used to capture the center of the plot, and a total of 3 photos were used to capture the complete pages of the field forms.

In addition to the vegetation classification plots, PACN field crews collected vegetation and environmental data at several observation points. Data recorded at observation points reflected the vegetation of an area of variable spatial extent around the point rather than a measured plot and were less detailed (Appendix A). Overall conditions at each observation point were documented by one or more digital photographs. These data were intended primarily to support modeling and interpretation of the base imagery, but were also used to help describe plant associations when local descriptions were prepared.

Specifically, observation point data were collected when:

- The vegetation was homogenous, representative, and several classification plots had been sampled;
- Sampling the environs outside the WAPA boundary;
- The vegetation was highly disturbed, ecotonal, or otherwise anomalous and therefore unlikely to be classified under the USNVC;
- CTI requested documentation of a specific photo-signature or area;
- To document special features as requested by WAPA staff including invasive plant stands;
- To document a vegetation type that consistently occurred in stands smaller than the 0.5 ha (1.2 ac) MMU;
- The sample point could not be safely accessed to complete the full plot.

The classification data were collected between January and March 2009. Vegetation sampling included 40 classification plots and 34 observation points (Figure 8).

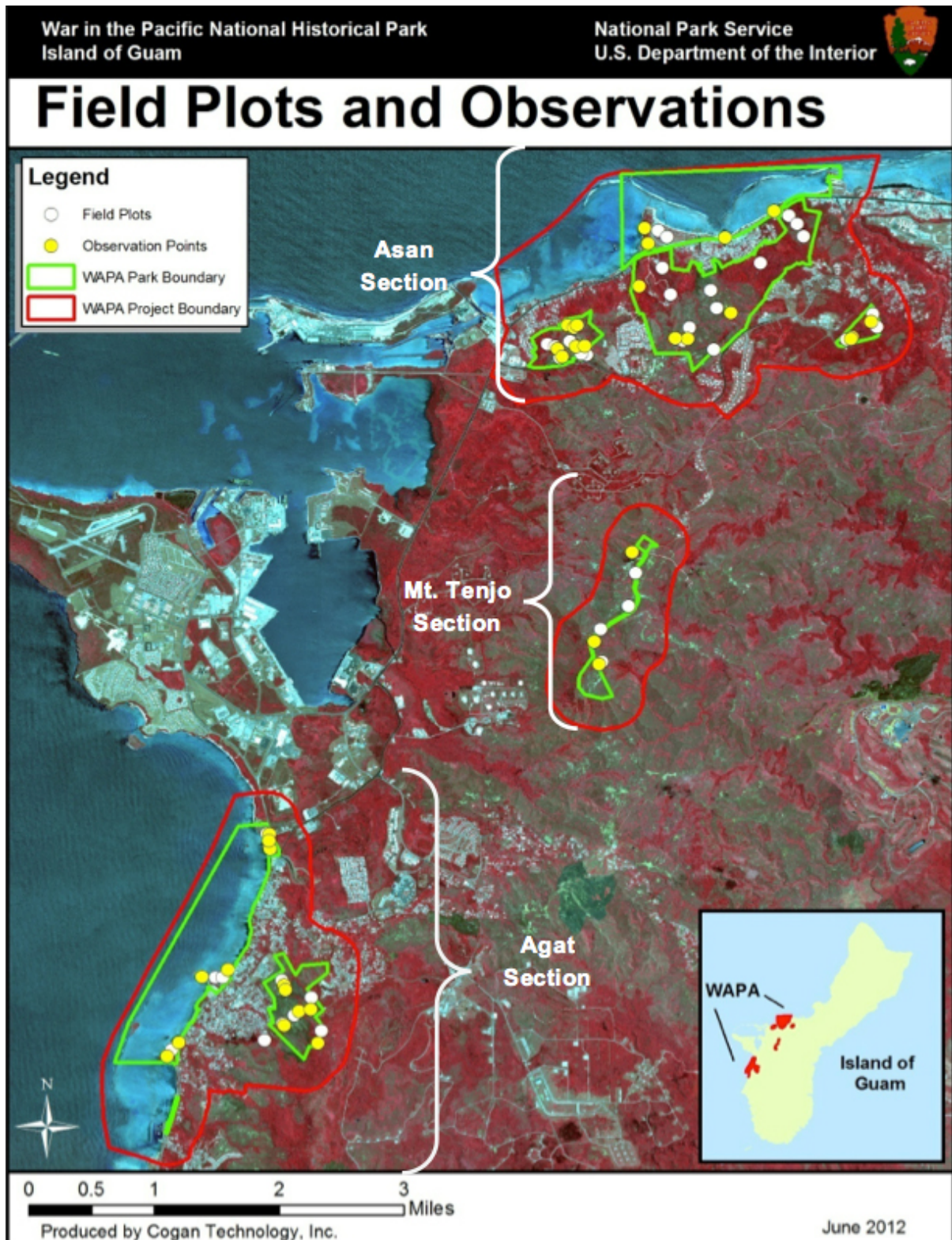


Figure 8. Vegetation plots and observation points collected at WAPA.

Vegetation Classification

The first step in classifying the vegetation at WAPA was to prepare a preliminary classification prior to vegetation sampling. While no preliminary data were available from the NatureServe BIOTICs database, and very few previous studies on vegetation have been conducted on Guam. Whistler (2009) reviewed available publications on the vegetation including Fosberg (1960) and Fosberg and Mueller-Dombois (1998). Whistler's report provides a brief historic and geologic overview of the island and descriptions of broad vegetation "types" as described by various authors, with an attempt to crosswalk among the names and categories. These descriptions are broad categories that can be thought of as dominance or habitat types, and were previously described in the introduction of this report.

One important aspect of developing a classification of vegetation on Guam is to determine which types may fall into the "natural" or native dominated category and which types fall into the "semi-natural" or non-native dominated category. The PACN park staff provided a by-island list of "origin" (native versus non-native) for each plant species. NatureServe used additional sources of information to determine species origins, such as Pacific Island Ecosystems at Risk (PIER) [<http://www.hear.org/Pier/index.html>] and the Australian department of Agriculture, Fisheries and Forestry [for example: http://www.daff.gov.au/brs/publications/series/forest_profiles/australian_forest_profiles_casuarina].

Upon completion of the plot data collection, all data were transferred by PACN staff to a Microsoft (MS) Access database. The database mirrored the standard field form with fields and tables that matched all of the data recorded on the field forms. Following data entry, quality assurance checking was performed to minimize errors associated with duplicate entries or erroneously selected plant or association names.

Unknown species identification, especially those with high cover were resolved, as were other taxonomic issues such as identifying accepted nomenclature. Plot locations were verified by field crew members by overlaying coordinate data on the Quickbird imagery. At the completion of the field work the final database was used by NatureServe for quantitative analysis.

Plant nomenclature in the USNVCS is that of the Integrated Taxonomic Information System (ITIS) as reflected by the PLANTS Database (USDA -NRCS 2007). For this study, some USNVCS names were modified based on Wagner et al. 1999 and Wagner et al. 2012 and these changes are identified throughout the document. Plant association names used indicator (dominant or diagnostic) species for each of the vegetative strata present. The indicator species of the upper strata was listed first, followed by successively lower strata (e.g., canopy, subcanopy, tall shrub, short shrub, herbaceous vegetation, etc.). Plant species that may only be occasionally present in the same stratum are separated by parentheses (). Species that always occurred in the same stratum (or were the same lifeform) are separated by a hyphen (-). Indicator species that occurred in different strata (or are a different lifeform) were separated by a slash (/). Plant association names incorporated the physiognomic class in which the association was classified (e.g., Forest, Woodland, or Herbaceous) (FGDC 1997, 2008).

Data Analysis

NatureServe began the formal classification by reviewing field data. WAPA data had 74 sample points (40 plots and 34 observation points) documenting the abundance of 137 plant species (Appendix C). This data set is small enough that quantitative analysis was deemed unwarranted, as a high number of species and low number of plots violates some of the rules of quantitative analyses. NatureServe examined each plot or observation point individually. With historic parks, the landscape position of each plot as well as the historic context of the surrounding area are equally important as the environmental and species composition data collected at each plot or observation point. The most difficult determination in the WAPA classification was the amount of tree cover in the upland savanna hills. Grass cover was very high (70-90%) while the frequent fires kept tree cover very open and scattered. However some individual plot data had >10% cover of tree canopy. These stands were determined to be savanna, where the herbaceous cover is very high relative to tree cover. Even though 10% tree cover is often used as a cut off for determining a wooded type from an herbaceous type, in a savanna situation the relative cover of herbaceous cover to tree cover is important. Another classification difficulty was the determination of mowed lawns versus grasslands. Crew field photographs were invaluable for correct interpretation of composition and environmental setting of plots located on mowed lawns. Mowed lawns are located near parking lots and buildings, and were considered as “Cultural Formations” within the USNVC. In addition, the mowed lawns occurred at lower elevations than the savannas and had high diversity of scattered trees when present.

Digital Imagery and Mapping

Since WAPA represented a fairly small and accessible site, no new imagery or aerial photography was deemed necessary for this project. Instead, existing sources of imagery were evaluated and the 2005 Quickbird product was supplied to CTI by PACN (Figure 9). The 2005 product was deemed adequate for vegetation mapping by CTI technicians since it had high resolution, contained the color infrared (CIR) band, had low cloud cover, and reflected most of the recent landscape changes at WAPA. After obtaining the 2005 imagery, it was color balanced in Imagine Software to remove some of the edge-matching issues and to sharpen the image. The resulting image from the 2005 imagery was clipped for each WAPA mapping section to just beyond the extent of the project boundary.

Interpretation of the vegetation at WAPA involved a three step process: (1) image segmentation, (2) cleaning and smoothing, and (3) ground-truthing of the data. First, the 2005 imagery was re-sampled to a 3-meter pixel resolution to reduce noise and to generalize the vegetation signatures. Next, this imagery was segmented to delineate obvious landforms (e.g. open water and fields) and physiognomic features (e.g. grasslands versus woodlands). The initial segments were created using a series of trial and error multi-resolution segmentation routines in the software. The settings for scale and shape were manipulated until a desired network of images resulted. The objective of the segmentation was to create a system of lines with as coarse a scale as possible without omitting most of the small, important and obvious land cover patches. By incrementally increasing segmentation size within the program, small image objects (i.e., preliminary polygons) were continuously merged into larger ones. Completion of the segmentation was based on visual judgment of the CTI analyst when obvious, distinct features were lost. At this point in the process, the previous segmentation was adopted as the final treatment.

Following segmentation, the lines were exported as ArcInfo shapefiles and converted to ArcInfo coverages. The resulting coverages were run through a series of smoothing routines provided in the ArcGIS software. Smoothing was conducted to reduce the stair-stepping pattern of the lines resulting from the large pixels. Smoothing ended when no obvious artificial or relict breaks in the lines were visible. Following smoothing, the line-work was manually cleaned to remove extraneous lines, small polygons, and polygons that obviously split a homogenous stand of vegetation. The cleaning stage was considered complete when all resulting polygons matched homogenous stands of vegetation apparent on the 2005 imagery.

The lines resulting from the 2005 imagery segmentation were visually inspected in ArcInfo. Any obvious problems in the mapping (such as shifting and sliver polygons) were edited and resolved. Review of the merged polygon layer revealed that the roads and infrastructure were not adequately separated from the surrounding vegetation. To resolve this, all developed areas, roads, beaches, shorelines and other linear or rectangular features were manually digitized directly off the 2005 imagery and incorporated into the final segmentation. After merging the digitized lines with the segmented linework the resulting preliminary GIS layer was considered complete and ready to be ground-truthed in the field.

Ground-truthing the preliminary vegetation layer for WAPA involved printing 1:6,000-scale hardcopy maps. These contained the 2005 basemaps and the preliminary mapping linework as an overlay. WAPA and PACN staff reviewed the draft maps based on their knowledge and experience within the park and visited target sites in the field. All comments and information from this ground-truthing effort were used to update the final GIS layer and individual observations were retained in the WAPA field plots GIS spatial layer.

After the ground-truthing, CTI researchers used the latest draft of the vegetation classification supplied by NatureServe to create the mapping scheme. In most cases, the map classes were derived on a one association to one map class basis. Due to the limitations of the imagery and the complicated intermixing of the herbaceous vegetation, some of the associations could not be recognized consistently. This issue was addressed by either scaling up the USNVC or combining similar associations/alliances into complexes. All of the resulting map classes were then correlated or crosswalked by noting when plant associations were used as a map class or when they were grouped. To round-out the mapping scheme, map classes were created for non-USNVC plant associations and land use types. A separate class of map modifiers or “Park Specials” was defined for WAPA to cover vegetation types that were cultural, ornamental, or influenced by human activity. These included the Mixed Semi-natural / Ornamental Tree Woodland, the Clay and Rock Outcrop Sparse Vegetation, and other map classes not currently in the USNVC. The WAPA land-use types were based on a mapping system developed by Anderson et al. (1976) and included unvegetated lands not in the USNVC, such as roads, facilities, and cemeteries. All of the resulting map class names, map class codes, USNVC information, and other relevant attributes were added to each polygon in the GIS layer (Table 3).

2005 Quickbird
CIR Example



2005 Quickbird
True Color Example

Figure 9. Examples of the 2005 Quickbird imagery for WAPA.

Table 3. Polygon attribute items and descriptions used in the WAPA GIS coverage.

ATTRIBUTE	DESCRIPTION
AREA*	Surface area of the polygon in meters squared
PERIMETER*	Perimeter of the polygon in meters
WAPA_VEG#*	Unique code for each polygon
WAPA_VEG-ID*	Unique identification code for each polygon
VEG_CODE	Final Map class Codes – Project specific
MAP_DESC	Map class Common Description Name – Project specific
DENS_MOD	Modifier - Percent cover of the upper stratum layer in the polygon
	Percent cover classes:
	Sparse 10 - 25%,
	Open 25 - 60%,
	Discontinuous - Closed > 60%
PTRN_MOD	Modifier - Vegetation pattern within the polygon
	Vegetation pattern classes:
	Evenly Dispersed = Homogeneous,
	Grouped Stands of Vegetation = Bunched /Clumped,
	String of Vegetation = Linear
HT_MOD	Modifier - Height range of the dominant vegetation layer
	Height classes: < 1, 1-5, 5-15, 15-30 & >30 meters
NVC_ELCODE	Corresponding Association Code – USNVC derived (NatureServe)
	Association = Community Element Global Code – Elcode link to the USNVC
ASSN_NAME	Project Community Name - USNVC Association(s)
ASSN_CNAME	Project Common Community Name - synonym name of Association(s)
ALL_CODE	Alliance Name Code – USNVC derived (NatureServe)
	Alliance = Alliance Global Code – Alliance Link to the USNVC
ALL_NAME	Project Alliance Name = USNVC Alliance(s)
ALL_CNAME	Project Common Alliance Name = USNVC Alliance(s)
GROUP	NVCS Hierarchy - Group Name= USNVC Code – Group name
MACROGROUP	NVCS Hierarchy - MacroGroup = USNVC Code – MacroGroup name
DIVISION	NVCS Hierarchy - Division = USNVC Code – Division name
FORMATION	NVCS Hierarchy - Formation = USNVC Code – Formation name
LUC_II_GEN	General Land Use and Land Cover Classification System Name
	Project specific based on Level I or II of Anderson et al. (1976)
LUC_II	Specific Land Use and Land Cover Classification System Name
	Project specific Level II or Level III of Anderson et al. (1976)
COMMENTS	Additional Comments about the Vegetation in Individual Polygons
ACRES	Surface area of the polygon in acres

(*ArcInfo® default items)

Accuracy Assessment

Once the vegetation layer was completed and finalized, the accuracy assessment (AA) was conducted. Typically, in mapping exercises both thematic or attribute map accuracy as well as the positional or polygon line accuracy are considered. In the case of the NVIP however, the

positional accuracy is usually omitted since rarely does vegetation split on discrete edges that can be positively located in the field. The subjectivity involved in this effort plus the high resolution and accuracy of Quickbird imagery allows for the assumption that all products derived from them are well within National Map Accuracy Standards for 1:12,000-scale maps (± 9 m; 30 ft).

The thematic accuracy of the vegetation map was assessed using the methodology following the standards provided by the NVIP (TNC and ESRI 1994c). This protocol has since been revised by the NVIP (Lea and Curtis 2010) but this project was started before the new standards were in place. The previous protocols included a four step AA process consisting of a sample design, sample site selection, data collection, and data analysis. The design of the AA process followed the five possible scenarios provided in the field manual with stratified random targets placed in each map class based on their respective frequency and abundance (Table 4).

Table 4. NVIP sampling protocol for AA points.

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

These parameters were loaded into a custom GIS program along with the vegetation layer. This program picked the random target locations and also buffered them 10 m (33 ft) away from any polygon boundary and 50 m (165 ft) away from any other point. Being able to choose minimum distance to polygon boundaries helped to minimize confusion and accounted for the horizontal error typically encountered in common GPS receivers (± 5 m). To complete the sampling targets, additional points were added to long linear polygons and rare types. The resulting target locations were restricted to those within the boundaries of WAPA.

Once the target locations were selected, PACN and WAPA botanists were provided with draft field maps, overview maps, map class definitions (Appendix E), the key to the associations (Appendix D), and digital GPS files containing the location of the target AA sites. Between January 2010 and February 2011, the botanists traveled to the AA target sites and determined the vegetation association using the field key. At each target they recorded the primary and secondary associations that occurred within the mapped polygon roughly up to 40 m (131 ft) radius (Figure 11). They also recorded height and cover of vegetative strata, environmental data, and percent canopy cover of the major species (see AA point form in Appendix A). Other nearby vegetation types and any recent disturbance were recorded. To better assist the analysis, a minimum of four photographs were taken at each AA point in the sequence of cardinal directions, N-E-S-W. If the point was too close to dense, especially shrubby vegetation, one or more optional photographs were taken at a distance to show the character of the vegetation.

Between January 2010 and February 2011, a total of 150 points were sampled (Figure 10). The data recorded on the field forms were subsequently entered into a Microsoft Access database and reviewed for data entry errors by PACN staff. Incomplete data on the field sheets were corrected if possible. The results were imported from the database into a GIS layer where they were visually compared in two stages to the vegetation map layer. The first step was to compare the AA points to the original target locations to check for errors and correct if possible. General errors in the data included incorrect UTM coordinates (standing outside of the target polygon), incorrect field call (based on actual species cover values), or incomplete polygons (unclosed polygons). Changes were made and recorded in the comments field of the AA point layer. The most common GPS receiver errors included transposing two UTM coordinate numbers or collecting coordinates outside of the target polygon due to segments being spatially offset from real transition zones (e.g. forest and swamp edges).

The second review step involved deciding between the primary and secondary field call for the plant association as recorded by the field crew. To accomplish this, CTI had to assign a final map class for every point by choosing between the different calls. This was done by first adding the Final Code attribute to the AA point layer and then comparing the assigned field names of the point with its corresponding location on the digital imagery. In most cases, the primary vegetation map class name assigned by the field crew was used. However, some points were assigned their secondary field call based on one of the following reasons: (1) it appeared that the second call was the better choice due to the overhead perspective (e.g. a stand judged to be sparse woodland on the imagery vs. herbaceous vegetation in the field), (2) the data were actually recorded in a stand that was too small (i.e. inclusion below MMU size), or (3) the second call more appropriately matched the ecological context (e.g. coastal strand vegetation along the coast vs. upland vegetation).

It is not uncommon in complex parks such as WAPA to make changes to the classification following the AA data collection. This is mainly due to AA field crews being dispersed into new areas with undocumented vegetation types not previously sampled during the classification stage. For WAPA, the AA field crews noted the presence of potentially new plant associations that included some potential associations that occurred at more than one AA target location. All new associations or stands were noted in the AA GIS layer and comparisons were made to the 2005 Quickbird imagery. If the new association or stand was discernable on the imagery a new coresponding “Unclassified Map Class” was created to provide more information for park management.

Once these data were reviewed, the accuracy analysis was conducted using CTI custom GIS programs and AA templates supplied by the NVIP. Through this automated process, the final map classes in the AA layer were compared to the map class designations for their corresponding polygons. All of the statistics and calculations used to analyze these data are described at length in the program manuals (TNC and ESRI 1994c and Lea and Curtis 2010). Final assessments for each point were recorded using error matrices.

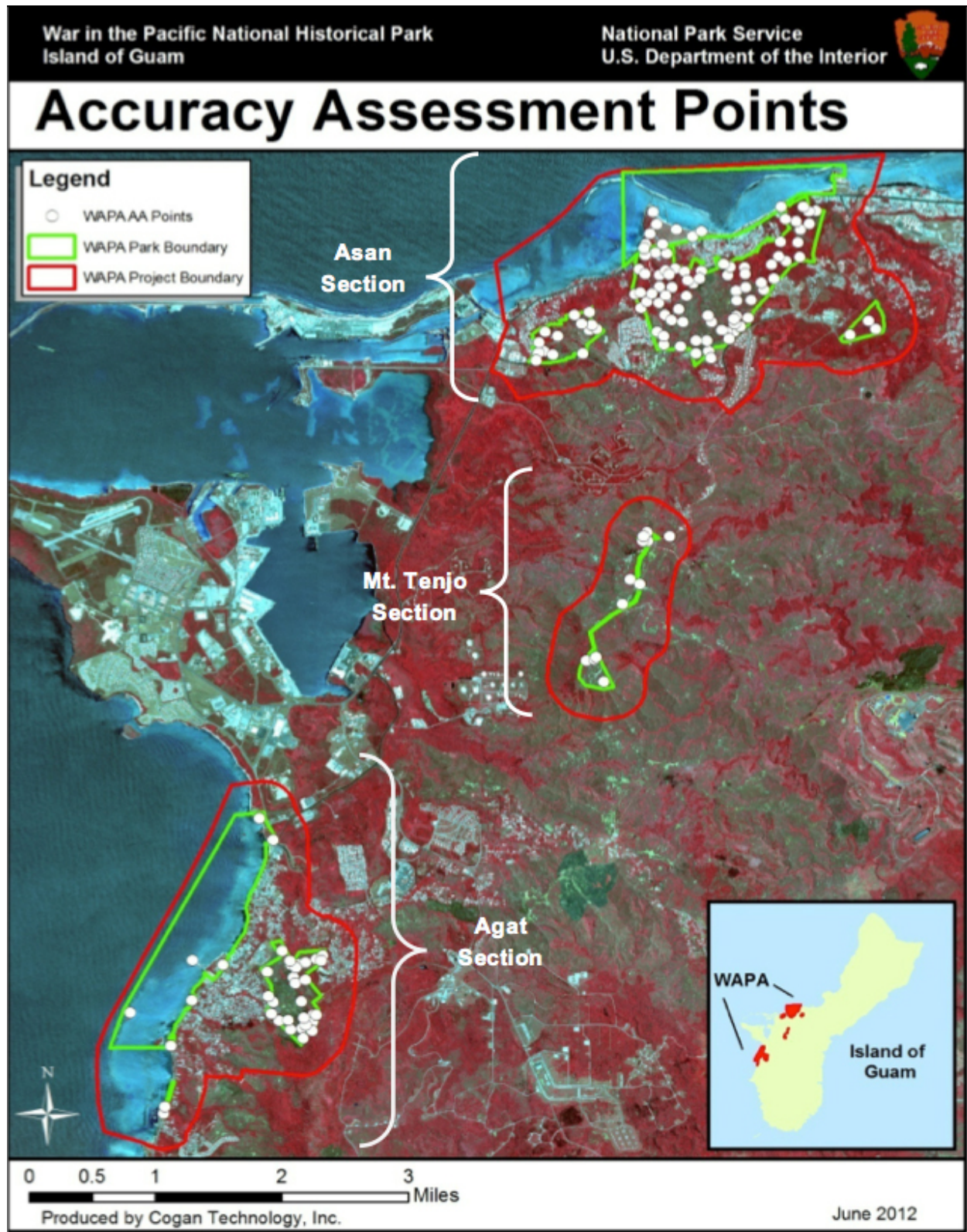


Figure 10. Location of accuracy assessment points collected at WAPA.

Results

Vegetation Classification

WAPA contains a variety of island habitats scattered throughout its many units comprised of coastal shoreline, forests, and upland grasslands. Seventy four samples (plots and observation points) were classified into 25 plant associations (Table 5). These comprise 15 native communities: five lowland forests, three grasslands, a savanna type, two grasslands invaded by non-native shrubs, two wooded coastal strands, a native forb/vine strand community, and a freshwater marsh. Nine communities are dominated by non-native species. These comprise five non-native lowland forest types, a shrubland, two grasslands, and a freshwater wetland. Lastly, there is a cultivated and maintained mowed lawn community. In the table below the term “semi-natural” in the Macrogroup and Group name indicates non-native dominated communities. One plot remained unclassified and was omitted from table 5 because it is from a disturbed old homestead site consisting of a mix of several non-native species.

Table 5. Associations and upper USNVC units of WAPA vegetation classification

Division	MacroGroup	Group	NVC Status	WAPA Final Classification	# Plots
1.A.2.Oa Polynesian Lowland Rainforest	M189 Micronesian Lowland Rainforest	G602 Micronesian Lowland Rainforest	CEGL008128	<i>Heterospathe elata</i> / <i>Nephrolepis hirsutula</i> Semi-natural Woodland [Provisional]	6
			CEPS009548	<i>Heterospathe elata</i> - <i>Hibiscus tiliaceus</i> / (<i>Phragmites karka</i> , <i>Miscanthus floridulus</i>) Semi-natural Woodland [Park Special]	2
			CEPS009549	<i>Hibiscus tiliaceus</i> Woodland [Park Special]	2
			CEPS009550	<i>Morinda citrifolia</i> / <i>Nephrolepis hirsutula</i> Woodland [Park Special]	1
			CEPS009551	<i>Tabebuia heterophylla</i> / <i>Dimeria chloridiformis</i> Semi-natural Woodland [Park Special]	1
	M190 Polynesian Semi-natural Lowland Rainforest	G390 Polynesian Semi-natural Lowland Rainforest	CEPS009552	<i>Bambusa vulgaris</i> Semi-natural Forest [Park Special]	2
			CEPS009553	<i>Mangifera indica</i> Semi-natural Woodland [Park Special]	2
			CEPS009554	<i>Spathodea campanulata</i> Semi-natural Woodland [Park Special]	3
			CEPS009555	<i>Swietenia macrophylla</i> Semi-natural Forest [Park Special]	1
			CEPS009556	<i>Vitex parviflora</i> Semi-natural Woodland [Park Special]	2
2.A.1.OI Polynesian Lowland Shrubland, Grassland & Savanna	M219 Micronesian Lowland Shrubland, Grassland & Savanna	G603 Micronesian Lowland Shrub, Grassland & Savanna	CEGL008125	<i>Dimeria chloridiformis</i> Herbaceous Vegetation [Provisional]	3

Table 5. Associations and upper USNVC units of WAPA vegetation classification (*continued*).

Division	MacroGroup	Group	NVC Status	WAPA Final Classification	# Plots
			CEGL008126	<i>Miscanthus floridulus</i> - (<i>Cenchrus polystachios</i> , <i>Bothriochloa bladhii</i>) Semi-natural Herbaceous Vegetation [Provisional] ¹	10
			CEPS009544	<i>Casuarina equisetifolia</i> / <i>Miscanthus floridulus</i> - <i>Cenchrus polystachios</i> Semi-natural Wooded Grassland [Park Special] ¹	2
			CEPS009545	<i>Dicranopteris linearis</i> Herbaceous Vegetation [Park Special]	2
			CEPS009546	<i>Leucaena leucocephala</i> / <i>Miscanthus floridulus</i> Semi-natural Shrubland [Park Special]	2
			CEPS009547	<i>Leucaena leucocephala</i> / <i>Nephrolepis hirsutula</i> Semi-natural Shrubland [Park Special]	1
	M220 Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna	G413 Polynesian Semi-natural Lowland Shrub, Grassland & Savanna	CEGL008114	<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	6
			CEGL008127	<i>Bothriochloa bladhii</i> - (<i>Dactyloctenium aegyptium</i> , <i>Paspalum conjugatum</i>) Semi-natural Herbaceous Vegetation [Provisional]	2
2.A.3.Ob Polynesian Wooded, Scrub & Herb Coastal Vegetation	M233 Micronesian Wooded, Scrub & Herb Coastal Vegetation	G607 Micronesian Coastal Wooded Strand	CEGL008121	<i>Casuarina equisetifolia</i> Woodland [Provisional]	2
			CEGL008129	<i>Cocos nucifera</i> - <i>Hibiscus tiliaceus</i> / Mixed Grass Wooded Strand [Provisional]	5
		G608 Micronesian Coastal Herbaceous Vegetation	CEGL008130	<i>Ipomoea pes-caprae</i> Herbaceous Vegetation [Provisional]	2
	M234 Polynesian Semi-natural Scrub & Herb Coastal Strand	G423 Micronesian Semi-natural Scrub & Herb Coastal Strand	CEGL008123	<i>Cenchrus</i> (<i>polystachios</i> , <i>purpureus</i>) Semi-natural Herbaceous Vegetation ¹	4
2.A.5.Ob Polynesian & Eastern Melanesian Freshwater Marsh	M042 Polynesian Freshwater Marsh	G605 Polynesian Freshwater Marsh	CEGL008131	<i>Phragmites karka</i> Herbaceous Vegetation [Provisional]	5

Table 5. Associations and upper USNVC units of WAPA vegetation classification (*continued*).

Division	MacroGroup	Group	NVC Status	WAPA Final Classification	# Plots
	M246 Polynesian & Eastern Melanesian Semi-natural Freshwater Marsh	G604 Polynesian Semi-natural Freshwater Wet Meadow & Marsh Group	CEPS009557	<i>Antigonon leptopus</i> - <i>Urochloa maxima</i> Semi-natural Herbaceous Vegetation [Park Special]	1
7.C.1.1 Lawn & Recreational Grassland	M546 Tropical Lawn	G721 Tropical Open Lawn	CEGL008124	<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn [Provisional]	4

¹USNVC name modified based on Wagner et al. 1999 and Wagner et al. 2012.

Digital Imagery and Mapping

For WAPA, 43 map classes (25 vegetated, three barren, and 15 land-use / land-cover) were developed for use in the vegetation mapping. The final list of map classes was directly crosswalked or matched to corresponding plant associations and land use classes (Table 6). WAPA map classes represent a compromise between the detail of the USNVC, the needs of the resource management staff, and the limitations of the imagery. As a result, the mapping legend does not exactly match the USNVC. In most cases the USNVC associations were used as map classes. However, in some cases associations had to be grouped into larger map classes and other non-USNVC vegetation map classes (Unclassified) were added to provide more detail. Appendix F contains descriptions and representative photographs for all vegetation map classes.

One widespread and disturbance oriented grassland association occurred in multiple map classes. This many-to-one relationship was created for the *Cenchrus (polystachios, purpureus)* Semi-natural Herbaceous Vegetation¹ association as it was found to occur in two distinct areas of WAPA. Specifically, mission and Napier grasses were recorded as being part of both the upland savanna grassland complex (H_SAVA) and also in the coastal stand (SV_CS) areas.

The following types represent the possible map scenarios for the WAPA project:

1. **One-to-one Relationship** = When a plant association or vegetation alliance had a unique photo signature and could be readily delineated on the imagery, the map class adopted the plant association/alliance name or similar synonym.
2. **One-to-many Relationship** = When related plant associations shared the same signature and could not be distinguished on the imagery, several plant associations were combined into a single complex.
3. **Unclassified Map Class** = When unique stands of vegetation apparent on the imagery did not have a corresponding USNVC plant association or vegetation alliance.
4. **Land Use – Land Cover** = Non-vegetated areas and vegetation types not recognized by the USNVC received Anderson et al. (1976, updated 2002) map class designations.
5. **Many-to-one Relationship** = When a WAPA association occurred in more than one distinct area of the project area.

¹USNVC name modified based on Wagner et al. 1999 and Wagner et al. 2012.

Table 6. Map classes and relationships to plant associations and other map classes.

