



Vegetation Inventory Project

American Memorial Park

Natural Resource Report NPS/PACN/NRR—2013/744



ON THE COVER

Coastal shoreline at American Memorial Park
Photograph by: David Benitez

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Dan Cogan¹, Gwen Kittel², Meagan Selvig³, Alison Ainsworth⁴, David Benitez⁵

¹Cogan Technology, Inc.
21 Valley Road
Galena, IL 61036

²NatureServe
2108 55th Street, Suite 220
Boulder, CO 80301

³Hawaii-Pacific Islands Cooperative Ecosystem Studies Unit (HPI-CESU)
University of Hawaii at Hilo
200 W. Kawili St.
Hilo, HI 96720

⁴National Park Service
Pacific Island Network – Inventory and Monitoring
PO Box 52
Hawaii National Park, HI 96718

⁵National Park Service
Hawaii Volcanoes National Park – Resources Management
PO Box 52
Hawaii National Park, HI 96718

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Executive Summary

American Memorial Park (AMME) and adjacent ocean areas cover approximately 54 ha (133 ac) on the island of Saipan in the Northern Mariana Islands. The park was established in 1978 to commemorate those who lost their lives on the Mariana Islands in military campaigns during World War II. Designated as a “living memorial,” AMME protects several historical and cultural sites and provides recreational areas for the public. AMME supports over 128 species of vascular plants (Raulerson & Rinehart 1989) including examples from coastal strand, mangrove/swamp, and woodland/forest communities. Much of the landscape has been severely altered and many non-native species dominate the park’s vegetation. However, remnant native mangrove (mangle lahi; *Bruguiera gymnorhiza*) forests persist and efforts are made to mitigate previous degradation. Woodlands are generally dominated by gagu (*Casuarina equisetifolia*), an indigenous tree that often grows with non-native trees or shrubs such as kamachile (*Pithecellobium dulce*), royal poinciana (*Delonix regia*) or tangan-tangan (*Leucaena leucocephala*). Introduced grasses, such as Australian beardgrass (*Bothriochloa bladhii*), Napier grass (*Cenchrus purpureus*) and Hilo grass (*Paspalum conjugatum*), are common in semi-natural communities and manicured lawns. To better understand the distribution of the plant assemblages located on this site, the National Park Service (NPS) Pacific Island Network (PACN) Inventory and Monitoring Program (I&M) started a vegetation inventory effort at AMME in 2009.

A three-year, four phase program was initiated to complete the task of mapping and classifying the vegetation at AMME. PACN staff collected 11 field plots and 9 observation points in 2009 during Phase 1. In phase two, NatureServe’s Western Regional Office used this field data to classify 10 new plant associations for AMME based on the National Vegetation Classification (NVC). 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 48 accuracy assessment points between 2010 and 2011 to check and finalize the map.

To produce the spatial database and map layer, 0.6-meter, 4-band Quickbird satellite imagery from 2006 was provided by PACN. By comparing the signatures on the imagery to field and ground data 27 map classes (16 vegetated, three barren, and eight land-use / land-cover) were developed and directly crosswalked or matched to their corresponding NVC 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 48 independent accuracy assessment points. The final overall accuracy of the map layer was determined to be 92% with a Kappa value of 88%.

Products developed for AMME 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 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://biology.usgs.gov/npsveg/index.html>.

Acknowledgments

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

We would like to specifically thank Penny Latham with the Pacific West Region Inventory and Monitoring Program, and Corie Yanger, Koa Awong, and Kelly Kozar at the Pacific Island Network Inventory and Monitoring Program for their support and assistance with contracting, work flow, and technical review through all aspects of this project.

We would also like to thank Marion Reid the NatureServe project manager for the American Memorial Park project.

We are grateful to the staff at American Memorial Park and War in the Pacific National Historical Park especially Jenny Coffman, Mike Gawel, and Barbara Alberti, who conducted field work and assisted with field logistics.

Special recognition goes to Karl Brown with NPS for prioritizing the need for this project and providing funding. Without the financial support from the NPS Vegetation Inventory Program the project would not have been possible.

Introduction

National Vegetation Inventory Program

The National Vegetation Inventory Program (NVIP) was started 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 (USNVCv1), 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 the 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 Universal Transverse Mercator (UTM) coordinates (NAD 83) with a 1:24,000 scale and a minimum mapping unit 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 National Vegetation Inventory Program (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 in 2008 the FGDC formally endorsed the National Vegetation Standard, Version 2 (NVCSv2) (FGDC 2008).

Use of a standardized vegetation classification system, such as the NVCSv2 helps ensure data compatibility throughout the NPS and other agencies (FGDC 2008). This is critical to foster efficient stewardship and prioritize conservation efforts for a systematic inventory and classification of the nation's biological resources. The revised US National Vegetation Classification (rUSNVC) is being used for vegetation classification and mapping projects at American Memorial Park (AMME) 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 NVCSv2 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 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 NVC, are the alliance and association and are distinguished by differences in local floristic composition. 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 rUSNVC 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 rUSNVC 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. Phase one descriptions are currently undergoing peer review (Faber-Langendoen et al. 2010). 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 revised hierarchy levels and criteria for natural vegetation.

Hierarchy Level	Criteria
Upper:	Physiognomy plays a predominant role.
L1 – Formation Class	Dominant growth forms that are adapted to basic temperature (energy budget), moisture, and substrate/aquatic conditions.
L2 - Formation Subclass	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 USNVCv1, although revisions have begun in certain areas such as PACN projects. Substantial revisions of the alliances have begun and will continue in the future. For AMME, Macrogroups, Groups and plant associations have been developed for this project and NatureServe will continue vegetation hierarchical unit review and revision as other PACN vegetation inventory projects are completed. Currently (fall 2013) new NVC hierarchy revisions are being implemented, the best source to review these new concepts is at <http://usnvc.org/explore-classification/>. Although NatureServe’s documentation of vegetation associations is the most accessible national listing ([www. natureserve.org/explorer/](http://www.natureserve.org/explorer/)), the data within the USNVC are not complete, and projects such as this one constantly add to the documentation and listing of USNVC types.

USNVC associations and upper hierarchical units 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 Sāmoa (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 Molokai, respectively and VALR (formally the USS Arizona Memorial) is located on the island of O‘ahu. National Park of American Sāmoa spans three American Sāmoa Islands and the smaller parks KAHO, PUHE, and PUHO along with ALKA are located on the island of Hawai‘i. American Memorial 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. 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 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>.

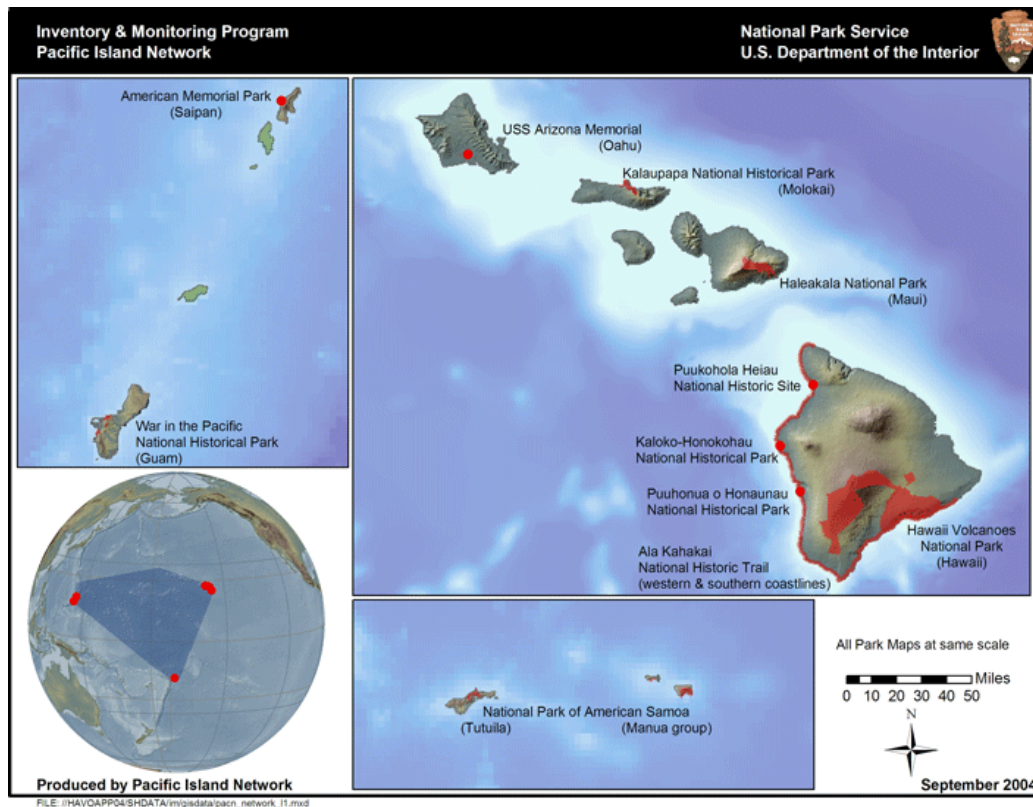


Figure 1. The 11 national parks included within the Pacific Island Network.

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American Memorial Park

AMME encompasses 54 ha (133 ac) on the western shores of the island of Saipan of the Commonwealth of the Northern Mariana Islands (CNMI). Designated as a “living memorial,” in 1978, AMME protects historical and cultural sites such as remnant military bunkers and early Carolinian village sites. War memorials honor servicemen, Chamorro, and Carolinian people who died in CNMI during World War II. AMME provides interpretive activities and historical information is available in four languages: English, Chamorro, Carolinian, and Japanese. Additionally, AMME includes beaches, wetlands, woodlands, and recreational areas. AMME protects 12 ha (30 ac) of undeveloped mangrove and swamp forest. Until the 1980s, the mangrove wetland was used as a landfill site. Even though construction of marinas and roads has blocked natural tidal fluctuation, the ground water remains saline enough to support the mangrove system (Hess and Pratt 2006). Tanapag Harbor Reservation and Micro Beach border AMME’s western coasts. Monsignor Guerrero Road (16 Hwy) runs along AMME’s eastern border, while south and southeastern boundaries are surrounded by the town of Garapan. CNMI government owned Puerto Rico dump/Lower base lies northeast of the park (Figure 2).

Natural Setting

A warm, wet tropical climate encompasses AMME, where average daily temperatures are 81.5° F, with little annual variation. Mean annual rainfall at AMME is 1982 mm (78 in), receiving up to 75% of this precipitation during the wet season, July-December (Perreault 2007). Tropical storms and typhoons are common during the rainy season and winds of up to 64 kph (40 mph)

can develop rapidly; invariably damaging vegetation. This destructive weather pattern is in part responsible for the high frequency of secondary forests (Whistler 2009). The NE and ENE trade winds are prominent during the dry season (January-June; Whistler 2009), prevailing at an average velocity of 17 kph (10.5 mph; Raulerson and Rinehart 1989). Mean annual humidity for Saipan is 82%, which is greatest during July-November (Liu and Fischer 2007, Whistler 2009).

The Mariana archipelago (21° and 13° N, 144° and 146° E; Mueller-Dombois and Fosberg 1998) is derived from a 2608 km volcanic arc of Tertiary origin; while the Northern Mariana Islands remain active, no volcanic activity is believed to have occurred in the southern islands since the Miocene (Reagan et al. 2008). Thus, Saipan is composed of ancient volcanic rock overlain with limestone terraces resultant from ancient tectonic uplifting (Anberger and Anberger 2001, Falanruw et al. 1989, Reagan et al. 2008). The highest point on Saipan, Mt. Tapotchau (467m), has NW slopes which abruptly descend towards the sea (Taylor 1951). AMME areas in low lying coastal regions are derived of quaternary deposits of limesand, clay, alluvium, and

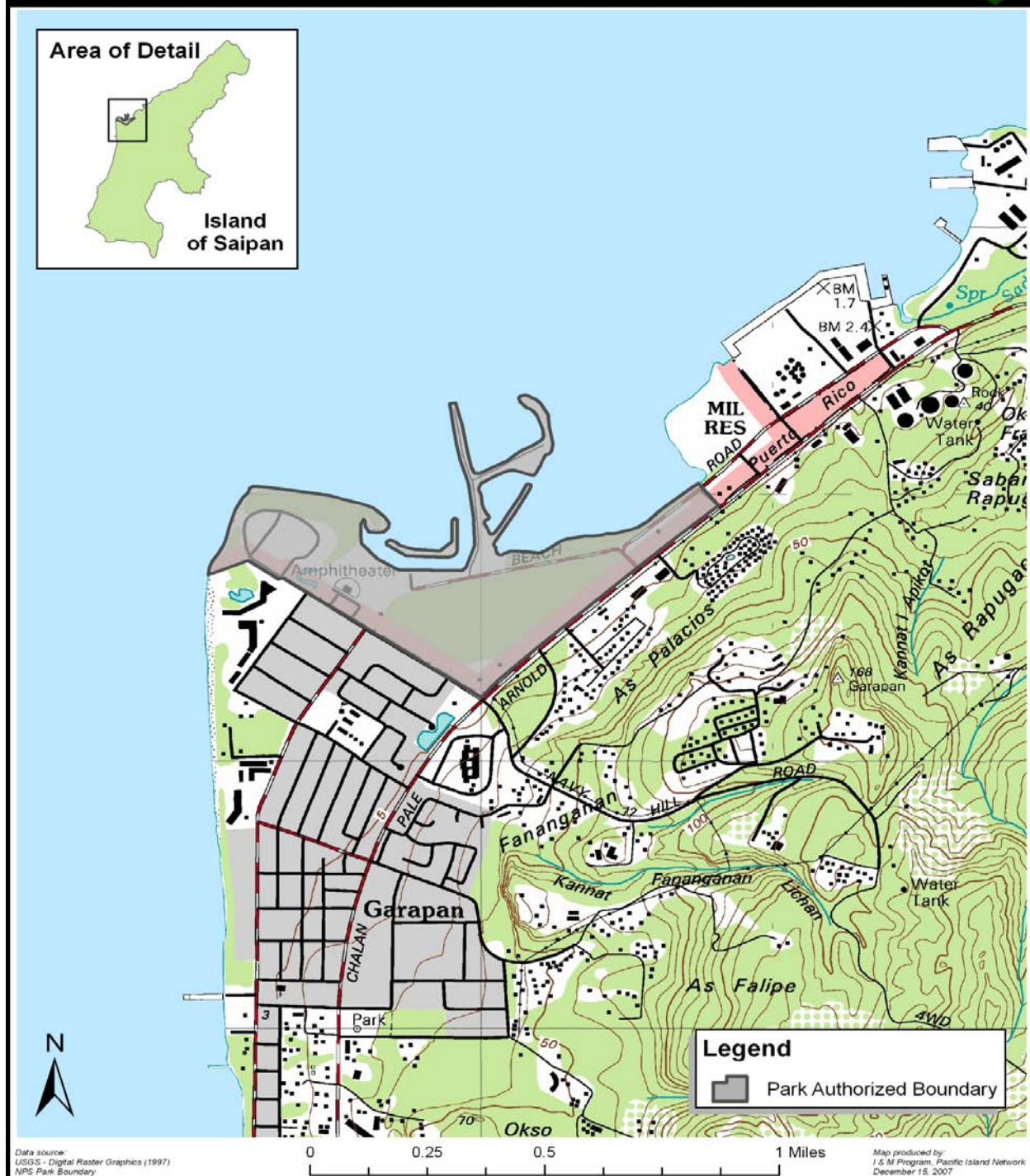


Figure 2. NPS American Memorial Park map.

limestone (Perreault 2007). The average elevation of AMME is below 3 m (Raulerson and Rinehart 1989), lies within the flood plain and encompasses landforms of beach, strand, coastal, intertidal, lowland, wetland swamp, plateaus among others (Figures 3 and 4).

Vegetation

Prior to this project, the vegetation of Saipan has been classified and mapped by Falanruw et al. (1989) using 1976 aerial photography. Raulerson and Rinehart (1989) mapped 12 vegetation communities within AMME from 1987 aerial photographs and transect data. In 1998, Mueller-Dombois and Fosberg described the vegetation of Saipan. Only two of the four vegetation types documented on Saipan by Mueller-Dombois and Fosberg (1998) are found within AMME; Secondary Vegetation on Coastal Plains and Strand Vegetation. The U.S.D.A. Forest Service (Liu and Fischer 2007) used the vegetation classification of Falanruw et al. (1989) to map the vegetation of Saipan, Tinian, and Rota. Recently, in 2009 Whistler reviewed the vegetation types described by Raulerson and Rinehart (1989) and Mueller-Dombois and Fosberg (1998) and identified seven different community types for AMME; Mangrove Community, Swamp Forest Community, Freshwater Community, Marsh Community, Littoral Strand Community, Secondary Scrub Community, Secondary Forest Community, and Managed Land Vegetation Community.

The work of Raulerson and Rinehart (1989) documented 128 species of vascular plants, 13 (10%) of which are ferns or ferns allies within AMME. The remaining 115 species are angiosperms. No endemic species were documented for the Marianas, although 56 (44%) are indigenous and 72 species (56%) are introduced (Raulerson and Rinehart 1989). Common native tree species include mangle lahi (*Bruguiera gymnorhiza*), the only mangrove species on Saipan, and hau (*Hibiscus tiliaceus*) a facultative wetland tree species. Polynesian introduced tronkon niyok (*Cocos nucifera*) are scattered throughout AMME. Gagu (*Casuarina equisetifolia*) is found across many vegetation types within AMME, from coastal strand to swamp forest. Although this nitrogen fixing tree is indigenous to Saipan (Raulerson and Rinehart 1989), it is present in disturbed areas and within AMME does not represent natural vegetation assemblages. A few native fern, graminoid, and vine species are supported within AMME and include tropical fimbry (*Fimbristylis cymosa*), langayao (*Acrostichum aureum*), seabean (*Mucuna gigantea*) and alalag-tasi (*Ipomoea pes-caprae*) (Synder 2006, Whistler 2009).

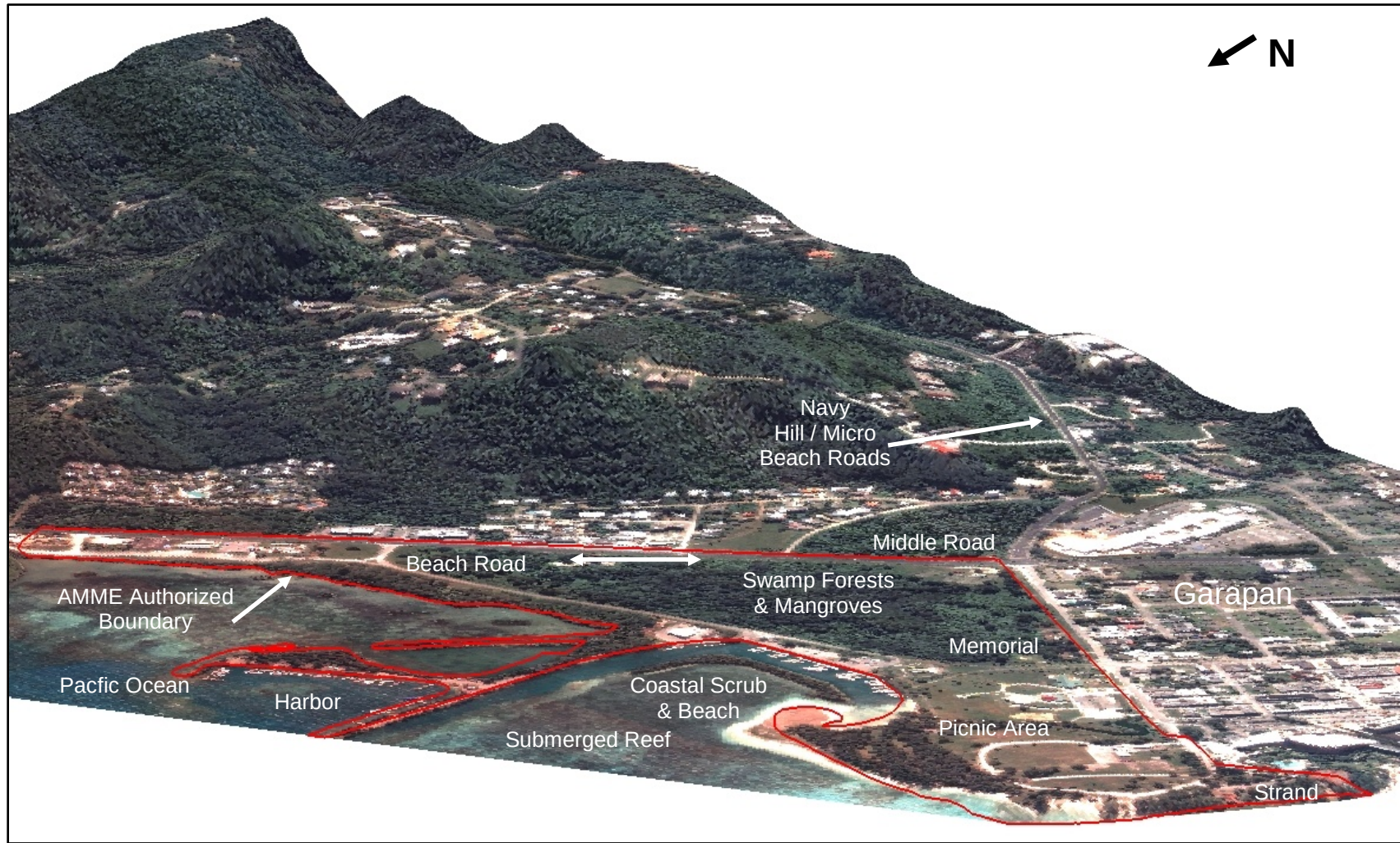
The landscape at AMME and its environs is severely altered due to historical military influence and extensive clearing (Figure 4). As a result, non-native species dominate much of AMME across various substrates and elevations. Semi-natural communities of gagu and kamachile (*Pithecellobium dulce*) are common in secondary forests. Common invasive non-native species include tangan-tangan (*Leucaena leucocephala*), mile-a-minute vine (*Mikania micrantha*), Napier grass (*Cenchrus purpureus*) and guinea grass (*Urochloa maxima*) (Whistler 2009). The ivy gourd (*Coccinia grandis*) vine is of special concern as it encroaches upon the native wetland systems (Synder 2006). Planted landscapes, non-native herbaceous vegetation and highly disturbed forests are evidence of the land use history.



Figure 3. Representative landforms at AMME. Intertidal (top) and beach, strand, and coastal (bottom).

Vegetation communities at AMME are comprised of a mix of native and non-native species, trending from less degraded, native mangrove and swamp forests to completely converted, non-native lawn and planted landscapes (Figures 5 and 6). The northeast coastal strand supports native mangle lahi and nonag (*Hernandia sonora*). Non-native stands of royal poinciana (*Delonix regia*) and mother-in-law's tongue (*Sansevieria trifasciata*) lie adjacent to Micro Beach Road and on the margins of the swamp forest. Intermixed hau, mangle lahi, and gagu are common in central AMME's marsh and swamp forest with non-native Indian pluchea (*Pluchea indica*) and guinea grass. Open wetlands of langayao are scattered throughout the mangrove swamps in areas of standing water. Trees, shrubs, and ground covered by fufgu (*Ipomoea indica*) are common in the marsh and swamp forest. Non-native stands of the dry tangan-tangan shrub forms thickets along the margins of the marsh and swamp forest. Gagu is common along the coastal park boundary and small islet in the bay. Small tronkon niyok stands occur along the NW strand. Developed lawns of Australian beardgrass (*Bothriochloa bladhii*) and inifuk (*Chrysopogon aciculatus*) are common around trails, picnic areas, and memorials. Planted trees of kamachile, African tulip tree (*Spathodea campanulata*), da'ok (*Callophyllum inophyllum*), peregrina (*Jatropha integerrima*) and other species are common along developed areas.

Ground photo examples of AMME's more prominent vegetation communities contained in these life zones are shown in Figure 6.



Source: CTI, USGS 10-meter DEM, and 2006 Digital Globe Imagery

Figure 4. 3D overview image of AMME and surrounding areas showing vegetation patterns and landscape features.

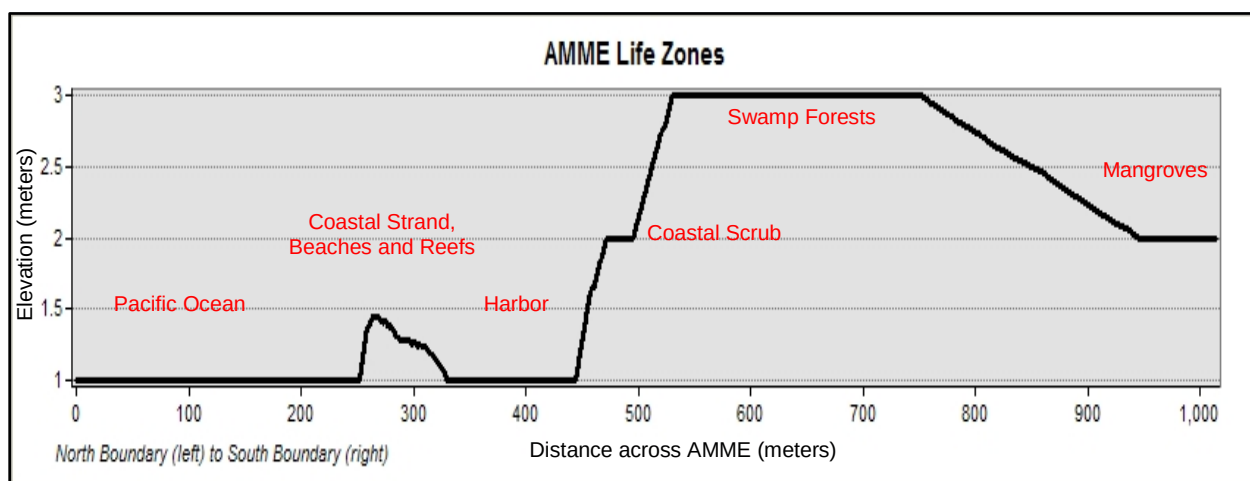


Figure 5. Representative cross-section of AMME's topography showing life zones.

Non-native Vegetation Control and Restoration

The primary designation for AMME is a historic monument thus management priorities focus on historical, cultural, and recreational issues (Bush et al. 2008). Regardless, the Park provides community outreach and career development (Youth Conservation Program) and has coordinated wetland restoration through removal of invasive hyacinths (*Hyacinthus* spp.) and outplanting of native mangroves. The park also participates in various inventory and monitoring projects of the natural resources which exist within AMME.

AMME staff monitors and protects the resources within the undeveloped “natural area” which encompasses swamp forests and mangroves (Figure 4). It is probable that mangroves were much more abundant on Saipan prior to sugar cane cultivation and coastal development thus the remaining mangrove swamps are of high conservation value. Additionally, mangrove swamps and wetlands are uncommon on other Mariana Islands, and AMME is the only park within the PACN to support a native mangrove swamp community (Hess and Pratt 2006).



Mangle lahi coastal mangrove forest



Langayao swamp forest



Hau swamp forest



Royal Poinciana and mother-in-law's tongue



Gagu and Indian pluchea swamp forest



Vegetation overgrown by fufgu



Tangan-tangan woodland



Tronkon niyok coastal strand



Australian beardgrass/inifuk lawn
with planted gagu



Gagu strand on islet

Figure 6. Ground photo examples of AMME's more prominent vegetation communities.

Vegetation Inventory Project

The specific decision to classify and map the vegetation at AMME 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 AMME in 2008 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 (World War II Valor in the Pacific National Monument 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 Area Service Office (WASO) Inventory Coordinator 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 2008 and collect the accuracy assessment data in 2010. 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 AMME-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

- rUSNVC-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 AMME occurred within an approximate 138 hectare (340 acre) project boundary, encompassing both the authorized and administrative boundaries of AMME (as provided by PACN) and some buffering in the environs along the Navy Hill and Micro Beach Roads to the south of AMME. The final project area determination was based on management needs, financial constraints, and time limitations. The nominal environs were used in this project to insure completeness and capture the reef area included in the authorized boundary. Since the areas south, east and north of AMME are mostly developed, mapping stopped along the highway right-of-ways in these locations.



Project Area



Figure 7. The vegetation mapping project boundary and AMME park boundary.

Methods

The vegetation mapping project at AMME 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).

1. Plan, gather data, and coordinate tasks;
2. Survey AMME to understand and sample the vegetation;
3. Classify the vegetation using the field data to rUSNVC standard associations and crosswalk these to recognizable map classes;
4. Acquire current digital imagery and interpret the vegetation from these using the classification scheme and a map class crosswalk;
5. 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 The Nature Conservancy and Environmental Research Systems Institute (1994a, 1994b, and 1994c) and later revisions (Lea and Curtis 2010) and can be found at this website: <http://biology.usgs.gov/npsveg>.

Planning, Data Gathering and Coordination

A series of planning conference calls were held throughout 2008 and attended by representative CTI, PACN and AMME 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 2006 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 Saipan. The specific imagery tiles covering the AMME 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) 2003 Ikonos imagery was also obtained for AMME, but due to cloud cover and ensuing changes at AMME since 2003 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 AMME 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 AMME
- 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 NVC 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 AMME
- Write a field key to the vegetation types found at AMME
- 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 NVC
- Provide field maps and 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 AMME followed the methodology outlined by the NVIP (TNC and ESRI 1994b) for small sized parks. Field work was conducted by a PACN ecologist with plant community sampling experience in the Pacific Islands and the WAPA vegetation biological technician. The list of ecological systems 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 AMME 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 minimum mapping unit (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). Sample plots were consistent with NVIP guidelines (TNC and ESRI 1994b). Measuring tapes were used to establish 12.6 m radius circular sampling plots for all five physiognomies sampled at AMME (Table 2).

Table 2. Plot sizes used for classification sampling at AMME.

Dominant physiognomy	Plot size	Plot area
Forest: trees have their crowns overlapping, usually forming 60-100% cover, and Woodland: open stands of trees with crowns usually not touching. Canopy tree cover 25-60%, OR exceeds shrub, dwarf-shrub, herb, and nonvascular cover.	Circular 12.6 m radius	500 m ²
Shrubland: shrubs greater than 0.5 m tall are dominant, usually forming more than 25% cover OR exceeding tree, dwarf-shrub, herb, and nonvascular cover, and Dwarf-shrubland (e.g., heath): Shrubs less than 0.5 m tall are dominant, usually forming more than 25% cover OR exceeds tree, shrub, herb, and nonvascular cover.	Circular 12.6 m radius	500 m ²
Herbaceous (e.g., grassland, meadow, marsh): Herbs dominant, usually forming more than 25% cover OR exceeds tree, shrub, dwarf-shrub, and nonvascular cover.	Circular 12.6 m radius	500 m ²
Nonvascular (e.g., fen, bog, cliff): nonvascular cover dominant, usually forming more than 25% cover.	Circular 12.6 m radius	500 m ²
Sparse vegetation (e.g., blowout, beach): less than 10% total vegetation cover.	Circular 12.6 m radius	500 m ²

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 to 10 cm),

sand (0.1 to 2 mm), lichens, and mosses. Next the vegetation was visually divided into strata, with the height and canopy cover of the dominant vegetation estimated for each stratum. Within each stratum, all taxa within the plot area were identified and the foliar cover of each taxon was estimated using cover classes (Table 3).

Table 3. Cover classes and vegetation strata.

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

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.

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 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, 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 AMME boundary;

- The vegetation was highly disturbed, ecotonal, or otherwise anomalous and therefore unlikely to be classified under the rUSNVC;
- CTI requested documentation of a specific photo-signature or area;
- To document vegetation types that consistently occurred in stands smaller than the 0.5 ha (1.24 acre) MMU.

The classification data were collected between January and February 2009. Vegetation sampling included 11 classification plots and 9 observation points.



Field Plots and Observations



Figure 8. Location of vegetation plots and observation points collected at AMME.