Map Code	Map Class Name	NVC Association Assigned to Map Class (or Map Class Description)	Relationship
Forests and Woodlands			
F_ADPA	<i>Adenanthera pavonina</i> Semi-natural Forest Stand	(No Association)	Unclassified Map Class
F_BAVU	<i>Bambusa vulgaris</i> - (<i>Bambusa blumeana</i>) Semi-natural Forest	<i>Bambusa vulgaris</i> Semi-natural Forest [Park Special]	1 : 1
F_SWMA	<i>Swietenia macrophylla</i> Semi-natural Forest	<i>Swietenia macrophylla</i> Semi-natural Forest [Park Special]	1 : 1
W_CAEQ	<i>Casuarina equisetifolia</i> Woodland	<i>Casuarina equisetifolia</i> Woodland [Provisional]	1 : 1
W_CAMI	<i>Casuarina equisetifolia</i> / <i>Miscanthus floridulus</i> - <i>Cenchrus polystachios</i> Semi-natural Wooded Grassland	<i>Casuarina equisetifolia</i> / <i>Miscanthus floridulus</i> - <i>Cenchrus polystachios</i> Semi-natural Wooded Grassland [Park Special] ¹	1 : 1
W_CONU	<i>Cocos nucifera</i> – (<i>Hibiscus tiliaceus</i>) / Mixed Grass Wooded Strand	<i>Cocos nucifera</i> - <i>Hibiscus tiliaceus</i> / Mixed Grass Wooded Strand [Provisional]	1 : 1
W_FIAM	<i>Ficus macrophylla</i> – (<i>Pipturus argenteus</i>) Woodland Stand	(No Association)	Unclassified Map Class
W_HEEL	<i>Heterospathe elata</i> Semi-natural Woodland & Forest Complex	<i>Heterospathe elata</i> / <i>Nephrolepis hirsutula</i> Semi-natural Woodland [Provisional] <i>Heterospathe elata</i> - <i>Hibiscus tiliaceus</i> / (<i>Phragmites karka</i> , <i>Miscanthus floridulus</i>) Semi-natural Woodland	1 : Many
W_HITI	<i>Hibiscus tiliaceus</i> Woodland	<i>Hibiscus tiliaceus</i> Woodland [Park Special]	1 : 1
W_LELE	<i>Leucaena leucocephala</i> Semi-natural Woodland Complex	(Woodland Form of S_LELE)	1 : Many
W_MAIN	<i>Mangifera indica</i> Semi-natural Woodland	<i>Mangifera indica</i> Semi-natural Woodland [Park Special]	1 : 1
W_MOCI	<i>Morinda citrifolia</i> / <i>Nephrolepis hirsutula</i> Woodland	<i>Morinda citrifolia</i> / <i>Nephrolepis hirsutula</i> Woodland [Park Special]	1 : 1
W_ORNA	Mixed Semi-natural / Ornamental Tree Woodland	(No Association)	Unclassified Map Class
W_PEPT	<i>Peltophorum pterocarpum</i> Woodland Stand	(No Association)	Unclassified Map Class
W_SPCA	<i>Spathodea campanulata</i> Semi-natural Woodland	<i>Spathodea campanulata</i> Semi-natural Woodland [Park Special]	1 : 1

Table 6. Map classes and relationships to plant associations and other map classes (*continued*).

Map Code	Map Class Name	NVC Association Assigned to Map Class (or Map Class Description)	Relationship
Forests and Woodlands			
W_TAHE	<i>Tabebuia heterophylla</i> / <i>Dimeria chloridiformis</i> Semi-natural Woodland	<i>Tabebuia heterophylla</i> / <i>Dimeria chloridiformis</i> Semi-natural Woodland [Park Special]	1 : 1
W_VIPA	<i>Vitex parviflora</i> Semi-natural Woodland	<i>Vitex parviflora</i> Semi-natural Woodland [Park Special]	1 : 1
Shrublands			
S_LELE	<i>Leucaena leucocephala</i> Semi-natural Shrubland Complex	<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland <i>Leucaena leucocephala</i> / <i>Miscanthus floridulus</i> Semi-natural Shrubland [Park Special] <i>Leucaena leucocephala</i> / <i>Nephrolepis hirsutula</i> Semi-natural Shrubland [Park Special]	1 : Many
Herbaceous Vegetation			
H_ANUR	<i>Antigonon leptopus</i> - <i>Urochloa maxima</i> Semi-natural Herbaceous Vegetation	<i>Antigonon leptopus</i> - <i>Urochloa maxima</i> Semi-natural Herbaceous Vegetation [Park Special]	1 : 1
H_DILI	<i>Dicranopteris linearis</i> Herbaceous Vegetation	<i>Dicranopteris linearis</i> Herbaceous Vegetation [Park Special]	1 : 1
H_LAWN	<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn	<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn [Provisional]	1 : 1
H_PHKA	<i>Phragmites karka</i> Herbaceous Vegetation	<i>Phragmites karka</i> Herbaceous Vegetation [Provisional]	1 : 1
H_SAVA	Mixed Savanna Herbaceous Vegetation	<i>Bothriochloa bladhii</i> - (<i>Dactyloctenium aegyptium</i> , <i>Paspalum conjugatum</i>) Semi-natural Herbaceous Vegetation [Provisional] <i>Dimeria chloridiformis</i> Herbaceous Vegetation [Provisional] <i>Miscanthus floridulus</i> - (<i>Cenchrus polystachios</i> , <i>Bothriochloa bladhii</i>) Semi-natural Herbaceous Vegetation [Provisional] ¹ <i>Cenchrus (polystachios, purpureus)</i> Semi-natural Herbaceous Vegetation [Provisional] ¹	1 : Many

Table 6. Map classes and relationships to plant associations and other map classes (*continued*).

Map Code	Map Class Name	NVC Association Assigned to Map Class (or Map Class Description)	Relationship
Sparse Vegetation			
SV_CS	Coastal Strand Sparse Vegetation	<i>Ipomoea pes-caprae</i> Herbaceous Vegetation [Provisional] <i>Cenchrus (polystachios, purpureus)</i> Semi-natural Herbaceous Vegetation [Provisional] ¹	1 : Many
SV_RK	Clay and Rock Outcrop Sparse Vegetation	(No Association)	Unclassified Map Class
Geology – Bare Ground			
B_BE	Beaches	(Barren Sand Beaches)	N/A
B_ER	Exposed Reef and Tidal Pools	(Submerged Reef Features)	N/A
B_SA	Submerged Sand and Rock	(Submerged Sand and Rock Features)	N/A
Land Use – Land Cover			
L_BAY	Bay / Estuary	(Semi-protected Bays, Harbors, and Estuaries)	N/A
L_CANL	Canal / Ditch	(Man-made Linear Water Conveyance Systems)	N/A
L_CEM	Cemeteries	(Cemeteries)	N/A
L_COM	Communications and Utilities	(Water towers and Treatment Plants)	N/A
L_FACL	Government Facilities	(NPS and Government Buildings and Facilities)	N/A
L_HEIN	Heavy Industry	(Factories and Industrial Complexes)	
L_LIIN	Commercial / Light Industry	(Businesses, Churches, Schools and Surrounding lands)	N/A
L_POND	Lake / Pond	Natural and Mad-made Water Impoundments)	N/A
L_RECR	Entertainment / Recreation	(Baseball Diamonds, Tennis Courts and other Park Facilities)	N/A
L_RESO	Residential	(Single and Multi Family Housing and Surrounding Landscaped Areas)	N/A
L_ROAD	Transportation	(Roads and major trails)	N/A

Table 6. Map classes and relationships to plant associations and other map classes (*continued*).

Map Code	Map Class Name	NVC Association Assigned to Map Class (or Map Class Description)	Relationship
L_ROCK	Bare Rock / Sand / Other Bare Ground	(Unvegetated Rock, Soil Cleared Land)	
L_SEA	Sea / Ocean	(Pacific Ocean)	N/A
L_STRM	Stream / River	(Perennial Rivers and Streams)	N/A
L_TRAN	Transistional	(Unvegetated Areas including Former Military Installations, Foundations, Clearings, and Gravel Areas)	N/A

Vegetation Map

Within the project area, the WAPA vegetation map consisted of 2269 polygons totaling 2551 ha (6303 ac; Appendix G) and average polygon size was about 1.1 ha (2.3 ac; Table 7). The small polygon size at WAPA was due in part to the small size of the park and the importance of the rare vegetation and small stands of non-native/ semi-natural vegetation. The mapping was also finely detailed since the imagery was of high resolution allowing for very small stands of vegetation to be delineated.

Including the adjacent ocean areas next to WAPA, 743 ha (1835 ac), or 29% of the project areas consisted of submerged sand, reef, tidal pools, open ocean, bays, and harbors. Of the remaining terrestrial map classes, 15% were considered to be land-use / land-cover types covering 371 ha (915 ac) in 489 individual polygons. The largest vegetation map class was the Mixed Savanna Herbaceous Vegetation consisting of 213 polygons covering 270 ha (668 ac). The largest woodland map classes were the *Hibiscus tiliaceus* Woodland and *Heterospathe elata* Semi-natural Woodland & Forest Complex with a combined area of 306 ha (758 ac) in 295 individual polygons. Within the WAPA boundary other interesting trends were observed which included: (1) approximately 405 ha (999 ac) of ocean and reef, (2) 18 ha (43.2 ac) of *Cocos nucifera*-(*Hibiscus tiliaceus*) Mixed Grass Wooded Strand and Coastal Strand Sparse Vegetation, 13 ha (31 ac) of *Bothriochloa bladhii*-*Chrysopogon aciculatus* Lawn and 14 ha (43 ac) of land use / land cover types, and (3) the largest vegetation map class was the Mixed Savanna Herbaceous Vegetation encompassing 99 ha (245 ac).

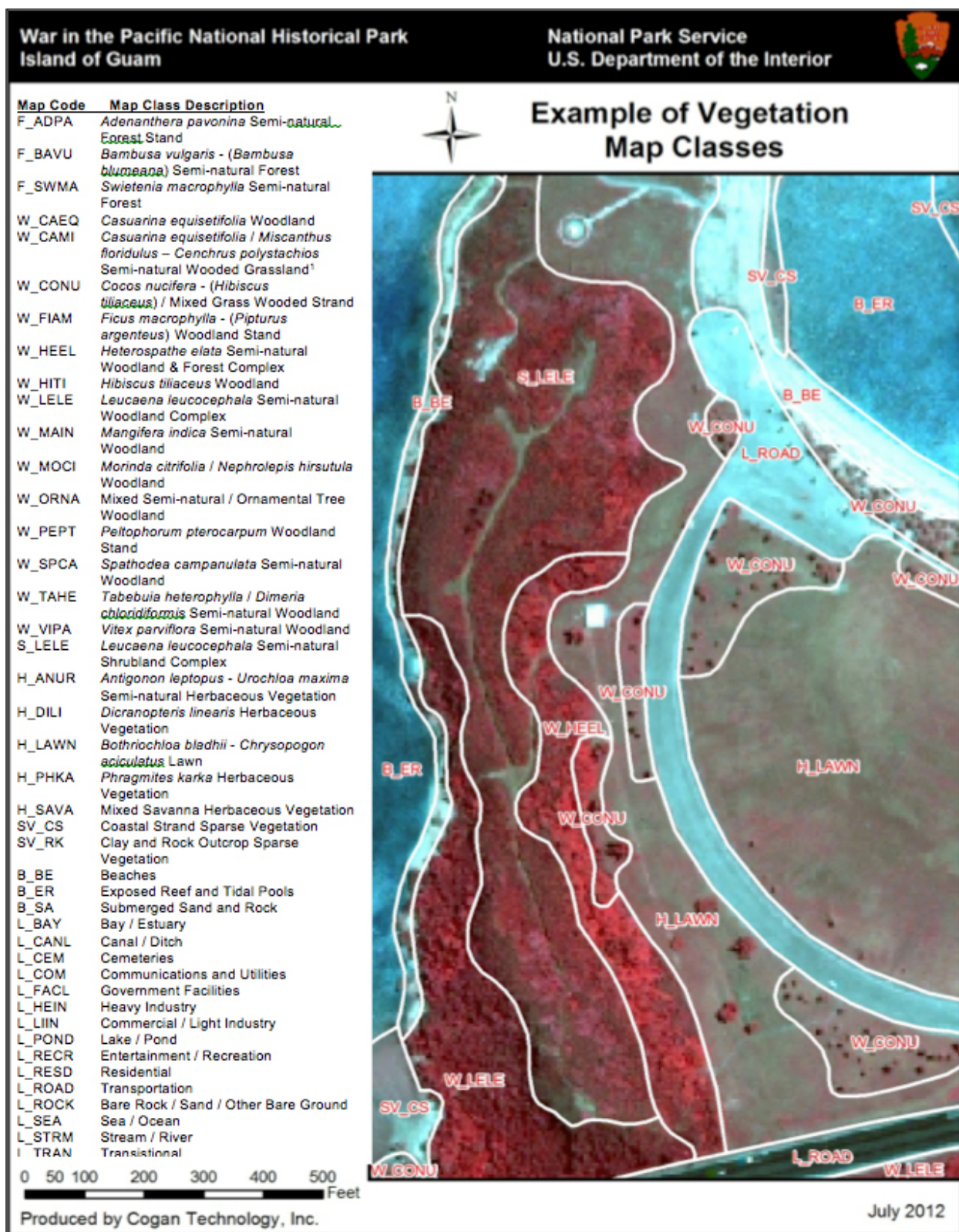
The WAPA vegetation map should more appropriately be considered a spatial database that also contains many additional polygon attributes not presented in the preceding table. The extensive data are difficult to convey in a table or on a two-dimensional map, but it should be understood that the different attributes can be combined at different scales and resolutions to produce additional products better representing the full spectrum of the vegetative diversity. For example, older, more mature stands of non-native vegetation can quickly be located by querying the GIS vegetation layer for exotic vegetation types along with high density (>60%) and the tallest height class (15-30 m). Figure 11 is an example of a fine scale (1:6000-scale) WAPA vegetation map created from the GIS spatial database with the 2005 Quickbird imagery as the background.

Table 7. Summary statistics for the WAPA map class polygons.

Map Code	Map Class Description	WAPA Lands			Total Project Area		
		# of Polygons	Acres	Hectares	# of Polygons	Acres	Hectares
F_ADPA	<i>Adenanthera pavonina</i> Semi-natural Forest Stand	7	17.0	6.8	12	38.4	15.5
F_BAVU	<i>Bambusa vulgaris</i> - (<i>Bambusa blumeana</i>) Semi-natural Forest	10	19.1	7.8	38	64.3	26.0
F_SWMA	<i>Swietenia macrophylla</i> Semi-natural Forest	7	10.5	4.3	16	23.3	9.5
W_CA EQ	<i>Casuarina equisetifolia</i> Woodland	3	2.0	0.8	11	5.8	2.4
W_CAMI	<i>Casuarina equisetifolia</i> / <i>Miscanthus floridulus</i> - <i>Cenchrus polystachios</i> Semi-natural Wooded Grassland ¹	24	46.6	18.9	51	85.1	34.5
W_CONU	<i>Cocos nucifera</i> - (<i>Hibiscus tiliaceus</i>) / Mixed Grass Wooded Strand	43	28.2	11.4	132	89.6	36.3
W_FIAM	<i>Ficus macrophylla</i> - (<i>Pipturus argenteus</i>) Woodland Stand	1	15.4	6.2	2	19.9	8.0
W_HEEL	<i>Heterospatha elata</i> Semi-natural Woodland & Forest Complex	40	107.4	43.5	112	387.3	156.7
W_HITI	<i>Hibiscus tiliaceus</i> Woodland	29	66.3	26.9	183	370.4	149.9
W_LELE	<i>Leucaena leucocephala</i> Semi-natural Woodland Complex	37	79.6	32.2	123	335.6	135.9
W_MAIN	<i>Mangifera indica</i> Semi-natural Woodland	3	4.7	1.9	43	71.1	28.8
W_MOCI	<i>Morinda citrifolia</i> / <i>Nephrolepis hirsutula</i> Woodland	0	0	0	7	22.1	8.9
W_ORNA	Mixed Semi-natural / Ornamental Tree Woodland	12	6.0	2.5	57	27.7	11.2
W_PEPT	<i>Peltophorum pterocarpum</i> Woodland Stand	9	18.4	7.5	10	30.2	12.3
W_SPCA	<i>Spathodea campanulata</i> Semi-natural Woodland	4	13.4	5.4	11	30.9	12.4
W_TAHE	<i>Tabebuia heterophylla</i> / <i>Dimeria chloridiformis</i> Semi-natural Woodland	7	13.5	5.5	9	16.4	6.7
W_VIPA	<i>Vitex parviflora</i> Semi-natural Woodland	3	10.2	4.2	12	59.6	24.1
S_LELE	<i>Leucaena leucocephala</i> Semi-natural Shrubland Complex	39	68.2	27.6	145	314.6	127.3
H_ANUR	<i>Antigonon leptopus</i> - <i>Urochloa maxima</i> Semi-natural Herbaceous Vegetation	4	3.3	1.3	12	11.0	4.4
H_DILI	<i>Dicranopteris linearis</i> Herbaceous Vegetation	51	79.8	32.4	169	368.5	149.3
H_LAWN	<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn	25	31.1	12.6	141	150.2	60.6
H_PHKA	<i>Phragmites karka</i> Herbaceous Vegetation	29	23.9	9.7	97	219.2	88.8
H_SAVA	Mixed Savanna Herbaceous Vegetation	60	244.5	98.9	213	667.5	270.3
SV_CS	Coastal Strand Sparse Vegetation	21	15.0	6.1	43	22.2	9.0
SV_RK	Clay and Rock Outcrop Sparse Vegetation	19	18.4	7.4	69	90.7	36.6

Table 7. Summary statistics for the WAPA map class polygons (*continued*).

Map Code	Map Class Description	WAPA Lands			Total Project Area		
		# of Polygons	Acres	Hectares	# of Polygons	Acres	Hectares
B_BE	Beaches	11	16.3	6.7	40	30.7	12.4
B_ER	Exposed Reef and Tidal Pools	2	549.6	222.4	7	1,038.6	420.3
B_SA	Submerged Sand and Rock	6	7.9	3.2	11	11.0	4.5
L_BAY	Bay / Estuary	0	0	0	2	13.8	5.6
L_CANL	Canal / Ditch	1	0.1	0.0	5	3.4	1.4
L_CEM	Cemeteries	1	1.4	0.6	13	25.0	10.1
L_COM	Communications and Utilities	2	1.6	0.6	2	1.9	0.8
L_FACL	Government Facilities	13	5.6	2.3	16	17.9	7.3
L_HEIN	Heavy Industry	0	0	0	2	5.8	2.4
L_LIIN	Commercial / Light Industry	3	0.7	0.2	40	73.0	29.6
L_POND	Lake / Pond	0	0	0	3	1.7	0.7
L_RECR	Entertainment / Recreation	0	0	0	4	5.1	2.0
L_RESD	Residential	24	7.5	3.2	340	517.0	209.4
L_ROAD	Transportation	3	16.4	6.6	14	227.2	92.0
L_ROCK	Bare Rock / Sand / Other Bare Ground	3	4.3	1.7	4	4.8	2.0
L_SEA	Sea / Ocean	2	425.6	172.3	2	772.0	312.4
L_STRM	Stream / River	6	2.7	1.1	26	9.9	4.0
L_TRAN	Transistional	2	0.9	0.4	20	22.3	9.0
Total Vegetation		487	942.5	381.8	1,718	3,521.6	1,425.3
Total Barren Geology		19	573.8	232.2	58	1,080.3	437.2
Total Land Use / Land Cover		60	466.8	189.0	493	1,700.8	688.7
Totals		566	1,983.1	803.0	2269	6,302.7	2,551.2



USNVC name modified based on Wagner et al. 1999 and Wagner et al. 2012.

Figure 11. Example of the WAPA vegetation map layer.

Accuracy Assessment

The January 2010 to February 2011 AA field effort yielded 150 points distributed throughout all three mapping sections of WAPA. In addition to using the AA points in the map analysis, many of the points were also used throughout the project to update the classification and to revise the field key and local descriptions. Actual analysis of the AA points involved a point-by-point review in two stages. In stage one, an AA GIS point file was created from the point coordinates recorded in the field. These sites were digitally overlaid on the vegetation map and a comparison of the final AA field call versus the vegetation polygon label was conducted by CTI staff. Stage one resulted in a preliminary error matrix that was reviewed by CTI staff. Adjustments were made to the field calls at this time based on the actual cover values recorded and taking into account possible correct second field calls. In most cases, the correct second calls were very closely related to the incorrect primary call.

During stage one, four additional unclassified map classes were added to the vegetation map based on comments and cover values recorded by the field crews. The four new map classes and the reasons for adding them are listed below:

1. **F_ADPA** - *Adenanthera pavonina* Semi-natural Forest Stand – Localized dominant tree species not previously sampled.
2. **W_PEPT** - *Peltophorum pterocarpum* Woodland Stand – Localized dominant tree species not previously sampled.
3. **W_FIAM** - *Ficus macrophylla* – (*Pipturus argenteus*) Woodland Stand – Localized dominant tree species not previously sampled.
4. **SV_RK** - Clay and Rock Outcrop Sparse Vegetation – Added to distinguish sparse savanna and grassland vegetation on rock and eroded soils from surrounding dense vegetation.

Stage two of the analysis involved incorporating the new unclassified map classes and re-running the accuracy assessment using the new NVIP protocols (Lea and Curtis 2010). Following vegetation map update, errors were reported in both a sample contingency table (Table 8) and a population contingency table (Table 9). The sample contingency table includes the observation counts, with the predicted, sample data values (vegetation map classes) as rows and the observed reference data values (vegetation types as identified on the ground) as columns. The value in the cells is the number of accuracy assessment observations mapped in each class (row) that were found to be of a specific class (column) in the field. The values in the shaded cells along the diagonal represent counts for correctly classified observations, where the reference data (column) vegetation type matches the mapped vegetation type (row) value.

The population contingency table is similar to the sample table; however the values in each cell are the proportion of the target area in the corresponding true and mapped vegetation classes, rather than the raw count of observations. The row sums p_{i+} are the proportions of the total area mapped as type i . The column sums p_{+j} are the proportions of the total area that are truly class J , which is not known, but can be estimated from the reference data values.

Table 8. Sample contingency table for WAPA. Columns represent predicted mapping class names (polygon labels) and rows represent AA observation names (field calls).

Map Code	F_ADPA	F_BAVU	F_SWMA	H_ANUR	H_DILI	H_LAWN	H_PHKA	H_SAVA	SV_CS	SV_RK	S_LELE	W_CAMI	W_CAEQ	W_CONU	W_FIAM	WHEEL	W_HITI	W_LELE	W_MAIN	W_MOCI	W_ORNA	W_PEPT	W_SPCA	W_TAHE	W_VIPA	Row Total
F_ADPA	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
F_BAVU	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2
F_SWMA	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
H_ANUR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H_DILI	0	0	0	0	2	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
H_LAWN	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
H_PHKA	0	0	0	0	1	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
H_SAVA	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	30
SV_CS	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
SV_RK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S_LELE	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	1	0	9
W_CAMI	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	2	0	12
W_CAEQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W_CONU	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	7
W_FIAM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
WHEEL	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	17	1	0	0	0	0	0	0	0	0	19
W_HITI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	8
W_LELE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	15
W_MAIN	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3
W_MOCI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W_ORNA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
W_PEPT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	3	0	0	0	5
W_SPCA	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
W_TAHE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
W_VIPA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
Column Total	5	1	2	0	3	5	6	33	4	0	12	10	0	7	2	18	11	15	2	0	2	3	0	6	3	

Table 9. Population contingency table for WAPA.

Map Code	F_ADPA	F_BAVU	F_SWMA	H_DILI	H_LAWN	H_PHKA	H_SAVA	SV_CS	S_LELE	W_CAMI	W_CONU	W_FIAM	W_HEEL	W_HITI	W_LELE	W_MAIN	W_ORNA	W_PEPT	W_SPCA	W_TAHE	W_VIPA	1	2	3	4
F_ADPA	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	100%	90%	100%	0.018
F_BAVU	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	50%	0%	100%	0.021
F_SWMA	0.000	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	100%	75%	100%	0.011
H_DILI	0.000	0.000	0.000	0.024	0.000	0.000	0.048	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	29%	0%	64%	0.084
H_LAWN	0.000	0.000	0.000	0.000	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	100%	90%	100%	0.032
H_PHKA	0.000	0.000	0.000	0.004	0.000	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	88%	57%	100%	0.025
H_SAVA	0.000	0.000	0.000	0.000	0.000	0.000	0.252	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.000	97%	90%	100%	0.280
SV_CS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	100%	88%	100%	0.018
S_LELE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.085	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	89%	86%	100%	0.073
W_CAMI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.041	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	83%	61%	100%	0.049
W_CONU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	100%	93%	100%	0.030
W_FIAM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	100%	75%	100%	0.018
W_HEEL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.103	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	89%	75%	100%	0.115
W_HITI	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.000	100%	94%	100%	0.071
W_LELE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.085	0.000	0.000	0.000	0.000	0.000	0.000	100%	97%	100%	0.085
W_MAIN	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	67%	5%	100%	0.005
W_ORNA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	100%	75%	100%	0.008
W_PEPT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.004	0.000	0.000	0.000	0.012	0.000	0.000	0.000	60%	14%	100%	0.020
W_SPCA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0%	0%	50%	0.014
W_TAHE	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.000	100%	75%	100%	0.015
W_VIPA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	100%	83%	100%	0.011
A	100.0%	100.0%	100.0%	87.3%	100.0%	100.0%	84.0%	100.0%	65.6%	100.0%	100.0%	100.0%	98.3%	77.8%	100.0%	100.0%	100.0%	100.0%	0.0%	38.8%	100.0%				
B	100.0%	98.8%	100.0%	84.6%	100.0%	99.5%	82.5%	100.0%	63.6%	99.2%	100.0%	100.0%	95.1%	77.8%	100.0%	99.8%	100.0%	99.3%	0.0%	36.6%	100.0%				
C	100.0%	100.0%	100.0%	89.9%	100.0%	100.0%	85.5%	100.0%	67.3%	100.0%	100.0%	100.0%	97.6%	78.0%	100.0%	100.0%	100.0%	100.0%	0.0%	37.0%	100.0%				
D	6.73	3.80	4.19	10.18	11.90	7.77	110.82	5.75	36.49	15.03	10.92	6.05	39.40	33.71	31.40	1.24	2.24	4.33	0.00	14.57	4.00				

ROW A = PRODUCERS' ACCURACY ($P_{i=y|j=y}$)ROW B = LOWER LIMIT, 90% CONFIDENCE INTERVAL,
PRODUCERS' ACCURACYROW C = UPPER LIMIT, 90% CONFIDENCE INTERVAL,
PRODUCERS' ACCURACYROW D = ESTIMATED TRUE AREA (A_{+j}) (HECTARES)COLUMN 1 = USERS' ACCURACY ($P_{j=x|i=x}$)COLUMN 2 = LOWER LIMIT, 90% CONFIDENCE INTERVAL,
USERS' ACCURACYCOLUMN 3 = UPPER LIMIT, 90% CONFIDENCE INTERVAL,
USERS' ACCURACYCOLUMN 4 = π_i

The final overall accuracy, kappa statistics and 90% confidence intervals for WAPA are as follows:

OVERALL ACCURACY (P_o)	=	84.1%
LOWER LIMIT, 90% CONFIDENCE INTERVAL	=	80.3%
UPPER LIMIT, 90% CONFIDENCE INTERVAL	=	87.8%
KAPPA (K):	=	87.5%
LOWER LIMIT, 90% CONFIDENCE INTERVAL, K	=	82.8%
UPPER LIMIT, 90% CONFIDENCE INTERVAL, K	=	92.2%

Examination of the contingency tables finds that 21 out of 25 vegetated map classes for WAPA were accessed. Of the four not sampled during the AA, the Clay and Rock Outcrop Sparse Vegetation was not accessed as it was added to the vegetation map after the AA field work was conducted. The *Casuarina equisetifolia* Woodland was not accessed since it only occurred in three polygons within WAPA and these were previously documented during the plot data collection stage. Similarly the *Morinda citrifolia* / *Nephrolepis hirsutula* Woodland and the *Antigonon leptopus* - *Urochloa maxima* Semi-natural Herbaceous Vegetation map classes were also not sampled since they primarily occurred outside of WAPA in the environs and the polygons in the park were previously sampled with observations and plots.

All of the classes that were accessed had high user's accuracy except for the F_BAVU (marginal), H_DILI (low), W_PEPT (marginal) and W_SPCA (zero accuracy) map classes; likely for the following reasons:

F_BAVU = most polygons of this type were already sampled during the plot data collection stage and one of the remaining polygons was found to be co-dominated by *Heterospathe elata* trees. Since *Bambusa vulgaris* was also present at this location this stand is likely a heterogeneous mix of trees. Changing this point to F_BAVU would increase the accuracy to 100%. More AA sampling of this type outside of WAPA would also likely increase the user's accuracy of F_BAVU to over 80%.

H_DILI = this herbaceous vegetation map class was closely aligned with the Mixed Savanna Herbaceous Vegetation map class and many of the dominant species overlapped and intermixed. Four points were found to be H_SAVA although *Dicranopteris linearis* was also found in most of them. More ground-truthing of this type would likely increase the accuracy and further help to distinguish the grassland vegetation from this low-growing fern map class.

W_PEPT = *Peltophorum pterocarpum* Woodland Stand was added to the classification after the accuracy assessment. Two polygons were found to be highly heterogeneous with multiple tree species having the same amount of cover including *Peltophorum pterocarpum*. Since *Peltophorum pterocarpum* was not in the original field key the other co-dominant species were likely used as the diagnostic species.

W_SPCA = all polygons of this type except one were already sampled during the plot data collection stage and the remaining polygon was found to be dominated by *Leucaena leucocephala* shrubs and *Artocarpus altilis* (Lemai) emergent trees. The presence of tall

Artocarpus altilis trees likely mimicked the photo signature of *Spathodea campanulata* leading to the mapping confusion.

It is likely that the lower than expected accuracies for all four types were compounded by their low sample sizes and the fact that they often occurred in small stands. The sources of producer's error can likely be explained by the difficulty in resolving the difference in scale and perspective between viewing the vegetation on the imagery and assessing it on the ground. For example, sampling could have occurred in inclusions or canopy openings that were mapped as W_SPCA or W_PEPT but appeared on the ground to be part of larger woodland polygons. Conversely, sparse woodlands and shrublands with mixed grass understories appeared dense enough to map but were likely judged to be herbaceous vegetation and not true woodlands or shrubland by the AA field crews.

The accuracy for these types were accepted by PACN and left in the map layer due to their importance for resource management.

Discussion

WAPA is truly a special place combining a rich mix of WWII historical sites, reefs, beaches, and remnants of native coastal, savanna, and forest plant communities. Across this landscape a variety of non-native plants thrive in upland and mesic, marsh, swamp, and ravine habitats typical of the leeward coast of Guam. WAPA's past history of human occupation and development coupled with areas of thick, jungle-like environments made it very challenging to inventory the vegetation. However, due to the small size of the park and the accessibility afforded the sampling and verification efforts, an accurate classification and detailed map layer was completed. Even though the accuracy is high, there are still some areas where improvements can be made which are summarized below.

Approaches that worked well: Field data and feedback provided by PACN ecologists were extremely helpful in the classification and delineation of the different plant associations. High-quality plot, observation point, and legacy data, in addition to focused local plant association descriptions greatly aided this project on all levels.

Areas for Improvement: Inherent to all vegetation inventory projects is the need to pigeon-hole a continuum of vegetation into discrete units. This is made even more difficult at places like WAPA with a long history of anthropogenic disturbance. When the native vegetation has been replaced and altered it is extremely hard to correctly determine where one plant association starts and where the other ends. This can be witnessed in the classification stage by the high overlap in dominant species between the different plant associations. Further in the mapping stage, subtle vegetation characteristics such as cover value breaks (e.g. $< > 10\%$) that can be seen on the ground are not necessarily apparent on the imagery. Canopy closure, shadows, soil reflections and the timing of the imagery acquisition can all impact where lines are drawn. Newer, high-resolution imagery and more ground-based observations will improve the classification of the non-native vegetation and its delineation.

Field Survey

The vegetation classification data presented in this project should be used as the baseline from which to begin future vegetation studies. New survey work in a judicious timeframe would improve both the classification (some association descriptions are based only on one or two plots) and mapping (refined linework) efforts. Using the accuracy assessment as a guide, map classes with lower accuracy could be further surveyed and boundaries delineated in the field to create a more accurate GIS layer. While it may appear that there are a large number of plant associations and vegetation alliances described for this very small study area, some were only minimally sampled likely due to access limitations. Future restoration efforts to reduce invasive tree and shrub cover on or surrounding archeological sites may greatly alter the existing plant assemblages. Likewise, future control efforts of the CRB will likely change distribution of some plant species, particularly *tronkon niyok*. It is recommended that these changes be recorded and used to update the GIS layer and classification as needed.

Classification

The vegetation of WAPA is diverse and represents a variety of habitats of Guam as the park spans from coastal strand to over 225 m (750 ft). About half of the plant associations mapped and described are characterized by non-native species. Several new plant associations have been described for the park, but these are merely official documentation and application of the USNVC standard (FDGC 2008) and are not new to what is known about the ecology of the park. Most of the USNVC associations can be crosswalked to the seven general habitat types described by Whistler (2009), which is a summary of prior vegetation research on the island (Table 10).

Table 10. Crosswalk USNVC plant associations to modified* Whistler 2009 habitats.