Vegetation Classification

The first step in classifying the vegetation at AMME was to prepare a preliminary classification prior to vegetation sampling. No preliminary data were available from the NatureServe BIOTICs database, and very few previous studies on vegetation have been conducted on Saipan. Raulerson and Rinehart (1989) developed a vegetation map from aerial photography and collected data along 5 transects. Whistler (2009) recently reviewed available publications on the vegetation including Fosberg (1960), Raulerson and Rinehart (1989), and Mueller-Dombois and Fosberg (1998). Whistler's report provides a brief historic and geologic overview of the island and descriptions of broad vegetation "types", 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 Saipan is to determine which vegetated types fall into the "natural" or native dominated category and which types fall into the "ruderal" or non-native dominated category. The PACN park staff provided a by-island list of "origin" (native versus non-native) for each plant species. However there are discrepancies between this list and Whistler's discussion of the vegetation of AMME and WAPA. For example *Casuarina equisetifolia* is native according to Raulerson and Rinehart (1989), but is considered non-native by Whistler (2009). In addition there were species in the data that were not on the PACN list. NatureServe used additional sources of information to determine species origins, such as PIER (Pacific Island Ecosystems At Risk) [<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 Access database. The MS Access 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 including grouping subspecies and varieties judged to be ecologically similar. Data were regularly compiled and at the completion of the field work the final database was used by NatureServe for analysis. A GIS data layer was also developed at this time to document the plot locations.

Plant nomenclature in the NVCS is that of the Integrated Taxonomic Information System (ITIS) as reflected by the PLANTS Database (USDA -NRCS 2007). For this study, some NVCS names were modified based on Wagner et al. (1999; 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).



Figure 9. Left: Photo from Observation Point AMME.0907. Showing the highly cultivated aspect of the vegetation recorded by this observation point, classified as *Casuarina equisetifolia* Artificial Reef [Park Special]. Right: Photo of the plot number AMME. 0005, naturally occurring stand of gagu trees, classified as *Casuarina equisetifolia* Woodland [Provisional].

Data Analysis

NatureServe began the formal classification by reviewing the data. AMME data had 20 plots and 77 species (32 native to the island, 45 non-native species). 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 as important as the environmental and species composition data collected at each plot or observation point. The photographs taken by field crews were invaluable for understanding the landscape setting of each plot. For example, observation point AMME.0907 was initially classified as a “*Casuarina equisetifolia* Strand Forest” Type based on the vegetation cover data and environmental setting information. However upon examination of the photographs, NatureServe ecologists realized that the trees were in a straight line and the stand is bordered by an asphalt road on one side and by a cement jetty on the other side. This point is a clear example of landscaped vegetation. This plot was reclassified as a Cultural Class, “*Casuarina equisetifolia* Artificial Reef” Type. In comparison, a stand of naturally occurring gagu trees (i.e. not planted) (Plot AMME.005, Figure 9), was classified as Micronesian Wooded Scrub & Herb Coastal Vegetation, *Casuarina equisetifolia* Woodland [Provisional] Association.

Digital Imagery and Mapping

Since AMME 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 two products were selected to be used as base maps. These included the 2006

Quickbird and 2003 Ikonos products (Figure 10). The 2006 product was deemed superior by CTI technicians since it had better resolution, contained the color infrared (CIR) band, and reflected most of the recent landscape changes at AMME (road/trail removals and the new visitor center). The 2003 product had 1-meter resolution and was provided in true-color format (3-bands).

After obtaining both sets, the 2006 imagery was color balanced in Imagine Software to remove some of the edge-matching issues and sharpen the image. The 2003 imagery was also color balanced, but edge-matching was not performed. The resulting image from the 2006 imagery was pieced together as a mosaic and clipped to just beyond the extent of the project boundary.

Interpretation of the vegetation at AMME involved a three step process: (1) image segmentation, (2) cleaning and smoothing, and (3) ground-truthing of the data. First, the 2006 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 2006 imagery.



2003 Ikonos
True Color Example

2006 Quickbird
CIR Example



2006 Quickbird
True Color Example

Figure 10. Examples of the Ikonos 2003 and Quickbird 2006 imagery for AMME.

The lines resulting from the 2006 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 the facilities were not adequately separated from the surrounding vegetation. To resolve this, all developed areas, roads, streams and other linear or rectangular features were manually digitized directly off the 2006 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 AMME involved printing 1:6,000-scale hardcopy maps. These contained the 2006 basemaps and the preliminary mapping linework as an overlay. AMME 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 AMME 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. The map classes were derived on a one association to one map class basis. To round-out the mapping scheme, map classes were created for non-NVC plant associations and land use types. A separate class of map modifiers or “Unclassified Map Classes” was defined especially for AMME to cover vegetation types that were cultural, ornamental, or influenced by human activity. These included the Ruderal Lawn / Ornamental Trees and other map classes not currently in the NVC. The AMME land-use types were based on a mapping system developed by Anderson et al. (1976) and included unvegetated lands not in the NVC, such as roads and facilities. All of the resulting map class names, map class codes, NVC information, and other relevant attributes were added to each polygon in the GIS layer (Table 4).

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 (± 30 feet).

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 5).

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 AMME.

Table 4. Polygon attribute items and descriptions used in the AMME GIS coverage.

ATTRIBUTE	DESCRIPTION
AREA*	Surface area of the polygon in meters squared
PERIMETER*	Perimeter of the polygon in meters
AMME_VEG#*	Unique code for each polygon
AMME_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 – NVCS derived (NatureServe) Association = Community Element Global Code – Elcode link to the NVCS
ASSN_NAME	Project Community Name - NVCS Association(s)
ASSN_CNAME	Project Common Community Name - synonym name of Association(s)
ALL_CODE	Alliance Name Code – NVCS derived (NatureServe) Alliance = Alliance Global Code – Alliance Link to the NVCS
ALL_NAME	Project Alliance Name = NVCS Alliance(s)
ALL_CNAME	Project Common Alliance Name = NVCS Alliance(s)
GROUP	NVCS Hierarchy - Group Name= NVCS Code – Group name
MACROGROUP	NVCS Hierarchy - MacroGroup = NVCS Code – MacroGroup name
DIVISION	NVCS Hierarchy - Division = NVCS Code – Division name
FORMATION	NVCS Hierarchy - Formation = NVCS Code – Formation name
SUBCLASS	NVCS Hierarchy - Subclass = NVCS Code – Subclass name
CLASS	NVCS Hierarchy - Class = NVCS Code – Class 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)

Once the target locations were selected, PACN and AMME staff were provided with draft field maps, overview maps, map class definitions, the key to the associations (Appendix D), and digital GPS files containing the location of the target AA sites. In 2010, a PACN ecologist traveled to the AA target sites and with the AMME vegetation technician 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 (130 ft) radius or 0.5 hectares (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 also 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.

Table 5. 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

Between 2010 and 2011, a total of 48 points were sampled (Figure 12). These data recorded on the field forms were subsequently entered into a Microsoft Access database and reviewed for data entry errors by NPS 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 coverage. 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 (i.e. unclosed polygons). Changes were made and recorded in the comments field of the AA point layer. The most common GPS receiver error included transposing two UTM coordinate numbers or recording the GPS coordinates outside of the intended target polygon (e.g. forest and swamp edges).

The second review step involved deciding between the primary, secondary or tertiary 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. called 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. swamp or upland vegetation).

Once the data were reviewed, the accuracy analysis was conducted. This was accomplished by 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.



Accuracy Assessment Points



Figure 11. Location of accuracy assessment points collected at AMME.

Results

Vegetation Classification

AMME comprises 54 ha (133 ac), 12 ha (30 ac) of which is considered wetland (mangrove, marshes, mudflats), and 42 ha (103 ac) of upland. Ten associations were recognized from the 11 plots and 9 observation points. The park has forested freshwater wetlands (lowland swamps), herbaceous wetlands, saltwater wetlands (mangrove forests), coastal strand (woody and herbaceous) communities, introduced shrubs, mowed lawns and ornamental planted landscaping trees. Table 6 lists the 10 associations and 6 Unclassified Map Classes identified in the park, nested into their NVC Hierarchical units. Unclassified Map Classes are vegetated areas for which we had no plots or observations plots to represent them within AMME, but were encountered during accuracy assessment field work.

Table 6. Associations and unclassified map classes for AMME.

Division	MacroGroup	Group	NVC Status	AMME Final Classification	# Plots
1.A.3.Ob Polynesian Flooded & Swamp Forest	MG203 Micronesian Flooded & Swamp Forest	G606 Micronesian Lowland Swamp Forest Group	CEGL008120	Hibiscus tiliaceus / Asplenium nidus Swamp Woodland [Provisional]	3
			CEPS009540	Casuarina equisetifolia / Pluchea indica Swamp Forest [Park Special]	3
1.A.4.Ob Indo-West Pacific Mangrove	MG208 West Pacific (East Melanesia, Micronesia, Polynesia) Mangrove	G402 West Pacific (East Melanesia, Micronesia, Polynesia) Mangrove Group	CEGL008119	Bruguiera gymnorhiza Mangrove Forest [Provisional]	1
2.A.1.Oa Polynesian Lowland Shrubland, Grassland & Savanna	MG220 Polynesian Ruderal Lowland Shrubland, Grassland & Savanna	G415 Micronesian Ruderal Lowland Shrubland, Grassland & Savanna Group	CEGL008114 as [Unclassified Map Class]	Leucaena leucocephala Lowland Dry Semi-natural Shrubland	0
2.A.3.Ob Polynesian Wooded Scrub & Herb Coastal Vegetation	MG233 Micronesian Wooded Scrub & Herb Coastal Vegetation	G607 Micronesian Coastal Strand Group	[Unclassified Map Class]	Cocos nucifera Stand Wooded Scrub [Park Special]	0
			CEGL008121	Casuarina equisetifolia Woodland [Provisional]	2
			CEPS009541	Casuarina equisetifolia / Paspalum spp. Wooded Herbaceous [Park Special]	1
			CEPS009542	Delonix regia / Sansevieria trifasciata Ruderal Woodland [Park Special]	1

Division	MacroGroup	Group	NVC Status	AMME Final Classification	# Plots
		G425 Micronesian Dry Scrub & Herb Coastal Strand Group	[Unclassified Map Class]	Coastal Strand Sparse Vegetation [Park Special]	0
		G608 Micronesian Herbaceous Coastal Vegetation Group	CEGL008122	<i>Ipomoea indica</i> Herbaceous Vegetation [Provisional]	2
	MG234 Polynesian Ruderal Scrub & Herb Coastal Strand	G425 Micronesian Ruderal Scrub & Herb Coastal Strand Group	CEGL008123	<i>Cenchrus (polystachios, purpureus)</i> Ruderal Herbaceous Vegetation [Provisional] ¹	1
2.A.5.Ob Polynesian & Eastern Melanesian Freshwater Marsh	MG042 Polynesian Freshwater Marsh	G605 Polynesian Freshwater Marsh	[Unclassified Map Class]	<i>Acrostichum aureum</i> - <i>Polypodium</i> sp. Open Wetland Herbaceous Vegetation [Park Special]	0
8.1.A.1 Lawn	MG491 Temperate and Tropical Lawn	G622 Cool season, Warm season, Dry season Lawn	CEGL008124	<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn [Provisional]	5
8.A.3.a Other Urban / Build Up Vegetation	MG492 Temperate and Tropical Planted Landscaping & Gardens	G623 Treed Landscaping	[Unclassified Map Class]	Mixed Semi-natural / Ornamental Trees [Park Special]	0
			[Unclassified Map Class]	<i>Pithecellobium dulce</i> Semi-natural Woodland Stand [Park Special]	0
			CEPS009543	<i>Casuarina equisetifolia</i> Artificial Reef Woodland Stand [Park Special]	1

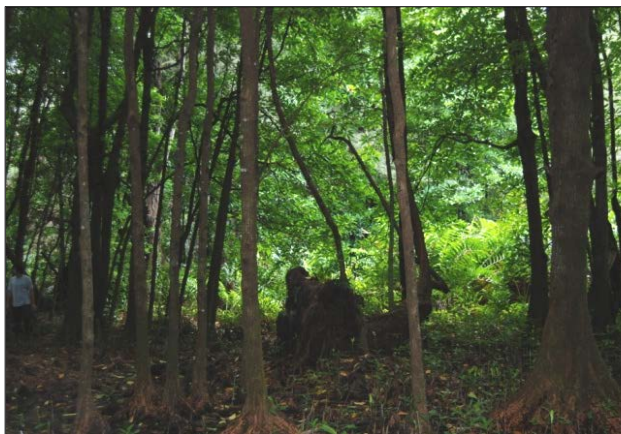
¹USNVC name *Pennisetum (polystachion, purpureum)* Ruderal Herbaceous Vegetation modified based on Wagner et al. (2012).



AMME.0902-- MG203 Micronesian Flooded & Swamp Forest



AMME.0901-- MG234 Polynesian Ruderal Scrub & Herb Coastal Strand



AMME.004 -- MG208 West Pacific (East Melanesia, Micronesia, Polynesia) Mangrove



AMME.0010 --MG491 Temperate and Tropical Lawn



AMME.906--MG233 Micronesian Wooded Scrub & Herb Coastal Vegetation



AMME.909-- classified for the lawn in the foreground, the background is representative of this macrogroup – M492 Temperate and Tropical Planted Landscaping & Gardens

Figure 12. NVC macrogroups within AMME.

Table 7. List of AMME plant associations and number of field samples.

Association	Element Code	Field Samples
Forests and Woodlands		
Bruguiera gymnorhiza Mangrove Forest [Provisional]	CEGL008119	1
Casuarina equisetifolia / Artificial Reef Woodland [Park Special]	CEPS009543	1
Casuarina equisetifolia Woodland [Provisional]	CEGL008121	2
Casuarina equisetifolia / Paspalum spp. Wooded Herbaceous Vegetation [Park Special]	CEPS009541	2
Casuarina equisetifolia / Pluchea indica Swamp Forest [Park Special]	CEPS009540	3
Delonix regia / Sansevieria trifasciata Ruderal Woodland [Park Special]	CEPS009542	1
Hibiscus tiliaceus / Asplenium nidus Swamp Woodland [Provisional]	CEGL008120	3
Pithecellobium dulce Semi-natural Woodland [Park Special]	CEGL005409	*
Shrublands		
Leucaena leucocephala Lowland Dry Semi-natural Shrubland	CEGL008114	*
Herbaceous Vegetation		
Cenchrus (polystachios, purpureus) Ruderal Herbaceous Vegetation [Provisional] ¹	CEGL008123	1
Ipomoea indica Herbaceous Vegetation [Provisional]	CEGL008122	2
Bothriochloa bladhii - Chrysopogon aciculatus Lawn [Provisional]	CEGL008124	4

¹rUSNVC name Pennisetum (polystachion, purpureum) Ruderal Herbaceous Vegetation modified based on Wagner et al. (2012).

*indicates association verified only using Accuracy Assessment Points.

Digital Imagery and Mapping

For AMME, 27 map classes (16 vegetated, three barren, and eight land-use/land-cover) were developed. The final list of map classes/units was directly crosswalked or matched to corresponding plant associations and land use classes (Table 8). AMME map classes represent a compromise between the detail of the NVC, the needs of the resource management staff, and the limitations of the imagery. As a result, the mapping legend does not exactly match the NVC. In most cases the NVC associations were used as map classes. However, in some cases additional vegetation map classes (Unclassified Map Class) were used to provide more detail. Appendix F contains descriptions and representative photographs for all vegetation map classes.

The following types represent the possible map scenarios for the AMME 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. **Unclassified Map Class** = When unique stands of vegetation apparent on the imagery did not have a corresponding NVC plant association or vegetation alliance.
3. **Land Use – Land Cover** = Non-vegetated areas and vegetation types not recognized by the NVCS received Anderson et al. (1976, updated 2002) map class designations.