Whistler (2009)	WAPA Plant Associations
zLittoral Strand	<i>Casuarina equisetifolia</i> Strand Woodland [Provisional]
	<i>Cocos nucifera</i> - <i>Hibiscus tiliaceus</i> / Mixed Grass Wooded Strand [Provisional]
	<i>Hibiscus tiliaceus</i> Woodland [Park Special]
	<i>Ipomoea pes-caprae</i> Herbaceous Vegetation [Provisional]
	<i>Cenchrus (polystachios, purpureus)</i> Semi-natural Herbaceous Vegetation [Provisional] ¹
Limestone Forest	<i>Bambusa vulgaris</i> Semi-natural Forest [Park Special]
	<i>Heterospathe elata</i> / <i>Nephrolepis hirsutula</i> Semi-natural Woodland
	<i>Hibiscus tiliaceus</i> Woodland [Park Special]
	<i>Leucaena leucocephala</i> / <i>Nephrolepis hirsutula</i> Semi-natural Shrubland [Park Special]
	<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland
	<i>Vitex parviflora</i> Semi-natural Woodland [Park Special]
Mahogany	<i>Swietenia macrophylla</i> Semi-natural Forest [Park Special]
Managed Land Vegetation (Lawns)	<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn [Provisional]
Marsh	<i>Antigonon leptopus</i> - <i>Urochloa maxima</i> Semi-natural Herbaceous Vegetation [Park Special]
	<i>Phragmites karka</i> Herbaceous Vegetation [Provisional]
Ravine Forest	<i>Heterospathe elata</i> - <i>Hibiscus tiliaceus</i> / (<i>Phragmites karka</i> , <i>Miscanthus floridulus</i>) Semi-natural Woodland [Park Special]
	<i>Heterospathe elata</i> / <i>Nephrolepis hirsutula</i> Semi-natural Woodland [Provisional]
Savanna	<i>Bothriochloa bladhii</i> - (<i>Dactyloctenium aegyptium</i> , <i>Paspalum conjugatum</i>) Semi-natural Herbaceous Vegetation [Provisional]
	<i>Casuarina equisetifolia</i> / <i>Miscanthus floridulus</i> - <i>Cenchrus polystachios</i> Semi-natural Wooded Grassland [Park Special] ¹
	<i>Dicranopteris linearis</i> Herbaceous Vegetation [Park Special]
	<i>Dimeria chloridiformis</i> Herbaceous Vegetation [Provisional]

¹USNVC name modified based on Wagner et al. 1999 and Wagner et al. 2012.

Table 10. Crosswalk USNVC plant associations to modified* Whistler 2009 habitats (*continues*).

Whistler (2009)	WAPA Plant Associations
	<i>Leucaena leucocephala</i> / <i>Miscanthus floridulus</i> Semi-natural Shrubland [Park Special]
	<i>Miscanthus floridulus</i> (<i>Cenchrus polystachios</i> - <i>Bothriochloa bladhii</i>) Semi-natural Herbaceous Vegetation [Provisional] ¹
	<i>Cenchrus</i> (<i>polystachios</i> , <i>purpureus</i>) Semi-natural Herbaceous Vegetation [Provisional] ¹
	<i>Tabebuia heterophylla</i> / <i>Dimeria chloridiformis</i> Semi-natural Woodland [Park Special]
Secondary Forest ²	<i>Mangifera indica</i> Semi-natural Woodland [Park Special]
	<i>Morinda citrifolia</i> / <i>Nephrolepis hirsutula</i> Woodland [Park Special]
	<i>Spathodea campanulata</i> Semi-natural Woodland [Park Special]

²Modified from Whistler's (2009) summarized habitat types for Guam. Secondary forests are not described in Whistler's seven habitat types; however secondary forests are described in the reports summarized by Whistler and thus, included in the table above.

Digital Imagery and Mapping

The vegetation map for WAPA was based on the 2005 Quickbird ortho-imagery. Therefore, all of the resulting mapping products correspond to the 2005 timing of the image acquisition (i.e. snapshot in time). As the data are used, please remember that fires, resource management actions, or landscape altering events since 2005 are not included. In the future it would be beneficial to update the map based on newer imagery or from GPS coordinates of the events.

Accuracy Assessment

An important and necessary aspect of this project is the accuracy assessment; collecting independent ground data determines the usefulness of the vegetation map. As such, users of this product should remember that the GIS mapping and the classification portions of this project were conducted separately from both the plot and AA field data collection. Employing divisions in completing tasks created some challenges related to communication among the teams, including: 1) adequately conveying changes to the vegetation classification based on finding potentially new vegetation types during the field portion of the AA, 2) thoroughly testing and adjusting the field key to remove confusing splits among similar types, 3) insuring that adequate sample sizes are collected for rare and infrequent types, and 4) avoiding having to collect more than the estimated 30 data points for common types.

Actual errors in the mapping likely stemmed from the limitations of the ortho-photography as previously described, natural changes in the vegetation between sampling and the acquisition date of the imagery, errors in the field key, or difficulty in establishing an overhead perspective to exactly match the ground view. Although the accuracy for WAPA appears moderate to high, improvements can be made and users should fully explore and understand the sources of error as presented in the error matrix.

It is also important for users to remember that since the mapping portion of this project is primarily a remotely sensed exercise and the field work was conducted on site, all resulting products are scale dependent. In general the mapping portions should be viewed as a broader overview and the field data as more site specific. Although one can zoom in further than

1:12,000-scale using GIS software, the actual mapping was conducted at this scale. As such, any work performed with this product at a finer scale could lead to some uncertainty. In contrast, the field work was conducted at individual locations at one specific time and any extrapolation from these locations to out-lying areas or using them to determine what is there at different times is less reliable. Future users should fully appreciate these scale limitations and balance their efforts accordingly.

Future Recommendations

This project represents the best efforts put forth by a multi-disciplinary team. In order to create the best possible “long-term” vegetation classification for WAPA and the most accurate and detailed GIS layer, this project should be viewed as a place to start rather than an end product. In other words, present and future NPS staff should be encouraged to scrutinize this project, building from its strengths and bolstering its weaknesses. One way would be to periodically perform field checking by examining the map in the field by qualified NPS or contract staff, documenting any changes, and incorporating these into newer versions. By keeping in mind that this project represents just a snapshot in time, future efforts can help complete the understanding of the vegetation in and around WAPA and how it changes. It is the hope of the producers that the products presented here will help direct future efforts, as follows:

1. The close proximity of this site to highly disturbed lands in the environs should be addressed by seeking permission to sample and verify the vegetation through **periodic field surveys**. In this way new plant associations could be discovered, existing types could be updated, and integrated invasive species management strategies could be expanded. All new information could be used to update both the GIS map layer (i.e. better delineation) and the classification (i.e. new associations).
2. Any changes to the landscape as a result of the coconut rhinoceros beetle infestation and **documenting control efforts** could update the existing types. All new information could be used to update both the GIS map layer (i.e. better delineation) and the classification (i.e. new associations).
3. Remote sensing does not replace on-the-ground knowledge provided by GPS-linked plots, observations, photographs, and ground verification. Time, topographic features, and funding limitations curtailed the amount of map **ground-truthing** performed. As research opportunities arise, maps should be examined in the field by experienced crews. Also GPS receiver data and other GIS layers (such as soils and geology) should be used to improve and update the spatial data. Data could be collected on a standard field form, stored, and then used to update the GIS layer on an annual basis. The vegetation map layer should not be viewed as static but should be updated with more current and accurate information.
4. To better understand the limitations of the map, the **accuracy assessment** data presented in the error matrices should be thoroughly reviewed by NPS staff. Map classes with low accuracy should be examined to see if they could be improved with future studies using ground-truthing or other remote-sensing formats (i.e. fine-scale imagery, hyperspectral, etc). Also, landscape modeling may help to tease out the location of specific types based on specific habitat information. Finally, for some applications it may make sense to

combine map classes into higher units, such as alliances or ecological systems to improve their accuracy.

5. In the future, resource management personnel could link the habitat for **species of concern** to specific associations and map classes. These map classes could then be used to help locate potential sites of rare, endangered, or threatened species and communities in the field or identify areas for non-native plant removal or treatment. Known populations and individual species of concern can be overlain using point or small polygon layers.

Research Opportunities

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

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Appendix A: WAPA Field Data Forms

PACN PLOT SURVEY FORM 2008 VEGETATION MAPPING PROGRAM

SURVEY AND SITE INFORMATION

Plot Code: _____ Descriptive Location: _____ Survey Date: _____					
Park Site Name: _____			Park Name: _____		
Surveyors: _____					
Datum: WGS 84 NAD 83 Other: _____ Field Northing: _____ (UTM) Field Easting: _____ (UTM)					
GPS UNIT: Garmin 76 Garmin 5 Other: _____ Error: +/- _____ m					
GPS Comments: _____					
Directions to Plot: _____					
Sq plot (20 x 20) (10m x 10m)		Rect Plot: len(m) _____ x wid(m) _____		Circ. Plot (100 m ² , 400 m ² , 1000m ²)	
				Azi _____ deg	
Camera ID _____ Camera Ht: _____ m Photopoint coords (if not plot center) Northing: _____ (UTM) Easting: _____ (UTM)					
Description of Photopoint: _____					
View#	Time	V or H	Bearing	Photographer	View from Photopoint
1					
2					
3					
4					
a					
Views 1-4 - cardinal directions N,E,S,W; view a - person standing on the photopoint itself to help relocate it in future, additional representative views					
Plot representativeness (discuss plot placement and explain non-representativeness): _____ _____					

ENVIRONMENTAL DESCRIPTION

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

PLOT CODE: _____ DATE: _____

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

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

Plot Name:

Date: _____

Provisional Community Name:

[illegible]

PACN VEGETATION OBSERVATION FORM
2008 VEGETATION MAPPING PROGRAM

SURVEY AND SITE INFORMATION

Location: _____		Survey Date: _____	
Park Site Name: _____		Park Name: _____	
Surveyors: _____			
Datum: WGS 84 NAD 83 Other: _____ Field Northing: _____ (UTM) Field Easting: _____ (UTM)			
GPS UNIT: Garmin 76 Garmin 5 Other: _____ Error: +/- _____ m			
GPS Comments: _____			
Camera ID: _____ Camera Ht: _____ m Photopoint coords (if not plot center) Northing: _____ (UTM) Easting: _____ (UTM)			
Description of Photopoint: _____			
View#	Time	V or H	Bearing
1			
2			
3			
4			
a			
Photographer: _____			
View from Photopoint: _____			
Views 1-4 - cardinal directions N,E,S,W; view a - person standing on the photopoint itself to help relocate it in future, additional representative views			
Representativeness (estimate extent of uniform vegetation): _____			

ENVIRONMENTAL DESCRIPTION

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

Ground Cover: (please estimate to the nearest percentage. Sum = 100%)			
___ Bare soil (<0.1 mm)	___ Litter/Duff (dead plant material <3 cm diameter)	___ Lichen (ground)	
___ Sand (0.1-2 mm)	___ Coarse woody debris (dead wood 3-10 cm)	___ Moss (ground)	
___ Gravel (2 mm - 6.4 cm)	___ Woody debris structure (dead >10 cm deep & wide)	___ Microbiotic soil crust	
___ Rock (>6.4 cm)	___ Live veg (litter / wood)	___ Water	
___ Bedrock (solid surface)	___ Other: _____		
Soil Texture (optional - see soil key): ___ sand ___ loam ___ silt ___ clay ___ peat ___ muck			
Surface Water w/in 25m? YES/NO Seep, Spring, Stream, ~~Bothole~~ , River, ~~Anchialine Pond~~ , Ocean, Estuary.		Soil Moisture: Dry, Moist, Saturated, Standing Water	

Appendix B: Plant Species Found within Sample Plots at War in the Pacific National Historical Park

One-hundred and ninety plant species were encountered while sampling field plots, observation points, and accuracy assessment plots. Family, genus species, common names and origin are reported. Nomenclature follows that of Wagner et al. (1999), Wagner et al. (2012), and Raulerson and Rinehart (1991) for flowering plants and Palmer (2003) and Raulerson and Rinehart (1992) for ferns. Common names listed were selected primarily from Wagner et al. (1999) and Raulerson and Rinehart (1991) by PACN and used throughout the document. Where no species name information was available, online sources were used U.S. Department of Agriculture Natural Resources Conservation Service (USDA NRCS), Integrated Taxonomic Information System (ITIS), and The Taxonomic Name Resolution Service (TNRS) respectively. Species names that differ from those in the USNVC are identified with footnotes.

Family	Scientific Name	Common Name	Origin
Acanthaceae	<i>Ruellia blechum</i> L.	Yerbas babui	Non-Native
Agavaceae	<i>Agave americana</i> L.	centuryplant	Non-Native
Agavaceae	<i>Agave sisalana</i> Perrine	sisal	Non-Native
Anacardiaceae	<i>Mangifera indica</i> L.	mango	Non-Native
Annonaceae	<i>Annona reticulate</i> L.	custard apple	Non-Native
Annonaceae	<i>Cananga odorata</i> (Lam.) Hook. f. & T. Thomson	lengileng	Non-Native
Annonaceae	<i>Guamia mariannae</i> (Saff.) Merr.	paipai	Native
Apocynaceae	<i>Allamanda cathartica</i> L.	golden trumpet	Non-Native
Apocynaceae	<i>Neisosperma oppositifolia</i> (Lam.) Fosb. & Satchet	fagot	Native
Apocynaceae	<i>Nerium oleander</i> L.	oleander	Non-Native
Araceae	<i>Alocasia macrorrhizos</i> (L.) G. Don	giant taro	Non-Native
Araceae	<i>Syngonium angustatum</i> Schott	fivefingers	Unknown
Araucariaceae	<i>Agathis macrophylla</i> (Lindley) M. T. Masters	Fiji kauri	Non-Native
Arecaceae	<i>Cocos nucifera</i> L.	tronkon niyok	Non-Native
Arecaceae	<i>Heterospathe elata</i> Scheffer	palma brava	Native
Asclepiadaceae	<i>Telosma cordata</i> (N.L. Burman) Merrill	rubervine	Non-Native
Aspleniaceae	<i>Asplenium nidus</i> L.	bird's nest fern	Non-Native
Asteraceae	<i>Ageratina adenophora</i> (Spreng.) R. King & H. Robinson	masigsig	Native
Asteraceae	<i>Bidens alba</i> (L.) DC.	romerillo	Non-Native
Asteraceae	<i>Elephantopus mollis</i> Kunth	elephant's foot	Non-Native
Asteraceae	<i>Mikania micrantha</i> Kunth	mile-a-minute vine	Non-Native
Asteraceae	<i>Mikania scandens</i> (L.) Willd.	climbing hempvine	Non-Native
Asteraceae	<i>Sphagneticola trilobata</i> (L.) Pruski	Wedelia	Non-Native
Asteraceae	<i>Synedrella nodiflora</i> (L.) Gaertn.	nodeweed	Non-Native

Family	Scientific Name	Common Name	Origin
Asteraceae	<i>Wedelia biflora</i> (L.) DC.	beach sunflower	Non-Native
Bignoniaceae	<i>Catalpa longissima</i> (Jacq.) Dum.-Cours.	yokewood	Native
Bignoniaceae	<i>Spathodea campanulata</i> P. Beauv.	African tulip tree	Non-Native
Bignoniaceae	<i>Tabebuia heterophylla</i> (DC.) Britton	white cedar	Non-Native
Bignoniaceae	<i>Tabebuia rosea</i> (A. Bertoloni) A.P. de Candolle	pink tabebuia	Non-Native
Bixaceae	<i>Bixa orellana</i> L.	achiote	Non-Native
Campanulaceae	<i>Hippobroma longiflora</i> (L.) G. Don	Star-of-Bethlehem	Non-Native
Caricaceae	<i>Carica papaya</i> L.	papaya	Non-Native
Caryophyllaceae	<i>Dianthus chinensis</i> L.	rainbow pink	Non-Native
Casuarinaceae	<i>Casuarina equisetifolia</i> L.	gagu	Non-Native
Clusiaceae	<i>Calophyllum inophyllum</i> L.	da'ok	Native
Clusiaceae	<i>Hypericum canariense</i> L.	Canary Island St. Johnswort	Native
Commelinaceae	<i>Tradescantia spathacea</i> Sw.	boatlily	Non-Native
Convolvulaceae	<i>Ipomoea indica</i> (Burm.) Merr.	blue morning glory	Non-Native
Convolvulaceae	<i>Ipomoea littoralis</i> Blume	lagun-tasi	Native
Convolvulaceae	<i>Ipomoea obscura</i> (L.) Ker Gawl.	obscure morning glory	Native
Convolvulaceae	<i>Ipomoea pes-caprae</i> (L.) R. Br.	alalag-tasi	Non-Native
Convolvulaceae	<i>Ipomoea purpurea</i> (L.) Roth	common morninglory	Native
Convolvulaceae	<i>Stictocardia tiliifolia</i> (Desr.) Hallier f.	spottedheart	Non-Native
Cucurbitaceae	<i>Luffa aegyptiaca</i> P. Mill.	vegetable sponge	Non-Native
Cyperaceae	<i>Eleocharis geniculata</i> (L.) Roemer & J.A. Schultes	Canada spikesedge	Unknown
Cyperaceae	<i>Fimbristylis cymosa</i> R. Br.	tropical fimbry	Native
Cyperaceae	<i>Fimbristylis dichotoma</i> (L.) Vahl	forked fimbry	Native
Cyperaceae	<i>Fimbristylis tristachya</i> R. Br.	fimbry	Native
Cyperaceae	<i>Machaerina</i> spp. Vahl		Native
Cyperaceae	<i>Rhynchospora rubra</i> Domin	rhynchospora	Unknown
Cyperaceae	<i>Scleria lithosperma</i> (L.) Sw.	Florida Keys nutrush	Native
Cyperaceae	<i>Scleria polycarpa</i> Boeck.	nutrush	Native
Davalliaceae	<i>Davallia solida</i> (Forster f.) Swartz	Rabbit foot fern	Native
Dennstaedtiaceae	<i>Hypolepis hawaiiensis</i> Brownsey	birds nest fern	Native
Elaeocarpaceae	<i>Muntingia calabura</i> L.	Panama cherry	Native
Euphorbiaceae	<i>Glochidion marianum</i> Muell.-Arg.	chosgo	Non-Native
Euphorbiaceae	<i>Macaranga thompsonii</i> Merrill	pengua	Native
Euphorbiaceae	<i>Phyllanthus saffordii</i> Merrill		Native
Fabaceae	<i>Abrus precatorius</i> L.	crab's eye	Native
Fabaceae	<i>Adenanthera pavonina</i> L.	coral bean tree	Native
Fabaceae	<i>Albizia lebbbeck</i> (L.) Benth.	tronkon-kalaskas	Non-Native

Family	Scientific Name	Common Name	Origin
Fabaceae	<i>Alysicarpus vaginalis</i> (L.) DC.	white moneywort	Non-Native
Fabaceae	<i>Chamaecrista nictitans</i> ssp. <i>patellaria</i> var. <i>glabrata</i> (L.) Moench; (DC. Ex Collad.) H. S. Irwin & Barneby; (Vogel) H. S. Irwin & Barneby	partridge pea	Non-Native
Fabaceae	<i>Crotalaria pallida</i> Aiton	smooth rattlepod	Non-Native
Fabaceae	<i>Crotalaria retusa</i> L.	rattleweed	Non-Native
Fabaceae	<i>Cynometra ramiflora</i> L.	gulos	Non-Native
Fabaceae	<i>Derris elliptica</i> (Wallich) Benth.	derris	Native
Fabaceae	<i>Derris trifoliata</i> Lour.	threeleaf derris	Non-Native
Fabaceae	<i>Desmodium triflorum</i> (L.) DC.	threeflower ticktrefoil	Native
Fabaceae	<i>Entada phaseoloides</i> (L.) Merr.	bagogo	Non-Native
Fabaceae	<i>Fabaceae</i> spp.		Native
Fabaceae	<i>Flemingia strobilifera</i> (L.) Ait. & Ait. f.	wildhops	Unknown
Fabaceae	<i>Intsia bijuga</i> (Colebr.) Kuntze	ifit	Non-Native
Fabaceae	<i>Leucaena leucocephala</i> (Lam.) de Wit	tangan-tangan	Native
Fabaceae	<i>Macroptilium atropurpureum</i> (DC.) Urb.	purple bushbean	Non-Native
Fabaceae	<i>Mimosa pudica</i> L.; (Duchass. & Walp.) Griseb.	sleeping grass	Non-Native
Fabaceae	<i>Peltophorum pterocarpum</i> (DC.) Backer ex K. Heyne	yellow poinciana	Non-Native
Fabaceae	<i>Pithecellobium dulce</i> (Roxb.) Benth.	kamachile	Non-Native
Fabaceae	<i>Teramnus labialis</i> (L. f.) Sprengel	blue wiss	Non-Native
Flagellariaceae	<i>Flagellaria indica</i> L.	bejuco halum-tano	Non-Native
Gleicheniaceae	<i>Dicranopteris linearis</i> (Burm. f.) Underw.	uluhe	Native
Goodeniaceae	<i>Scaevola taccada</i> (Gaertn.) Roxb. ¹	nanaso	Native
Hernandiaceae	<i>Hernandia Sonora</i> L.	nonag	Native
Lamiaceae	<i>Clerodendrum quadriloculare</i> (Blanco.) Merr.		Native
Lamiaceae	<i>Hyptis capitata</i> Jacq.	false ironwort	Non-Native
Lamiaceae	<i>Hyptis suaveolens</i> (L.) Poit.	mumutun	Non-Native
Lamiaceae	<i>Vitex parviflora</i> Juss.	smallflower chastetree	Non-Native
Lauraceae	<i>Cassytha filiformis</i> L.	agace	Non-Native
Lecythidaceae	<i>Barringtonia asiatica</i> (L.) Kurz	putting	Native
Liliaceae	<i>Hymenocallis littoralis</i> (Jacq.) Salisb.	lirio	Native
Lindsaeaceae	<i>Lindsaea ensifolia</i> Sw.	graceful necklace fern	Non-Native
Loganiaceae	<i>Geniostoma micranthum</i> A. DC.	majlocjajo	Native
Lomariopsidaceae	<i>Nephrolepis biserrata</i> (Sw.) Schott	giant swordfern	Native
Lomariopsidaceae	<i>Nephrolepis hirsutula</i> (G. Forst.) C.	scaly swordfern	Native

Family	Scientific Name	Common Name	Origin
	Presl 'Superba'		
Lycopodiaceae	<i>Lycopodiella cernua</i> (L.) Pic. Serm.	staghorn clubmoss	Native
Lythraceae	<i>Pemphis acidula</i> Forst. & Forst.	nigas	Native
Malvaceae	<i>Hibiscus tiliaceus</i> L.	hau	Native
Malvaceae	<i>Melochia aristata</i> A. Gray	ma'o	Native
Malvaceae	<i>Thespesia populnea</i> (L.) Sol. ex Corrêa	milo	Unknown
Malvaceae	<i>Urena lobata</i> L.	dadangsi	Native
Malvaceae	<i>Waltheria indica</i> L.	escobilla sabana	Non-Native
Melastomataceae	<i>Melastoma malabathricum</i> var. <i>mariannum</i> L. var. <i>mariannum</i> (Naudin) Fosberg & Sachet (ined.)	gafau	Non-Native
Meliaceae	<i>Aglaia mariannensis</i> Merrill	mapunao	Native
Meliaceae	<i>Azadirachta indica</i> A. Juss.	neem	Native
Meliaceae	<i>Swietenia macrophylla</i> G. King	broad-leaved mahogany	Non-Native
Menispermaceae	<i>Tinospora homosepala</i> Diels		Non-Native
Moraceae	<i>Artocarpus altilis</i> (Parkinson) Fosberg	lemai	Native
Moraceae	<i>Artocarpus heterophyllus</i> Lam.	jackfruit	Non-Native
Moraceae	<i>Artocarpus mariannensis</i> Trec.	dogduk	Non-Native
Moraceae	<i>Ficus benjamina</i> L.	weeping fig	Native
Moraceae	<i>Ficus macrophylla</i> Desf. ex Pers.	Moreton Bay fig	Non-Native
Moraceae	<i>Ficus microcarpa</i> L. f.	Chinese banyan	Non-Native
Moraceae	<i>Ficus prolixa</i> Forst. f.	nunu	Native
Moraceae	<i>Ficus tinctoria</i> Forst. f.	hodda	Native
Musaceae	<i>Musa</i> spp.	banana	Native
Myrtaceae	<i>Decaspermum fruticosum</i> J.F. & G. Forster	nu'anua	Non-Native
Myrtaceae	<i>Eugenia javanica</i> Lam.	wax apple	Native
Myrtaceae	<i>Myrtella bennigseniana</i> (Volkens) Diels		Non-Native
Myrtaceae	<i>Pimenta racemosa</i> (Mill.) J. W. Moore	bay rum	Native
Myrtaceae	<i>Psidium guajava</i> L.	guava	Non-Native
Oleaceae	<i>Jasminum marianum</i> DC.	banago	Non-Native
Orchidaceae	<i>Arundina graminifolia</i> (D. Don) Hochr.	bamboo orchid	Native
Orchidaceae	<i>Spathoglottis plicata</i> Blume	Philippine ground orchid	Non-Native
Oxalidaceae	<i>Averrhoa bilimbi</i> L.	bilimbi	Non-Native
Pandanaceae	<i>Pandanus dubius</i> Sprengel	pahong	Non-Native
Pandanaceae	<i>Pandanus tectorius</i> Parkinson ex Z	kafu	Native
Passifloraceae	<i>Passiflora foetida</i> L.	love-in-a-mist	Native
Passifloraceae	<i>Passiflora suberosa</i> L.	corky passionflower	Non-Native

Family	Scientific Name	Common Name	Origin
Passifloraceae	<i>Passiflora subpeltata</i> Ortega	white passionflower	Non-Native
Piperaceae	<i>Piper betle</i> L.	betel-pepper	Non-Native
Poaceae	<i>Axonopus compressus</i> (Sw.) P. Beauv.	carpet grass	Non-Native
Poaceae	<i>Bambusa blumeana</i> Schultes fils	spiny bamboo	Non-Native
Poaceae	<i>Bambusa vulgaris</i> J.C. Wendl.	piao palaoan	Non-Native
Poaceae	<i>Bothriochloa bladhii</i> (Retz.) S.T. Blake	Australian beardgrass	Non-Native
Poaceae	<i>Cenchrus echinatus</i> L.	burgrass	Non-Native
Poaceae	<i>Cenchrus polystachios</i> (L.) Morrone ²	mission grass	Non-Native
Poaceae	<i>Cenchrus purpureus</i> (Schumach.) Morrone ³	napier grass	Unknown
Poaceae	<i>Centotheca lappacea</i> (L.) Desv.	sefa	Non-Native
Poaceae	<i>Chloris barbata</i> (L.) Sw.	fingergrass	Native
Poaceae	<i>Chrysopogon aciculatus</i> (Retz.) Trin.	inifuk	Non-Native
Poaceae	<i>Cynodon dactylon</i> (L.) Pers.	Bermuda grass	Native
Poaceae	<i>Dactyloctenium aegyptium</i> (L.) Willd.	beach wiregrass	Non-Native
Poaceae	<i>Dichanthium caricosum</i> (L.) Camus ⁴	roadside bluestem	Non-Native
Poaceae	<i>Digitaria ciliaris</i> (Retz.) Koeler	Henry's crabgrass	Non-Native
Poaceae	<i>Digitaria</i> spp.		Native
Poaceae	<i>Dimeria chloridiformis</i> (Gaud.) K. Shum. & Lauterbach		Unknown
Poaceae	<i>Eleusine indica</i> (L.) Gaertn.	goose grass	Native
Poaceae	<i>Heteropogon contortus</i> (L.) P. Beauv. ex Roem. & Schult.	tanglehead	Non-Native
Poaceae	<i>Imperata conferta</i> (J.S. Presl) Ohwi	plumegrass	Native
Poaceae	<i>Miscanthus floridulus</i> (Labill.) Warburg ex Schum. & Lauterbach.	neti	Non-Native
Poaceae	<i>Oplismenus compositus</i> (L.) P. Beauv.	running mountaingrass	Native
Poaceae	<i>Oplismenus hirtellus</i> (L.) P. Beauv.	basketgrass	Native
Poaceae	<i>Paspalum conjugatum</i> P. J. Bergius	Hilo grass	Non-Native
Poaceae	<i>Paspalum</i> spp.		Non-Native
Poaceae	<i>Phragmites karka</i> (Retz.) Trin. ex Steud.	karriso	Non-Native
Poaceae	<i>Poa</i> spp.	Unknown Grass	Native
Poaceae	<i>Saccharum spontaneum</i> L.	wildcane	Non-Native
Poaceae	<i>Sporobolus virginicus</i> (L.) Kunth	seashore dropseed	Non-Native
Poaceae	<i>Urochloa maxima</i> (Jacq.) R. D. Webster	guinea grass	Native
Poaceae	<i>Zoysia matrella</i> (L.) Merr.	makila grass	Non-Native
Poaceae	<i>Zoysia</i> spp. Willd.		Native

Family	Scientific Name	Common Name	Origin
Polygalaceae	<i>Polygala paniculata</i> L.	milkwort	Unknown
Polygonaceae	<i>Antigonon leptopus</i> Hook. & Arn.	chain-of-love	Native
Polypodiaceae	<i>Belvisia spicata</i> (Linnaeus f.) Mirbel ex Copeland		Non-Native
Polypodiaceae	<i>Microsorium punctatum</i> (L.) Copel. ⁴	climbing bird's nest fern	Native
Polypodiaceae	<i>Phymatosorus grossus</i> (Langsd. & Fisch.) Brownlie	monarch fern	Native
Polypodiaceae	<i>Pyrrosia lanceolata</i> (L.) Farw.		Native
Proteaceae	<i>Macadamia integrifolia</i> Maiden & Betcher	macadamia nut	Native
Ptericaceae	<i>Adiantum philippense</i> L.	maidenhair fern	Non-Native
Pteridaceae	<i>Adiantum tenerum</i> Sw.	fan maidenhair	Native
Pteridaceae	<i>Pteris quadriaurita</i> auct. non Retz.	striped brake	Non-Native
Pteridaceae	<i>Pteris vittata</i> L.	Chinese brake	Native
Rhamnaceae	<i>Colubrina asiatica</i> (L.) Brongn.	gasoso	Non-Native
Rubiaceae	<i>Aidia cochinchinensis</i> Lour.	Sumak	Native
Rubiaceae	<i>Ixora finlaysoniana</i> Wall.	ixora	Non-Native
Rubiaceae	<i>Morinda citrifolia</i> L.	lada	Non-Native
Rubiaceae	<i>Paederia foetida</i> L.	maile pilau	Native
Rubiaceae	<i>Spermacoce assurgens</i> Ruiz & Pav.	false buttonweed	Non-Native
Rubiaceae	<i>Timonius nitidus</i> (Bartl. ex DC.) F.-Vill.	sumac-lada	Non-Native
Rutaceae	<i>Citrus macroptera</i> Montr.	bitter orange	Native
Rutaceae	<i>Triphasia trifolia</i> (Burm. f.) P. Wilson	limeberry	Non-Native
Sapindaceae	<i>Dodonaea viscosa</i> Jacq.	lampauye	Non-Native
Schizaeaceae	<i>Lygodium microphyllum</i> (Cav.) R. Br.	small leaf climbing fern	Native
Thelypteridaceae	<i>Thelypteris opulenta</i> (Kaulfuss) Fosberg	jeweled maiden fern	Native
Urticaceae	<i>Pipturus argenteus</i> (G. Forst.) Wedd.	amahadyan	Native
Verbenaceae	<i>Phyla nodiflora</i> (L.) Greene	sawtooth frogfruit	Native
Verbenaceae	<i>Premna serratifolia</i> L. ⁵	ahgao	Non-Native
Verbenaceae	<i>Stachytarpheta jamaicensis</i> (L.) Vahl	false verbena	Native
Xanthorrhoeaceae	<i>Dianella saffordiana</i> Fosberg & Sachet		Non-Native

¹ Listed in USNVC as *Scaevola sericea* var. *taccada*.

² Listed in USNVC as *Pennisetum polystachion*.

³ Listed in USNVC as *Pennisetum purpureum*.

⁴ Listed in USNVC as *Polypodium punctatum*.

⁵ Listed in USNVC as *Premna obtusifolia*.

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Appendix C: Field Plot Crosswalk to U.S. National Vegetation Classification Associations

At War in the Pacific National Historical Park 73 plots and observation points were assigned to the USNVC associations and park specials. A total of 25 USNVC associations, 14 “Park Specials” and 9 “Provisional” types were classified. Element codes are used by NatureServe and state Natural Heritage Programs to track nomenclature and status of rare plants, rare animals, and communities (“elements”). Nomenclature used by the USNVC follows Kartesz (1999) with Pacific Island modifications based on Wagner et al. (1999), Wagner et al. (2012), Palmer (2003) and Raulerson and Rinehart (1991,1992).

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plots and Observation Points
Forest and Woodland			
Casuarina equisetifolia / Miscanthus floridulus - Cenchrus polystachios Semi-natural Wooded Grassland [Park Special] ¹	CEPS009544	2	WAPA.0004, WAPA.0901
Casuarina equisetifolia Woodland [Provisional]	CEGL008121	2	WAPA.0915, WAPA.0933
Cocos nucifera - Hibiscus tiliaceus / Mixed Grass Wooded Strand [Provisional]	CEGL008129	5	WAPA.0009, WAPA.0013, WAPA.0014, WAPA.0914, WAPA.0916
Heterospathe elata / Nephrolepis hirsutula Semi-natural Woodland [Provisional]	CEGL008128	6	WAPA.0030, WAPA.0032, WAPA.0033, WAPA.0034, WAPA.0905, WAPA.0932
Heterospathe elata - Hibiscus tiliaceus / (Phragmites karka, Miscanthus floridulus) Semi-natural Woodland [Park Special]	CEPS009548	2	WAPA.0904, WAPA.0927
Hibiscus tiliaceus Woodland [Park Special]	CEPS009549	2	WAPA.0011, WAPA.0029
Morinda citrifolia / Nephrolepis hirsutula Woodland [Park Special]	CEPS009550	1	WAPA.0038
Tabebuia heterophylla / Dimeria chloridiformis Semi-natural Woodland [Park Special]	CEPS009551	1	WAPA.0040
Bambusa vulgaris Semi-natural Forest [Park Special]	CEPS009552	2	WAPA.0035, WAPA.0906
Mangifera indica Semi-natural Woodland [Park Special]	CEPS009553	2	WAPA.0907, WAPA.0926
Spathodea campanulata Semi-natural Woodland [Park Special]	CEPS009554	3	WAPA.0021, WAPA.0921, WAPA.0923
Swietenia macrophylla Semi-natural Forest [Park Special]	CEPS009555	1	WAPA.0008

Plant Association Scientific Name	Element Code	No. of Samples	Supporting Plots and Observation Points
Vitex parviflora Semi-natural Woodland [Park Special]	CEPS009556	2	WAPA.0031, WAPA.0934
Shrubland			
Leucaena leucocephala / Miscanthus floridulus Semi-natural Shrubland [Park Special]	CEPS009546	2	WAPA.0025, WAPA.0929
Leucaena leucocephala / Nephrolepis hirsutula Semi-natural Shrubland [Park Special]	CEPS009547	1	WAPA.0931
Leucaena leucocephala Lowland Dry Semi-natural Shrubland	CEGL008114	6	WAPA.0036, WAPA.0902, WAPA.0903, WAPA.0919, WAPA.0920, WAPA.0930
Herbaceous Vegetation			
<i>Dimeria chloridiformis</i> Herbaceous Vegetation [Provisional]	CEGL008125	3	WAPA.0017, WAPA.0024, WAPA.0026
<i>Miscanthus floridulus</i> (<i>Cenchrus polystachios</i> - <i>Bothriochloa bladhii</i>) Semi-natural Herbaceous Vegetation [Provisional] ¹	CEGL008126	10	WAPA.0002, WAPA.0005, WAPA.0006, WAPA.0018, WAPA.0019, WAPA.0020, WAPA.0023, WAPA.0028, WAPA.0039, WAPA.0922
<i>Dicranopteris linearis</i> Herbaceous Vegetation [Park Special]	CEPS009545	2	WAPA.0027, WAPA.0909
<i>Bothriochloa bladhii</i> - (<i>Dactyloctenium aegyptium</i> , <i>Paspalum conjugatum</i>) Semi-natural Herbaceous Vegetation [Provisional]	CEGL008127	2	WAPA.0015, WAPA.0016
<i>Ipomoea pes-caprae</i> Herbaceous Vegetation [Provisional]	CEGL008130	2	WAPA.0910, WAPA.0912
<i>Phragmites karka</i> Herbaceous Vegetation [Provisional]	CEGL008131	5	WAPA.0908, WAPA.0911, WAPA.0913, WAPA.0917, WAPA.0928
<i>Antigonon leptopus</i> - <i>Urochloa maxima</i> Semi-natural Herbaceous Vegetation [Park Special]	CEPS009557	1	WAPA.0037
<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn [Provisional]	CEGL008124	4	WAPA.0003, WAPA.0010, WAPA.0012, WAPA.0022
<i>Cenchrus</i> (<i>polystachios</i> , <i>purpureus</i>) Semi-natural Herbaceous Vegetation ¹	CEGL008123	4	WAPA.0001, WAPA.0007, WAPA.0924, WAPA.0925
¹ USNVC name modified based on Wagner et al. 1999 and Wagner et al. 2012.			

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Appendix D: Field Key to the Vegetation of War in the Pacific National Historical Park (WAPA), Guam

The vegetation of War in the Pacific National Historical Park (WAPA) was described using field data collected in 2009 under the National Park Service's National Vegetation Mapping Program. This dichotomous key has been developed from plot data to assist in the accurate field identification of the 25 plant associations and 18 map codes.

This key is structured to facilitate identification of vegetation types with one or a combination of dominant or diagnostic species, and in some cases, the key also relates types to their primary habitats and range within the park. Because of natural variation within vegetation types, it is possible that a community can be keyed using more than one of the physiognomic keys. For sites within ecotones (boundary or transition zones between vegetation types where diagnostic species intermix), it may be difficult to determine a definitive type. A mapped type may have small inclusions of other vegetation types.

How to use the key

The key can be used to identify at two hierarchical levels within the revised US National Vegetation Classification (USNVC). The broadest level is the Group and the finest scale is the Association. The key focuses on the Association level and when the association is identified, the group is known because of the hierarchical nature of the USNVC (Table 5).

“Park Specials” represent local vegetation types that differ significantly from existing USNVC association concepts, but lack enough data to develop into a new association. Park Special types are not officially included in the USNVC hierarchy, but many times can be linked to the Group level for classification and mapping purposes (Table 5).

The key is divided into Forest and Woodland, Shrubland and Herbaceous Vegetation. Some vegetation types may occur in multiple zones so if the key is not working well try using other zones in key before assuming vegetation is not described. The name of each Association and Park Special are provided using both common names and scientific names for species as well as the map class in parentheses. In some instances, multiple associations are included in a single map class, or conversely, one association is included in multiple map classes (e.g. **Neti-(Mission Grass-Australian Beardgrass) Semi-natural Herbaceous Vegetation**; *Miscanthus floridulus* – (*Cenchrus polystachios*- *Bothriochloa bladhii*) Semi-natural Herbaceous Vegetation¹). This key does not include the additional Unclassified Map Classes that were not part of the original classification data (e.g. Coral Bean Tree Semi-natural Forest Stand; *Adenanthera pavonina* Semi-natural Forest Stand).

Special instructions

1. There are a number of closely related vegetation types at WAPA that may be confusing in the field (e.g., grasslands with scattered trees or shrubs vs. open shrublands or woodlands). We are using a 5% minimum tree cover threshold for forests and woodlands with a strong herbaceous layer. Less than 5% tree cover is included in shrublands and grasslands unless the tree layer exceeds herbaceous cover. Percent canopy cover values are all absolute, not relative. Species dominance is important in keying vegetation. Dominant species are the predominant species in a community because of size, abundance or coverage. A dominant or co-dominant species might have high relative cover in the tree, shrub or herbaceous layer or be the largest and most prominent species present in the stand, such as coconut trees in an open coconut palm strand woodland, but not necessarily the most abundant or have the highest cover (e.g. **Tronkon Niyok Stand Wooded Scrub; *Cocos nucifera* Stand Wooded Scrub**).
2. Tangan-tangan (*Leucaena leucocephala*) can be a small tree; however it is considered a shrub in this key. For Hawaii parks it is considered to be a shrub life form, so to be consistent across the Pacific Island Network, stands dominated by tangan-tangan are classified as shrublands.
3. When keying vegetation with seasonally deciduous trees and shrubs, estimate what the live crown canopy would be at full foliage during the peak growing season of the year. Canopy cover is used as a measure of species dominance in plant community classification and should not vary seasonally.
4. Not all species are given equal weight in classification. Native species are given more diagnostic value over non-native species in determining the vegetation type. Stands will be considered a native vegetation type when invaded by non-native species (in other words a disturbed stand) as long as the non-native species do not strongly dominate the vegetation type (at which point the stand would be no longer recognizable as the native type, also known as complete conversion).
5. Some vegetation types may be in both coastal strand and inland portions of the key, but if you are in coastal strand and the key is not working well, try the inland portion of the key as some inland vegetation types extend to the coast.

A Key to the Vegetation Associations at War in the Pacific National Historical Park (WAPA)

- 1a) Vegetation includes trees that are at least 5 feet tall and have at least 5% cover. **(2)**
- 1b) Vegetation where trees are absent, or if present have <5% cover or are < 5 feet tall AND shrubs or herbaceous cover has at least 10% of the ground. **(13)**
- 1c) Unvegetated areas such as beaches, open water and parking lots are not part of this key.

Forest and Woodland Key

2a) Vegetation characterized by mostly native species. Canopy dominants include gagu (*Casuarina equisetifolia*), hau (*Hibiscus tiliaceus*), and lada (*Morinda citrifolia*). If gagu (*Casuarina equisetifolia*) is a dominant, mission grass (*Cenchrus polystachios*) is not present or dominant in the herbaceous layer. **(3)**

2b) Vegetation characterized by non-native or mixed non-native and native vegetation. Canopy dominants include palma brava (*Heterospatha elata*), gagu (*Casuarina equisetifolia*), mango (*Mangifera indica*) African tulip tree (*Spathodea campanulata*), broad-leaved mahogany (*Swietenia macrophylla*), smallflower chastetree (*Vitex parviflora*), piao palaoan (*Bambusa vulgaris*), and white cedar (*Tabebuia heterophylla*). **(5)**

3a) Canopy dominated by gagu (*Casuarina equisetifolia*), and herbaceous understory is absent or of low cover. – **Gagu Woodland [Provisional]; *Casuarina equisetifolia* Woodland [Provisional] (W_CAEQ)**

3b) Canopy dominated by hau (*Hibiscus tiliaceus*) or lada (*Morinda citrifolia*). **(4)**

4a) Dense subcanopy dominated by hau (*Hibiscus tiliaceus*). Canopy associates may include yokewood (*Catalpa longissima*) and tangan-tangan (*Leucaena leucocephala*), but are never codominant- **Hau Woodland [Park Special]; *Hibiscus tiliaceus* Woodland [Park Special] (W_HITI)**

4b) Subcanopy dominated by lada (*Morinda citrifolia*) with a moderately dense herbaceous layer of scaly swordfern (*Nephrolepis hirsutula*). Other tree species may be present in the canopy, but are never codominant. – **Lada / Scaly Swordfern Woodland [Park Special]; *Morinda citrifolia* / *Nephrolepis hirsutula* Woodland [Park Special] (W_MOCI)**

5a) Vegetation characterized by an open canopy of white cedar (*Tabebuia heterophylla*) with a graminoid layer dominated by *Dimeria chloridiformis* sometimes codominant with mission grass (*Cenchrus polystachios*). – **White cedar/ *Dimeria* Semi-natural Woodland [Park Special]; *Tabebuia heterophylla* / *Dimeria chloridiformis* Semi-natural Woodland [Park Special]¹ (W_TAHE)**

5b) Vegetation not characterized by an open canopy of white cedar (*Tabebuia heterophylla*) with a graminoid layer dominated by *Dimeria chloridiformis*. **(6)**

6a) Vegetation with canopies dominated by palma brava (*Heterospatha elata*). **(7)**

6b) Vegetation with canopies dominated by gagu (*Casuarina equisetifolia*), mango (*Mangifera indica*) African tulip tree (*Spathodea campanulata*), broad-leaved mahogany (*Swietenia macrophylla*), smallflower chastetree (*Vitex parviflora*), or piao palaoan (*Bambusa vulgaris*). (8)

7a) Subcanopy dominated by hau (*Hibiscus tiliaceus*) with graminoid layer dominated by neti (*Miscanthus floridulus*) and/or karriso (*Phragmites karka*). – **Palma Brava – Hau / (Karriso, Neti) Semi-natural Woodland [Park Special]; *Heterospathe elata* - *Hibiscus tiliaceus* / (*Phragmites karka*, *Miscanthus floridulus*) Semi-natural Woodland [Park Special] (W_HEEL)**

7b) Herbaceous layer characterized by a sparse to moderately dense (2-20%) layer of scaly swordfern (*Nephrolepis hirsutula*). – **Palma brava/ Scaly Swordfern Semi-natural Woodland [Provisional]; *Heterospathe elata* / *Nephrolepis hirsutula* Semi-natural Woodland [Provisional] (W_HEEL)**

8a) Canopy and subcanopy dominated by mango (*Mangifera indica*) often with tangan-tangan (*Leucaena leucocephala*) in the subcanopy. – **Mango Semi-natural Woodland [Park Special]; *Mangifera indica* Semi-natural Woodland [Park Special] (W_MAIN)**

8b) Canopy dominated by African tulip tree (*Spathodea campanulata*), gagu (*Casuarina equisetifolia*), broad-leaved mahogany (*Swietenia macrophylla*), smallflower chastetree (*Vitex parviflora*), or piao alaoan (*Bambusa vulgaris*). (9)

9a) Canopy dominated by African tulip tree (*Spathodea campanulata*). Palma brava (*Heterospathe elata*) may be present in the canopy, but not codominant.-**African Tulip Tree Semi-natural Woodland [Park Special]; *Spathodea campanulata* Semi-natural Woodland [Park Special] (W_SPCA)**

9b) Canopy dominated by gagu (*Casuarina equisetifolia*), broad-leaved mahogany (*Swietenia macrophylla*), smallflower chastetree (*Vitex parviflora*), or piao palaoan (*Bambusa vulgaris*). (10)

10a) Vegetation characterized by a widely spaced, sparse canopy (<10% cover) of gagu (*Casuarina equisetifolia*) with a dense understory of neti (*Miscanthus floridulus*) and/or mission grass (*Cenchrus polystachios*).- **Gagu/Neti-Mission Grass Semi-natural Wooded Grassland [Park Special]; *Casuarina equisetifolia* / *Miscanthus floridulus* – *Cenchrus polystachios* Semi-natural Wooded Grassland [Park Special]¹ (W_CAMI)**

10b) Canopy dominated by broad-leaved mahogany (*Swietenia macrophylla*), smallflower chastetree (*Vitex parviflora*), or piao palaoan (*Bambusa vulgaris*). (11)

11a) Canopy dominated by broad-leaved mahogany (*Swietenia macrophylla*).-**Broad-leaved Mahogany Semi-natural Forest [Park Special]; *Swietenia macrophylla* Semi-natural Forest [Park Special] (F_SWMA)**

11b) Canopy dominated by smallflower chastetree (*Vitex parviflora*) or piao palaoan (*Bambusa vulgaris*) (12)

12a) Canopy dominated by smallflower chastetree (*Vitex parviflora*).-**Smallflower Chastetree**

Semi-natural Woodland [Park Special]; *Vitex parviflora* Semi-natural Woodland [Park Special] (W_VIPA)

12b) Canopy dominated by piao palaoan (*Bambusa vulgaris*). - **Piao Palaoan Semi-natural Forest [Park Special]; *Bambusa vulgaris* Semi-natural Forest [Park Special] (F_BAVU)**

Shrubland and Herbaceous Key

13a) Upland savanna, shrub and grassland vegetation dominated by neti (*Miscanthus floridulus*), uluhe (*Dicranopteris linearis*), *Dimeria chloridiformis*, tangan-tangan (*Leucaena leucocephala*), scaly swordfern (*Nephrolepis hirsutula*), mission grass (*Cenchrus polystachios*), napier grass (*Cenchrus purpureus*), Australian beardgrass (*Bothriochloa bladhii*), beach wiregrass (*Dactyloctenium aegyptium*), and Hilo grass (*Paspalum conjugatum*). Gagu (*Casuarina equisetifolia*) may be present as scattered trees. **(14)**

13b) Palustrine and coastal vegetation dominated by karriso (*Phragmites karka*), tronkon niyok (*Cocos nucifera*), hau (*Hibiscus tiliaceus*), alalag-tasi (*Ipomoea pes-caprae*), chain-of-love (*Antigonon leptopus*), and/or guinea grass (*Urochloa maxima*). **(23)**

14a) Vegetation characterized by a dense grassland of neti (*Miscanthus floridulus*) and/or mission grass (*Cenchrus polystachios*) with widely spaced trees of gagu (*Casuarina equisetifolia*). The density of trees varies and may be clumpy in their distribution.- **Gagu / Neti – Mission Grass Semi-natural Wooded Grassland [Park Special]; *Casuarina equisetifolia* / *Miscanthus floridulus* – *Cenchrus polystachios* Semi-natural Wooded Grassland [Park Special]¹ (W_CAMI)**

14b) Shrub and herbaceous vegetation not as above. **(15)**

15a) Shrublands dominated by tangan-tangan (*Leucaena leucocephala*). **(16)**

15b) Herbaceous vegetation dominated by uluhe (*Dicranopteris linearis*), *Dimeria chloridiformis*, neti (*Miscanthus floridulus*), mission grass (*Cenchrus polystachios*), napier grass (*Cenchrus purpureus*), Australian beardgrass (*Bothriochloa bladhii*), beach wiregrass (*Dactyloctenium aegyptium*), inifuk (*Chrysopogon aciculatus*) and/or Hilo grass (*Paspalum conjugatum*). **(18)**

16a) Open stands of tangan-tangan (*Leucaena leucocephala*) (~10-15% cover) with an herbaceous layer dominated by scaly swordfern (*Nephrolepis hirsutula*) or neti (*Miscanthus floridulus*) **(17)**

16b) Moderately dense to densely vegetated thickets (~25-60%) cover of tangan-tangan (*Leucaena leucocephala*) occurring in multiple strata with a highly variable herbaceous layer.- **Tangan-tangan Lowland Dry Semi-natural Shrubland; *Leucaena leucocephala***

Lowland Dry Semi-natural Shrubland (S_LELE)

17a). Herbaceous layer dominated by scaly swordfern (*Nephrolepis hirsutula*)(50%).-**Tangan-tangan / Scaly Swordfern Semi-natural Shrubland [Park Special]; *Leucaena leucocephala* / *Nephrolepis hirsutula* Semi-natural Shrubland [Park Special] (S_LELE)**

17b) Herbaceous layer dominated by neti (*Miscanthus floridulus*)(12-30%). Other herbaceous species are frequent, but do not codominate.-**Tangan-tangan / Neti Semi-natural Shrubland [Park Special]; *Leucaena leucocephala* / *Miscanthus floridulus* Semi-natural Shrubland [Park Special] (S_LELE)**

18a) Semi-natural or lawn vegetation dominated by Australian beardgrass (*Bothriochloa bladhii*) or codominant with other graminoids. Neti (*Miscanthus floridulus*) is never codominant.(19)

18b) Herbaceous vegetation dominated by species other than Australian beardgrass (*Bothriochloa bladhii*). (20)

19a) Semi-natural (not mowed or maintained) vegetation dominated by Australian beardgrass (*Bothriochloa bladhii*). - **Australian Beardgrass – (Beach Wiregrass, Hilo Grass) Semi-natural Herbaceous Vegetation [Provisional]; *Bothriochloa bladhii* - (*Dactyloctenium aegyptium* – *Paspalum conjugatum*) Semi-natural Herbaceous Vegetation [Provisional]¹ (H_SAVA)**

19b) Mowed vegetation dominated by Australian beardgrass (*Bothriochloa bladhii*) and inifuk (*Chrysopogon aciculatus*).-**Australian Beardgrass – Inifuk Lawn [Provisional]; *Bothriochloa bladhii* - *Chrysopogon aciculatus* Lawn [Provisional]¹ (H_LAWN)**

20a) Fern-dominated vegetation characterized by an open to moderately dense herbaceous layer of uluhe (*Dicranopteris linearis*).- **Uluhe Herbaceous Vegetation [Park Special]; *Dicranopteris linearis* Herbaceous Vegetation [Park Special] (H_DILI)**

20b) Graminoid vegetation dominated by neti (*Miscanthus floridulus*), *Dimeria chloridiformis*, mission grass (*Cenchrus polystachios*), and/or napier grass (*Cenchrus purpureus*). (21)

21a) Open to moderately dense herbaceous layer dominated by *Dimeria chloridiformis*.-***Dimeria* Herbaceous Vegetation [Provisional]; *Dimeria chloridiformis* Herbaceous Vegetation [Provisional] (H_SAVA)**

21b) Graminoid vegetation dominated by neti (*Miscanthus floridulus*), mission grass (*Cenchrus polystachios*), and/or napier grass (*Cenchrus purpureus*). (22)

22a) Graminoid vegetation strongly dominated by mission grass (*Cenchrus polystachios*) (30-76%) cover. Other non-native graminoids are also present and abundant. Native grasses when present are less than half the cover of the non-natives. – **(Mission Grass, Napier Grass) Semi-natural Herbaceous Vegetation [Provisional]; *Cenchrus (polystachios, purpureus)* Semi-natural Herbaceous Vegetation [Provisional]¹ (H_SAVA)**

22b) Graminoid vegetation dominated by neti (*Miscanthus floridulus*) with Australian beardgrass (*Bothriochloa bladhii*) and/or mission grass (*Cenchrus polystachios*) as codominants – **Neti-(Mission Grass-Australian Beardgrass) Semi-natural Herbaceous Vegetation [Provisional]; *Miscanthus floridulus* – (*Cenchrus polystachios*- *Bothriochloa bladhii*) Semi-natural Herbaceous Vegetation [Provisional]**¹ (H_SAVA, SV_CS)

23a) Coastal vegetation dominated by alalag-tasi (*Ipomoea pes-caprae*), tronkon niyok (*Cocos nucifera*), milo (*Thespesia populnea*) and/or hau (*Hibiscus tiliaceus*). **(24)**

23b) Marsh and wet meadow vegetation dominated by karriso (*Phragmites karka*), chain-of-love (*Antigonon leptopus*), and/or guinea grass (*Urochloa maxima*). **(25)**

24a) Herbaceous vegetation dominated by alalag-tasi (*Ipomoea pes-caprae*). Scattered tangantangan (*Leucaena leucocephala*) may occur – **Alalag-tasi Herbaceous Vegetation [Provisional]; *Ipomoea pes-caprae* Herbaceous Vegetation [Provisional]** (SV_CS)

24b) Wooded – herbaceous vegetation with tronkon niyok (*Cocos nucifera*), milo (*Thespesia populnea*) and/or hau (*Hibiscus tiliaceus*) dominant in the shrub layer with a mixed graminoid dominated herbaceous layer –**Tronkon Niyok-Hau/Mixed Grass Wooded Strand [Provisional]; *Cocos nucifera* - *Hibiscus tiliaceus* / Mixed Grass Wooded Strand [Provisional]** (W_CONU)

25a) Freshwater marshes dominated by the native karriso (*Phragmites karka*) **Karriso Herbaceous Vegetation [Provisional], *Phragmites karka* Herbaceous Vegetation [Provisional]** (H_PHKA)

25b) Freshwater wetlands dominated by chain-of-love (*Antigonon leptopus*), and/or guinea grass (*Urochloa maxima*). **Chain-of-love – Guinea Grass Semi-natural Herbaceous Vegetation [Park Special] *Antigonon leptopus* – *Urochloa maxima* Semi-natural Herbaceous Vegetation [Park Special]** (H_ANUR)

¹USNVC name modified based on Wagner et al. 1999 and Wagner et al. 2012.

Appendix E: Plant Associations and Descriptions for War in the Pacific National Historical Park

REVISED US NATIONAL VEGETATION CLASSIFICATION

Vegetation Associations of War in the Pacific National Historical Park

6 August 2010

by

NatureServe

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



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

United States

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

Canada

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

Latin American and Caribbean

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

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1.A.2. Tropical Lowland Humid Forest

1.A.2.Oa. Polynesian Lowland Rainforest

M189. Micronesian Lowland Rainforest

G602. Micronesian Lowland Rainforest

Heterospathe elata - *Hibiscus tiliaceus* / (*Phragmites karka*, *Miscanthus floridulus*) Semi-natural Woodland [Park Special]

Identifier: CEPS009548

USNVC CLASSIFICATION

Formation Tropical Lowland Humid Forest (1.A.2)
Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup Micronesian Lowland Rainforest (M189)
Group Micronesian Lowland Rainforest (G602)
Association (Local name) Palma Brava – Hau / (Karriso, Neti) Semi-natural Woodland [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This information is from only two observation points. This forested type occurs at 22-82 m in elevation on steep ravines draining the plateau. Stands were observed on 17 and 44% slopes. Both stands are moist, and one is adjacent to an intermittent stream.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This forest is dominated by the emergent palma brava (*Heterospathe elata*)(8-35% cover) with several lower canopy trees including hau (*Hibiscus tiliaceus*) and kafu (*Pandanus tectorius*)(8-15% cover). Other woody species may include gulos (*Cynometra ramiflora*) and nanaso (*Scaevola taccada*). The understory is primarily herbaceous with karriso (*Phragmites karka*)(5-8%), neti (*Miscanthus floridulus*)(0-15%), and wedelia (*Sphagneticola trilobata*)(0-5%).

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved	palma brava
Subcanopy Tree	Broad-leaved	hau
Graminoid	Perennial	karriso

ELEMENT DISTRIBUTION

Range: Asan Inland and Mt. Tenjo units

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0904, WAPA.0927

Local Description Author(s): G. Kittel

Version Date: 2010

Heterospathe elata / *Nephrolepis hirsutula* Semi-natural Woodland [Provisional]

Identifier: CEG008128

USNVC CLASSIFICATION

Formation Tropical Lowland Humid Forest (1.A.2)
Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogrou p Micronesian Lowland Rainforest (M189)
Group Micronesian Lowland Rainforest (G602)
Association (Local name) Palma brava / Scaly Swordfern Semi-natural Woodland [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This forest type was sampled six times in the park and occurs at 22-61 m in elevation on rocky side slopes, valley bottoms, ridges and plateaus. Slopes can be low to very steep (0-22%). Aspects are northwest to northeast Although streams often run through the ravine, it is not wet enough to be considered a riparian forest. These forests may border wetter, riparian vegetation in ravines, and other stands occur in more topographically open and less steep areas, thus it is considered a mesic forest type and not a palustrine wetland type.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This forest is dominated by palma brava (*Heterospathe elata*) with 10-17% cover. Other trees in the upper canopy may include African tulip tree (*Spathodea campanulata*), smallflower chastetree (*Vitex parviflora*), hau (*Hibiscus tiliaceus*), bay rum (*Pimenta racemosa*), kamachile (*Pithecellobium dulce*), and limeberry (*Triphasia trifolia*). One stand has 45% cover of young reproducing palma brava in the understory layer. The herbaceous understory is dominated by scaly swordfern (*Nephrolepis hirsutula*). Other herbaceous species that may be present include bird's nest fern (*Asplenium nidus*), *Belvisia spicata*, chosgo (*Glochidion marianum*), tangan-tangan (*Leucaena leucocephala*), and lada (*Morinda citrifolia*).

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved	palma brava
Subcanopy Tree	Broad-leaved	hau
Forb	Perennial	scaly swordfern

ELEMENT DISTRIBUTION

Range: Fonte Plateau and Asan Inland units

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0030, WAPA.0032, WAPA.0033, WAPA.0034, WAPA.0905, WAPA.0932

Local Description Author(s): G. Kittel

Version Date: 2010

Hibiscus tiliaceus Woodland [Park Special]

Identifier: CEPS009549

USNVC CLASSIFICATION

Formation Tropical Lowland Humid Forest (1.A.2)
Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup Micronesian Lowland Rainforest (M189)
Group Micronesian Lowland Rainforest (G602)
Association (Local name) Hau Woodland [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This information is from only two plots. One stand occurs at the edge of the beach as strand vegetation and the other in an old quarry. Elevation ranges from 1.5 to 56 m above sea level. Slopes are flat. Soil is sandy or rocky. Both stands are subject to continued disturbance.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: The upper canopy is dominated by hau (*Hibiscus tiliaceus*) with 40-75% cover. Other woody species present may include tronkon niyok (*Cocos nucifera*), tangantangan (*Leucaena leucocephala*), three leaf derris (*Derris trifoliata*), yokewood (*Catalpa longissima*), gagu (*Casuarina equisetifolia*), gasoso (*Colubrina asiatica*), and lada (*Morinda citrifolia*). The understory is different between the two locations and includes herbaceous species such as milkwort (*Polygala paniculata*), *Pyrrosia lanceolata*, love-in-a-mist (*Passiflora foetida*), corky passionflower (*Passiflora suberosa*), climbing hempvine (*Mikania scandens*), sleeping grass (*Mimosa pudica*), alalag-tasi (*Ipomoea pes-caprae*), lirio (*Hymenocallis littoralis*), romerillo (*Bidens alba*), guinea grass (*Urochloa maxima*), and wildcane (*Saccharum spontaneum*).

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved	hau

ELEMENT DISTRIBUTION

Range: Agat and Fonte Plateau units

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0011, WAPA.0029

Local Description Author(s): G. Kittel

Version Date: 2010

Morinda citrifolia / *Nephrolepis hirsutula* Woodland [Park Special]

Identifier: CEPS009550

USNVC CLASSIFICATION

Formation Tropical Lowland Humid Forest (1.A.2)
Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup Micronesian Lowland Rainforest (M189)
Group Micronesian Lowland Rainforest (G602)
Association (Local name) Lada / Scaly Swordfern Woodland [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This information is based on only one plot. This forested stand occurs up on the plateau at 54 m in elevation on a rocky side slope with a north exposure. It is surrounded by grasslands.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This description is based on only one plot, so cover values are expected to vary. This forested type is part of the savanna complex with dense cover of grass and a gradation of tree cover from none to a dense overstory canopy. Lada (*Morinda citrifolia*) dominates this site with 20% cover; other woody species present include custard apple (*Annona reticulata*), tangan-tangan (*Leucaena leucocephala*), pahong (*Pandanus dubius*), smallflower chastetree (*Vitex parviflora*), ifit (*Intsia bijuga*), and ahgao (*Premna serratifolia*). The herbaceous understory is dominated by scaly swordfern (*Nephrolepis hirsutula*), having the highest cover of all other herbaceous species present (in the one area sampled, it had 20% cover). Other herbaceous species include spottedheart (*Stictocardia tiliifolia*), sefa (*Centotheca lappacea*), running mountaingrass (*Oplismenus compositus*), and mission grass (*Cenchrus polystachios*).

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved	lada
Forb	Perennial	scaly swordfern

ELEMENT DISTRIBUTION

Range: Mt. Alifan and Agat units

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0038

Local Description Author(s): G. Kittel

Version Date: 2010

Tabebuia heterophylla / *Dimeria chloridiformis* Semi-natural Woodland [Park Special]¹

Identifier: CEPS009551

USNVC CLASSIFICATION

Formation Tropical Lowland Humid Forest (1.A.2)
Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup Micronesian Lowland Rainforest (M189)
Group Micronesian Lowland Rainforest (G602)
Association (Local name) White cedar / *Dimeria* Semi-natural Woodland [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This information is from only one plot. This forest occurs on the upper plateau at 52 m in elevation on volcanic clay soils. It occurs on a high slope.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: The upper tree canopy is dominated by non-native white cedar (*Tabebuia heterophylla*) with 15% cover. Other trees present include gagu (*Casuarina equisetifolia*). The understory has 25% cover of the native graminoid *Dimeria chloridiformis*, and many other herbaceous species, including corky passionflower (*Passiflora suberosa*), milkwort (*Polygala paniculata*), false buttonweed (*Spermacoce assurgens*), wedelia (*Sphagneticola trilobata*), false verbena (*Stachytarpheta jamaicensis*), white moneywort (*Alysicarpus vaginalis*), escobilla sabana (*Waltheria indica*), *Rhynchospora rubra*, mission grass (*Cenchrus polystachios*), neti (*Miscanthus floridulus*), Florida Keys nutrush (*Scleria lithosperma*), Australian beardgrass (*Bothriochloa bladhii*), fimbry (*Fimbristylis tristachya*), forked fimbry (*Fimbristylis dichotoma*), and tropical fimbry (*Fimbristylis cymosa*).

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved	white cedar
Graminoid	Perennial	dimeria

ELEMENT DISTRIBUTION

Range: Asan Inland Unit

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0040

Local Description Author(s): G. Kittel

Version Date: 2010

M190. Polynesian Semi-natural Lowland Rainforest

G390. Polynesian Semi-natural Lowland Rainforest

***Bambusa vulgaris* Semi-natural Forest [Park Special]**

Identifiers: CEPS009552

USNVC CLASSIFICATION

Formation Tropical Lowland Humid Forest (1.A.2)
Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup Polynesian Semi-natural Lowland Rainforest (M190)
Group Polynesian Semi-natural Lowland Rainforest (G390)
Association (Local name) Piao Palaoan Semi-natural Forest [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This information is based on one plot and one observation point. This forest occurs at 9-22 m in elevation on rocky side slopes on limestone or volcanic substrates. Piao palaoan or bamboo (*Bambusa vulgaris*) is usually planted as landscaping or as natural fence near houses and fields and has been known to spread (i.e., become ruderal). One plot is near houses.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This forest is dominated by the introduced piao palaoan or bamboo (*Bambusa vulgaris*). Other woody species include native and non-native species such as hau (*Hibiscus tiliaceus*), paipai (*Guamia mariannae*), hodda (*Ficus tinctoria*), tangan-tangan (*Leucaena leucocephala*), and papaya (*Carica papaya*). The understory is sparse due to heavy shading. One stand has 20% cover of piao palaoan seedlings.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Perennial	piao palaoan

ELEMENT DISTRIBUTION

Range: Asan Inland, Mt. Alifan and Agat units

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0035, WAPA.0906

Local Description Author(s): G. Kittel

Version Date: 2010

Mangifera indica Semi-natural Woodland [Park Special]

Identifier: CEPS009553

USNVC CLASSIFICATION

Formation Tropical Lowland Humid Forest (1.A.2)
Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup Polynesian Semi-natural Lowland Rainforest (M190)
Group Polynesian Semi-natural Lowland Rainforest (G390)
Association (Local name) Mango Semi-natural Woodland [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This forest is a remnant of gardens as it is planted for its fruit, the mango (*Mangifera indica*). Two stands were observed at 9-22 m in elevation. They occur in flat concave moist pockets on volcanic clay.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This planted forest is dominated by the fruit tree mango (*Mangifera indica*) with 25-50% cover. Abandoned stands have numerous woody invaders such as tangan-tangan (*Leucaena leucocephala*), ixora (*Ixora finlaysonia*), hau (*Hibiscus tiliaceus*), and tronkon niyok (*Cocos nucifera*). The herbaceous understory is typical of shaded moist forests and has scaly swordfern (*Nephrolepis hirsutula*) with 10% cover in one stand.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved	mango

ELEMENT DISTRIBUTION

Range: Asan Inland, Mt. Alifan and Agat units

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0907, WAPA.0926

Local Description Author(s): G. Kittel

Version Date: 2010

Spathodea campanulata Semi-natural Woodland [Park Special]

Identifier: CEPS009554

USNVC CLASSIFICATION

Formation Tropical Lowland Humid Forest (1.A.2)
Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup Polynesian Semi-natural Lowland Rainforest (M190)
Group Polynesian Semi-natural Lowland Rainforest (G390)
Association (Local name) African Tulip Tree Semi-natural Woodland [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: African tulip tree (*Spathodea campanulata*) is a planted ornamental that can develop into a semi-natural forest with abandonment. Observed stands occur at 6-14 m in elevation adjacent to mahogany plantations and near current and historic neighborhoods. All stands are on volcanic clay soils.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: The upper canopy of this semi-natural forest is dominated by African tulip tree (*Spathodea campanulata*) with 15-70% cover. Other woody species present may include hau (*Hibiscus tiliaceus*), tangan-tangan (*Leucaena leucocephala*), and kafu (*Pandanus tectorius*). The herbaceous understory may include bird's nest fern (*Asplenium nidus*), giant swordfern (*Nephrolepis biserrata*), obscure morning glory (*Ipomoea obscura*), and neti (*Miscanthus floridulus*).