Vegetation Map

The AMME vegetation map consisted of 210 polygons totaling 138 ha (340 ac) (Appendix G); average polygon size was about 0.7 ha (1.6 ac) (Table 12). The small polygon size was due to the small size of the park and the importance of the rare vegetation and small stands of non-native/ruderal 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 AMME, 73 ha (180 ac), or 51% of the project areas consisted of submerged sand, reef, tidal pools, open ocean, bays, and harbors. Of the remaining terrestrial map classes within AMME, 10% were comprised of the mowed lawn grasslands (W_LAWN), covering 14 ha (34 ac) in 53 individual polygons. The four woodland map classes dominated by gagu comprised 20 ha (50 ac) or 14% of AMME in 54 polygons.

The AMME 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 (5 to 15 meters). Figure 13 is an example of a fine scale (1:6,000-scale) AMME vegetation map created from the GIS spatial database with the 2006 Quickbird imagery as the background.

Table 8. 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			
W_BRGY	<i>Bruguiera gymnorhiza</i> Mangrove Forest	<i>Bruguiera gymnorhiza</i> Mangrove Forest [Provisional]	1 : 1
W_CAAR	<i>Casuarina equisetifolia</i> / Artificial Reef Woodland	<i>Casuarina equisetifolia</i> / Artificial Reef Woodland [Park Special]	1 : 1
W_CAEQ	<i>Casuarina equisetifolia</i> Woodland	<i>Casuarina equisetifolia</i> Woodland [Provisional]	1 : 1
W_CAPA	<i>Casuarina equisetifolia</i> / <i>Paspalum</i> spp. Wooded Herbaceous Vegetation	<i>Casuarina equisetifolia</i> / <i>Paspalum</i> spp. Wooded Herbaceous Vegetation [Park Special]	1 : 1
W_CAPL	<i>Casuarina equisetifolia</i> / <i>Pluchea indica</i> Swamp Forest	<i>Casuarina equisetifolia</i> / <i>Pluchea indica</i> Swamp Forest [Park Special]	1 : 1
W_COCS	<i>Cocos nucifera</i> Stand Wooded Scrub	(No Association)	Unclassified Map Class
W_DERE	<i>Delonix regia</i> / <i>Sansevieria trifasciata</i> Ruderal Woodland	<i>Delonix regia</i> / <i>Sansevieria trifasciata</i> Ruderal Woodland [Park Special]	1 : 1
W_HESO	<i>Hernandia sonora</i> / <i>Bruguiera gymnorhiza</i> Forest	(No Association)	Unclassified Map Class
W_HIAS	<i>Hibiscus tiliaceus</i> / <i>Asplenium nidus</i> Swamp Woodland	<i>Hibiscus tiliaceus</i> / <i>Asplenium nidus</i> Swamp Woodland [Provisional]	1 : 1
W_PIDU	<i>Pithecellobium dulce</i> Semi-natural Woodland	(No Association)	Unclassified Map Class
W_RUOR	Ruderal Lawn / Ornamental Trees	(No Association)	Unclassified Map Class
Shrublands			
S_LELE	<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland	1 : 1
Herbaceous Vegetation			
H_ACRO	<i>Acrostichum aureum</i> - <i>Microsorium</i> spp. Open Wetland Herbaceous Vegetation	(No Association)	Unclassified Map Class
H_CENC	<i>Cenchrus (polystachios, purpureus)</i> Ruderal Herbaceous Vegetation	<i>Cenchrus (polystachios, purpureus)</i> Ruderal Herbaceous Vegetation ¹	1 : 1
H_IPIN	<i>Ipomoea indica</i> Herbaceous Vegetation	<i>Ipomoea indica</i> Herbaceous Vegetation	1 : 1
H_LAWN	<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn	<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn	1 : 1

Map Code	Map Class Name	NVC Association Assigned to Map Class (or Map Class Description)	Relationship
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_FACL	Facilities	(NPS Buildings and Facilities)	N/A
L_LIIN	Commercial / Light Industry	(Businesses and surrounding lands in environs)	N/A
L_RECR	Entertainment / Recreation	(Hotel Facilities, Tennis Courts, Swimming Pools, etc.)	N/A
L_ROAD	Transportation	(Roads and major trails)	N/A
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

¹rUSNVC name *Pennisetum (polystachion, purpureum)* Ruderal Herbaceous Vegetation modified based on Wagner et al. (2012).

Table 10. Summary statistics for the AMME map class polygons.

Map Code	Map Class Description	AMME Project Area (includes adjacent ocean area)		
		# of Polygons	Acres	Hectares
W_BRGY	<i>Bruguiera gymnorhiza</i> Mangrove Forest	6	8.6	3.5
W_CAAR	<i>Casuarina equisetifolia</i> / Artificial Reef Woodland	15	7.4	3.0
W_CAEQ	<i>Casuarina equisetifolia</i> Woodland	3	7.4	3.0
W_CAPA	<i>Casuarina equisetifolia</i> / <i>Paspalum</i> spp. Wooded Herbaceous Vegetation	28	10.0	4.1
W_CAPL	<i>Casuarina equisetifolia</i> / <i>Pluchea indica</i> Swamp Forest	10	25.6	10.4
W_COCS	<i>Cocos nucifera</i> Stand Wooded Scrub	2	0.4	0.2
W_DERE	<i>Delonix regia</i> / <i>Sansevieria trifasciata</i> Ruderal Woodland	3	5.2	2.1
W_HESO	<i>Hernandia sonora</i> / <i>Bruguiera gymnorhiza</i> Forest	2	2.1	0.9
W_HIAS	<i>Hibiscus tiliaceus</i> / <i>Asplenium nidus</i> Swamp Woodland	11	6.8	2.8
W_PIDU	<i>Pithecellobium dulce</i> Semi-natural Woodland	2	1.1	0.4
W_RUOR	Ruderal Lawn / Ornamental Trees	11	4.9	2.0
S_LELE	<i>Leucaena leucocephala</i> Lowland Dry Semi-Natural Shrubland	2	1.1	0.4
H_ACRO	<i>Acrostichum aureum</i> – <i>Microsorium</i> spp. Open Wetland Herbaceous Vegetation	5	3.1	1.3
H_CENC	<i>Cenchrus (polystachios, purpureus)</i> Ruderal Herbaceous Vegetation ¹	3	1.2	0.5
H_IPIN	<i>Ipomoea indica</i> Herbaceous Vegetation	6	8.9	3.6
H_LAWN	<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn	53	32.4	13.1
B_BE	Beaches	3	2.7	1.1
B_ER	Exposed Reef and Tidal Pools	3	100.8	40.8
B_SA	Submerged Sand and Rock	6	23.1	9.4
L_BAY	Bay / Estuary	2	8.9	3.6
L_FACL	Facilities	18	4.1	1.7
L_LIIN	Commercial / Light Industry	6	4.2	1.7
L_RECR	Entertainment / Recreation	2	1.7	0.7
L_ROAD	Transportation	1	17.9	7.2
L_SEA	Sea / Ocean	4	47.0	19.0
L_STRM	Stream / River	1	0.8	0.3
L_TRAN	Transitional	6	2.5	1.0
Total Vegetation		162	126	51
Total Barren Geology		12	127	51
Total Land Use / Land Cover		40	87	35
Totals		214	340	138

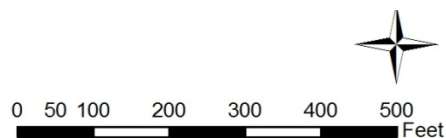
¹rUSNVC name *Pennisetum (polystachion, purpureum)* Ruderal Herbaceous Vegetation modified based on Wagner et al. (2012).



Example of Vegetation Map Classes

Map Code Map Class Description

W_BRGY	<i>Bruguiera gymnorrhiza</i> Mangrove Forest
W_CAAR	<i>Casuarina equisetifolia</i> / Artificial Reef Woodland
W_CAEQ	<i>Casuarina equisetifolia</i> Woodland
W_CAPA	<i>Casuarina equisetifolia</i> / <i>Paspalum</i> spp. Wooded Herbaceous Vegetation
W_CAPL	<i>Casuarina equisetifolia</i> / <i>Pluchea indica</i> Swamp Forest
W_COCS	<i>Cocos nucifera</i> Stand Wooded Scrub
W_DERE	<i>Delonix regia</i> / <i>Sansevieria</i> <i>trifasciata</i> Ruderal Woodland
W_HESO	<i>Hernandia sonora</i> / <i>Bruguiera</i> <i>gymnorhiza</i> Forest
W_HIAS	<i>Hibiscus tiliaceus</i> / <i>Asplenium</i> <i>nidus</i> Swamp Woodland
W_PIDU	<i>Pithecellobium dulce</i> Semi- natural Woodland
W_RUOR	Ruderal Lawn / Ornamental Trees
S_LELE	<i>Leucaena leucocephala</i> Lowland Dry Semi-natural Shrubland
H_ACRO	<i>Acrostichum aureum</i> - <i>Microsorium</i> spp. Open Wetland Herbaceous Vegetation
H_CENC	<i>Cenchrus (polystachios,</i> <i>purpureus)</i> Ruderal Herbaceous Vegetation ¹
H_IPIN	<i>Ipomoea indica</i> Herbaceous Vegetation
H_LAWN	<i>Bothriochloa bladhii</i> - <i>Chrysopogon aciculatus</i> Lawn
B_BE	Beaches
B_ER	Exposed Reef and Tidal Pools
B_SA	Submerged Sand and Sand Bay / Estuary
L_BAY	Facilities
L_FACL	Commercial / Light Industry
L_LIIN	Entertainment / Recreation
L_RECR	Transportation
L_ROAD	Sea / Ocean
L_SEA	Stream / River
L_STRM	Transitional
L_TRAN	



Produced by Cogan Technology, Inc.

April 2012

¹USNVC name *Pennisetum (polystachion, purpureum)* Ruderal Herbaceous Vegetation modified based on Wagner et al. (2012).
Figure 13. Example of the AMME vegetation map layer.

Accuracy Assessment

The 2010-2011 AA effort yielded 48 points distributed throughout AMME. In addition to using the AA points in the map analysis, many of the points were also used to update the classification and to revise the field key and local descriptions. 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 PACN and CTI. Adjustments were made to the field calls at this time based on the actual cover values recorded and taking into account possible correct second and third field calls. In most cases, the correct second and third calls were very closely related to the incorrect primary call. Following incorporation of changes, the raw, overall accuracy of the AMME vegetation layer was found to be 92%. Results were presented to PACN staff for review and approval.

Analyzing the existing AA data shows that most of the map units had high user's accuracy of at least 80%. The map units below 80% accuracy include those that had marginal accuracy of 60% – 79% and map units that had low accuracy of < 60%. One source of error is likely caused by the small AA point sample sizes (for some of the map classes) that fall below the minimum number of AA target locations as directed by NVIP standards (Lea and Curtis 2010). Sampling was limited in part due to the rugged swamp-like logistics in the central portion of AMME and difficulty associated with trying to get a GPS signal in this dense forest. Also many of the map units like the W_PIDU map class were only represented by one or two polygons. Some of these were already sampled during the field data collection and were omitted in the AA stage. More sampling in the under-sampled types, such as the *Casuarina equisetifolia*/*Pluchea indica* Swamp Forest and *Ipomoea indica* Herbaceous Vegetation would likely improve the individual map class accuracy and reduce the corresponding large confidence intervals.

Other sources of error in the map units with marginal accuracy 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 of shrublands or herbaceous vegetation in canopy openings that were actually part of a larger woodland or forest type (e.g. *Hibiscus tiliaceus* / *Asplenium nidus* Swamp Woodland vs. tall *Leucaena leucocephala* Lowland Dry Semi-Natural Shrubland). Also the similar appearance of closely related mapping units likely caused some confusion in the mapping signatures leading to incorrect polygon labels (e.g. *Bruguiera gymnorrhiza* / *Acrostichum aureum* Mangrove Forest vs. *Hibiscus tiliaceus* / *Asplenium nidus* Swamp Woodland).

Two map units, W_CAEQ and W_PIDU had low accuracy but were retained in the AMME mapping layer for resource management purposes. The W_CAEQ map unit was closely related to the other three *Casuarina equisetifolia* map units but an effort was made to separate this type as it appeared to be more mature, denser and have little understory. The W_CAEQ type could be grouped with the W_CAPA map unit to improve accuracy for future studies. Similarly the W_PIDU map class had zero accuracy since the only polygon sampled was classified as W_CAPA. The *Pithecellobium dulce* Semi-natural Woodland was included in the mapping to provide more information on the various upland trees that were possibly planted in and around the picnic and memorial grounds. During the AA field work, individual *Pithecellobium dulce*

trees were likely grouped with the larger nearby stand of *Casuarina equisetifolia* trees. Like the W_CA EQ map class, the W_PIDU map class could also be combined with the W_CAPA map unit to improve accuracy for future studies.

Stage two of the analysis involved incorporating the NPS recommendations 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 13) and a population contingency table (Table 14). 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 11. Sample contingency table for AMME. Columns represent predicted mapping unit names (polygon labels) and rows represent AA observation names (field calls).

Map Code	H_ACRO	H_CENC	H_LAWN	S_LELE	W_BRGY	W_CAAR	W_CAEQ	W_CAPA	W_COCS	W_DERE	W_HESO	W_HIAS	W_PIDU	W_RUOR	Row Total
H_ACRO	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
H_CENC	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
H_LAWN	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
S_LELE	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
W_BRGY	0	0	0	0	4	0	0	0	0	0	0	1	0	0	5
W_CAAR	0	0	0	0	0	4	0	0	0	0	0	0	0	0	4
W_CAEQ	0	0	0	0	1	0	2	1	0	0	0	0	0	0	4
W_CAPA	0	0	0	0	0	0	0	8	0	0	0	0	0	0	8
W_COCS	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
W_DERE	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
W_HESO	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
W_HIAS	0	0	0	1	0	0	0	0	0	0	0	3	0	0	4
W_PIDU	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
W_RUOR	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
Column Total	1	2	10	2	5	4	2	10	1	2	2	4	0	3	

Table 12. Population contingency table for AMME.

Map Code	H_ACRO	H_CENC	H_LAWN	S_LELE	W_BRGY	W_CAAR	W_CAEQ	W_CAPA	W_COCS	W_DERE	W_HESO	W_HIAS	W_PIDU	W_RUOR	1	2	3	4
H_ACRO	0.0485	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	100.0%	50.0%	100.0%	0.0485
H_CENC	0.0000	0.0124	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	100.0%	75.0%	100.0%	0.0124
H_LAWN	0.0000	0.0000	0.3478	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	100.0%	95.0%	100.0%	0.3478
S_LELE	0.0000	0.0000	0.0000	0.0114	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	100.0%	50.0%	100.0%	0.0114
W_BRGY	0.0000	0.0000	0.0000	0.0000	0.0710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0178	0.0000	0.0000	80.0%	40.6%	100.0%	0.0888
W_CAAR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0753	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	100.0%	87.5%	100.0%	0.0753
W_CAEQ	0.0000	0.0000	0.0000	0.0000	0.0188	0.0000	0.0377	0.0188	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	50.0%	0.0%	100.0%	0.0753
W_CAPA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1063	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	100.0%	93.8%	100.0%	0.1063
W_COCS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0041	0.0000	0.0000	0.0000	0.0000	0.0000	100.0%	50.0%	100.0%	0.0041
W_DERE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0537	0.0000	0.0000	0.0000	0.0000	100.0%	75.0%	100.0%	0.0537
W_HESO	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0217	0.0000	0.0000	0.0000	100.0%	75.0%	100.0%	0.0217
W_HIAS	0.0000	0.0000	0.0000	0.0175	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0526	0.0000	0.0000	75.0%	26.9%	100.0%	0.0702
W_PIDU	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0114	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0%	0.0%	50.0%	0.0114
W_RUOR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0733	100.0%	83.3%	100.0%	0.0733
A	100.0%	100.0%	100.0%	39.3%	79.0%	100.0%	100.0%	77.9%	100.0%	100.0%	100.0%	74.8%	0.0%	100.0%				
B	100.0%	100.0%	100.0%	39.1%	76.0%	100.0%	97.0%	77.4%	100.0%	100.0%	100.0%	71.7%	0.0%	100.0%				
C	100.0%	100.0%	100.0%	39.5%	82.1%	100.0%	100.0%	78.4%	100.0%	100.0%	100.0%	77.9%	0.0%	100.0%				
D	1.90	0.49	13.65	1.13	3.53	2.96	1.48	5.36	0.16	2.11	0.85	2.76	0.00	2.88				

ROW A = PRODUCERS' ACCURACY ($P_{i=Y|J=Y}$)

ROW B = LOWER LIMIT, 90% CONFIDENCE INTERVAL, PRODUCERS' ACCURACY

ROW C = UPPER LIMIT, 90% CONFIDENCE INTERVAL, PRODUCERS' ACCURACY

ROW D = ESTIMATED TRUE AREA (A_{+J}) (HECTARES)

COLUMN 1 = USERS' ACCURACY ($P_{J=X|i=X}$)

COLUMN 2 = LOWER LIMIT, 90% CONFIDENCE INTERVAL, USERS' ACCURACY

COLUMN 3 = UPPER LIMIT, 90% CONFIDENCE INTERVAL, USERS' ACCURACY

COLUMN 4 = π_i

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

OVERALL ACCURACY (P_c)	=	91.6%
LOWER LIMIT, 90% CONFIDENCE INTERVAL	=	86.8%
UPPER LIMIT, 90% CONFIDENCE INTERVAL	=	96.3%
KAPPA (K):	=	88.2%
LOWER LIMIT, 90% CONFIDENCE INTERVAL, K	=	80.1%
UPPER LIMIT, 90% CONFIDENCE INTERVAL, K	=	96.4%

Examination of the contingency tables finds that 14 out of 16 vegetated map classes for AMME were accessed. The *Ipomoea indica* Herbaceous Vegetation and *Casuarina equisetifolia* / *Pluchea indica* Swamp Forest were not accessed since most of the polygons in these types were either inaccessible or were previously sampled during the field plot data collection stage. In addition, the H_IPIN map class represents an association dominated by a vine species that grow on trees and shrubs belonging to other map classes likely leading to some confusion in the field. All of the classes that were accessed had high user's accuracy except for the W_HIAS (marginal), W_CAEQ (low) and W_PIDU (no accuracy) classes for the following possible reasons:

- The Hau / Bird's Nest Fern Swamp woodland (W_HIAS) was retained despite low accuracy due to one polygon dominated by tall tangtan-tangtan (*Leucaena leucocephala*) shrubs. Hau (*Hibiscus tiliaceus*) trees were common in the area and the tall nature of the shrubs created a similar signature on the 2006 imagery. More AA sampling of this type would likely increase the user's accuracy to over 80%.
- The Gagu Woodland (W_CAEQ) polygons sampled were co-dominated by mangle lahi (*Bruguiera gymnorhiza*) trees or *Paspalum* grass in the understory. All types had similar canopy photo signatures and the closed-canopy nature of these polygons made it difficult to see if the understory had grasses or not.
- The Kamachile Semi-natural Woodland (W_PIDU) contained one sampled polygon dominated by gagu (*Casuarina equisetifolia*) trees likely indicating that the kamachile (*Pithecellobium dulce*) weren't found at the point, were judged to be an inclusion, or were co-dominant.

It is likely that the lower than expected accuracies for all three 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 S_LELE or H_LAWN but appeared on the ground to be part of larger woodland polygons. Conversely, sparse woodlands with mowed grass understories appeared dense enough to map but were likely judged to be herbaceous vegetation and not true woodlands 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

American Memorial Park is truly a special place combining a rich mix of World War II archeological sites, reefs, small beaches, and remnants of native coastal and swamp plant communities. Across this landscape a variety of non-native plants thrive in manicured upland, mesic, and marsh habitats typical of the leeward coast of Saipan. AMME'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 were 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 and AMME staff were extremely helpful in the classification and delineation of the different plant associations. High-quality plot and observation point 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 AMME 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.

Map Improvements

- The vegetation map for AMME was based on the 2006 Quickbird ortho-imagery. Updating the map using newer imagery would better reflect any recent changes to the vegetation communities resulting from fires, resource management actions, or landscape altering events.
- Similarly, since AMME is small in size, newer, multi-band imagery along with LIDAR data could be efficiently collected at a finer scale (e.g. 1:6,000 scale or 1-inch pixels) and at specific times (i.e. flowering or peak green) to better identify and capture the complexity of the vegetation.
- The Wide Area Augmentation System (WAAS) signal is not available in Saipan, and although positional accuracy remains within the National standards (30m), the spatial accuracy of the field recorded plot and data point locations may have some limitations due to high GPS error (up to 20m) in areas where WAAS is unavailable. NPS migration from the NAD83 to NAD83(PacP00) projection, which is specific to the Pacific plate, would increase GPS positional accuracy and may more finely define vegetation boundaries on the ground.

- AMME is located over 7,200 miles from the center of the continental United States and about 3,800 miles from Honolulu, HI. As such, travel to AMME is cost prohibitive in relation to the small size of the park. In the future, as opportunities arise experienced mapping professionals could be funded or teamed with other scientists to conduct ground-based mapping by directly comparing plant community signatures on the imagery using GPS receivers and hand-held digital data recorders.

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 described for this very small study area, some were only minimally sampled likely due to access limitations. Also future restoration efforts to reduce vine cover may alter the existing plant assemblages. It is recommended that these changes be recorded and used to update the GIS layer and classification as needed.

Classification

Two new Cultural Macrogroups were created for the landscaped lawns and planted ornamental trees that occur in and around the buildings and monuments. The current vegetation classification captures all the habitat types and mapping units from past studies (Table 13) and has refined the natural areas into plant associations. As AMME is located on a small area of coastal plain, with very little elevation relief, this classification is a microcosm of the island of Saipan. We have captured mostly just the littoral zone and mangrove swamps, with a small amount of freshwater swamp. But the bulk of the vegetation is secondary growth of introduced species that belong to the ruderal category (MG234 Polynesian Ruderal Scrub & Herb Coastal Strand and MG220 Polynesian Ruderal Lowland Shrubland, Grassland & Savanna).

All of the vegetation sampled and mapped on AMME currently were crosswalked to earlier studies, and can be seen in Table 13.

Table 13. Crosswalk with previous vegetation mapping, classification and descriptive works.

AMME NVC CLASSIFICATION (Plant Associations)	Whistler (2009)	Falanruw et al. (1989)	Raulerson and Rihehart (1989) (as crosswalked by Whistler 2009)	Mueller-Dombois and Fosberg 1998 (as crosswalked by Whistler 2009)
Acrostichum aureum – Microsorium spp. Open Wetland Herbaceous Vegetation [Park Special]*	Freshwater Marsh Community	Freshwater Marsh (MF)	(4) Open wetland with Acrostichum aureum	Secondary Vegetation on Coastal Plains
Bothriochloa bladhii - Chrysopogon aciculatus Lawn [Provisional]	Managed Land Vegetation Community	Savanna/Grassland (GG)	(11) Open dry area with mixed grasses (mowed areas)	Secondary Vegetation on Coastal Plains

AMME NVC CLASSIFICATION (Plant Associations)	Whistler (2009)	Falanruw et al. (1989)	Raulerson and Rihehart (1989) (as crosswalked by Whistler 2009)	Mueller-Dombois and Fosberg 1998 (as crosswalked by Whistler 2009)
Bruguiera gymnorhiza Mangrove Forest [Provisional]	Mangrove Community	Mangrove (MN)	(1) Closed wet mixed forest with mangroves	On Saipan= Strand Vegetation "tiny mangrove swamp"
Casuarina equisetifolia / Paspalum spp. Wooded Herbaceous [Park Special]	Littoral Strand Community	Casuarina thicket (CA)	(6) closed mesic native shrubs -- "Coastal scrub"	Secondary Vegetation on Coastal Plains
Casuarina equisetifolia / Pluchea indica Swamp Forest [Park Special]	Freshwater Swamp Community	Casuarina thicket, freshwater marsh (CAMF)	(3) Open wet ironwood forest with other native trees	Secondary Vegetation on Coastal Plains
Casuarina equisetifolia Artificial Reef [Park Special]	Managed Land Vegetation Community	Casuarina thicket (CA)	(12) Planted Ornamentals	Secondary Vegetation on Coastal Plains
Casuarina equisetifolia Woodland [Provisional]	Littoral Strand Community	Casuarina thicket (CA)	(6) closed mesic native shrubs -- "Coastal scrub"	Secondary Vegetation on Coastal Plains
Coastal Strand Sparse Vegetation [Park Special]	Littoral Strand Community	Atoll Forest (AT)	(6) closed mesic native shrubs -- "Coastal scrub"	Secondary Vegetation on Coastal Plains
Cocos nucifera Strand Wooded Scrub [Park Special]	Littoral Strand Community	Atoll Forest (AT)	(6) closed mesic native shrubs -- "Coastal scrub"	Secondary Vegetation on Coastal Plains
Delonix regia / Sansevieria trifasciata Ruderal Woodland [Park Special]	Littoral Strand Community	Introduced Trees (IF)	(6) closed mesic native shrubs -- "Coastal scrub"	Secondary Vegetation on Coastal Plains
Hibiscus tiliaceus / Asplenium nidus Swamp Woodland [Provisional]	Freshwater Swamp Community	Secondary Vegetation (SVH)	(2) Closed Hibiscus forest	Secondary Vegetation on Coastal Plains
Ipomoea indica Herbaceous Vegetation [Provisional]	Littoral Strand Community	Savanna/Grassland (GG)	(6) closed mesic native shrubs -- "Coastal scrub"	Secondary Vegetation on Coastal Plains
Leucaena leucocephala Lowland Dry Semi-natural Shrubland	Secondary Scrub Community	Secondary Vegetation Class (SVL)	(7) Closed mesic tagantangan scrub with vines	Secondary Vegetation on Coastal Plains
Mixed Semi-natural / Ornamental Trees [Park Special]	Managed Land Vegetation Community	Introduced Trees (IF)	(12) Planted Ornamentals	Secondary Vegetation on Coastal Plains
Cenchrus (polystachios, purpureus) Ruderal Herbaceous Vegetation [Provisional] ¹	Littoral Strand Community	Savanna/Grassland, short grass component (Gg)	(10) Open mesic grassland with morning glory vines	Secondary Vegetation on Coastal Plains
Pithecellobium dulce Semi- natural Woodland Stand [Park Special]	Managed Land Vegetation Community	Introduced Trees (IF)	(12) Planted Ornamentals	Secondary Vegetation on Coastal Plains

¹USNVC name *Pennisetum (polystachion, purpureum)* Ruderal Herbaceous Vegetation modified based on Wagner et al. (2012).

Digital Imagery and Mapping

The vegetation map for AMME was based on the 2006 Quickbird ortho-imagery. Therefore, all of the resulting mapping products correspond to the 2006 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 2006 are not included. In the future it would be beneficial to update the map based on newer imagery or from GPS coordinates.

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 20 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 AMME 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 over a short time period. In order to create the best possible “long-term” vegetation classification for AMME 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 AMME 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 high amount of non-native plant species at AMME seems to warrant future, periodic **field surveys** of the vegetation by experienced ecologists. Further, 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. 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. 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) could 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 could be updated with more current and accurate information.
3. 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.
4. 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.
5. Close examination of associations with low accuracy and/or low sample size should be included in future map updates. Both the NVC classification and spatial boundaries would be enhanced through larger sample sizes. Of specific concern is *Casuarina equisetifolia* / *Pluchea indica* Swamp Forest in which the designation as a “Swamp Forest” may only represent a few plots from which the classification was developed, but on a larger landscape level may be more appropriately named “Forest”. Likewise, *Ipomoea indica* Herbaceous Vegetation often grows over gagu trees and may be appropriately named as a co-dominant species with gagu.

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: AMME 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): _____ _____ _____ _____ _____			

PACN PLOT SURVEY FORM
2008 VEGETATION MAPPING PROGRAM

PLOT CODE: _____

DATE: _____

ENVIRONMENTAL DESCRIPTION (Continued)

Ground Cover: (please estimate to the nearest percentage. Sum = 100%)		
☐ Bare soil (<0.1 mm) ☐ Sand (0.1-2 mm) ☐ Gravel (2 mm - 6.4 cm) ☐ Rock (> 6.4 cm) ☐ Bedrock (solid surface)	☐ Litter/Duff (dead plant material <3 cm diameter) ☐ Coarse woody debris (dead wood 3-10 cm) ☐ Woody debris structure (dead >10 cm deep & wide) ☐ Live veg (litter / wood)	☐ Lichen (ground) ☐ Moss (ground) ☐ Microbiotic soil crust ☐ Water ☐ Other: _____
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, ~~Arctic~~ Pond, Ocean, Estuary		Soil Moisture: dry moist saturated standing water
Animal Use Evidence: ☐ Burrows ☐ Animal / Game Trails ☐ Animal Sighting ☐ Scat (Whose? _____) ☐ Vegetation Damage (animal) ☐ Other: _____ ☐ Browsing Evidence ☐ Bedding Sites ☐ Grazing Evidence ☐ Nests (Whose? _____)		
Anthropogenic Disturbances: ☐ Campsite Evidence ☐ Vegetation Damage (human) ☐ Trails ☐ ORV Evidence ☐ Rock Cairns ☐ Historic Feature ☐ Archaeological Feature ☐ Other: _____		Natural disturbances: ☐ Drought (tree & shrub die-back) ☐ Fire ☐ Flood ☐ Mass Wasting ☐ Water gullies ☐ Vegetation Damage (natural) ☐ Other: _____
Other Comments. Describe surrounding communities and how they relate to the plot.		

VEGETATION DESCRIPTION (Only check one within each box)

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

Date: _____

Provisional Community Name:

SPECIES/STRATA TABLE / TREES & SHRUBS					SPECIES/STRATA TABLE / HERBACEOUS				
Strata / Species Scientific Name		Cover	%	Spec	Strata / Species Scientific Name		Cover	%	Spec
		Class	Cover	✓			Class	Cover	✓
Whole Plot:		Total Vegetation Cover ____ (%)			Maximum Vegetation Height ____ (m)				
T1					H1 HERBACEOUS				
EMERGENT		Strata Height ____	Strata Cover ____		Sum of H1, H2, H3, H4		Strata Height	Strata Cover	
					H1 GRAMINOIDS		Strata Height ____	Strata Cover ____	
T2									
CANOPY		Strata Height ____	Strata Cover ____						
T3									
SUBCANOPY		Strata Height ____	Strata Cover ____						
S1 TALL SHRUB (>2m)		Strata Height	Strata Cover						
S2 SHORT SHRUB (<2m)		Strata Height ____	Strata Cover ____						
S3 DWARF SHRUB (<0.5m)		Strata Height ____	Strata Cover ____						
					H3 FERNS & ALLIES				
					Strata Height		Strata Cover		
					H4 TREE SEEDLINGS				
					Strata Height		Strata Cover		
					N NON-VASCULAR				
					Strata Height		Strata Cover		

Cover Scale for Species

c = few	T = <1%	1a = 5.01 ->10%	2 = 15.01 ->25%	4 = 35.01 ->45%	6 = 55.01 ->65%	8 = 75.01 ->85%	10 = >95%
	P = 1-5%	1b = 10.01 ->15%	3 = 25.01 ->35%	5 = 45.01 ->55%	7 = 65.01 ->75%	9 = 85.01 ->95%	

Height Scale for Strata

01 = <0.5 m	03 = 1.01 ->2 m	05 = 5.01 ->10 m	07 = 15.01 ->20 m	09 = 35.01 ->50 m
02 = 0.5-1 m	04 = 2.01 ->5 m	06 = 10.01 ->15 m	08 = 20.01 ->35 m	10 = >50 m

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, ~~Boothole~~ , River, ~~Anchialine Pond~~ , Ocean, Estuary.		Soil Moisture: Dry, Moist, Saturated, Standing Water

Appendix B: Plant Species Found within Sample Plots at American Memorial Park

One-hundred and fourteen plant species were encountered while sampling field plots, observation points, and accuracy assessment plots. Family, genus, species, common names and origin are reported. Plant species are indicated that were not present in sample plots at AMME, but are important for community classification. 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. (2012) and Raulerson and Rinehart (1991) by PACN and used throughout the document. Species names that differ from those in the rUSNVC are identified with footnotes.