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

Stratum

Canopy Tree

Lifeform

Broad-leaved

Species

African tuliptree

ELEMENT DISTRIBUTION

Range: Piti Guns unit

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0021, WAPA.0921, WAPA.0923

Local Description Author(s): G. Kittel

Version Date: 2010

Swietenia macrophylla Semi-natural Forest [Park Special]

Identifier: CEPS009555

USNVC CLASSIFICATION

Formation Tropical Lowland Humid Forest (1.A.2)
Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup Polynesian Semi-natural Lowland Rainforest (M190)
Group Polynesian Semi-natural Lowland Rainforest (G390)
Association (Local name) Broad-leaved Mahogany Semi-natural Forest [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This planted mahogany forest was sampled once and occurs on a 14% slope at 17 m in elevation.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This is a broad-leaved mahogany (*Swietenia macrophylla*) forest that was planted in the 1920s. Today broad-leaved mahogany has 16-84 % cover. Other woody species present include papaya (*Carica papaya*) and palma brava (*Heterospathe elata*). The herbaceous understory is insignificant in terms of cover.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved	broad-leaved mahogany

ELEMENT DISTRIBUTION

Park Range: Piti Guns unit

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0008

Local Description Author(s): G. Kittel

Version Date: 2010

Vitex parviflora Semi-natural Woodland [Park Special]

Identifier: CEPS009556

USNVC CLASSIFICATION

Formation Tropical Lowland Humid Forest (1.A.2)
Division Polynesian Lowland Rainforest (1.A.2.Oa)
Macrogroup Polynesian Semi-natural Lowland Rainforest (M190)
Group Polynesian Semi-natural Lowland Rainforest (G390)
Association (Local name) Smallflower Chastetree Semi-natural Woodland [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This forest is the product of plantations for ornamental purposes and was sampled twice in the park. It was observed at 54-62 m in elevation on the upper plateau near an old park complete with benches, and a transition from limestone to savanna area. These are essentially abandoned landscaped areas that have become semi-natural forests.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: Smallflower chastetree (*Vitex parviflora*) dominates the upper canopy with 7-12 % cover. Other woody species present include tangan-tangan (*Leucaena leucocephala*), palma brava (*Heterospatha elata*), bay rum (*Pimenta racemosa*), lada (*Morinda citrifolia*), sumac-lada (*Timonius nitidus*), custard apple (*Annona reticulata*), achiote (*Bixa orellana*), pahong (*Pandanus dubius*), bitter orange (*Citrus macroptera*), white cedar (*Tabebuia heterophylla*), and kamachile (*Pithecellobium dulce*). The herbaceous understory is eclectic with scaly swordfern (*Nephrolepis hirsutula*), climbing bird's nest fern (*Microsorium punctatum*), monarch fern (*Phymatosorus grossus*), bejuco halum-tano (*Flagellaria indica*), climbing hempvine (*Mikania scandens*), gasoso (*Colubrina asiatica*), corky passionflower (*Passiflora suberosa*), rubbervine (*Telosma cordata*), crab's eye (*Abrus precatorius*), and mission grass (*Cenchrus polystachios*).

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved	smallflower chastetree

ELEMENT DISTRIBUTION

Range: Fonte Plateau, Mt. Alifan and Agat units

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0031, WAPA.0934

Local Description Author(s): G. Kittel

Version Date: 2010

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

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

M219. Micronesian Lowland Shrubland, Grassland & Savanna

G603. Micronesian Lowland Shrub, Grassland & Savanna

Casuarina equisetifolia / *Miscanthus floridulus* - *Cenchrus polystachios* Semi-natural Wooded Grassland [Park Special]¹

Identifier: CEPS009544

USNVC CLASSIFICATION

Formation Tropical Lowland Grassland, Savanna & Shrubland (2.A.1)
Division Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.OI)
Macrogroup Micronesian Lowland Shrubland, Grassland & Savanna (M219)
Group Micronesian Lowland Shrubland, Grassland & Savanna (G603)
Association (Local name) Gagu / Neti- Mission Grass Semi-natural Wooded Grassland [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This wooded grassland was sampled twice in the park and occurs from 18-32 m in elevation on moderately sloping rolling hillsides of 10-19%, and are usually located at mid to upper slopes. Soils are clay. Aspects are southeast to west.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This wooded grassland is part of the savanna complex of the upper slopes/plateau of Guam. This is dense grassland with very open tree cover, a.k.a. "wooded grassland". Tree cover can be as high as 15%, but the grass cover is usually 4-5 times that, with 70-90% cover. Dominant trees are gagu (*Casuarina equisetifolia*), lada (*Morinda citrifolia*), and white cedar (*Tabebuia heterophylla*). Herbaceous cover is dominated by the native grass neti (*Miscanthus floridulus*) (40-70%) and often non-native mission grass (*Cenchrus polystachios*). Other herbaceous species present include inifuk (*Chrysopogon aciculatus*), Australian beardgrass (*Bothriochloa bladhii*), uluhe (*Dicranopteris linearis*), and *Dimeria chloridiformis*.

Local Dynamics: This grassland burns frequently (every 3-5 years), keeping the tree cover low.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Needle-leaved evergreen	gagu
Graminoid	Perennial	neti
		mission grass

CHARACTERISTIC SPECIES

War in the Pacific National Historical Park: gagu, neti, mission grass

ELEMENT DISTRIBUTION

Range: Asan Inland Unit

Nation(s): US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0004, WAPA.0901

Local Description Author(s): G. Kittel

Version Date: 2010

Dicranopteris linearis Herbaceous Vegetation [Park Special]

Identifier: CEPS009545

USNVC CLASSIFICATION

Formation Tropical Lowland Grassland, Savanna & Shrubland (2.A.1)
Division Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.OI)
Macrogroup Micronesian Lowland Shrubland, Grassland & Savanna (M219)
Group Micronesian Lowland Shrubland, Grassland & Savanna (G603)
Association (Local name) Uluhe Herbaceous Vegetation [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This open fern-dominated herbaceous association was sampled twice in the park and occurs between 28-84 m in elevation on flat to 11% sloping ridge tops and upper slopes. Soils are volcanic clay.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This fern-dominated association is part of the savanna complex of the upper slopes/plateau of Guam. This herbaceous vegetation is dominated by the native fern uluhe (*Dicranopteris linearis*) with 35-70% cover. Other herbaceous species include native staghorn clubmoss (*Lycopodiella cernua*), *Dimeria chloridiformis*, neti (*Miscanthus floridulus*) and non-native mission grass (*Cenchrus polystachios*). A few woody species may be present at low cover, such as tangan-tangan (*Leucaena leucocephala*) and gafau (*Melastoma malabathricum* var. *mariannum*).

Local Dynamics: This type burns frequently (every 3-5 years), keeping the tree cover low.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Fern or fern-ally	Perennial	uluhe

CHARACTERISTIC SPECIES

War in the Pacific National Historical Park: uluhe

ELEMENT DISTRIBUTION

Range: Mt. Tenjo and Alifan/Agat units

Nation(s): US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0027, WAPA.0909

Local Description Author(s): G. Kittel

Version Date: 2010

Dimeria chloridiformis Herbaceous Vegetation [Provisional]

Identifier: CEG008125

USNVC CLASSIFICATION

Formation Tropical Lowland Grassland, Savanna & Shrubland (2.A.1)
Division Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.OI)
Macrogroup Micronesian Lowland Shrubland, Grassland & Savanna (M219)
Group Micronesian Lowland Shrubland, Grassland & Savanna (G603)
Association (Local name) *Dimeria* Herbaceous Vegetation [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This grassland was sampled three times in the park and occurs at 26-94 m in elevation on rolling slopes of the upper plateau. Soils are well-drained volcanic-derived clays. Stands are positioned on mid to upper slopes, with southwest to north aspects.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Environment Vegetation: This grassland is part of the savanna complex of the upper slopes/plateau of Guam. It is identified by the native indicator species *Dimeria chloridiformis* with 30-40% cover. Other grasses present and often abundant include mission grass (*Cenchrus polystachios*) and neti (*Miscanthus floridulus*). Other herbaceous species include uluhe (*Dicranopteris linearis*), false ironwort (*Hyptis capitata*), mumutum (*Hyptis suaveolens*), agace (*Cassytha filiformis*), and escobilla sabana (*Waltheria indica*). Few scattered shrubs and trees may be present and include lada (*Morinda citrifolia*), tangan-tangan (*Leucaena leucocephala*), and gagu (*Casuarina equisetifolia*).

Local Dynamics: Grasslands on the plateau burn frequently (every 3-5 years), keeping the tree cover at bay.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Graminoid	Perennial	dimeria
		neti
		mission grass

CHARACTERISTIC SPECIES

War in the Pacific National Historical Park: dimeria

ELEMENT DISTRIBUTION

Range: Piti Guns and Mt. Tenjo units

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0017, WAPA.0024, WAPA.0026

Local Description Author(s): G. Kittel

Version Date: 2010

Leucaena leucocephala / *Miscanthus floridulus* Semi-natural Shrubland [Park Special]

Identifier: CEPS009546

USNVC CLASSIFICATION

Formation Tropical Lowland Grassland, Savanna & Shrubland (2.A.1)
Division Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.OI)
Macrogroup Micronesian Lowland Shrubland, Grassland & Savanna (M219)
Group Micronesian Lowland Shrubland, Grassland & Savanna (G603)
Association (Local name) Tangan-tangan / Neti Semi-natural Shrubland [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This shrubland was sampled twice in the park and occurs imbedded in the grassland savanna environment of the plateau. It occurs at 73-85 m in elevation on nearly level slopes. Soils are volcanic clay.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This shrubland is part of the savanna complex of the upper slopes/plateau of Guam. It is dominated by tangan-tangan (*Leucaena leucocephala*) with 10-12% cover and high cover of neti (*Miscanthus floridulus*) with 12-30% cover. Other woody species present include gagu (*Casuarina equisetifolia*) and nanaso (*Scaevola taccada*) with 1-2% cover. Other herbaceous species include mission grass (*Cenchrus polystachios*), Australian beardgrass (*Bothriochloa bladhii*), *Dimeria chloridiformis*, giant swordfern (*Nephrolepis biserrata*), and uluhe (*Dicranopteris linearis*).

Classification Comments: This shrubland is part of the savanna complex of the upper slopes/plateau of Guam. Tangan-tangan (*Leucaena leucocephala*) is often referred to as a small tree. In this classification, we consider it a tall shrub, and therefore, this is a shrubland association. This allows us to be consistent with other Pacific Island classifications.

Local Dynamics: This area burns frequently (every 3-5 years), which keeps grass cover high and woody cover low.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tall Shrub	Broad-leaved	tangan-tangan
Graminoid	Perennial	neti

CHARACTERISTIC SPECIES

War in the Pacific National Historical Park: tangan-tangan, neti

ELEMENT DISTRIBUTION

Range: Mt. Tenjo unit

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0025, WAPA.0929

Local Description Author(s): G. Kittel

Version Date: 2010

Leucaena leucocephala / *Nephrolepis hirsutula* Semi-natural Shrubland [Park Special]

Identifier: CEPS009547

USNVC CLASSIFICATION

Formation Tropical Lowland Grassland, Savanna & Shrubland (2.A.1)
Division Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.OI)
Macrogroup Micronesian Lowland Shrubland, Grassland & Savanna (M219)
Group Micronesian Lowland Shrubland, Grassland & Savanna (G603)
Association (Local name) Tangan-tangan / Scaly Swordfern Semi-natural Shrubland [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This information is based on only one observation point. The stand occurs at 57 m in elevation on an east-facing 8% slope. The stand is midway up the slope and the bedrock is limestone.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This shrubland has 10% cover of tangan-tangan (*Leucaena leucocephala*) and 50% cover of scaly swordfern (*Nephrolepis hirsutula*) in the understory. Other woody species present include gagu (*Casuarina equisetifolia*) and nanaso (*Scaevola taccada*). No herbaceous species information was recorded.

Classification comments: Tangan-tangan (*Leucaena leucocephala*) is often referred to as a small tree. In this classification, we consider it a tall shrub, and therefore this is a shrubland association. This allows us to be consistent with other Pacific Island classifications.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Tall Shrub	Broad-leaved	tangan-tangan
Forb	Perennial	scaly swordfern

ELEMENT DISTRIBUTION

Range: Fonte Plateau unit

Nation(s): US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0931

Local Description Author(s): G. Kittel

Version Date: 2010

Miscanthus floridulus - (*Cenchrus polystachios*, *Bothriochloa bladhii*) Semi-natural Herbaceous Vegetation [Provisional]¹

Identifier: CEG008126

USNVC CLASSIFICATION

Formation Tropical Lowland Grassland, Savanna & Shrubland (2.A.1)
Division Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.OI)
Macrogroup Micronesian Lowland Shrubland, Grassland & Savanna (M219)
Group Micronesian Lowland Shrubland, Grassland & Savanna (G603)
Association (Local name) Neti – (Mission Grass, Australian Beardgrass) Semi-natural Herbaceous Vegetation [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This grassland was sampled at ten sites in the park and occurs at 11-82 m in elevations on volcanically derived clay soils. It occurs on ridges, slide slopes and terraces of the plateau on flat or 8-22% slopes. Aspects are north, northeast, southwest and southeast.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: In this grassland, neti (*Miscanthus floridulus*) is the dominant and indicator species with 15-60% cover. Other graminoids that can be co-dominant include mission grass (*Cenchrus polystachios*) and Australian beardgrass (*Bothriochloa bladhii*). Woody species present may include gagu (*Casuarina equisetifolia*), white cedar (*Tabebuia heterophylla*), lada (*Morinda citrifolia*), and tangan-tangan (*Leucaena leucocephala*) with up to 7% cover.

Classification comments: This grassland is part of the savanna complex of the upper slopes/plateau of Guam. The amount of woody cover should be less than 10% and the percent cover of graminoids greater than 50% to be classified as grassland. However, these are not hard rules, as high grass cover may hide many small woody trees.

Local Dynamics: This type frequently burns (every 3-5 years), keeping woody cover low.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Graminoid	Perennial	neti
		mission grass
		Australian beardgrass

ELEMENT DISTRIBUTION

Range: Mt Alifan, Agat, Agat Inland, Mt. Tenjo, Asan Inland, and Piti Guns units

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0002, WAPA.0005, WAPA.0006, WAPA.0018, WAPA.0019, WAPA.0020, WAPA.0023, WAPA.0028, WAPA.0039, WAPA.0922

Local Description Author(s): G. Kittel

Version Date: 2010

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

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

Leucaena leucocephala Lowland Dry Semi-natural Shrubland

Identifier: CEG008114

USNVC CLASSIFICATION

Formation Tropical Lowland Grassland, Savanna & Shrubland (2.A.1)
Division Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.OI)
Macrogroup Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (M220)
Group Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (G413)
Association (Local name) Tangan-tangan Lowland Dry Semi-natural Shrubland

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This shrubland was sampled at six sites in the park and occurs at 12-63 m in elevation, on 1-35% slopes. This type occurs on beachside hill slopes and upper terraces, and in ravines and valley bottoms up on the plateau. Soils are limestone or volcanic clay. Aspects are southeast, southwest and north.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This shrubland is dominated by tangan-tangan (*Leucaena leucocephala*) with 25-60 % cover. Other woody species present include tronkon niyok (*Cocos nucifera*), palma brava (*Heterospatha elata*), hau (*Hibiscus tiliaceus*), kafu (*Pandanus tectorius*), ahgao (*Premna obtusifolia*), smallflower chastetree (*Vitex parviflora*), nanaso (*Scaevola taccada*), gasoso (*Colubrina asiatica*), and corky passionflower (*Passiflora suberosa*) with 1-50% cover. The herbaceous understory is variable, with no consistent cover or species present among the six stands observed. Herbaceous species present include neti (*Miscanthus floridulus*), guinea grass (*Urochloa maxima*), limeberry (*Triphasia trifolia*), karriso (*Phragmites karka*), and nutrush (*Scleria polycarpa*); each may not be present or have high cover up to 70%. Stands with high cover of *Miscanthus floridulus* were not placed into the *Leucaena leucocephala* / *Miscanthus floridulus* shrubland because the shrub cover was 2 x as high as the other plots in that type. However with more sample points, this classification may change.

Classification comments: Tangan-tangan (*Leucaena leucocephala*) is often referred to as a small tree. In this classification, we consider it a tall shrub, and therefore this is a shrubland association. This allows us to be consistent with other Pacific Island classifications.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

Stratum

Tall Shrub

Lifeform

Broad-leaved

Species

tangan-tangan

ELEMENT DISTRIBUTION

Global Range: This type is dominated by a new-world tropical species that is invasive throughout Polynesia, and has been documented to occur in Hawaii and Guam.

Local Range: Fonte Plateau, Piti Guns, Asan Beach, and Asan Island

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0036, WAPA.0902, WAPA.0903, WAPA.0919, WAPA.0920, WAPA.0930

Local Description Author(s): G. Kittel

Version Date: 2010

Bothriochloa bladhii - (*Dactyloctenium aegyptium*, *Paspalum conjugatum*) Semi-natural Herbaceous Vegetation

Identifier: CEG008127

USNVC CLASSIFICATION

Formation Tropical Lowland Grassland, Savanna & Shrubland (2.A.1)

Division Polynesian Lowland Shrubland, Grassland & Savanna (2.A.1.OI)
 Macrogroup Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (M220)
 Group Polynesian Semi-natural Lowland Shrubland, Grassland & Savanna (G413)
 Association (Local name) Australian Beardgrass – (Beach Wiregrass, Hilo Grass) Semi-natural Herbaceous Vegetation

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This grassland was sampled twice in the park and occurs on the upper plateau at 22-31 m in elevation, on flat to 14% sloping terraces or side slopes on sandy clay soils.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This grassland is overwhelmingly dominated by Australian beardgrass (*Bothriochloa bladhii*) with 85-90% cover. Other graminoids present include neti (*Miscanthus floridulus*) with up to 6% cover. Other herbaceous species present (with <1% cover) may include false ironwort (*Hyptis capitata*), escobilla sabana (*Waltheria indica*), tropical fimbry (*Fimbristylis cymosa*), and forked fimbry (*Fimbristylis dichotoma*).

Local Dynamics: Fires are frequent (every 3-5 years) and may be very intense in these areas.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Graminoid	Perennial	Australian beardgrass

ELEMENT DISTRIBUTION

War in the Pacific National Historical Park Range: Piti Guns

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0015, WAPA.0016

Local Description Author(s): G. Kittel

Version Date: 2010

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

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

M233.Micronesian Scrub & Herb Coastal Vegetation

G607.Micronesian Coastal Wooded Strand

Cocos nucifera - *Hibiscus tiliaceus* / Mixed Grass Wooded Strand [Provisional]

Identifier: CEG008129

USNVC CLASSIFICATION

Formation Tropical Scrub & Herb Coastal Vegetation (2.A.3)
Division Polynesian Scrub & Herb Coastal Vegetation (2.A.3.Ob)
Macrogroup Micronesian Scrub & Herb Coastal Vegetation (M233)
Group Micronesian Coastal Wooded Strand (G607)
Association (Local name) Tronkon Niyok – Hau / Mixed Grass Wooded Strand [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Plots Environment: This is a coastal strand woodland that was sampled five times in the park. It occurs on sandy or rocky areas near the shore, within 3 m of sea level in elevation. Slopes are flat to very gentle. Stands are just above the high tide mark. Stands experience salt spray and are subject to severe wind shear during storms.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This is the classic strand vegetation with tall curving trunks of tronkon niyok (*Cocos nucifera*) mixed with other woody species. The canopy is dominated by tronkon niyok and hau (*Hibiscus tiliaceus*). Other woody species present include milo (*Thespesia populnea*), gagu (*Casuarina equisetifolia*), kafu (*Pandanus tectorius*), limeberry (*Triphasia trifolia*), and tangan-tangan (*Leucaena leucocephala*). The same species can occupy multiple canopy layers from past storm damage. The herbaceous understory is diverse, and species may have >20% cover individually and include monarch fern (*Phymatosorus grossus*), wedelia (*Sphagneticola trilobata*), gasoso (*Colubrina asiatica*), Makila grass (*Zoysia matrella*), Australian beardgrass (*Bothriochloa bladhii*), Bermuda grass (*Cynodon dactylon*), wildcane (*Saccharum spontaneum*), guinea grass (*Urochloa maxima*), and Henry's crabgrass (*Digitaria ciliaris*).

Local Dynamics: Subject to wind and storm surge damage.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved	tronkon niyok hau

ELEMENT DISTRIBUTION

Range: Agat Unit: Ga'an, Apaca and Bangi points

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0009, WAPA.0013, WAPA.0014, WAPA.0914, WAPA.0916

Local Description Author(s): G. Kittel

Version Date: 2010

Local Inventory Notes: Edge of beaches.

Casuarina equisetifolia Woodland [Provisional]

Identifier: CEG008121

USNVC CLASSIFICATION

Formation	Tropical Scrub & Herb Coastal Vegetation (2.A.3)
Division	Polynesian Scrub & Herb Coastal Vegetation (2.A.3.Ob)
Macrogroup	Micronesian Scrub & Herb Coastal Vegetation (M233)
Group	Micronesian Coastal Wooded Stand (G607)
Association (Local name)	Gagu Woodland [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This information is from only two observation points. This forest was sampled on a steep slope 12 m above sea level on limestone bedrock of the upper plateau and at sea level on a small rocky island 100 m from shore.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This information is from only two observation points. This forest is dominated by gagu (*Casuarina equisetifolia*) with 12-25% cover. Other tree species present may include pahong (*Pandanus dubius*), ahgao (*Premna serratifolia*), hau (*Thespesia populnea*), and tronkon niyok (*Cocos nucifera*) with up to 10% cover. The understory may have shrubs such as limeberry (*Triphasia trifolia*) or nigas (*Pemphis acidula*) with 2-40% cover. No herbaceous species were recorded in the data collected.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Needle-leaved evergreen	gagu

ELEMENT DISTRIBUTION

Range: Asan Inland and Agat-Yona Island units

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0915, WAPA.0933

Local Description Author(s): G. Kittel

Version Date: 2010

G608. Micronesian Coastal Herbaceous Vegetation

Ipomoea pes-caprae Herbaceous Vegetation [Provisional]

Identifier: CEG008130

USNVC CLASSIFICATION

Formation Tropical Scrub & Herb Coastal Vegetation (2.A.3)
Division Polynesian Scrub & Herb Coastal Vegetation (2.A.3.Ob)
Macrogroup Micronesian Scrub & Herb Coastal Vegetation (M233)
Group Micronesian Coastal Herbaceous Vegetation (G608)
Association (Local name) Alalag-tasi Herbaceous Vegetation [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This is coastal strand vegetation that was sampled twice and occurs at the upper edge of the sandy and rocky shores. Stands occur within 3 m of sea level in elevation and are subject to salt spray and storm surge. Stands may occur on sandy soils or rocky limestone substrates.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This is herbaceous strand dominated by alalag-tasi (*Ipomoea pes-caprae*) with 60-85% cover. Other herbaceous species may include Australian beardgrass (*Bothriochloa bladhii*). A few woody species may be present and include milo (*Thespesia populnea*), tangan-tangan (*Leucaena leucocephala*), and nanaso (*Scaevola taccada*) with less than 10% cover.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Forb	Perennial	alalag-tasi

ELEMENT DISTRIBUTION

Range: Agat unit: Ga'an and Apaca points

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0910, WAPA.0912

Local Description Author(s): G. Kittel

Version Date: 2010

M234. Polynesian Semi-natural Scrub & Herb Coastal Strand

G423. Polynesian Semi-natural Scrub & Herb Coastal Strand

*Cenchrus (polystachios, purpureus) Semi-natural Herbaceous Vegetation*¹

Identifier: CEG008123

USNVC CLASSIFICATION

Formation Tropical Scrub & Herb Coastal Vegetation (2.A.3)
Division Polynesian Scrub & Herb Coastal Vegetation (2.A.3.Ob)
Macrogroup Polynesian Semi-natural Scrub & Herb Coastal Strand (M234)
Group Polynesian Semi-natural Scrub & Herb Coastal Strand (G423)
Association (Local name) (Mission Grass, Napier Grass) Semi-natural Herbaceous Vegetation

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This exotic grassland was sampled four times in the park and occurs on the coastal strand and up on the plateau regions of the park. It occurs on sandy or clay soils, from sea level to 25 m in elevation, on flat sandy areas behind beaches and low slopes.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This semi-natural grassland is dominated by the non-native species mission grass (*Cenchrus polystachios*) with 30-76% cover. Additional non-native grasses include Napier grass (*Cenchrus purpureus*) with up to 10% cover, and Australian beardgrass (*Bothriochloa bladhii*) with 20% r. Other native grasses may be present, such as *Dimeria chloridiformis* with as much as 10% cover, but is always completely overwhelmed by the non-native species. Other herbaceous species include bamboo orchid (*Arundina graminifolia*), love-in-a-mist (*Passiflora foetida*), milkwort (*Polygala paniculata*), false ironwort (*Hyptis capitata*), and agave (*Cassytha filiformis*). A few scattered non-native woody species may be present, such as tanggan-tangan (*Leucaena leucocephala*) and gagu (*Casuarina equisetifolia*).

Local Dynamics: This type is maintained by heavy disturbance and fire.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Graminoid	Perennial	mission grass
		napier grass
		Australian beardgrass

ELEMENT DISTRIBUTION

War in the Pacific National Historical Park Range: Asan Inlands, Mt. Alifan, Agat, and Asan Beach units

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0001, WAPA.0007, WAPA.0924, WAPA.0925

Local Description Author(s): G. Kittel

Version Date: 2010

2.A.5. Tropical Freshwater Marsh, Wet Meadow & Shrubland

2.A.5.Ob. Polynesian & Eastern Melanesian Freshwater Marsh

M246. Polynesian & Eastern Melanesian Semi-natural Freshwater Marsh

G604. Polynesian Semi-natural Freshwater Wet Meadow & Marsh

Antigonon leptopus – *Urochloa maxima* Semi-natural Herbaceous Vegetation [Park Special]

Identifier: CEPS009557

USNVC CLASSIFICATION

Formation Tropical Freshwater Marsh, Wet Meadow & Shrubland (2.A.5)
Division Polynesian & Eastern Melanesian Freshwater Marsh (2.A.5.Ob)
Macrogrou p Polynesian & Eastern Melanesian Semi-natural Freshwater Marsh (M246)
Group Polynesian Semi-natural Freshwater Wet and Meadow & Marsh Group (G604)
Association (Local name) Chain-of-love – Guinea Grass Semi-natural Herbaceous Vegetation [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Palustrine

War in the Pacific National Historical Park Environment: This herbaceous wetland was sampled once in the park and occurs in low-lying concave areas at 5 m in elevation. Soils are muck.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This herbaceous wetland is dominated by non-native chain-of-love (*Antigonon leptopus*) and guinea grass (*Urochloa maxima*). Also present in abundance (5-10%) are romerillo (*Bidens alba*), blue morning glory (*Ipomoea indica*), and love-in-a-mist (*Passiflora foetida*). A few woody species may be present with less than 5% cover and include tangan-tangan (*Leucaena leucocephala*), papaya (*Carica papaya*), lada (*Morinda citrifolia*), African tulip tree (*Spathodea campanulata*), and kamachile (*Pithecellobium dulce*).

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Short Shrub	Evergreen vine	chain-of-love
Forb	Perennial	guinea grass

ELEMENT DISTRIBUTION

Range: Asan Inland unit.

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0037

Local Description Author(s): G. Kittel

Version Date: 2010

M042. Polynesian Freshwater Marsh**G605. Polynesian Freshwater Marsh***Phragmites karka* Herbaceous Vegetation [Provisional]**Identifier:** CEG008131

USNVC CLASSIFICATION

Formation Tropical Freshwater Marsh, Wet Meadow & Shrubland (2.A.5)
Division Polynesian & Eastern Melanesian Freshwater Marsh (2.A.5.Ob)
Macrogroup Polynesian Freshwater Marsh (M042)
Group Polynesian Freshwater Marsh (G605)
Association (Local name) Karriso Herbaceous Vegetation [Provisional]

ENVIRONMENTAL DESCRIPTION**USFWS Wetland System:** Palustrine

War in the Pacific National Historical Park Environment: This is an herbaceous wetland that occurs in low-lying areas at low and high elevations (1-77 m). Stands can occur on flat areas or on sloping ground following drainages and streams, where slopes can be up to 45%.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This is an herbaceous wetland type that was sampled in five sites and is usually overwhelmingly dominated by karriso (*Phragmites karka*) with 30-95% cover. Other herbaceous species that may be present include native small leaf climbing fern (*Lygodium microphyllum*), alalag-tasi (*Ipomoea pes-caprae*), neti (*Miscanthus floridulus*), and non-native lirio (*Hymenocallis littoralis*). A few woody species may be present with <5% cover, and include tangan-tangan (*Leucaena leucocephala*), palma brava (*Heterospathe elata*), kafu (*Pandanus tectorius*), and tronkon niyok (*Cocos nucifera*).

MOST ABUNDANT SPECIES**War in the Pacific National Historical Park:**

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Graminoid	Perennial	karriso

ELEMENT DISTRIBUTION**Range:** Mt. Alifan and Agat units; Ga'an and Apaca points; Piti Guns and Mt. Tenjo units**Nations:** US**States/Provinces:** Guam**ELEMENT SOURCES****War in the Pacific National Historical Park Plots:** WAPA.0908, WAPA.0911, WAPA.0913, WAPA.0917, WAPA.0928**Local Description Author(s):** G. Kittel**Version Date:** 2010

7.C.1. Lawn, Garden & Recreational Developed Vegetation

7.C.1.1. Lawn & Recreational Grassland

M546. Tropical Lawn

G721. Tropical Open Lawn

Bothriochloa bladhii - *Chrysopogon aciculatus* Lawn [Provisional]

Identifiers: C EGL008124

USNVC CLASSIFICATION

Formation Lawn, Garden & Recreational Developed Vegetation (7.C.1)
Division Lawn & Recreational Grassland (7.C.1.1)
Macrogroup Tropical Lawn (M546)
Group Tropical Open Lawn (G721)
Association (Local name) Australian Beardgrass – Inifuk Lawn [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

War in the Pacific National Historical Park Environment: This is a mowed lawn sampled four times in the park near buildings, parking areas and other structures. It occurs on flat, level ground within 3 m of sea level elevation, on sandy soils.

VEGETATION DESCRIPTION

War in the Pacific National Historical Park Vegetation: This mowed lawn is dominated by a mix of the non-native Australian beardgrass (*Bothriochloa bladhii*) and native inifuk grass (*Chrysopogon aciculatus*). Other herbaceous species present may include non-native threeflower ticktrefoil (*Desmodium triflorum*), carpet grass (*Axonopus compressus*), fingergrass (*Chloris barbata*), false buttonweed (*Spermacoce assurgens*), sleeping grass (*Mimosa pudica*), and native tropical fimbry (*Fimbristylis cymosa*), and Makila grass (*Zoysia matrella*). Surrounding the lawns are planted trees, whose canopy sometimes were recorded in quantitative plots and observations. Tronkon niyok (*Cocos nucifera*) is one of the trees recorded bordering the mowed lawns.

Local Dynamics: These are maintained by mowing.

MOST ABUNDANT SPECIES

War in the Pacific National Historical Park:

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Graminoid	Perennial	Austalian beardgrass
		Inifuk

ELEMENT DISTRIBUTION

Range: Asan Beach Unit, Agat Unit: Ga'an and Apaca points

Nations: US

States/Provinces: Guam

ELEMENT SOURCES

War in the Pacific National Historical Park Plots: WAPA.0003, WAPA.0010, WAPA.0012, WAPA.0022

Local Description Author(s): G. Kittel

Version Date: 2010

¹USNVC name modified based on Wagner et al. 1999 and Wagner et al. 2012.