Family	Genus species	Common Name	Origin
Acanthaceae	<i>Asystasia gangetica</i> (L.) T. Anderson	coromandel	Non-Native
Acanthaceae	<i>Ruellia blechum</i> L.	Yerbas babui	Non-Native
Amaranthaceae	<i>Achyranthes aspera</i> L.	devil's horsewhip	Native
Arecaceae	<i>Cocos nucifera</i> L.	tronkon niyok	Native
Arecaceae	<i>Livistona chinensis</i> (N. Jacquin) Martius var. subglobosa	fountain palm	Non-Native
Arecaceae	<i>Ptychosperma macarthurri</i> (Veitch.) J. D. Hooker	Macarthur feather palm	Non-Native
Aspleniaceae	<i>Asplenium nidus</i> L.	bird's nest fern	Native
Asteraceae	<i>Ageratina adenophora</i> (Spreng.) R. King & H. Robinson	masigsig	Non-Native
Asteraceae	<i>Bidens alba</i> (L.) DC.	romerillo	Non-Native
Asteraceae	<i>Conyza canadensis</i> (L.) Cronq.	horseweed	Non-Native
Asteraceae	<i>Cyanthillium cinereum</i> (L.) H. Rob.	little ironweed	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>Pluchea carolinensis</i> (Jacq.) G. Don	sourbush	Non-Native
Asteraceae	<i>Pluchea indica</i> (L.) Less.	Indian pluchea	Non-Native
Asteraceae	<i>Youngia japonica</i> (L.) D. C.	oriental hawksbeard	Non-Native
Bignoniaceae	<i>Spathodea campanulata</i> P. Beauv.	African tulip tree	Non-Native
Bignoniaceae	<i>Tabebuia heterophylla</i> (DC.) Britton	white cedar	Non-Native
Boraginaceae	<i>Heliotropium procumbens</i> Mill.	four-spike heliotrope	Non-Native
Cactaceae	<i>Opuntia cochenillifera</i> (L.) Mill.	cochineal cactus	Non-Native
Caricaceae	<i>Carica papaya</i> L.	papaya	Non-Native
Casuarinaceae	<i>Casuarina equisetifolia</i> L.	gagu	Native
Clusiaceae	<i>Calophyllum inophyllum</i> L.	da'ok	Native
Combretaceae	<i>Terminalia catappa</i> L.	Pacific almond	Native
Commelinaceae	<i>Tradescantia spathacea</i> Sw.	boatlily	Non-Native
Convolvulaceae	<i>Ipomoea indica</i> (Burm.) Merr.	fufgu	Native
Convolvulaceae	<i>Ipomoea pes-caprae</i> (L.) R. Br.	alalag-tasi	Native
Cucurbitaceae	<i>Coccinia grandis</i> (L.) Voigt	ivy gourd	Non-Native

Family	Genus species	Common Name	Origin
Cucurbitaceae	<i>Momordica charantia</i> L.	bittermelon	Non-Native
Cyperaceae	<i>Cyperus rotundus</i> L.	nut grass	Native
Cyperaceae	<i>Fimbristylis cymosa</i> R. Br.	tropical fimbry	Native
Cyperaceae	<i>Kyllinga nemoralis</i> (J.R. & G. Forst.) Dandy ex Hutch. & Dalziel	whitehead spikesedge	Non-Native
Davalliaceae	<i>Davallia solida</i> (Forster f.) Swartz	Rabbit foot fern	Native
Euphorbiaceae	<i>Euphorbia heterophylla</i> L.	Mexican fireplant	Non-Native
Euphorbiaceae	<i>Euphorbia hirta</i> L.	golondrina	Non-Native
Euphorbiaceae	<i>Jatropha integerrima</i> Jacq.	peregrina	Non-Native
Euphorbiaceae	<i>Melanolepis multiglandulosa</i> (Reinwardt) Reichb. f. & Zoll.	alom	Native
Fabaceae	<i>Abrus precatorius</i> L.	crab's eye	Native
Fabaceae	<i>Albizia lebbbeck</i> (L.) Benth.	tronkon-kalaskas	Non-Native
Fabaceae	<i>Alysicarpus vaginalis</i> (L.) DC.	white moneywort	Non-Native
Fabaceae	<i>Delonix regia</i> (Bojer ex Hook.) Raf.	royal poinciana	Non-Native
Fabaceae	<i>Desmodium</i> spp.		Unknown
Fabaceae	<i>Desmodium tortuosum</i> (Sw.) DC.	Florida beggarweed	Non-Native
Fabaceae	<i>Desmodium triflorum</i> (L.) DC.	threeflower ticktrefoil	Non-Native
Fabaceae	<i>Fabaceae</i> spp.		Unknown
Fabaceae	<i>Leucaena leucocephala</i> (Lam.) de Wit	tangan-tangan	Non-Native
Fabaceae	<i>Mimosa pudica</i> L.; (Duchass. & Walp.) Griseb.	sleeping grass	Non-Native
Fabaceae	<i>Mucuna gigantea</i> (Willd.) DC.	seabean	Native
Fabaceae	<i>Pithecellobium dulce</i> (Roxb.) Benth.	kamachile	Non-Native
Fabaceae	<i>Sesbania cannabina</i> Poir.	sesbania	Non-Native
Flagellariaceae	<i>Flagellaria indica</i> L.	bejuco halum-tano	Native
Hernandiaceae	<i>Hernandia sonora</i> L.	nonag	Native
Lecythidaceae	<i>Barringtonia asiatica</i> (L.) Kurz	putting	Native
Lomariopsidaceae	<i>Nephrolepis hirsutula</i> (G. Forst.) C. Presl 'Superba'	scaly swordfern	Native
Lythraceae	<i>Pemphis acidula</i> Forst. & Forst.	nigas	Native
Malvaceae	<i>Hibiscus tiliaceus</i> L.	hau	Native
Malvaceae	<i>Sida rhombifolia</i> L.	escobilla adumelon	Non-Native
Malvaceae	<i>Sida</i> spp.		Unknown
Malvaceae	<i>Thespesia populnea</i> (L.) Sol. ex Corrêa	miло	Native
Malvaceae	<i>Triumfetta procumbens</i> G. Forst.	burbark	Native
Moraceae	<i>Ficus prolixa</i> Forst. f.	nunu	Native
Moraceae	<i>Ficus</i> spp.		Unknown
Moraceae	<i>Ficus tinctoria</i> Forst. f.	hodda	Native
Myrtaceae	<i>Eugenia palumbis</i> Merrill	agatelong	Native
Nyctaginaceae	<i>Bougainvillea spectabilis</i> Willd.	bougainvillea	Non-Native
Oleaceae	<i>Jasminum marianum</i> DC.	banago	Native
Oxalidaceae	<i>Oxalis corniculata</i> L.	yellow wood sorrel	Native

Family	Genus species	Common Name	Origin
Pandanaceae	<i>Pandanus dubius</i> Sprengel	pahong	Native
Pandanaceae	<i>Pandanus tectorius</i> Parkinson ex Z	kafu	Native
Passifloraceae	<i>Passiflora foetida</i> L.	love-in-a-mist	Non-Native
Passifloraceae	<i>Passiflora suberosa</i> L.	corky passionflower	Non-Native
Phyllanthaceae	<i>Phyllanthus debilis</i> Klein ex Willd.	maigo-lalo	Non-Native
Poaceae	<i>Axonopus compressus</i> (Sw.) P. Beauv.	carpet grass	Non-Native
Poaceae	<i>Bothriochloa bladhii</i> (Retz.) S.T. Blake ³	Australian beardgrass	Non-Native
Poaceae	<i>Cenchrus echinatus</i> L.	burgrass	Non-Native
Poaceae	<i>Cenchrus polystachios</i> (L.) Morrone ^{1, 2}	mission grass	Non-Native
Poaceae	<i>Cenchrus purpureus</i> (Schumach.) Morrone ³	Napier grass	Non-Native
Poaceae	<i>Chloris barbata</i> (L.) Sw.	fingergrass	Non-Native
Poaceae	<i>Chrysopogon aciculatus</i> (Retz.) Trin.	inifuk	Native
Poaceae	<i>Cynodon dactylon</i> (L.) Pers.	Bermuda grass	Non-Native
Poaceae	<i>Dactyloctenium aegyptium</i> (L.) Willd.	beach wiregrass	Non-Native
Poaceae	<i>Echinochloa colona</i> (L.) Link	jungle-rice	Non-Native
Poaceae	<i>Eleusine indica</i> (L.) Gaertn.	goose grass	Non-Native
Poaceae	<i>Eragrostis</i> spp.	lovegrass	Unknown
Poaceae	<i>Lepturus repens</i> (G. Forst.) R. Br.	Pacific Island thintail	Native
Poaceae	<i>Panicum</i> spp.		Unknown
Poaceae	<i>Paspalum conjugatum</i> P. J. Bergius	Hilo grass	Non-Native
Poaceae	<i>Paspalum distichum</i> L.	saltgrass	Native
Poaceae	<i>Paspalum setaceum</i> (Forssk.) Chiov.	sand paspalum	Non-Native
Poaceae	<i>Paspalum</i> spp.		Unknown
Poaceae	<i>Paspalum vaginatum</i> Sw.	seashore paspalum	Native
Poaceae	<i>Poa</i> spp.	Unknown Grass	Non-Native
Poaceae	<i>Sporobolus fertilis</i> (Steud.) Clayton	Indian dropseed	Non-Native
Poaceae	<i>Urochloa maxima</i> (Jacq.) R. D. Webster	guinea grass	Non-Native
Poaceae	<i>Zoysia matrella</i> (L.) Merr.	makila grass	Native
Polygonaceae	<i>Coccoloba uvifera</i> (L.) L.	seagrape	Non-Native
Polypodiaceae	<i>Microsorium punctatum</i> (L.) Copel. <i>Phymatosorus grossus</i> (Langsd. & Fisch.) ⁵	climbing bird's nest fern	Native
Polypodiaceae	Brownlie	monarch fern	Native
Polypodiaceae	<i>Pyrrosia lanceolata</i> (L.) Farw.		Native
Pteridaceae	<i>Acrostichum aureum</i> L.	langayao	Native
Rhamnaceae	<i>Colubrina asiatica</i> (L.) Brongn.	gasoso	Native
Rhizophoraceae	<i>Bruguiera gymnorhiza</i> (L.) Lam.	mangle lahi	Native
Rubiaceae	<i>Ixora chinensis</i> Lamarck	Chinese ixora	Non-Native
Rubiaceae	<i>Morinda citrifolia</i> L.	lada	Native
Rubiaceae	<i>Spermacoce assurgens</i> Ruiz & Pav.	false buttonweed	Non-Native
Ruscaceae	<i>Sansevieria trifasciata</i> Prain	Mother-in-Laws tongue	Non-Native
Rutaceae	<i>Triphasia trifolia</i> (Burm. f.) P. Wilson	limeberry	Non-Native

Family	Genus species	Common Name	Origin
Thelypteridaceae	<i>Thelypteris opulenta</i> (Kaulfuss) Fosberg	jeweled maiden fern	Native
Urticaceae	<i>Pilea microphylla</i> (L.) Liebm.	rockweed	Non-Native
Verbenaceae	<i>Lantana camara</i> L.	lantana	Non-Native
Verbenaceae	<i>Phyla nodiflora</i> (L.) Greene	sawtooth frogfruit	Non-Native
Verbenaceae	<i>Premna serratifolia</i> ⁴	ahgao	Native
Verbenaceae	<i>Stachytarpheta</i> spp.		Unknown

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

² Listed in rUSNVC as *Pennisetum polystachion*.

³ Listed in rUSNVC as *Pennisetum purpureum*.

⁴ Listed in rUSNVC as *Premna obtusifolia*.

⁵ Listed in rUSNVC as *Polypodium punctatum*.

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Appendix C: Field Plot Crosswalk to Revised US National Vegetation Classification Associations

At American Memorial Park 20 plots and observation points were assigned to revised US National Vegetation Classification (rUSNVC) associations and park specials. A total of 10 rUSNVC associations, three “Park Specials” and six “Provisional” types were classified. Park Special status means these associations are not yet part of the NVC, and are considered preliminary “place holder” names until more data can be obtained on their composition and geographic range. “Provisional” status indicates these associations are added to the NVC but are subject to peer review. Park Special and Provisional status associations are *not* posted on NatureServe Explorer (<http://www.natureserve.org/explorer>). Nomenclature used by the NVC follows Kartesz (1999) with Pacific Island modifications based on Wagner et al. (2012) and Raulerson and Rinehart (1991,1992).

US NVC Plant Association Scientific Name	US NVC Code	No. of Samples	Supporting Plots and Observation Points
Forest and Woodland			
<i>Mangrove and Swamp Forests</i>			
Bruguiera gymnorrhiza Mangrove Forest [Provisional]	CEGL008119	1	AMME.0004
Casuarina equisetifolia / Pluchea indica Swamp Forest [Park Special]	CEPS009540	3	AMME.0001, AMME.0003 AMME.0905
<i>Coastal Strand Forests</i>			
Casuarina equisetifolia / Paspalum spp. Wooded Herbaceous Vegetation [Park Special]	CEPS009541	1	AMME.0904
Casuarina equisetifolia / Artificial Reef Woodland [Park Special]	CEPS009543	1	AMME.0907
Casuarina equisetifolia Woodland [Provisional]	CEGL008121	2	AMME.0005, AMME.0009
Delonix regia / Sansevieria trifasciata Ruderal Woodland [Park Special]	CEPS009542	1	AMME.0908
Hibiscus tiliaceus / Asplenium nidus Swamp Woodland [Provisional]	CEGL008120	3	AMME.0007, AMME.0008 AMME.0902

US NVC Plant Association Scientific Name	US NVC Code	No. of Samples	Supporting Plots and Observation Points
Herbaceous			
Bothriochloa bladhii - Chrysopogon aciculatus Lawn [Provisional]	CEGL008124	5	AMME.0006, AMME.0010, AMME.0011, AMME.0903 AMME.0909,
Ipomoea indica Herbaceous Vegetation [Provisional]	CEGL008122	2	AMME.0002, AMME.0906
Cenchrus (polystachios, purpureus) Ruderal Herbaceous Vegetation [Provisional] ¹	CEGL008123	1	AMME.0901

¹rUSNVC name Pennisetum (polystachion, purpureum) Ruderal Herbaceous Vegetation modified based on Wagner et al. (2012).

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Appendix D: Field Key to the Vegetation of American Memorial Park, Commonwealth of the Northern Mariana Islands, Saipan

The vegetation of American Memorial Park (AMME) was characterized using field data collected in 2008 under the National Park Service's National Vegetation Mapping Program. To assist in the accurate field identification of the 10 plant associations or vegetation cover types described for AMME, this dichotomous key has been developed from plot data. It includes all types in the AMME Vegetation Classification plus one type described for the West Hawai'i parks that was mapped, but not sampled at AMME as well as five map classes to help clarify the different vegetation types.

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 (rUSNVC). The broadest level is the Group and the finest scale is the rUSNVC Association. The key focuses on the Association level with an occasional reference to the Group level, as needed to allow for unclassified types. However, when the association is identified, then the group is known because of the hierarchical nature of the rUSNVC (Table 6). This allows the user to determine which hierarchy level is appropriate.

Park Specials represent local vegetation types that differ significantly from existing rUSNVC association concepts, but lack enough data to develop into a new association. Park Special types are not officially included in the rUSNVC hierarchy, but many times can be linked to the Group level for classification and mapping purposes (Table 6).

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 code in parentheses. If the type was mapped, but not sampled at the site then a description was not written and "(no description)" was also added to the couplet.

Special instructions

There are a number of closely related vegetation types at AMME that may be confusing in the field (e.g., grasslands with scattered trees or shrubs vs. open shrublands or woodlands). We are using a 10% minimum tree and shrub canopy cover threshold for woodlands and shrublands with a strong herbaceous layer. Stands with less than 10% tree or shrub canopy cover are included as grasslands unless the tree or shrub layer dominates the vegetation and the herbaceous cover is low. 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 coastal 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**).

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.

Not all species are given equal weight in classification. Native species are given more diagnostic value over introduced 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 introduced 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).

A Key to the Vegetation Associations and Park-specific Map Classes at American Memorial Park (AMME)

- 1a) Vegetation is present with 10% or more tree cover. Trees have at least 5' canopies. **(2)**
- 1b) Vegetation is present and dominated by shrubs or herbaceous plants covering at least 10% of the ground. **(12)**

Forest and Woodland Vegetation

- 2a) Forest and/or woodlands of dry or mesic upland, non-wetland settings or habitats. **(3)**
- 2b) Forests and/or woodlands of perennially or intermittently wet ground, wetlands, swamps, tidal, riparian or other wetland settings. **(9)**
- 3a) Forest or woodland dominated in the upper canopy by native gagu (*Casuarina equisetifolia*) or milo (*Thespesia populnea*). **(4)**
- 3b) Forest or woodland dominated in the upper canopy by non-native royal poinciana (*Delonix regia*), tronkon niyok (*Cocos nucifera*), kamachile (*Pithecellobium dulce*), or other non-native and/or planted trees. **(5)**
- 4a) Herbaceous cover is much higher cover (~70%) than the upper tree canopy cover (20%). Non-native Hilo grass (*Paspalum conjugatum*) or native saltgrass (*Paspalum distichum*) dominate the herbaceous layer. Stands not mowed or a part of landscaping around parking lots and buildings– **Gagu / Paspalum spp. Wooded Herbaceous Vegetation [Park Special]; Casuarina equisetifolia / Paspalum spp. Wooded Herbaceous Vegetation [Park Special] (W-CAPA)**
- 4b) Herbaceous cover abundant (55%), regularly mowed, and occur adjacent to parking lots or other human structures such as docks and jetties. The native makila grass (*Zoysia matrella*) may be abundant (55%). **Gagu / Artificial Reef Woodland [Park Special] Casuarina equisetifolia / Artificial Reef Woodland [Park Special] (W-CAAR)**
- 4c) Herbaceous cover generally low or not present due to heavy shaping of overstory canopy – This type is often at the edge of bare sand where blowing sand may bury any ground cover. – **Gagu Woodland [Provisional]; Casuarina equisetifolia Woodland [Provisional] (W-CAEQ)**
- 5a) Canopy is dominated by royal poinciana (*Delonix regia*) with mother-in-law's tongue (*Sansevieria trifasciata*) in the understory. – **Royal Poinciana / Mother-in-Law's Tongue Ruderal Woodland [Park Special]; Delonix regia / Sansevieria trifasciata Ruderal Woodland [Park Special] (W-DERE)**
- 5b) Canopy is not dominated by royal poinciana (*Delonix regia*). **(6)**
- 6a) Canopy is dominated by tronkon niyok (*Cocus nucifera*) or kamachile (*Pithecellobium dulce*). In general these are pure stands or with other non-native species. **(7)**
- 6b) Canopy is not dominated by tronkon niyok (*Cocus nucifera*) or kamachile (*Pithecellobium dulce*). **(8)**

- 7a) Canopy is dominated by tronkon niyok (*Cocus nucifera*). Tronkon may be the only tree species present, even at low cover, especially along the coast line, where they form iconic island scenery – **Tronkon Niyok Stand Wooded Scrub [Park Special]; *Cocos nucifera* Stand Wooded Scrub [Park Special] (W-COCS) (no description)**
- 7b) Canopy is dominated by kamachile (*Pithecellobium dulce*). – **Kamachile Semi-natural Woodland Stand [Park Special]; *Pithecellobium dulce* Semi-natural Woodland Stand [Park Special] (W-PIDU) (no description)**
- 8a) Canopy is dominated by ornamental trees or a mix of native (that are not mentioned in this key) or naturalized trees with planted and escaped ornamentals. Understory is maintained as a mowed lawn – **Ruderal Lawn / Ornamental Trees [Park Special] (W-RUOR) (no description)**
- 8b) Canopy is dominated by non-native trees otherwise not mentioned, or that do not fit the descriptions provided for AMME plant associations – **Undescribed AMME vegetation in the Micronesian Coastal Strand Group (GNEW)**
- 9a) Swamp or otherwise wetland forest or woodland dominated by mangle lahi (*Bruguiera gymnorhiza*).. – **Mangle Lahi Mangrove Forest [Provisional]; *Bruguiera gymnorhiza* Mangrove Forest [Provisional] (W-BRGY)**
- 9b) Forested wetlands not dominated by mangle lahi (*Bruguiera gymnorhiza*), dominated by hau (*Hibiscus tiliaceus*) or other species. **(10)**
- 10a) Wetland dominated by gagu (*Casuarina equisetifolia*) or has hau (*Hibiscus tiliaceus*) in the overstory with 20-55% cover. Pahong (*Pandanus dubius*) and hodda (*Ficus tinctoria*) may be present to abundant. **(11)**
- 10b) Treed wetland dominated by species other than those mentioned above. – **Undescribed AMME vegetation in the Micronesian Lowland Swamp Forest Group (GNEW)**
- 11a) Wetland dominated by gagu (*Casuarina equisetifolia*) with Indian pluchea (*Pluchea indica*) in the undergrowth. – **Gagu / Indian Pluchea Swamp Forest [Park Special]; *Casuarina equisetifolia* / *Pluchea indica* Swamp Forest [Park Special] (W-CAPL)**
- 11b) Wetland dominated by many other tree species, especially non-native trees. The presence of hau (*Hibiscus tiliaceus*) and the absence of mangle lahi (*Bruguiera gymnorhiza*) are indicators for this type. Hau may not be the dominant tree species. – **Hau / Bird's Nest Fern Swamp Woodland [Provisional]; *Hibiscus tiliaceus* / *Asplenium nidus* Swamp Woodland [Provisional] (W-HIAS)**

Shrub and Herbaceous

- 12a) Vegetation dominated by woody plants. **(13)**
- 12b) Vegetation dominated by herbaceous plants. **(15)**
- 13a) Stands of low trees or shrubs dominated by tangan-tangan (*Leucaena leucocephala*). – **Tangan-tangan Lowland Dry Semi-natural Shrubland; *Leucaena leucocephala* Lowland Dry Semi-natural Shrubland (S-LELE) (no description)**
- 13b) Stands not dominated by tangan-tangan (*Leucaena leucocephala*). **(14)**

- 14a) Shrublands covered by herbaceous vines. Native fufgu (*Ipomoea indica*) dominates, but non-native climbing hempvine (*Mikania scandens*) may also be abundant. – **Fufgu Herbaceous Vegetation [Provisional]; *Ipomoea indica* Herbaceous Vegetation [Provisional] (H-IPIN)**
- 14b) Stands of low trees or shrubs not like above. – **Undescribed AMME vegetation in the Micronesian Ruderal Lowland Shrubland, Grassland & Savanna Group (G415)**
- 15a) Upland Herbaceous meadow or grassland, dry to mesic, not wetland or intermittently flooded. **(16)**
- 15b) Wetland dominated by herbaceous plants or ferns. **(18)**
- 16a) Meadow covered by vines. Native fufgu (*Ipomoea indica*) dominates, but non-native climbing hempvine (*Mikania scandens*) may also be abundant. Grasses may co-dominant, but fufgu has the highest cover of any herbaceous plant present. – **Fufgu Herbaceous Vegetation[Provisional]; *Ipomoea indica* Herbaceous Vegetation [Provisional] (H-IPIN)**
- 16b) Meadow or grassland, not dominated by vines. **(17)**
- 17a) Grassland dominated by the introduced grass Australian beardgrass (*Bothriochloa bladhii*) often co-dominated with other grasses such as beach wiregrass (*Dactyloctenium aegyptium*) and/ or Hilo grass (*Paspalum conjugatum*). These grasslands are usually mowed at AMME. – **Australian Beardgrass Lawn [Provisional]; *Bothriochloa bladhii* Lawn [Provisional] (H-LAWN)**
- 17b) Grassland dominated by mission grass (*Cenchrus polystachios*) or napier grass (*Cenchrus purpureus*). – **(Mission Grass, Napier Grass) Ruderal Herbaceous Vegetation; *Cenchrus (polystachios, purpureus)* Ruderal Herbaceous Vegetation¹ (H-CENC)**
- 18a) Open wetland dominated by herbaceous plants such as langayao (*Acrostichum aureum*) and/or Polypodium ferns (*Polypodium* spp.). – **Langayao – Fern Open Wetland Herbaceous Vegetation[Park Special]; *Acrostichum aureum* – *Microsorium* spp. Open Wetland Herbaceous Vegetation [Park Special]¹ (H-ACRO) (no description)**
- 18b) Herbaceous wetland with some standing water dominated by wetland herbaceous species, other than those previously mentioned. – **Undescribed AMME vegetation in the Micronesian Forb Freshwater Marsh Group (GNEW)**

¹rUSNVC name Pennisetum (polystachion, purpureum) Ruderal Herbaceous Vegetation modified based on Wagner et al. (2012).

Appendix E: Plant Associations and Descriptions for American Memorial Park, Commonwealth of the Northern Mariana Islands, Saipan

REVISED US NATIONAL VEGETATION CLASSIFICATION

Vegetation Associations of American Memorial Park

2 June 2010

by

NatureServe

1101 Wilson Blvd., 15th floor
Arlington, VA 22209

4001 Discovery, Suite 2110
Boulder, CO 80303

This subset of the International Ecological Classification Standard covers vegetation associations of American Memorial 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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NatureServe
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Arlington, VA 22209

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NatureServe. 2012. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA. U.S.A. Data current as of 2 June 2010.

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NatureServe¹. 2010. International Ecological Classification Standard: Terrestrial Ecological Classifications. Vegetation Associations of American Memorial Park. NatureServe Central Databases. Arlington, VA. Data current as of 19 Oct 2012.

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.

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

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1.A.4. Mangrove

1.A.4.b. Indo-West Pacific Mangrove

MG208. West Pacific (East Melanesia, Micronesia, Polynesia) Mangrove

G402. West Pacific (East Melanesia, Micronesia, Polynesia) Mangrove Group

Mangle Lahi Mangrove Forest [Provisional]

Bruguiera gymnorhiza Mangrove Forest [Provisional]

Identifier: CEG008119

rUSNVC CLASSIFICATION

Formation Mangrove (1.A.4)
Division Indo-West Pacific Mangrove (1.A.4.b)
Macrogroup West Pacific (East Melanesia, Micronesia, Polynesia) Mangrove (MG208)
Group West Pacific (East Melanesia, Micronesia, Polynesia) Mangrove Group (G402)
Association (Local name) Mangle Lahi / Langayao Mangrove Forest [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Palustrine.

American Memorial Park Environment: This association was sampled once in the park. It was observed in tidal flooded areas with soils of muck. The ground surface gradient is very low, soils are permanently saturated. Tidal fluctuations are critical for mangrove persistence.

VEGETATION DESCRIPTION

American Memorial Park Vegetation: These are tidally flooded forests and woodlands dominated by mangle lahi (*Bruguiera gymnorhiza*), which has very thick overstory cover and reproduction occurring in the understory. Other upper canopy woody species present include gagu (*Casuarina equisetifolia*) and hau (*Hibiscus tiliaceus*). The ground is often inundated by standing water at high tides and has sparse cover. Langayao (*Acrostichum aureum*) is an herbaceous understory plant with 5% cover. Other herbaceous species present include climbing bird's nest fern (*Microsorium punctatum*).

MOST ABUNDANT SPECIES

American Memorial Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved Evergreen	mangle lahi
Forb	Broad-leaved Evergreen	langayao

CHARACTERISTIC SPECIES

American Memorial Park: mangle lahi

ELEMENT DISTRIBUTION

Range: This mangrove forest was sampled once in the park on the seaward side of the estuary.

Nation(s): CNMI

States/Provinces: Saipan

ELEMENT SOURCES

American Memorial Park Plots: AMME.0004

Local Description Authors: G. Kittel

Version Date: May 26, 2010

1.A.3. Tropical Flooded & Swamp Forest

1.A.3.b. Polynesian Flooded & Swamp Forest

MG203. Micronesian Flooded & Swamp Forest

G606 Micronesian Lowland Swamp Forest Group

Gagu / Indian Pluchea Swamp Forest [Park Special]

Casuarina equisetifolia / *Pluchea indica* Swamp Forest [Park Special]

Identifier: CEPS009540

rUSNVC CLASSIFICATION

Formation Tropical Flooded & Swamp Forest (1.A.3)
Division Polynesian Flooded & Swamp Forest (1.A.3.b)
Macrogroup Micronesian Flooded & Swamp Forest (MG203)
Group Micronesian Lowland Swamp Forest Group (G606)
Association (Local name) Gagu / Indian Pluchea Swamp Forest [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Palustrine

American Memorial Park Environment: This wooded swamp forest was sampled at three sites in the park. It occurs in low flat areas on limestone bedrock. Soils consist of moist to saturated loam.

VEGETATION DESCRIPTION

American Memorial Park Vegetation: This woodland has an overstory canopy dominated by gagu (*Casuarina equisetifolia*). Other trees present include pahong (*Pandanus dubius*), hau (*Hibiscus tiliaceus*), and kamachile (*Pithecellobium dulce*). Shrubs are often present with 20-40% cover and commonly represented by Indian pluchea (*Pluchea indica*) 10-40% cover. Tangan-tangan (*Leucaena leucocephala*) has 8% cover in one plot. In two of three areas surveyed the fern, langayao (*Acrostichum aureum*) was very abundant with 30-77% cover.

MOST ABUNDANT SPECIES

American Memorial Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Needle-leaved evergreen	gagu
Subcanopy Tree	Broad-leaved evergreen	pahong
Tall Shrub	Broad-leaved evergreen	sourbush, Indian pluchea
Fern or fern-ally	Perennial	langayao

CHARACTERISTIC SPECIES

American Memorial Park: gagu, langayao

ELEMENT DISTRIBUTION

Range: Currently known only from American Memorial Park

Nation(s): CNMI

States/Provinces: Saipan

ELEMENT SOURCES

American Memorial Park Plots: AMME.0001, AMME.0003, AMME.0905

Local Description Authors: G. Kittel

Version Date: June 2, 2010

Hau / Bird's Nest Fern Swamp Woodland [Provisional]

Hibiscus tiliaceus / *Asplenium nidus* Swamp Woodland [Provisional]

Identifier: CEG008120

rUSNVC CLASSIFICATION

Formation	Tropical Flooded & Swamp Forest (1.A.3)
Division	Polynesian Flooded & Swamp Forest (1.A.3.b)
Macrogroup	Micronesian Flooded & Swamp Forest (MG203)
Group	Micronesian Lowland Swamp Forest Group (G606)
Association (Local name)	Hau / Bird's Nest Fern Swamp Woodland [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Palustrine

American Memorial Park Environment: This wooded wetland was sampled at three sites in the park. It occurs on seeps, springs, and fringes of larger open water or other types of wetland. The land is usually flat with limestone bedrock geology. Soils consist of saturated muck.

VEGETATION DESCRIPTION

American Memorial Park Vegetation: These treed wetlands or swamps, have a mix of tree species and are quite diverse. Hau (*Hibiscus tiliaceus*) is the indicator overstory species for this association. It is always present with 20-55% cover but may not be the most abundant or the tallest tree present. Other species present may include trongkon niyok (*Cocos nucifera*) and gagu (*Casuarina equisetifolia*). The herbaceous undergrowth is lush (5-40% cover) with native ferns such as langayao (*Acrostichum aureum*), bird's nest fern (*Asplenium nidus*), and monarch fern (*Phymatosorus grossus*). Forbs such as gasoso (*Colubrina asiatica*) or Yervas babui (*Blechnum pyramidatum*) may be present with more than 5% cover.