Appendix F: Mapping Conventions and Visual Key

War in the Pacific National Historical Park- Map Classes

This appendix describes the map classes for the War in the Pacific National Historical Park (WAPA) Vegetation Inventory Project. Its purpose is to:

- Describe the vegetation of each map class;
- Provide a representative ground photograph/image for each map class;
- Describe the link between each map class and the revised U.S. National Vegetation Classification (NVC);
- Provide visual examples of each map class with digital overhead images and delineated overlays

The map classes for WAPA were based on a combination of USNVC plant associations, local requests (i.e. Park Specials), the limitations of the digital imagery, and land use / land cover classes. The vegetation described in this section reflects the classification designed specifically for this project. Non-vegetated and land-use map classes are not described in this key. For more information on the development of the mapping scheme for WAPA please reference the mapping sections of this report and the digital information (i.e. lookup tables, metadata) included on the project DVD.

This key follows the physiognomic grouping of each map class starting with forest and woodland types. Each map class is fully described by a variety of characteristics and features. First the USNVC crosswalk (if applicable) to associations and the common plant species for each association is presented. Next is a description of the mapping concept and a representative ground photograph. A map of the distribution for each mapping unit across the study area follows along with an example of the 2005 Quickbird digital basemap ortho-imagery (color infrared bands). The imagery snapshots also include representative polygon outlines that highlight the map class signatures. Many of the map class descriptions rely heavily on the vegetation plot data collected in 2009 and the accuracy assessment data collected in 2010 and 2011. The sample ground photographs were taken during the 2009 plot data collection or during the 2010-2011 accuracy assessment by National Park Service staff.

Forest and Woodlands

Map Code	Coral Bean Tree Semi-natural Forest Stand
F_ADPA	<i>Adenanthera pavonina</i> Semi-natural Forest Stand

Common Species

Coral bean tree (*Adenanthera pavonina*)
Custard apple (*Annona reticulata*)
Tronkon niyok (*Cocos nucifera*)
Bejuco halum-tano (*Flagellaria indica*)
Palma brava (*Heterospatha elata*)
Tangan-tangan (*Leucaena leucocephala*)
Neti (*Miscanthus floridulus*)
Nanaso (*Scaevola taccada*)
African tulip tree (*Spathodea campanulata*)

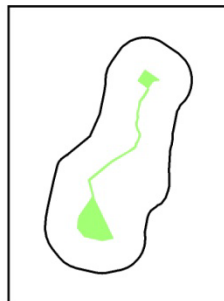
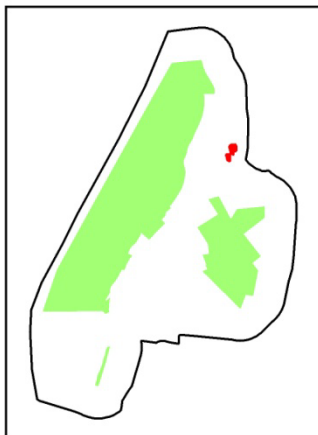
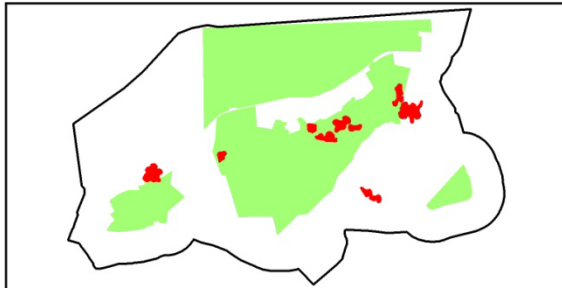
USNVC Association

-No Association Unclassified Map Class

Description

The coral bean tree forest map class was added to the WAPA vegetation map after the accuracy assessment field work. Prior to the accuracy assessment this map class was included in the W_HITI map class but further analysis of the imagery allowed for its separation. The various polygons of this type were located primarily in the northern section of WAPA. Trees of this type were medium to tall in stature and contained a thick understory of various herbaceous species. Coral bean trees often intermixed with hau and palma brava trees and tangan-tangan shrubs and some confusion likely exists in the mapping of these types at WAPA. On the Quickbird imagery trees of the F_ADPA map class had a characteristic puffy, dark red signature with pink to light red undertones representing herbaceous understory and shorter associated tree species.

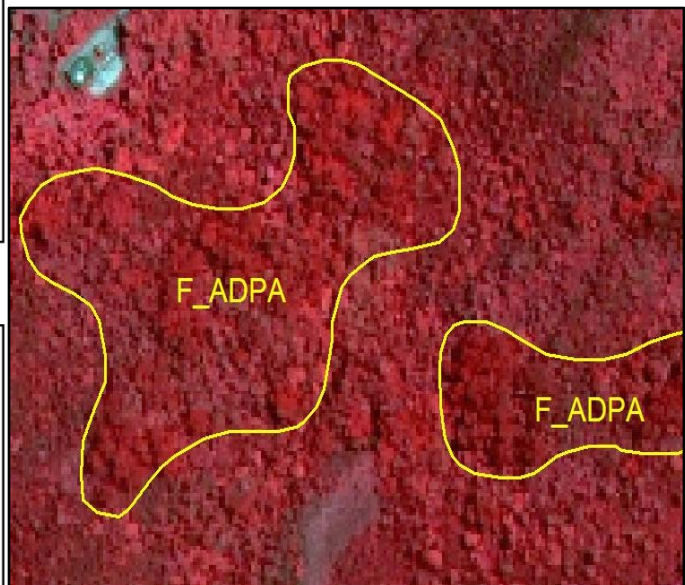
Range and Distribution



Representative Ground Photo



Photo Signature Example



Map Code	Piao Palaoan – (Spiny Bamboo) Semi-natural Forest
F_BAVU	<i>Bambusa vulgaris</i> - (<i>Bambusa blumeana</i>) Semi-natural Forest

Common Species

Piao Palaoan (*Bambusa vulgaris*)
Lemai (*Artocarpus altilis*)
Spiny bamboo (*Bambusa blumeana*)
Palma brava (*Heterospatha elata*)

USNVC Association

-*Bambusa vulgaris* Semi-natural Forest [Park Special]

Representative Ground Photo



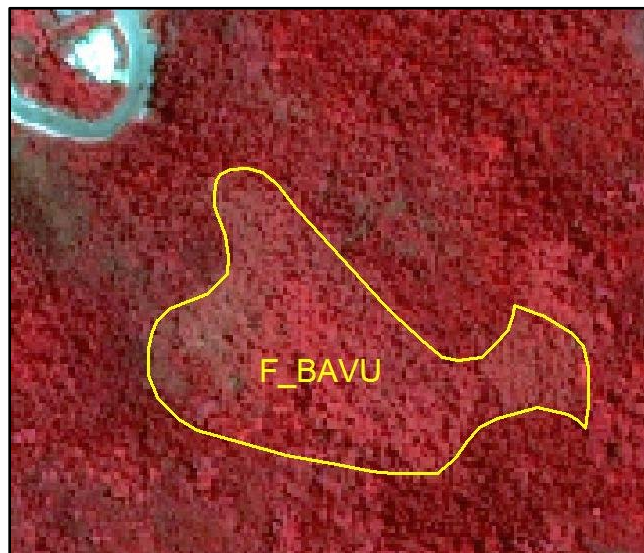
Description

Fairly homogeneous stands of piao palaoan and spiny bamboo forest were scattered throughout the upland portions WAPA occurring in jungle-like settings. Bamboo at WAPA was fairly tall ranging from 2-5 meters in height and contained very little understory diversity. Piao palaoan was initially classified as the only dominant bamboo species in the WAPA classification, but based on the accuracy assessment field work spiny bamboo was also found to occur in some areas and was included as an associate in the F_BAVU map class. Canopies for this type were mostly closed and had a mottled pink appearance. Other small F_BAVU polygons may exist in the project environs and more field work outside of WAPA may lead to future expansion of this map class.

Range and Distribution



Photo Signature Example



Map Code	Broad-leaved mahogany Semi-natural Forest
F_SWMA	<i>Swietenia macrophylla</i> Semi-natural Forest

Common Species

Broad-leaved mahogany (*Swietenia macrophylla*)
 Fan maidenhair (*Adiantum tenerum*)
 Papaya (*Carica papaya*)
 Bejuco halum-tano (*Flagellaria indica*)
 Palma brava (*Heterospathe elata*)
 Tangan-tangan (*Leucaena leucocephala*)
 Giant swordfern (*Nephrolepis biserrata*)
 Corky passionflower (*Passiflora suberosa*)
 Monarch fern (*Phymatosorus grossus*)
 Jeweled maiden fern (*Thelypteris opulenta*)

USNVC Association

-*Swietenia macrophylla* Semi-natural Forest [Park Special]

Representative Ground Photo



Description

Broad-leaved mahogany trees were a common associate of the mixed deciduous jungle-like forests found in the upland portion of northwest WAPA. Trees of this type only formed stands large enough to map in a few locations along the western boundary of the park. In this area the broad-leaved mahogany trees formed even-aged stands of medium to tall trees with an open understory of mixed herbaceous vegetation. On the color infrared F_SWMA polygons had a characteristic mottled, dark red signature that contrasted with the lighter red and pink colors of the surrounding W_HITI and W_HEEL map classes. Other small F_SWMA polygons may exist in the project environs and more field work outside of WAPA may lead to future expansion of this map class.

Range and Distribution

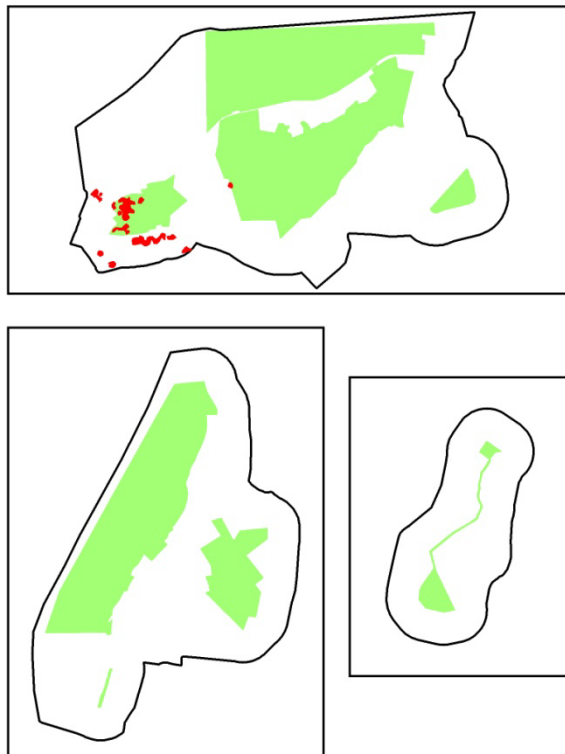
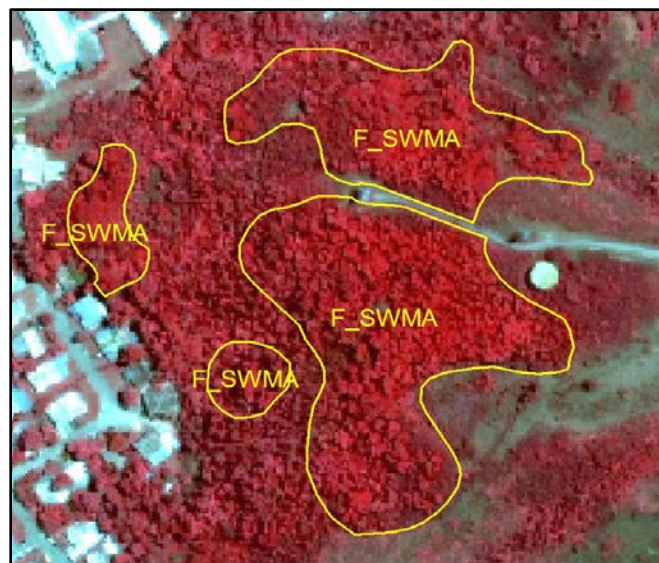


Photo Signature Example



Map Code	Gagu / Neti - Mission Grass Semi-natural Wooded Grassland
W_CAMI	<i>Casuarina equisetifolia</i> / <i>Miscanthus floridulus</i> - <i>Cenchrus polystachios</i> Semi-natural Wooded Grassland

Common Species

Gagu (*Casuarina equisetifolia*)
 Tronkon niyok (*Cocos nucifera*)
 Tangan-tangan (*Leucaena leucocephala*)
 Rhynchospora (*Rhynchospora rubra*)
 Neti (*Miscanthus floridulus*)
 Wildcane (*Saccharum spontaneum*)
 Mission grass (*Cenchrus polystachios*)
 Climbing hempvine (*Mikania scandens*)
 Yellow poinciana (*Peltophorum pterocarpum*)

USNVC Association

-*Casuarina equisetifolia* / *Miscanthus floridulus*-
Cenchrus polystachios Semi-natural Wooded
 Grassland [Park Special]¹

Representative Ground Photo



Description

Mature gagu trees were found throughout WAPA occurring in open settings in the upland savanna areas and as denser woodlands closer to the residential areas surrounding the park. In the open settings, polygons of this type usually contained a thick understory of neti, mission grass and various other grass species. The W_CAMI map class was used to distinguish stands of tall gagu trees with grass understories from the other gagu map class that occurred along the coastal margins. The gagu trees in this map class exhibited a dark brown color on the Quickbird imagery due to its evergreen physiogomy. Canopies for this type were open and had a mottled appearance with smooth blue-green undertones (grasses) beneath the trees. Since gagu was mapped using two different map classes much overlap likely exists and some confusion may have occurred during the mapping of the gagu types at WAPA.

Range and Distribution

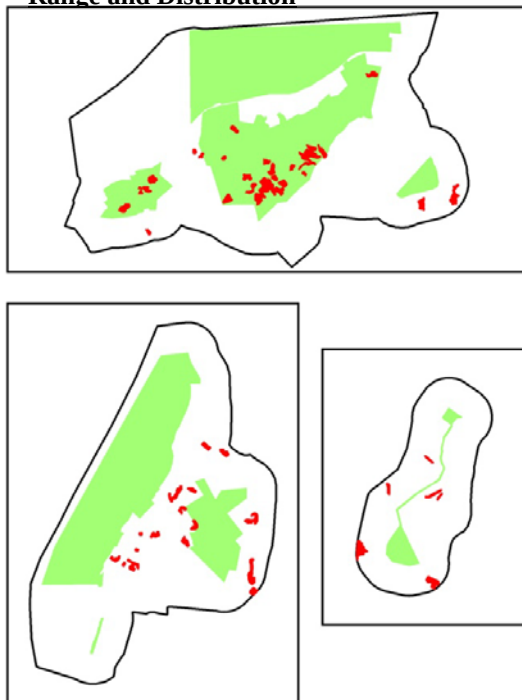
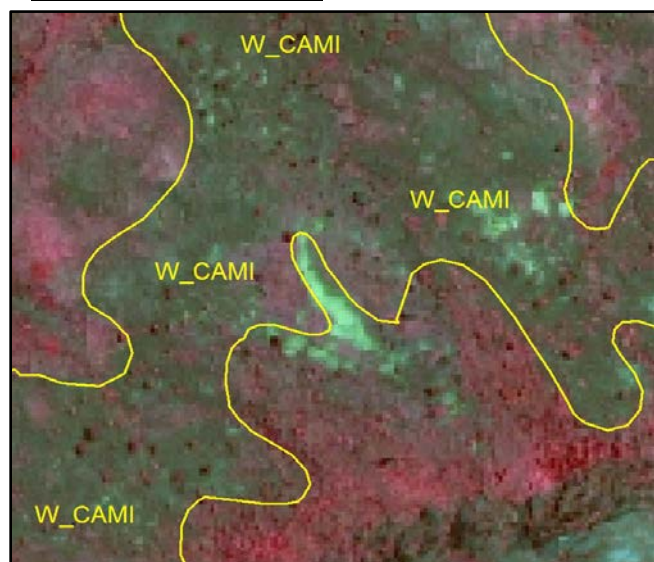


Photo Signature Example



Map Code	Gagu Woodland
W_CAEQ	<i>Casuarina equisetifolia</i> Woodland

Common Species

Gagu (*Casuarina equisetifolia*)
 Nigas (*Pemphis acidula*)
 Milo (*Thespesia populnea*)
 Limeberry (*Triphasia trifolia*)
 Tronkon niyok (*Cocos nucifera*)
 Tangan-tangan (*Leucaena leucocephala*)
 Pahong (*Pandanus dubius*)
 Ahgao (*Premna serratifolia*)

USNVC Association

- *Casuarina equisetifolia* Woodland [Provisional]

Description

The W_CAEQ woodland map class was used for coastal strand areas of gagu occurring primarily on flat ground next to the Pacific Ocean. In these locations the gagu trees were medium aged in size and formed a thick canopy with sparse lawn-like grasses in the interior of the understory. Along the margins thick herbaceous vegetation was common including coastal strand scrub and weedy scrub species. The W_CAEQ map class was used to distinguish coastal stands of gagu trees from the other gagu map class that occurred in the upland interior of the park. The gagu trees in this map class exhibited a dark reddish brown color on the Quickbird imagery due to its evergreen physiogomy. Canopies for this type were closed and had a mottled appearance. Since gagu was mapped using two different map classes some overlap likely exists and some confusion may have occurred during the mapping of the gagu types at WAPA.

Representative Ground Photo



Range and Distribution

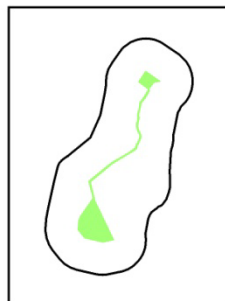
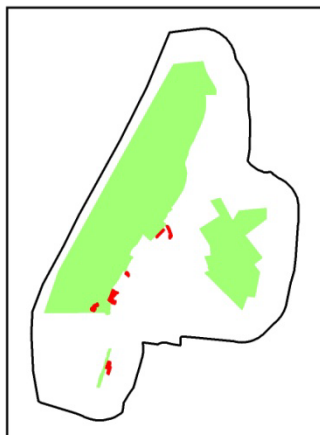
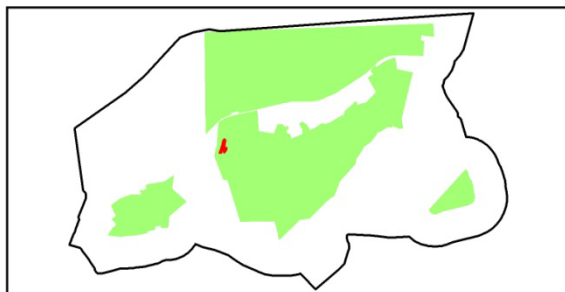


Photo Signature Example



Map Code **Tronkon Niyok – (Hau) / Mixed Grass Wooded Strand**

W_CONU ***Cocos nucifera* – (*Hibiscus tiliaceus*) / Mixed Grass Wooded Strand**

Representative Ground Photo

Common Species

Tronkon niyok (*Cocos nucifera*)

Hau (*Hibiscus tiliaceus*)

Tronkon-kalaskas, (*Albizia lebbbeck*)

Kafu (*Pandanus tectorius*)

Crowfoot grass (*Dactyloctenium aegyptium*)

Tangan-tangan (*Leucaena leucocephala*)

Milo (*Thespesia populnea*)

Guinea grass (*Urochloa maxima*)

Roadside bluestem (*Dichanthium caricosum*)



USNVC Association

-*Cocos nucifera* - *Hibiscus tiliaceus* / Mixed Grass
Wooded Strand [Provisional]

Description

Stands of tronkon niyoks were common at WAPA occurring along roadways, uplands, and along the beach and other coastal strand areas. Other individual tronkon niyok trees likely occur at WAPA but were mapped as part of the other woodland and forest map classes. Some of the tronkon niyok trees at WAPA were probably planted at one time and/or are descendants of ones planted by early island inhabitants. On the Quickbird imagery the coconut trees had a characteristic, dark red fan appearance due to their sparse canopy and the spreading of their fronds.

Range and Distribution

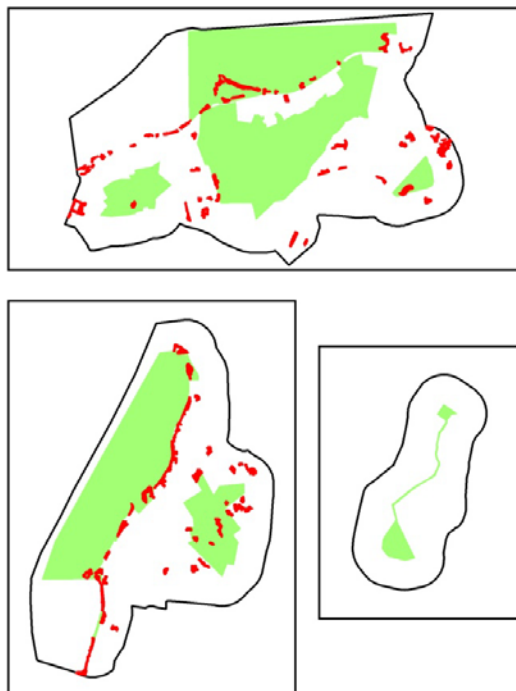


Photo Signature Example



Map Code	Moreton Bay Fig – (Amahadyan) Woodland Stand
W_FIAM	<i>Ficus macrophylla</i> – (<i>Pipturus argenteus</i>) Woodland Stand

Common Species

Moreton Bay fig (*Ficus macrophylla*)
 Custard apple (*Annona reticulata*)
 Pengua (*Macaranga thompsonii*)
 Pahong (*Pandanus dubius*)
 Amahadyan (*Pipturus argenteus*)
 Limeberry (*Triphasia trifolia*)
 Dogduk (*Artocarpus mariannensis*)
 Nunu (*Ficus prolixa*)
 Fagot (*Neisosperma oppositifolia*)

USNVC Association

-No Association Unclassified Map Class

Description

The Morton Bay fig with amahadyan woodland map class was added to the WAPA vegetation mapping after the accuracy assessment field work. Prior to the accuracy assessment this map class was included in the hau woodland map class but further analysis of the imagery allowed for the separation of these two map classes. The two polygons of this type were located primarily in the northern section of WAPA in the jungle-like upland. Trees of this type were medium to tall in stature and contained a thick understory of various herbaceous species. Morton Bay fig and amahadyan trees often intermixed with hau and palma brava trees and tanga-tanga shrubs and some confusion likely exists in the mapping of these types at WAPA. On the color infrared imagery trees of the W_FIAM map class had a characteristic bright pink signature consisting of puffy clumps (tree canopies) and pink to light red undertones representing the understory species.

Representative Ground Photo



Range and Distribution

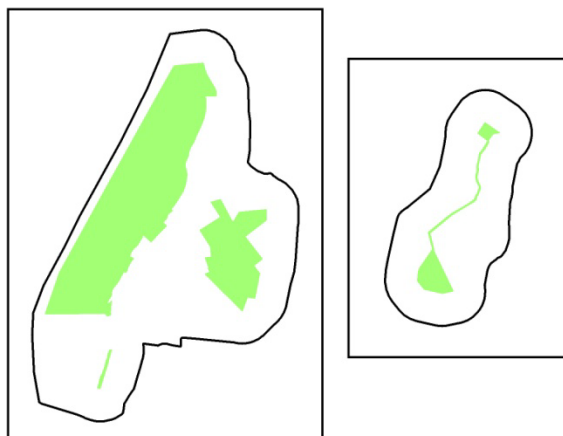
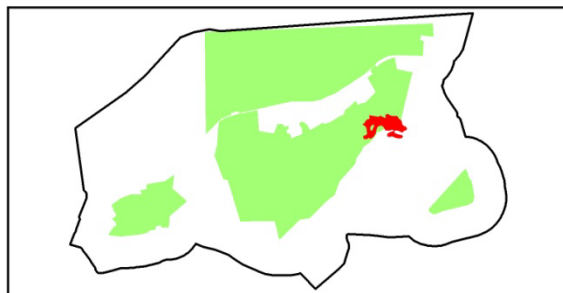
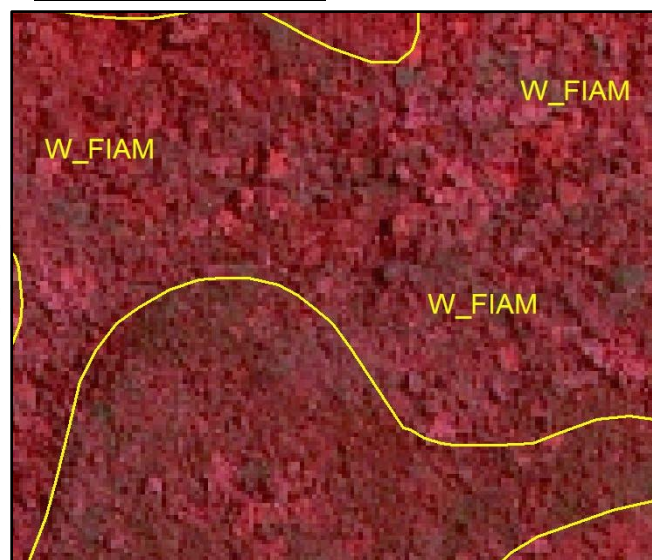


Photo Signature Example



Map Code **Palma brava Semi-natural Woodland & Forest Complex**
W_HEEL ***Heterospathe elata* Semi-natural Woodland & Forest Complex**

Representative Ground Photo

Common Species

Palma brava (*Heterospathe elata*),
Hau (*Hibiscus tiliaceus*),
Neti (*Miscanthus floridulus*),
Giant swordfern (*Nephrolepis biserrata*),
Kafu (*Pandanus tectorius*),
Yellow poinciana (*Peltophorum pterocarpum*),
Sumak (*Aidia cochinchinensis*),
Karriso (*Phragmites karka*),
White cedar (*Tabebuia heterophylla*),
Tangan-tangan (*Leucaena leucocephala*),
Bay rum (*Pimenta racemosa*)



USNVC Associations

-*Heterospathe elata* / *Nephrolepis hirsutula* Semi-natural Woodland [Provisional]
-*Heterospathe elata* - *Hibiscus tiliaceus* / (*Phragmites karka*, *Miscanthus floridulus*) Semi-natural Woodland [Park Special]

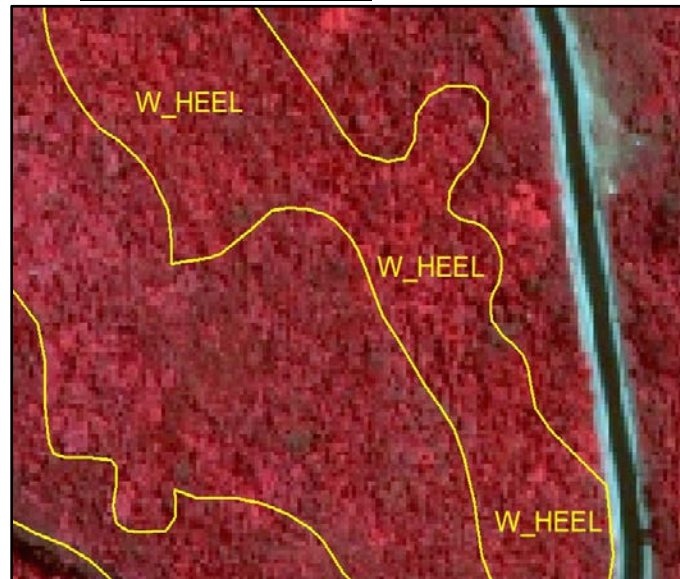
Description

The palma brava map class was found throughout the northern sections of WAPA on mostly mesic slopes and in drainage bottoms. W_HEEL polygons were usually very dense and ranged in size from 3 – 10 meters in height. Palma brava trees were typically shorter than the closely associated hau woodlands but some intermixing and confusion between these similar types likely exists. On the color infrared imagery trees of the W_HEEL map class had a characteristic mottled, dark red signature with pink undertones relating to the understory species composition.

Range and Distribution



Photo Signature Example



Map Code	Hau Woodland
W_HITI	<i>Hibiscus tiliaceus</i> Woodland

Representative Ground Photo

Common Species

Hau (*Hibiscus tiliaceus*)
 Palma brava (*Heterospatha elata*)
 Piao palaoan (*Bambusa vulgaris*)
 Coral bean tree (*Adenanthera pavonina*)
 Bejuco halum-tano (*Flagellaria indica*)
 Kafu (*Pandanus tectorius*)
 Yellow poinciana (*Peltophorum pterocarpum*)
 Lemai (*Artocarpus altilis*)
 Tronkon niyok (*Cocos nucifera*)
 Bejuco halum-tano (*Flagellaria indica*)
 Karriso (*Phragmites karka*)



USNVC Association

-*Hibiscus tiliaceus* Woodland [Park Special]

Description

Hau was a common species in the coastal and upland portions of WAPA. Stands of this type tended to have dense cover and occur in multi-layer canopies with thick to moderate cover of palma brava and various forbs and grasses in the understory. Hau formed both homogeneous polygons and also intermixed with almost all of the other woodland and forest types and some confusion likely exists in the mapping of this common type. On the color infrared imagery trees of this type had a coarse, pink to light red signature color.

Range and Distribution

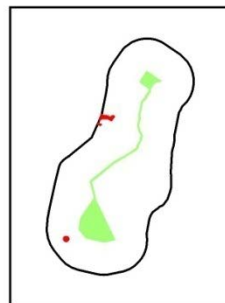
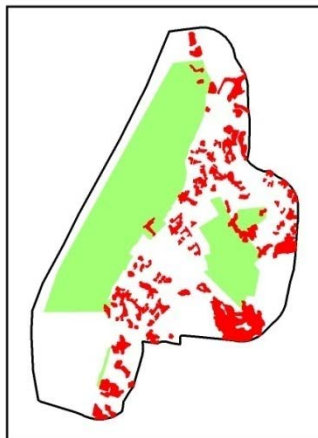
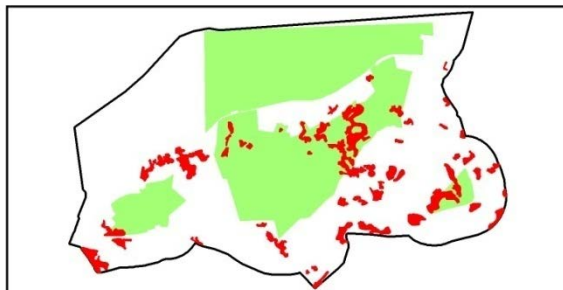
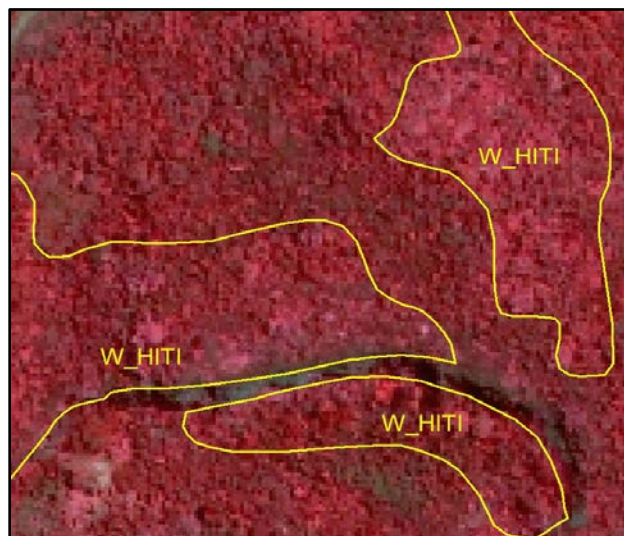


Photo Signature Example



Map Code **Tangan-tangan Semi-natural Woodland Complex**
W_LELE ***Leucaena leucocephala* Semi-natural Woodland Complex**

Representative Ground Photo

Common Species

Tangan-tangan (*Leucaena leucocephala*)
 Gagu (*Casuarina equisetifolia*)
 Tronkon niyok (*Cocos nucifera*)
 Climbing hempvine (*Mikania scandens*)
 Yellow poinciana (*Peltophorum pterocarpum*)
 Nanaso (*Scaevola taccada*)
 Palma brava (*Heterospatha elata*)
 African tulip tree (*Spathodea campanulata*)
 Coral bean tree (*Adenanthera pavonina*)
 Custard apple (*Annona reticulata*)
 White cedar (*Tabebuia heterophylla*)
 Limeberry (*Triphasia trifolia*)
 Monarch fern (*Phymatosorus grossus*)



USNVC Associations

-(Woodland Form of the S_LELE - *Leucaena leucocephala* Semi-natural Shrubland Complex)

Description

Tall tangan-tangan shrublands and woodlands were common throughout WAPA occurring as both dense polygons with little understory and as sparser variants with an obvious mixed grass understory. The W_LELE map class was created to help separate areas with tall woodland-like tangan-tangan shrubs with an average height of more than five meters from the younger, and shorter tangan-tangan shrublands. On the Quickbird imagery this map class had a characteristic smooth, brown-red signature that contrasted with the brighter pink and red woodlands and the blue-green grasslands.

Range and Distribution



Photo Signature Example



Map Code	Mango Semi-natural Woodland
W_MAIN	<i>Mangifera indica</i> Semi-natural Woodland

Common Species

Mango (*Mangifera indica*)
Tronkon niyok (*Cocos nucifera*)
Hau (*Hibiscus tiliaceus*)
Tangan-tangan (*Leucaena leucocephala*)
Smallflower chastetree (*Vitex parviflora*)

USNVC Association

-*Mangifera indica* Semi-natural Woodland [Park Special]

Representative Ground Photo



Description

Mango trees were a common associate of the mixed deciduous jungle-like woodlands found in the southern upland portions of WAPA. In these settings, medium to tall mango trees were found growing in semi-mesic clumped or bunched polygons. Polygons of W_MAIN were often associated with nearby stands of hau, palma brava and lada trees and some confusion between these types may have occurred. On the color infrared imagery trees of this type had a coarse, pink signature with blue-green understory colors relating to herbaceous savanna grasslands. More ground-truthing and mapping on the ground would likely help refine the delineation of the mango trees from the other dense woodland types like W_VIPA, W_HITI, and W_HEEL.

Range and Distribution

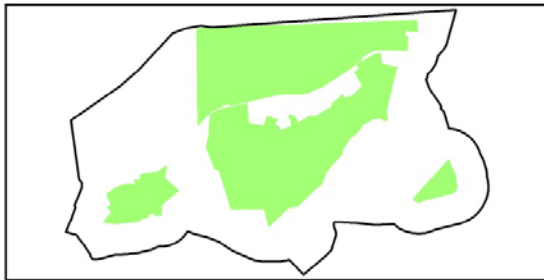
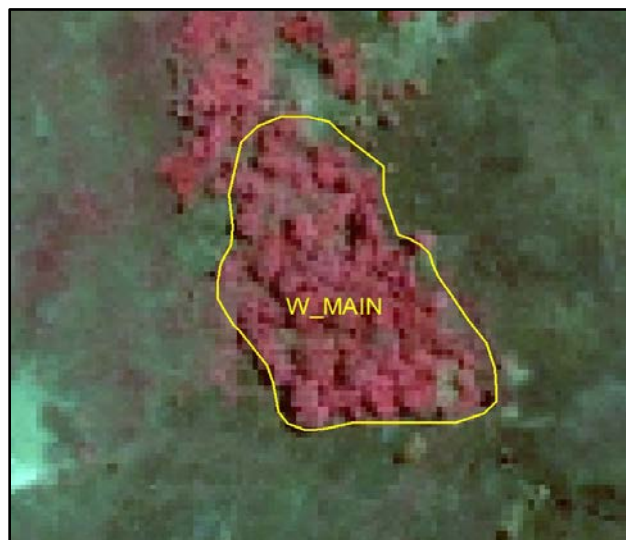


Photo Signature Example



Map Code **Lada / Scaly Swordfern Woodland**
W_MOCI ***Morinda citrifolia* / *Nephrolepis hirsutula* Woodland**

Representative Ground Photo

Common Species

Lada (*Morinda citrifolia*)
Scaly swordfern (*Nephrolepis hirsutula*)
Monarch fern (*Phymatosorus grossus*)
Ahgao (*Premna serratifolia*)
Chinese brake (*Pteris vittata*)
Spottedheart (*Stictocardia tiliifolia*)
Limeberry (*Triphasia trifolia*)
Smallflower chastetree (*Vitex parviflora*)
Tangan-tangan (*Leucaena leucocephala*)

USNVC Association

-*Morinda citrifolia* / *Nephrolepis hirsutula*
Woodland [Park Special]



Description

Lada trees were common throughout most of WAPA but only dominated some small upland areas in the southern portion of the project area. In this southern section the lada trees had an open canopy with various other associated trees and shrub species and contained a mixed herbaceous vegetation understory. The close proximity of the lada polygons to similar W_VIPA polygons may have led to some confusion and other small, undocumented polygons may exist in the project area. On the color infrared imagery trees of this type had a coarse, red signature with pink undertones.

Range and Distribution

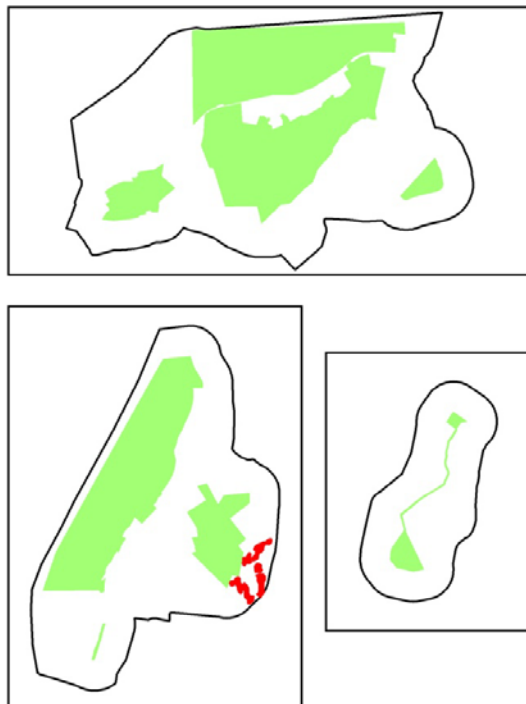
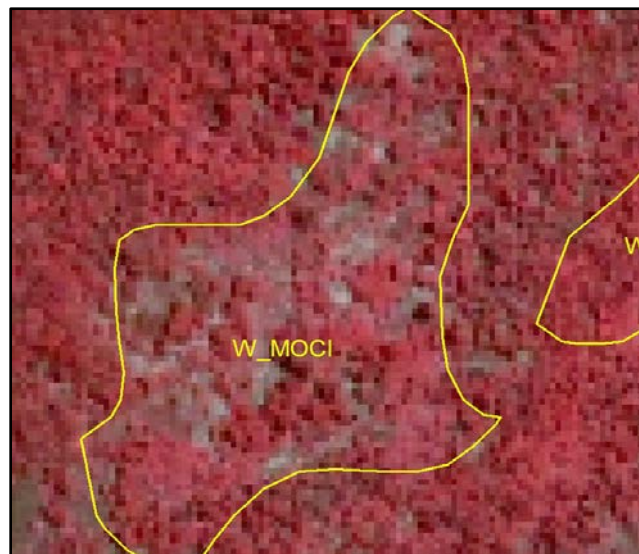


Photo Signature Example



Map Code **Mixed Semi-natural / Ornamental Tree Woodland**
W_ORNA

Common Species

Custard apple (*Annona reticulata*)
Bejuco halum-tano (*Flagellaria indica*)
Palma brava (*Heterospathe elata*)
Ifit (*Intsia bijuga*)
Obscure morning glory (*Ipomoea obscura*)
Tangan-tangan (*Leucaena leucocephala*)
Giant swordfern (*Nephrolepis biserrata*)
Pahong (*Pandanus dubius*)
Australian beardgrass (*Bothriochloa bladhii*)
Da'ok (*Calophyllum inophyllum*)
Threeflower ticktrefoil (*Desmodium triflorum*)
Oleander (*Nerium oleander*)

USNVC Association

-No Association Unclassified Map Class

Representative Ground Photo



Description

The mixed semi-natural and ornamental tree map class was used to map managed areas that were likely planted with, or contain an escaped mix of indigenous, fruit, and ornamental trees. This catch-all category was used to map tree stands that had unique signatures that differed from the known map classes and occurred mostly outside of the WAPA boundary. The trees in this map classes exhibited a range of signatures related to closed canopy or single large, spreading trees. Most of the canopies were dark red with a mottled appearance when viewed with the color infrared bands of the Quickbird imagery. More plot and verification data in these areas may warrant creating new woodland associations or merging this type with other existing woodland classes.

Range and Distribution



Photo Signature Example



Map Code	Yellow poinciana Woodland Stand
W_PEPT	<i>Peltophorum pterocarpum</i> Woodland Stand

Common Species

Yellow poinciana (*Peltophorum pterocarpum*)
 Gagu (*Casuarina equisetifolia*)
 Bejuco halum-tano (*Flagellaria indica*)
 Palma brava (*Heterospatha elata*)
 Tangan-tangan (*Leucaena leucocephala*)
 Nutrush (*Scleria polycarpa*)
 Scaly swordfern (*Nephrolepis hirsutula*)

USNVC Association

-No Association Unclassified Map Class

Description

Yellow poinciana trees were a common associate of the mixed deciduous jungle-like woodlands found in the upland portions of WAPA. Trees of this type only formed stands large enough to map in a few locations in the north and one area in the southern portion of WAPA. The W_PEPT map class was added to the WAPA vegetation map based on the accuracy assessment field work. Prior to the accuracy assessment the W_PEPT map class was included in the W_VIPA map class but further analysis of the imagery allowed for the separation of these two map classes. On the color infrared imagery trees of this type had a coarse, brown signature with pink (hau trees) and red (palma brava trees) understory colors. More ground-truthing and mapping on the ground would likely help refine the delineation of the yellow poinciana trees from the other dense woodland types like W_VIPA, W_HITI, and W_HEEL at WAPA.

Representative Ground Photo



Range and Distribution

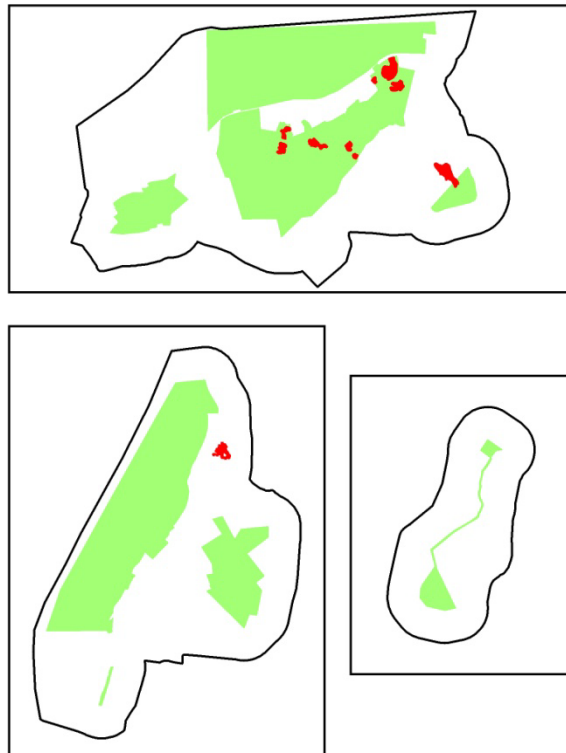
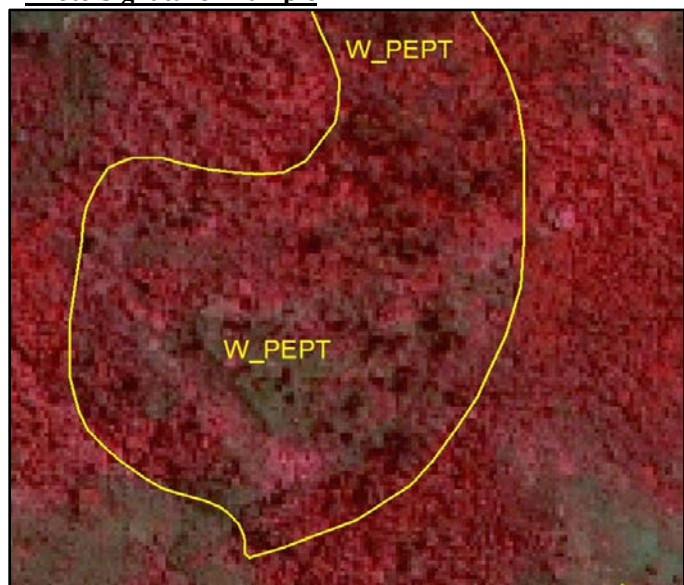


Photo Signature Example



Map Code	African tulip tree Semi-natural Woodland
W_SPCA	<i>Spathodea campanulata</i> Semi-natural Woodland

Common Species

African tulip tree (*Spathodea campanulata*)
 Tangan-tangan (*Leucaena leucocephala*)
 Broad-leaved mahogany (*Swietenia macrophylla*)
 Pink tabebuia (*Tabebuia rosea*)
 Hau (*Hibiscus tiliaceus*)
 Scaly swordfern (*Nephrolepis hirsutula*)
 Monarch fern (*Phymatosorus grossus*)

USNVC Association

- *Spathodea campanulata* Semi-natural Woodland
 [Park Special]

Representative Ground Photo



Description

African tulip trees formed a woodland association in a few polygons in the northwest section of WAPA. African tulip trees along with broad-leaved mahogany were also common associates in many of the more prevalent hau and palma brava woodland stands. Mapping of this type was based primarily on documented locations and other small polygons of W_SPCA may occur in the project area. On the Quickbird imagery African tulip trees appeared as emergant bright pink dots against a brown (tangan-tangan) or red (hau and palma brava) background.

Range and Distribution



Photo Signature Example



Map Code	White cedar / <i>Dimeria</i> Semi-natural Woodland
W_TAHE	<i>Tabebuia heterophylla</i> / <i>Dimeria chloridiformis</i> Semi-natural Woodland

Representative Ground Photo

Common Species

White cedar (*Tabebuia heterophylla*)
 Australian beardgrass (*Bothriochloa bladhii*)
 Gagu (*Casuarina equisetifolia*)
 Neti (*Miscanthus floridulus*)
 Karrisso (*Phragmites karka*)
 Rhynchospora (*Rhynchospora rubra*)
 Wildcane (*Saccharum spontaneum*)
 Rainbow pink (*Dianthus chinensis*)
 Majlocjayo (*Geniostoma micranthum*)
 Palma brava (*Heterospatha elata*)



USNVC Association

- *Tabebuia heterophylla* / *Dimeria chloridiformis*
 Semi-natural Woodland [Park Special]

Description

Stands of white cedar with a mixed herbaceous vegetation understory were found on a few small hills in the northern section of WAPA. Trees of this type were short in stature, shrub-like, and were interspersed within the upland savanna areas. White cedar trees were also common as associates and understory species in most of the other woodland types at WAPA and some confusion likely exists in the mapping of this type with the closely related S_LELE and W_CAMI map classes. On the color infrared imagery trees of the W_TAHE map class had a characteristic mottled brownish-red signature with various understory hues ranging from pink (in mesic areas) to blue-green in drier grassland settings.

Range and Distribution

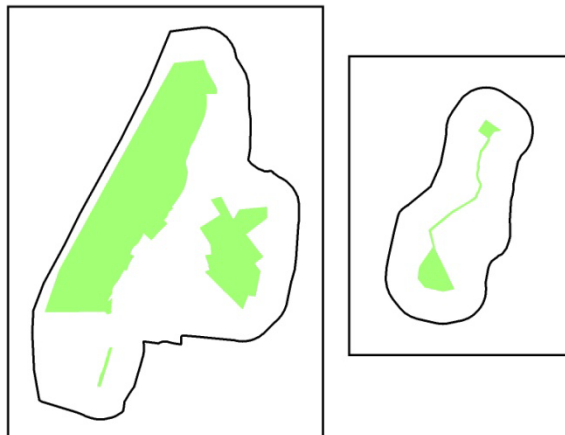
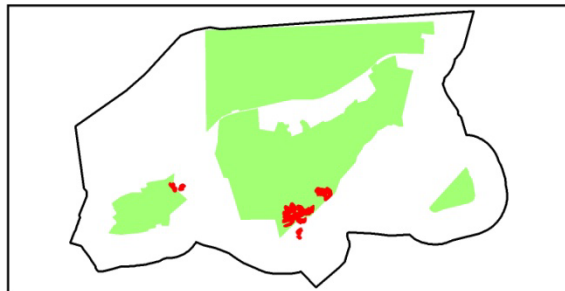
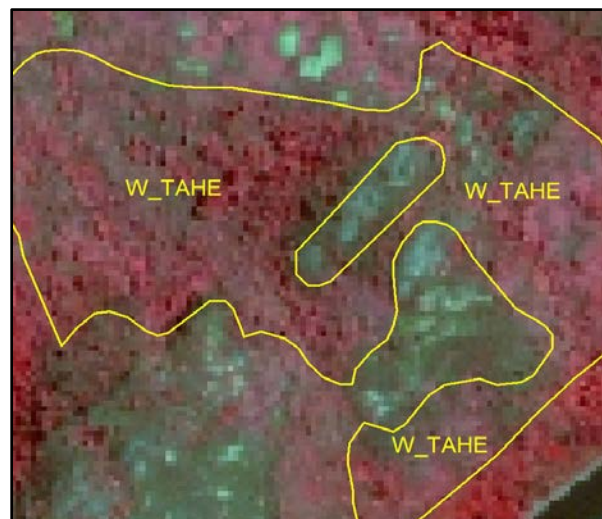


Photo Signature Example



Map Code	Smallflower chastetree Semi-natural Woodland
W_VIPA	Vitex parviflora Semi-natural Woodland

Common Species

Smallflower chastetree (*Vitex parviflora*)
 Hodda (*Ficus tinctoria*)
 Palma brava (*Heterospatha elata*)
 Karriso (*Phragmites karka*)
 Nutrush (*Scleria polycarpa*)
 Hau (*Hibiscus tiliaceus*)
 Climbing hempvine (*Mikania scandens*)
 White cedar (*Tabebuia heterophylla*)
 Tangan-tangan (*Leucaena leucocephala*)
 Kafu (*Pandanus tectorius*)
 Custard apple (*Annona reticulata*)
 Paipai (*Guamia mariannae*)

USNVC Association

-*Vitex parviflora* Semi-natural Woodland [Park Special]

Representative Ground Photo



Description

Smallflower chastetrees dominated a few isolated polygons in the northern and southern sections of WAPA. In these settings, medium-tall deciduous trees were found growing in semi-mesic linear polygons. Polygons of W_VIPA were often associated with nearby stands of hau, palma brava and lada trees and some confusion between these types may have occurred. On the color infrared Quickbird imagery trees of this type had a coarse red signature color with subtle pink undertones. More ground-truthing and field mapping would likely help refine the delineation of the various smallflower chastetree stands from the more prevalent W_HITI and WHEEL map classes.

Range and Distribution

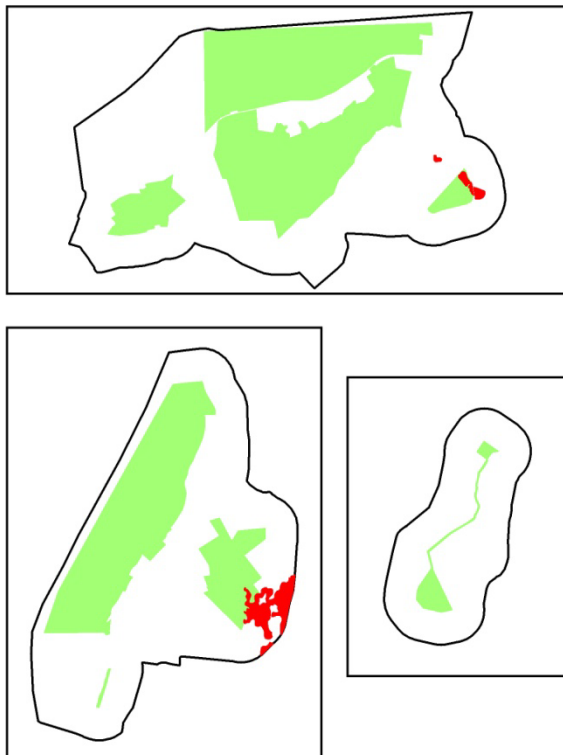
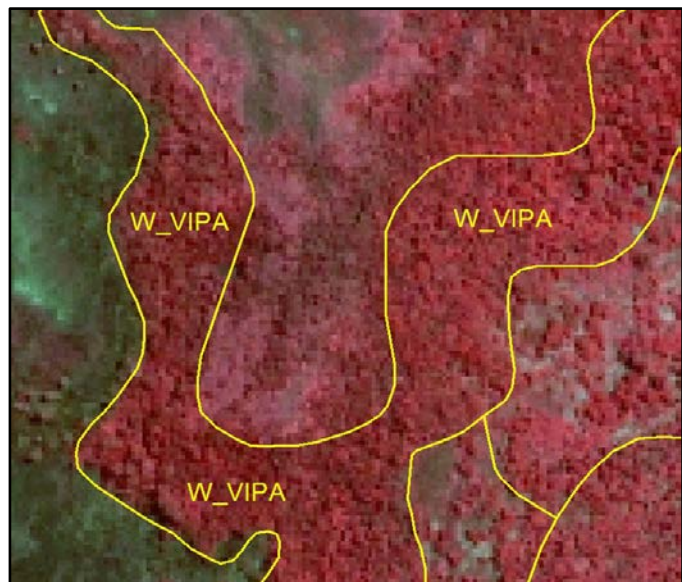


Photo Signature Example



Shrublands

Map Code	Tangan-tangan Semi-natural Shrubland
S_LELE	<i>Leucaena leucocephala</i> Semi-natural Shrubland Complex

Common Species

Tangan-tangan (*Leucaena leucocephala*)
 Gagu (*Casuarina equisetifolia*)
 Climbing hempvine (*Mikania scandens*)
 Yellow poinciana (*Peltophorum pterocarpum*)
 Gasoso (*Colubrina asiatica*)
 Bejuco halum-tano (*Flagellaria indica*)
 Palma brava (*Heterospatha elata*)
 Custard apple (*Annona reticulata*)
 White cedar (*Tabebuia heterophylla*)
 Monarch fern (*Phymatosorus grossus*)
 Napier grass (*Cenchrus purpureus*)

Representative Ground Photo



USNVC Associations

-*Leucaena leucocephala* Lowland Dry Semi-natural Shrubland
 -*Leucaena leucocephala* / *Miscanthus floridulus* Semi-natural Shrubland [Park Special]
 -*Leucaena leucocephala* / *Nephrolepis hirsutula* Semi-natural Shrubland [Park Special]

Description

Tangan-tangan shrublands were common throughout WAPA occurring as both dense polygons with little understory and as sparser variants with an obvious mixed grass understory. The S_LELE map class was created to help separate areas with tangan-tangan shrubs that had an average height of less than five meters from taller tangan-tangan woodlands and forests. On the Quickbird imagery this map class had a characteristic smooth, brown-red signature that contrasted with the brighter pink and red woodlands and the blue-green grasslands.

Range and Distribution

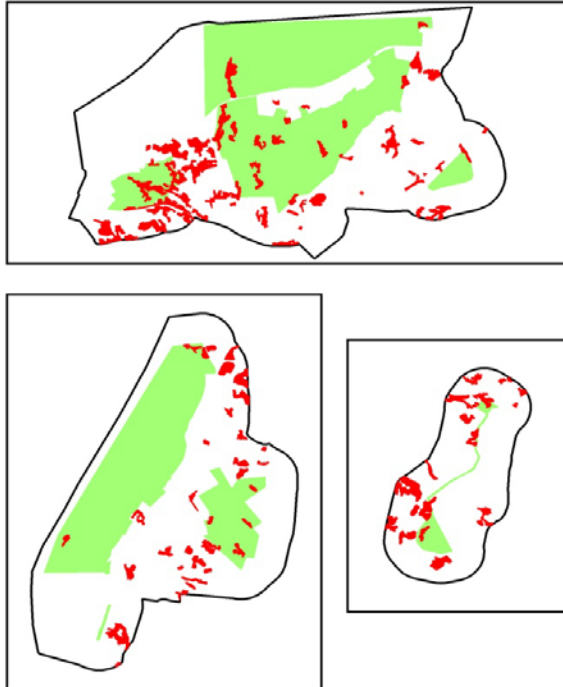


Photo Signature Example



Herbaceous Vegetation

Map Code	Chain-of-love - Guinea grass Semi-natural Herbaceous Vegetation
H_ANUR	<i>Antigonon leptopus</i> - <i>Urochloa maxima</i> Semi-natural Herbaceous Vegetation

Common Species

Chain-of-love (*Antigonon leptopus*)
 Guinea grass (*Urochloa maxima*)
 Giant taro (*Alocasia macrorrhizos*)
 Blue morning glory (*Ipomoea indica*)
 Tangan-tangan (*Leucaena leucocephala*)
 Climbing hempvine (*Mikania scandens*)
 Lada (*Morinda citrifolia*)
 Love-in-a-mist (*Passiflora foetida*)
 Karriso (*Phragmites karka*)
 Yervas babui (*Ruellia blechum*)

Representative Ground Photo



USNVC Association

- *Antigonon leptopus* - *Urochloa maxima* Semi-natural Herbaceous Vegetation [Park Special]

Description

Chain-of-love is a climbing buckwheat vine found in a few isolated polygons in and around WAPA. In these polygons chain-of-love was the dominant species occurring on tall grasses and minor trees and shrubs. The multi-strata nature of chain-of-love made it challenging to map and describe accurately and it is likely that other small pockets of this type exist elsewhere in the project area. For WAPA, sites were only mapped as H_ANUR when the vine had greater than 60% cover. The lush and broad-leaf nature of this species was apparent on the Quickbird imagery as bright pink colors with various textures depending on the vegetation it was growing on.

Range and Distribution

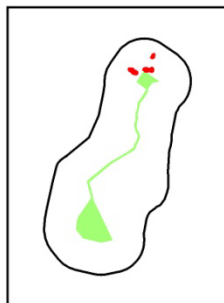
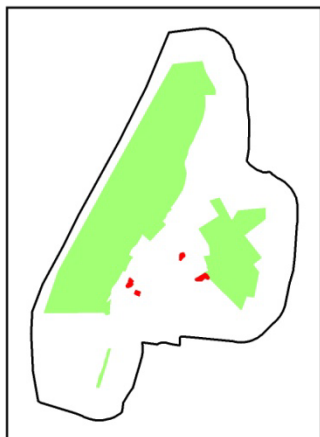
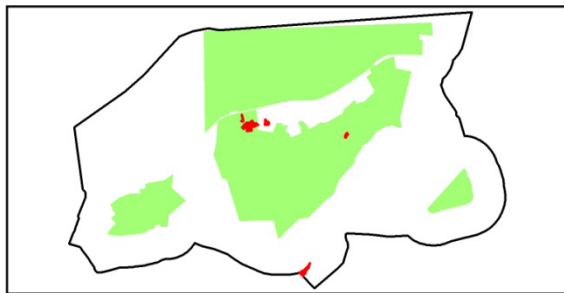
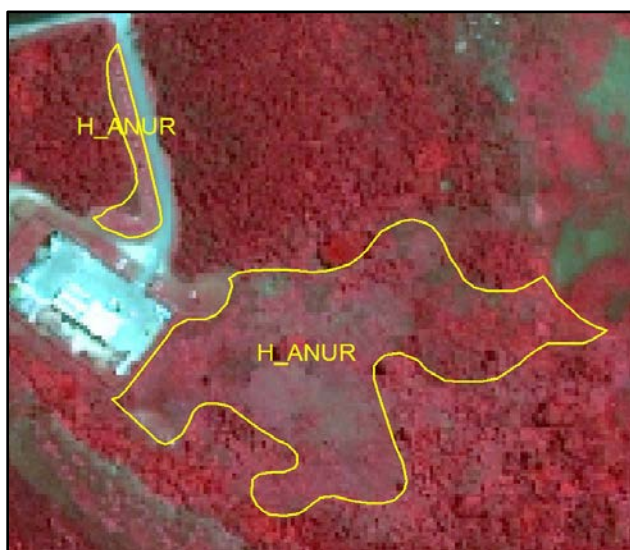


Photo Signature Example



Map Code	Uluhe Herbaceous Vegetation
H_DILI	<i>Dicranopteris linearis</i> Herbaceous Vegetation

Common Species

Uluhe (*Dicranopteris linearis*)
 Bamboo orchid (*Arundina graminifolia*)
 Australian beardgrass (*Bothriochloa bladhii*)
 Gagu (*Casuarina equisetifolia*)
 Mission grass (*Cenchrus polystachios*)
 Rainbow pink (*Dianthus chinensis*)
 Neti (*Miscanthus floridulus*)
 Rhynchospora (*Rhynchospora rubra*)
 Wildcane (*Saccharum spontaneum*)
 White cedar (*Tabebuia heterophylla*)

USNVC Association

-*Dicranopteris linearis* Herbaceous Vegetation [Park Special]

Representative Ground Photo



Description

Uluhe ferns formed common herbaceous vegetation polygons in mostly semi-mesic areas in the upland savanna regions of WAPA. Polygons dominated by H_DILI were found in low drainages, swales and bottomlands where they formed an herbaceous mosaic with the H_SAVA and H_PHKA map classes. Some polygons contained isolated tanganan-tangan and other common shrubs. On the Quickbird imagery areas dominated by uluhe exhibited a smooth, light pink to red signature (depending on density). Due to their close proximity and similar photo signatures it is likely that this type may have been confused with the H_PHKA and the H_ANUR map classes.

Range and Distribution

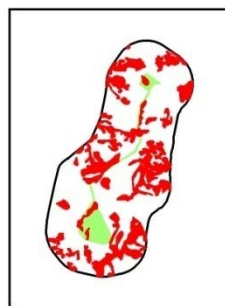
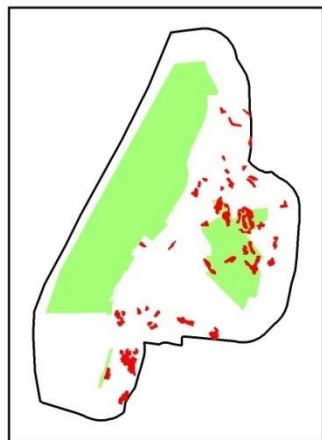
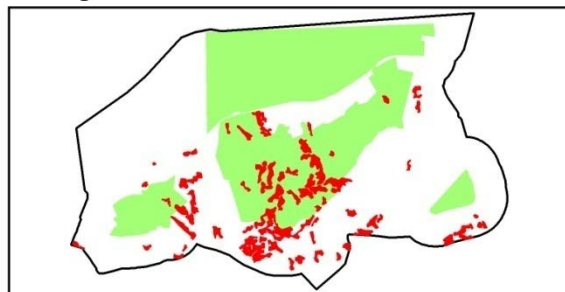
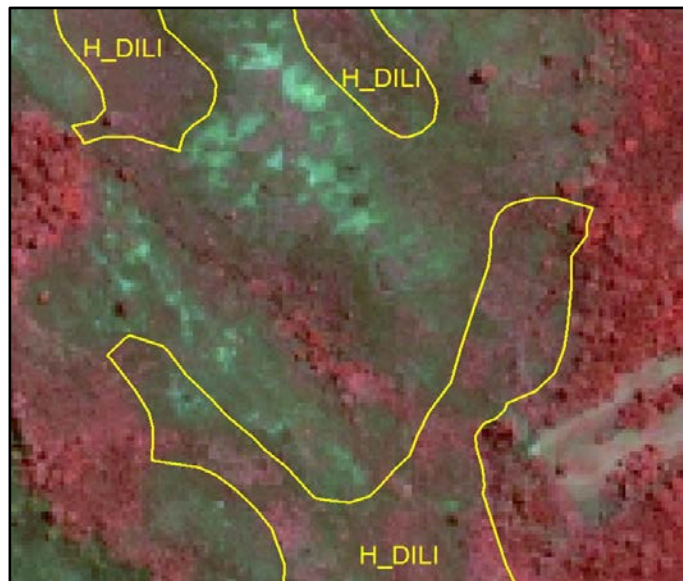


Photo Signature Example



Map Code	Australian beardgrass – Inifuk Lawn
H_LAWN	<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn

Common Species

Australian beardgrass (*Bothriochloa bladhii*)
 Romerillo (*Bidens alba*)
 Canada spikesedge (*Eleocharis geniculata*)
 Threeflower ticktrefoil (*Desmodium triflorum*)
 White moneywort (*Alysicarpus vaginalis*)
 Tropical fimbry (*Fimbristylis cymosa*)
 Purple bushbean (*Macroptilium atropurpureum*)
 Seashore dropseed (*Sporobolus virginicus*)
 False verbena (*Stachytarpheta jamaicensis*)
 Nodeweed (*Synedrella nodiflora*)
 Neem (*Azadirachta indica*)
 Tronkon niyok (*Cocos nucifera*)
 Guinea grass (*Urochloa maxima*)

Representative Ground Photo



USNVC Association

-*Bothriochloa bladhii* - *Chrysopogon aciculatus* Lawn [Provisional]

Description

Lawns are common at WAPA along the coast, in the picnic areas, around memorials/monuments/relics, surrounding the various government facilities, commercial businesses and residential areas. In all locations the dominant vegetation was dominated by a mix of short, maintained grasses and occasional non-native forbs. Common species in the H_LAWN map class also formed the understory of the various open woodland types that are regularly mowed and maintained at WAPA. On the Quickbird imagery the H_LAWN map class had a characteristic signature of smooth blue and green colors with pink (forbs) and gray (bare ground) hues.

Range and Distribution

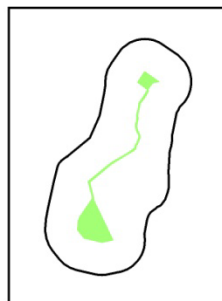
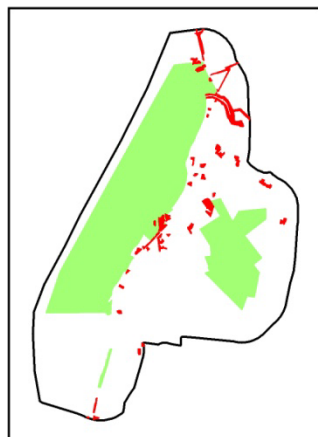
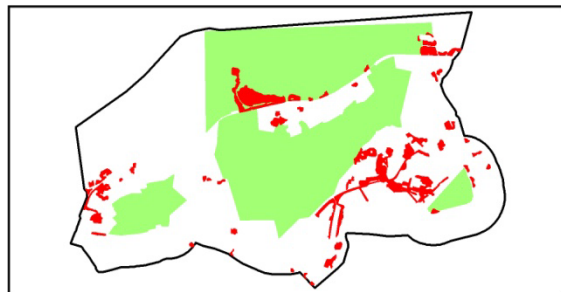


Photo Signature Example



Map Code	Karriso Herbaceous Vegetation
H_PHKA	<i>Phragmites karka</i> Herbaceous Vegetation

Common Species

Karriso (*Phragmites karka*)
 Hau (*Hibiscus tiliaceus*)
 Tronkon niyok (*Cocos nucifera*)
 Kafu (*Pandanus tectorius*)
 Tangan-tangan (*Leucaena leucocephala*)
 Fimbry (*Fimbristylis tristachya*)
 Canary Island St. Johnswort (*Hypericum canariense*)
 Neti (*Miscanthus floridulus*),
 Palma brava (*Heterospathe elata*),
 Climbing hempvine (*Mikania scandens*)

Representative Ground Photo



USNVC Association

-*Phragmites karka* Herbaceous Vegetation
 [Provisional]

Description

Karriso grass was a common reed species found in drainage bottoms and other mesic sites throughout all of the WAPA project area. Polygons of this type were mostly dominated by stands of karriso that were taller than the nearby manicured lawns and upland savanna grasses. H_PHKA polygons at WAPA were mostly lush and tall, traits that translated into a mottled, light pink to red signature (depending on the species composition) on the color infrared Quickbird imagery. Due to their close proximity and similar photo signatures it is likely that this type was confused with the H_DILI, S_SAVA and the S_LELE map classes during the mapping.

Range and Distribution

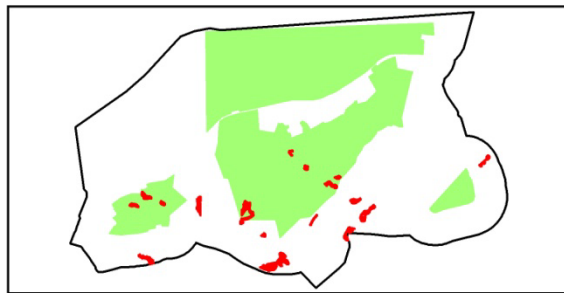
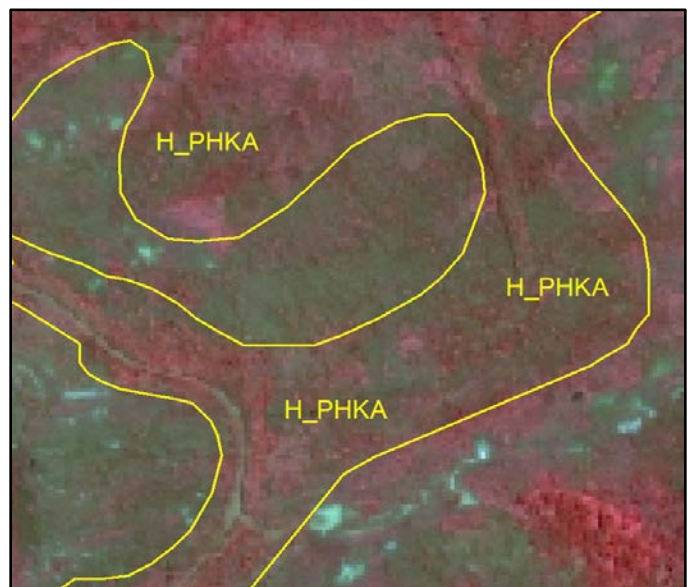


Photo Signature Example



Map Code Mixed Savanna Herbaceous Vegetation
H_SAVA

Common Species

Australian beardgrass (*Bothriochloa bladhii*)
 Neti (*Miscanthus floridulus*)
 Mission grass (*Cenchrus polystachios*)
 Dimeria (*Dimeria chloridiformis*)
 Bamboo orchid (*Arundina graminifolia*)
 Rhynchospora (*Rhynchospora rubra*)
 Wildcane (*Saccharum spontaneum*)
 False verbena (*Stachytarpheta jamaicensis*)
 Escobilla sabana (*Waltheria indica*)
 Tangan-tangan (*Leucaena leucocephala*)
 Gagu (*Casuarina equisetifolia*)

Representative Ground Photo



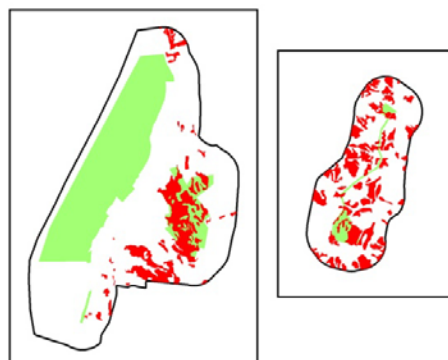
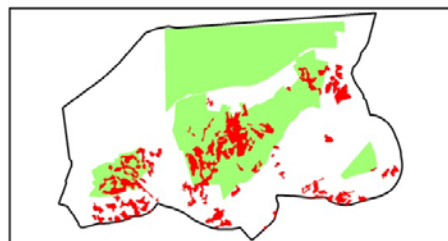
USNVC Associations

- Bothriochloa bladhii* – (*Dactyloctenium aegyptium*, *Paspalum conjugatum*) Semi-natural Herbaceous Veg. [Provisional]
- Dimeria chloridiformis* Herbaceous Vegetation [Provisional]
- Miscanthus floridulus* - (*Cenchrus polystachios*, *Bothriochloa bladhii*) Semi-natural Herb. Veg. [Provisional]¹
- Cenchrus* (*polystachios*, *purpureus*) Semi-natural Herbaceous Vegetation [Provisional]¹

Description

Mixed grasslands found in the upland savanna areas of WAPA were locally dominated by one of four grass species that were indistinguishable from each other on the Quickbird imagery. As a result all four grass associations were grouped into the H_SAVA map class to increase accuracy. Polygons of H_SAVA varied in cover likely based on moisture levels, disturbance, land-use history, soil type and topographic position. On more developed soils H_SAVA grasses were dense and tall. On shallow soils, this type tended to be sparse, patchy and stunted. On the Quickbird imagery the H_SAVA had a characteristic mottled, dark blue-green color (dense areas) with patches of

Range and Distribution



white
 some pink

Photo Signature Example



(single shrubs and trees).

(sparse areas) and
 and brown spots

Sparse Vegetation

Map Code Coastal Strand Sparse Vegetation
SV_CS

Common Species

Alalag-tasi (*Ipomoea pes-caprae*)
Tangan-tangan (*Leucaena leucocephala*)
Tronkon niyok (*Cocos nucifera*)
Mission grass (*Cenchrus polystachios*)
Napier grass (*Cenchrus purpureus*)

USNVC Associations

- *Ipomoea pes-caprae* Herbaceous Vegetation
- *Cenchrus (polystachios, purpureus)* Semi-natural
Herbaceous Vegetation [Provisional]¹

Description

The coastal strand sparse vegetation map class was used to map mostly linear polygons in around the beaches and coastal areas of WAPA. This broad catch-all class was used since no clear dominant species was established and since these sites likely vary in vegetation composition due to disturbance and beach use. Plant species of the SV_CS type also likely occur as understory constituents within the W_CONU and F_CAEQ map classes. On the color infrared imagery this type appeared as a light pink to brown haze on a white (sand) background. More plot and verification data in these areas may warrant creating a new herbaceous association or merging this type with other existing associations.

Representative Ground Photo



Range and Distribution

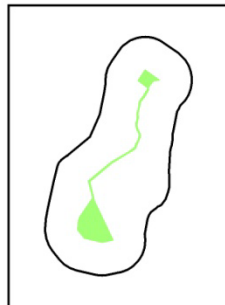
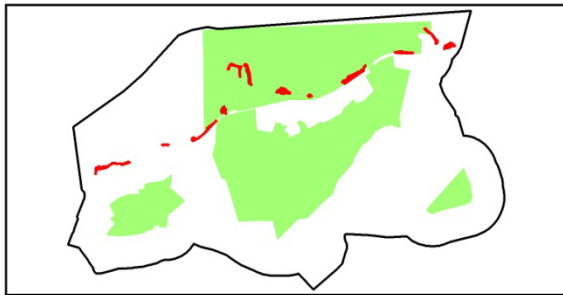
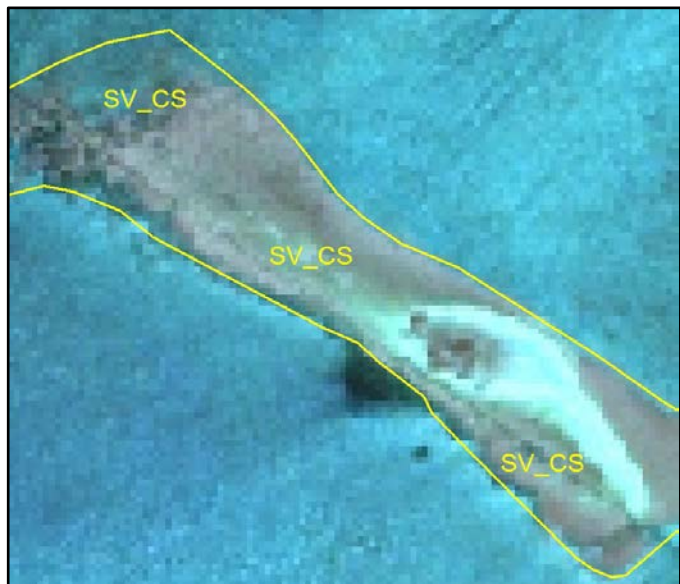


Photo Signature Example



Map Code **Clay and Rock Outcrop Sparse Vegetation**
SV_RK

Common Species

Australian beardgrass (*Bothriochloa bladhii*)
Neti (*Miscanthus floridulus*)
Mission grass (*Cenchrus polystachios*)
Dimeria (*Dimeria chloridiformis*)
Rhynchospora (*Rhynchospora rubra*)
Wildcane (*Saccharum spontaneum*)

USNVC Association

-No Association Unclassified Map Class

Description

The sparsely vegetated clay and rock outcrop map class was added to the WAPA vegetation map based on ground truthing efforts and its unique photos signature readily apparent on the Quickbird imagery. Rock and clay outcrops were found in all three sections of the project area and were closely associated with the H_SAVA map class. Common species included mats and bunches of Australian beardgrass, neti, and mission grass. Other minor species including short shrubs and some forbs were also present. The SV_RK is likely a dynamic map class that results from erosion, landslides and other disturbance events. On the Quickbird imagery this map class had a characteristic mottled white signature that contrasted with the surrounding dark blue-green of the H_SAVA map class. More polygons of this type may be present at WAPA after disturbance events and existing polygons may revert back to H_SAVA in time.

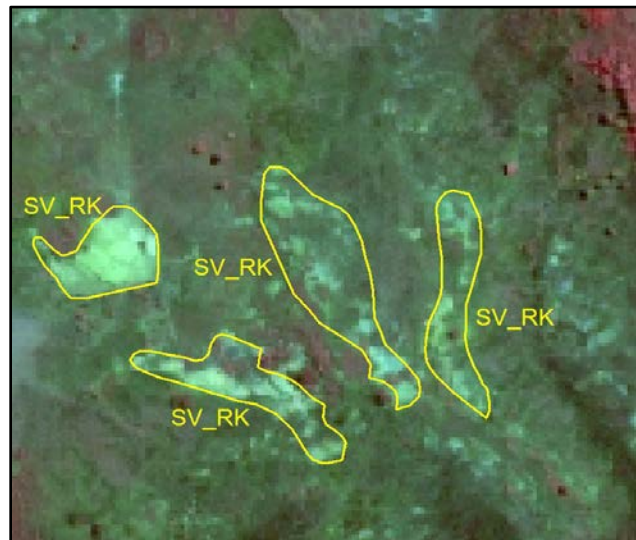
Representative Ground Photo



Range and Distribution

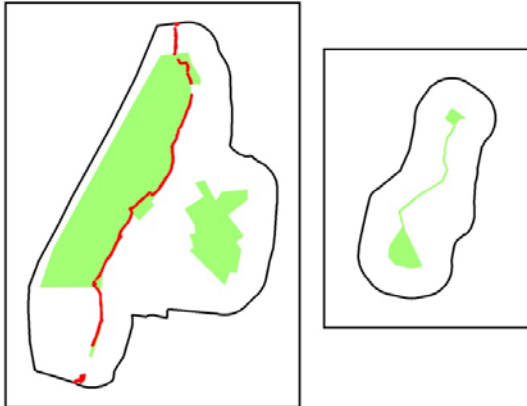
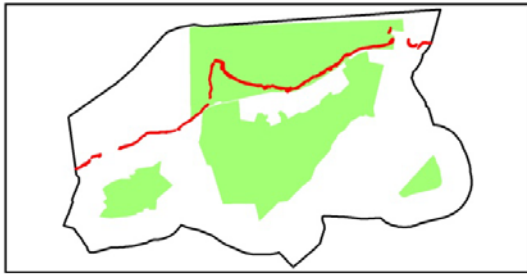


Photo Signature Example

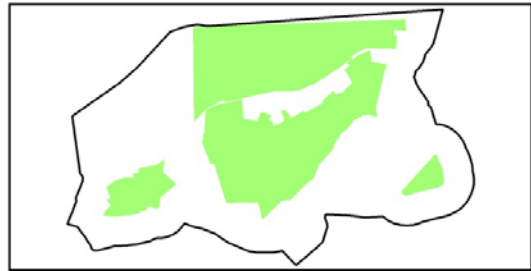


GEOLOGY – BARE GROUND

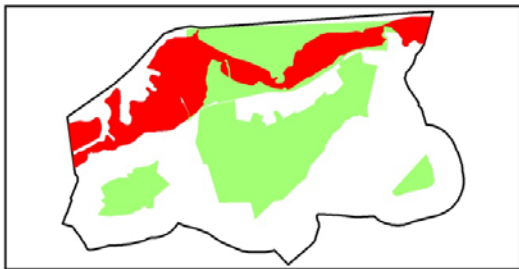
B_BE Beaches



B_SA Submerged Sand and Rock

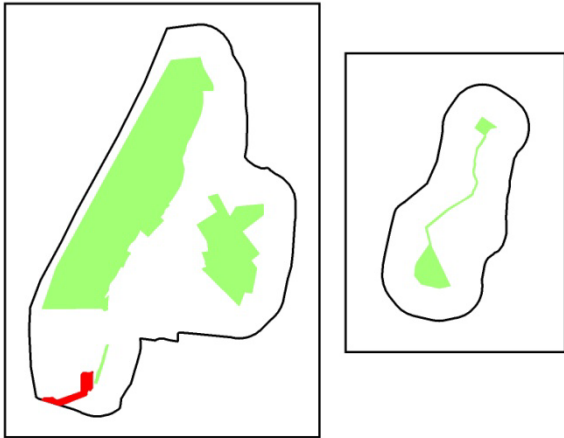
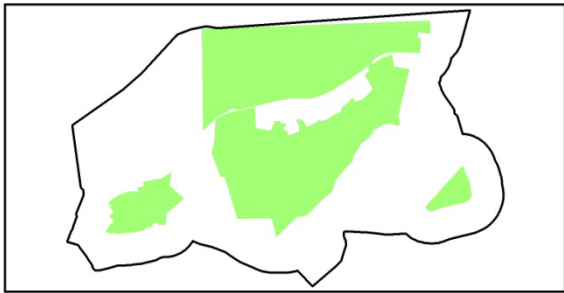


B_ER Exposed Reef and Tidal Pools

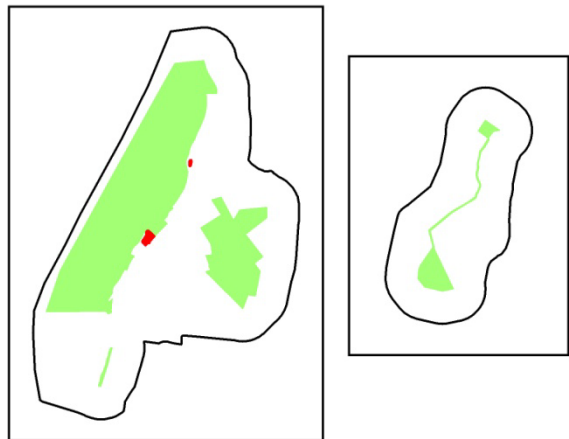
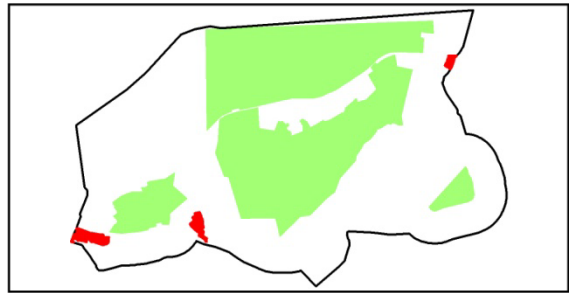


LAND COVER – LAND USE

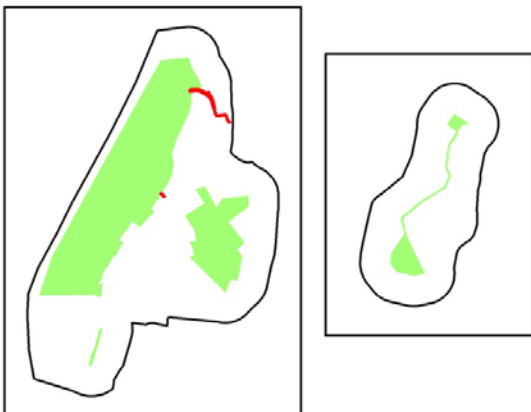
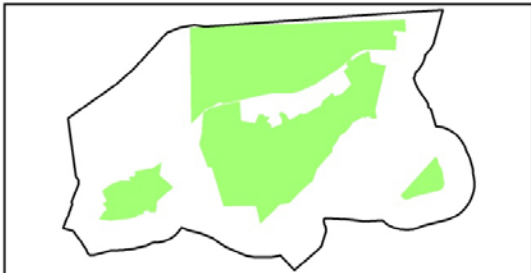
L_BAY Bay / Estuary



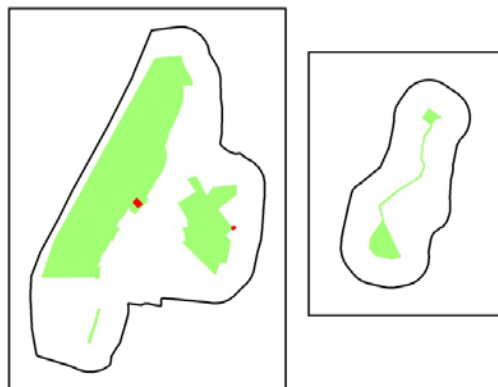
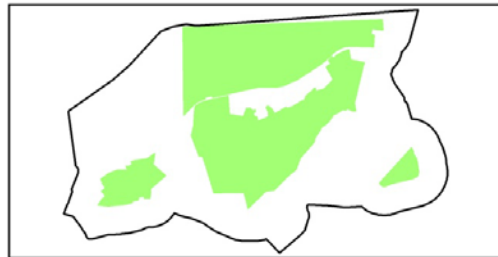
L_CEM Cemeteries



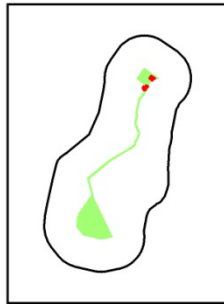
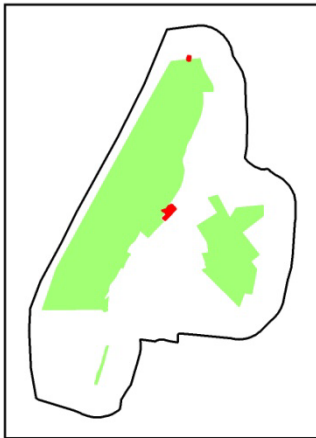
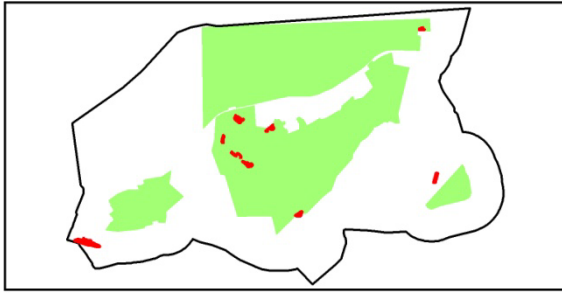
L_CANL Canal / Ditch



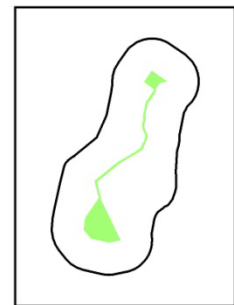
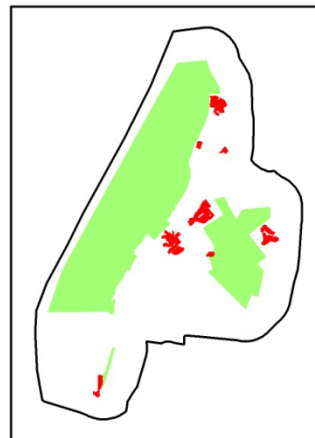
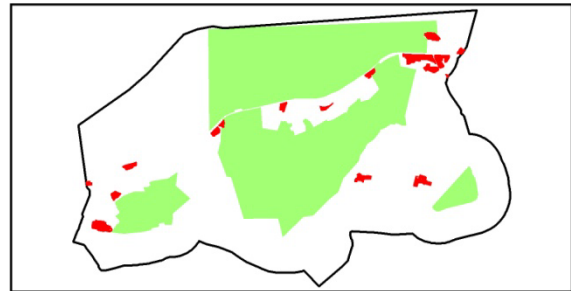
L_COM Communications and Utilities



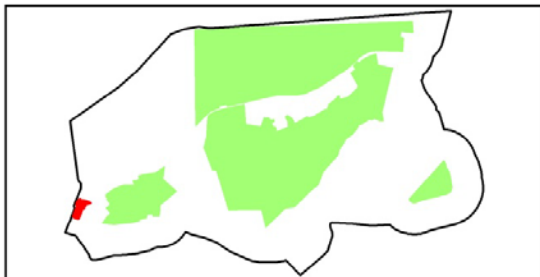
L_FACL Facilities



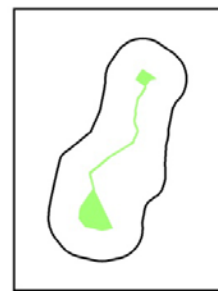
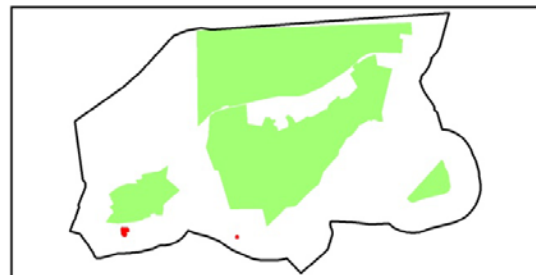
L_LIIN Commercial / Light Industry



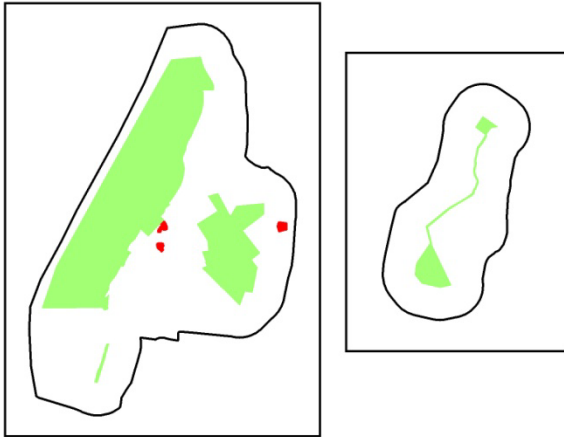
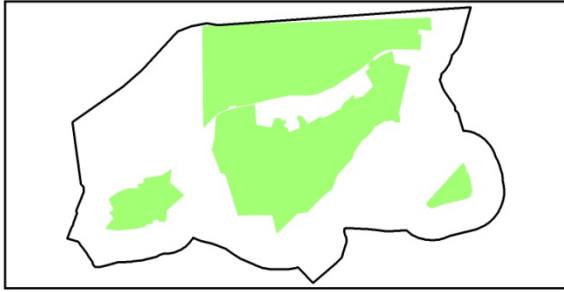
L_HEIN Heavy Industry



L_POND Lake / Pond



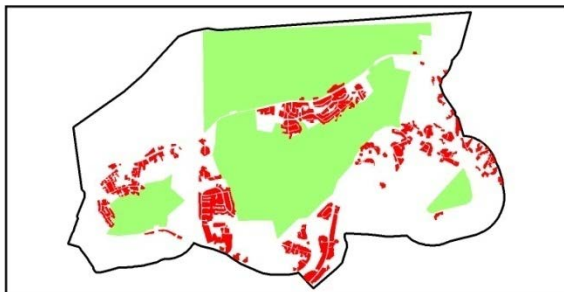
L_RECR Entertainment / Recreation



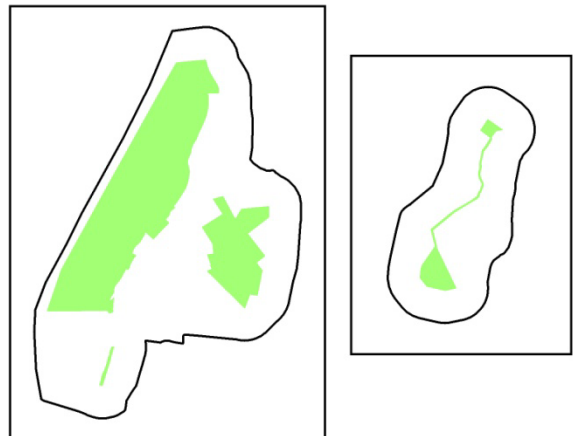
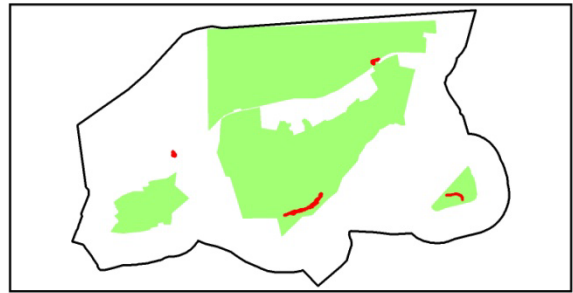
L_ROAD Transportation



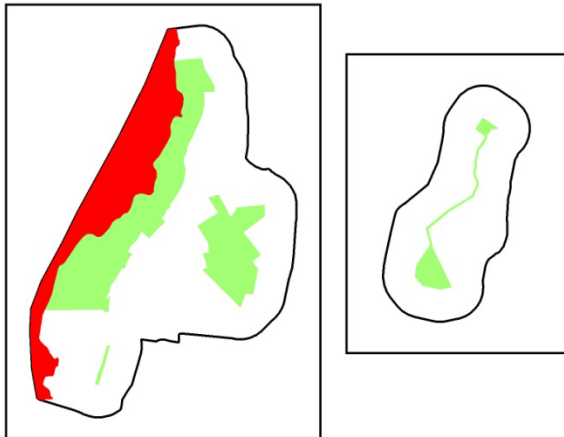
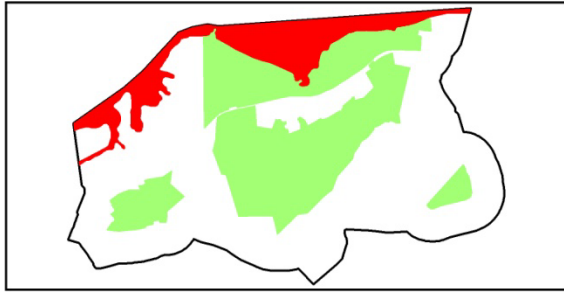
L_RESD Residential



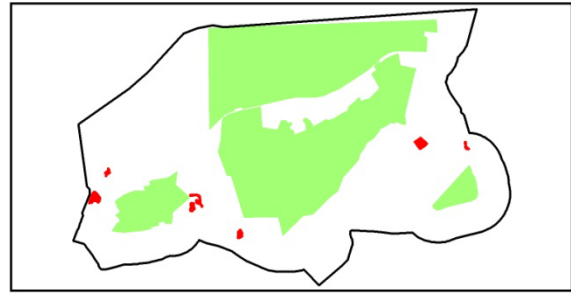
**L_ROCK Bare Rock / Sand / Other
Bare Ground**



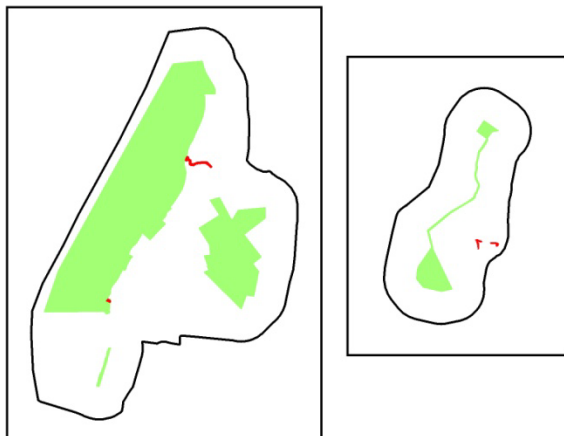
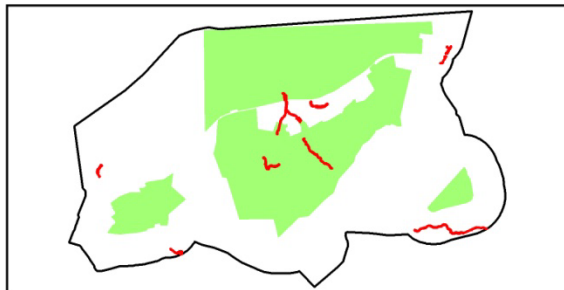
L_SEA Sea / Ocean



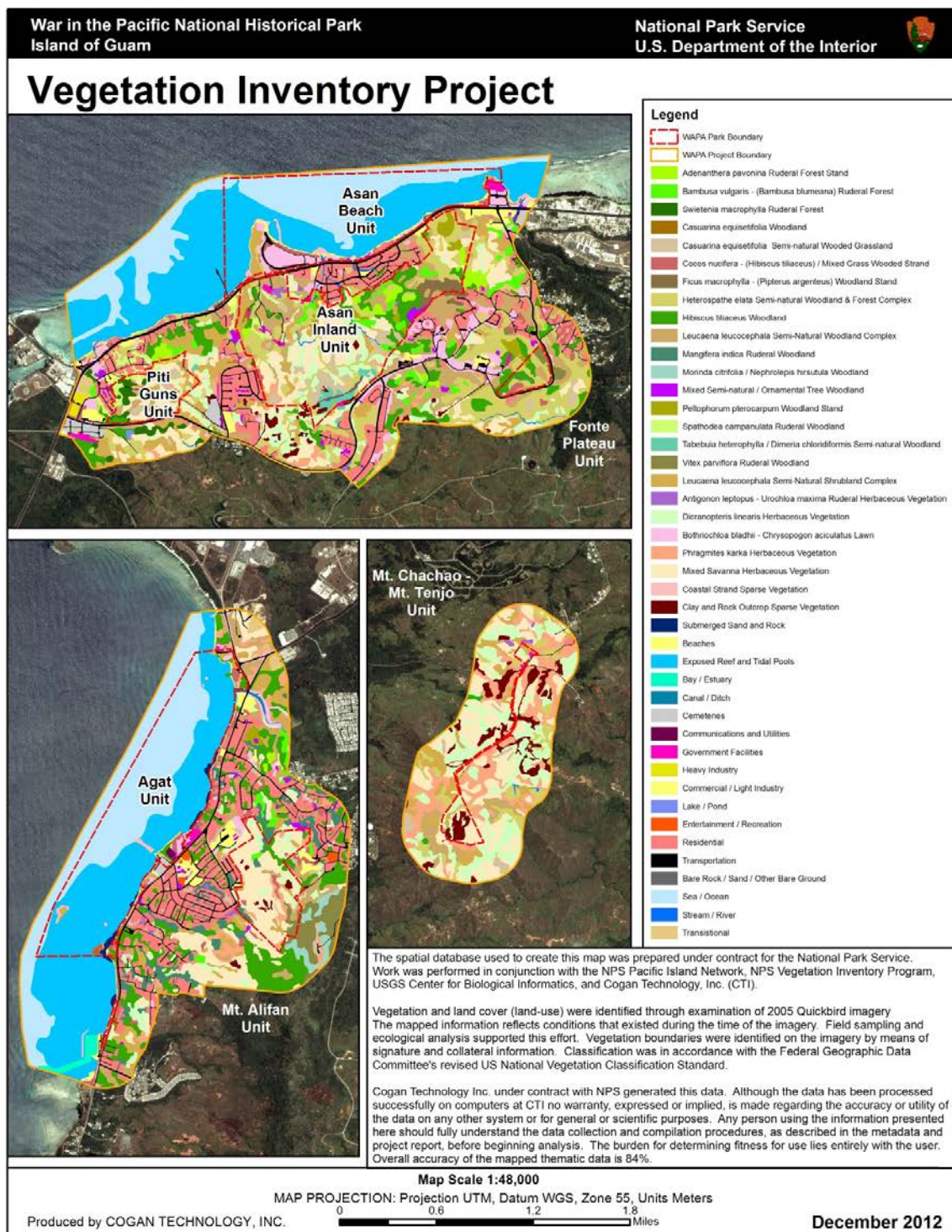
L_TRAN Transistional



L_STRM Stream / River



Appendix G: Final WAPA Vegetation Map



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 474/124541, May 2014

National Park Service
U.S. Department of the Interior



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