MOST ABUNDANT SPECIES

American Memorial Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved evergreen,	hau
Fern or fern-ally	Perennial,	langayao
		bird's nest fern
		monarch fern

CHARACTERISTIC SPECIES

American Memorial Park: hau, langayao, bird's nest fern, monarch fern

ELEMENT DISTRIBUTION

Range: Currently known only from American Memorial Park

Nation(s): CNMI

States/Provinces: Saipan

ELEMENT SOURCES

American Memorial Park Plots: AMME.0007, AMME.0008, AMME.0902

Local Description Authors: G. Kittel

Version Date: June 2, 2010

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

2.A.3.b. Polynesian Wooded Scrub & Herb Coastal Vegetation

MG233. Micronesian Wooded Scrub & Herb Coastal Vegetation

G607. Micronesian Coastal Wooded Strand Group

Gagu/ *Paspalum* spp. Wooded Herbaceous Vegetation [Park Special]

Casuarina equisetifolia / *Paspalum* spp. Wooded Herbaceous Vegetation [Park Special]

Identifier: CEPS009541

rUSNVC CLASSIFICATION

Formation Tropical Wooded Scrub & Herb Coastal Vegetation (2.A.3)
Division Polynesian Wooded Scrub & Herb Coastal Vegetation (2.A.3.b)
Macrogroup Micronesian Wooded Scrub & Herb Coastal Vegetation (MG233)
Group Micronesian Coastal Strand Group (G607)
Association (Local name) Gagu / *Paspalum* spp. Wooded Herbaceous Vegetation [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

American Memorial Park Environment: This open wooded grassland was sampled once in the park and occurred on the flat strand areas near the beach. Soils are sandy and well-drained. Litter cover is high.

VEGETATION DESCRIPTION

American Memorial Park Vegetation: This is a very open woodland that qualifies as grassland, though the 10-% tree cover prevents classification as pure grassland. The dominant grass is saltgrass (*Paspalum distichum*). Widely spaced or clumped, fully grown gagu (*Casuarina equisetifolia*), milo (*Thespesia populnea*), occur in the tree layer with up to about 15% cover. Other species present may include a few shrubs such as Indian pluchea (*Pluchea indica*). The herbaceous vine fufgu (*Ipomoea indica*) is also present.

MOST ABUNDANT SPECIES

American Memorial Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Needle-leaf Evergreen	gagu
	Broad-leaf Evergreen	milo
		trongkon niyok
Graminoid	Perennial	saltgrass
		Hilo grass
		Australian beardgrass

CHARACTERISTIC SPECIES

American Memorial Park: saltgrass

ELEMENT DISTRIBUTION

Range: Currently known only from American Memorial Park..

Nation(s): CNMI

States/Provinces: Saipan

ELEMENT SOURCES

American Memorial Park Plots: AMME.0904

Local Description Authors: G. Kittel **Version Date:** May 27, 2010

Gagu Woodland [Provisional]

Casuarina equisetifolia Woodland [Provisional]

Identifier: CEGl008121

rUSNVC CLASSIFICATION

Formation Tropical Wooded Scrub & Herb Coastal Vegetation (2.A.3)
Division Polynesian Wooded Scrub & Herb Coastal Vegetation (2.A.3.b)
Macrogroup Micronesian Wooded Scrub & Herb Coastal Vegetation (MG233)
Group Micronesian Coastal Strand Group (G607)
Association (Local name) Gagu Woodland [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

American Memorial Park Environment: This strand forest was sampled once on flat land near the coast. Soils are sandy and the bedrock often consists of limestone.

VEGETATION DESCRIPTION

American Memorial Park Vegetation: This open to closed woodland or forest is dominated by gagu (*Casuarina equisetifolia*). Stands are often pure gagu; however, a few other trees may occur in the upper canopy. The one stand sampled had a few forbs in the herbaceous understory including *Blechnum pyramidatum*, *Coccinia grandis*, *Conyza Canadensis*, *Euphorbia heterophylla*, *Fimbristylis cymosa*, *Lepturus repens*, and *Paspalum conjugatum* with trace to 6% cover.

MOST ABUNDANT SPECIES

American Memorial Park

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

ELEMENT DISTRIBUTION

Range: Currently known only from American Memorial Park

Nation(s): CNMI

States/Provinces: Saipan

ELEMENT SOURCES

American Memorial Park Plots: AMME.0005

Local Description Authors: G. Kittel

Version Date: May 28, 2010

Royal Poinciana / Mother-in-law's Tongue Ruderal Woodland [Park Special]

Delonix regia / *Sansevieria trifasciata* Ruderal Woodland [Park Special]

Identifier: CEPS009542

rUSNVC CLASSIFICATION

Formation Tropical Wooded Scrub & Herb Coastal Vegetation (2.A.3)
Division Polynesian Wooded Scrub & Herb Coastal Vegetation (2.A.3.b)
Macrogroup Micronesian Wooded Scrub & Herb Coastal Vegetation (MG233)
Group Micronesian Coastal Strand Group (G607)
Association (Local name) Royal Poinciana / Mother-in-law's Tongue Ruderal Woodland [Park Special]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland or Palustrine

American Memorial Park Environment: This open woodland was sampled once on a flat area known as strand with sandy soils not far from the coastline.

VEGETATION DESCRIPTION

American Memorial Park Vegetation: This open woodland is dominated by royal poinciana (*Delonix regia*) with up to 20% cover, and other trees present including gagu (*Casuarina equisetifolia*)(5%). Tangan-tangan (*Leucaena leucocephala*) may be present with 10% cover, and herbaceous ground cover is dominated by mother-in-law's tongue (*Sansevieria trifasciata*)(60%). This vegetation type is unusually rich for a strand woodland.

MOST ABUNDANT SPECIES

American Memorial Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Canopy Tree	Broad-leaved deciduous	royal poinciana
Forb	Perennial forb	mother-in-law's tongue

ELEMENT DISTRIBUTION

Range: Currently known only from American Memorial Park

Nation(s): CNMI

States/Provinces: Saipan

ELEMENT SOURCES

American Memorial Park Plots: AMME.0908

Local Description Authors: G. Kittel

Version Date: May 28, 2010

G608. Micronesian Herbaceous Coastal Vegetation Group

Fufgu Herbaceous Vegetation [Provisional]

***Ipomoea indica* Herbaceous Vegetation [Provisional]**

Identifier: CEG008122

rUSNVC CLASSIFICATION

Formation Tropical Wooded Scrub & Herb Coastal Vegetation (2.A.3)
Division Polynesian Wooded Scrub & Herb Coastal Vegetation (2.A.3.b)
Macrogroup Micronesian Wooded Scrub & Herb Coastal Vegetation (MG233)
Group Micronesian Herbaceous Coastal Vegetation Group (G608)
Association (Local name) Fufgu Herbaceous Vegetation [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

American Memorial Park Environment: This herbaceous association was sampled twice on flat and disturbed ground, in one case an old landfill. The soils consist of moist loam.

VEGETATION DESCRIPTION

American Memorial Park Vegetation: This herbaceous association is dominated by non-native vines, and has high graminoid cover. The vegetation appears to be secondary growth on disturbed ground. The vine fufgu (*Ipomoea indica*) is the dominant forb with about 60% cover; climbing hempvine (*Mikania scandens*) may also be present with up to 20% cover. Abundant graminoid species may include napier grass (*Pennisetum purpureum*) with 30% cover.

MOST ABUNDANT SPECIES

American Memorial Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Forb	Perennial forb	fufgu
		climbing hempvine

CHARACTERISTIC SPECIES

American Memorial Park: fufgu, climbing hempvine

ELEMENT DISTRIBUTION

Range: Currently known only from American Memorial Park, but likely to be found throughout Polynesian islands.

Nation(s): CNMI

States/Provinces: Saipan

ELEMENT SOURCES

American Memorial Park Plots: AMME.0002, AMME.0906

Local Description Authors: G. Kittel

Version Date: June 2, 2010

MG234. Polynesian Ruderal Scrub & Herb Coastal Strand

G425. Micronesian Ruderal Scrub & Herb Coastal Strand Group

(Mission Grass, Napier Grass) Ruderal Herbaceous Vegetation [Provisional]

Cenchrus (polystachios, purpureus) Ruderal Herbaceous Vegetation [Provisional]Identifier: CEG008123

rUSNVC CLASSIFICATION

Formation Tropical Wooded Scrub & Herb Coastal Vegetation (2.A.3)

Division Polynesian Wooded Scrub & Herb Coastal Vegetation (2.A.3.b)

Macrogroup Polynesian Ruderal Scrub & Herb Coastal Strand (MG234)

Group Micronesian Ruderal Scrub & Herb Coastal Strand Group (G425)

Association (Local name) (Mission Grass, Napier Grass) Ruderal Herbaceous Vegetation [Provisional]

ENVIRONMENTAL DESCRIPTION**USFWS Wetland System:** Upland / Palustrine

American Memorial Park Environment: This association was only sampled once in a grassland. It occurred on a flat, low-lying, moist area, which appeared to be a wetland based on the field notes.

VEGETATION DESCRIPTION

American Memorial Park Vegetation: This grassland is dominated (90% cover) by the non-native napier grass (*Cenchrus purpureus*) with two non-native vines also present: fufgu (*Ipomoea indica*) and climbing hempvine (*Mikania scandens*) with 6% and 4% cover, respectively.

MOST ABUNDANT SPECIES**American Memorial Park**Stratum

Graminoid

Lifeform

Perennial

Species

napier grass

CHARACTERISTIC SPECIES**American Memorial Park:** napier grass**ELEMENT DISTRIBUTION****Range:** Currently known only from American Memorial Park**Nation(s):** CNMI**States/Provinces:** Saipan**ELEMENT SOURCES****American Memorial Park Plots:** AMME.0901**Local Description Authors:** G. Kittel**Version Date:** June 2, 2010

8.1.A. Developed (Close-Cropped) Vegetation

8.1.A.1. Lawn

***M491* Temperate and Tropical Lawn**

G622 Cool Season, Warm Season, Dry Season Lawn

Australian Beardgrass - Inifuk Lawn [Provisional]

Bothriochloa bladhii - *Chrysopogon aciculatus* Lawn [Provisional]

Identifier: CEG008124

rUSNVC CLASSIFICATION

Formation Developed (Close Cropped) (8.1.A)
Division Lawn (8.1.A.1)
Macrogroup Temperate and Tropical Lawn (M491)
Group Cool Season, Warm Season, Dry Season Lawn (G622)
Association (Local name) (Mission Grass, Napier Grass) Ruderal Herbaceous Vegetation [Provisional]

ENVIRONMENTAL DESCRIPTION

USFWS Wetland System: Upland

American Memorial Park Environment: This grassland was sampled five times in the park. It grows on level ground and is regularly mowed. The bedrock consists of limestone, and soil ranges from loam to sand.

VEGETATION DESCRIPTION

American Memorial Park Vegetation: This association is a mix of introduced grasses, although a few native grasses may be present. It is most likely a product of landscaping. The introduced grass Australian beardgrass (*Bothriochloa bladhii* [= *Dichanthium bladhii*]) is present in every stand. Inifuk (*Chrysopogon aciculatus*) may be a co-dominant or absent. Any of the following introduced grass are usually present, including beach wiregrass (*Dactyloctenium aegyptium*), Hilo grass (*Paspalum conjugatum*), or Bermuda grass (*Cynodon dactylon*), along with a lower abundance of non-native Indian dropseed (*Sporobolus fertilis* [= *S. indicus* var. *major*]) and native grasses such as makila grass (*Zoysia matrella*). A few scattered trees may be present, but these are isolated and peripheral to the lawn area.

MOST ABUNDANT SPECIES

American Memorial Park

<u>Stratum</u>	<u>Lifeform</u>	<u>Species</u>
Graminoid	Perennial	Australian beardgrass
		Hilo grass
		beach wiregrass
		makila grass
		Indian dropseed

CHARACTERISTIC SPECIES

American Memorial Park: Australian beardgrass, Hilo grass, beach wiregrass, makila grass, Indian dropseed

ELEMENT DISTRIBUTION

Range: Currently known from American Memorial Park and War in the Pacific Historic Park

Nation(s): CNMI

States/Provinces: Saipan, Guam

ELEMENT SOURCES

American Memorial Park Plots: AMME.0006, AMME.0010, AMME.0011, AMME.0903, AMME.0909

Local Description Authors: G. Kittel

Version Date: June 2, 2010

8.A.3 Other Developed Urban / Built-Up Vegetation

8.A.3.a Other Urban / Built-Up Vegetation

M492 Temperate & Tropical Planted Landscaping & Gardens

G623 Treed Landscaping

Gagu / Artificial Reef Woodland Stand [Park Special]

Casuarina equisetifolia / Artificial Reef Woodland Stand [Park Special]

Cultural Type

Identifier: CEPS009543

rUSNVC CLASSIFICATION

Formation Other Developed Urban / Built Up Vegetation (8.1.B)

Division Other Urban / Built Up Vegetation (8.1.B.1)

Macrogroup Temperate and Tropical Planted Landscaping & Gardens (M492)

Group Treed Landscaping (G623)

Association (Local name) Gagu / Artificial Reef Woodland Stand [Park Special]

ENVIRONMENTAL DESCRIPTION

American Memorial Park Environment: This narrow strip between the paved parking lot/road and the shoreline was sampled once.

VEGETATION DESCRIPTION

American Memorial Park Vegetation: In the one area sampled, Gagu (*Casuarina equisetifolia*) trees are in a straight line, with the appearance of being planted for landscaping with 35% cover.. A minor shrub component consists of a single species, *Pluchea indica*, present with 10% cover and the herbaceous layer is comprised of *Zoysia matrella* with 50% cover, and appears to have been regularly mowed.

ELEMENT DISTRIBUTION

Range: Currently known only from American Memorial Park

Nation(s): CNMI

States/Provinces: Saipan

ELEMENT SOURCES

American Memorial Park Plots: AMME.0907

Local Description Authors: G. Kittel

Version Date: June 2, 2010

Appendix F: Response to AMME Map Review

No changes were made to the AMME final map based on the 2013 field review. Information generated from this additional field campaign revealed (1) some correct map classes, (2) likely lawn boundaries shifts since 2006, (3) GPS limitations especially when sampling near polygon boundaries, (4) under representation of non-native grasses and vines within CASEQU types, and (5) some spectral challenges in distinguishing between CASEQU and BRUGYM types.

Errors identified during this field review were all previously addressed in the final report as limitations to these map classes. Additional language has now been added to emphasize caution for some map classes and to highlight the need for additional information in the future. The imagery for this project which began in 2009 is from 2006 and therefore it is probable that the vegetation has changed particularly lawn management which may explain some of the discrepancy between the map and the field (e.g. plot 20 or plot 2?). Additionally, the lack of the Wide Area Augmentation System (WAAS) in Saipan yields poor GPS accuracy (up to 20m) and many of the 2013 review points were on or very near polygon boundaries which made interpreting the crew's notes difficult as in all situations there was an adjacent polygon of the suggested vegetation within 1-20m of field point. In several instances, the imagery depicts different vegetation than what is described by the field crews further supporting the likelihood of poor GPS accuracy at AMME.

It is probable that the CASEQU/PLUIND Swamp Forest is over mapped as indicated by the field review and since curiously this type had no accuracy assessment points. Based on the map review, it seems that there should be a CASEQU/vine and CASEQU/PENPUR types in the classification, but do currently not exist. Most of the CASEQU/vine and CASEQU/PENPUR types are mapped as CASEQU/PLUIND swamp forest. Additionally, it appears as though "Swamp Forest" is a poor physiognomic name for the CASEQU/PLUIND type. More classification data would help define this type in the future. Also, it is likely that there is confusion in the map between CASEQU/PLUIND and BRUGYM type due to their similar spectral signatures.

Further details on each review plot and how the field crew's suggestions are addressed and provided below. Review plots are displayed (Figure 1) highlighting the fact that many are on or near polygon boundaries.

Clearly, there are some limitations to this mapping product and these have been explicitly highlighted in the final report products. In 2014, PACN will establish 10 permanent monitoring plots (0.1ha) and six legacy non-native species transects (variable length) within the former mangrove forest (Figure 1). Importantly, these new data should provide the park managers substantially more quantitative data on the current status of this important resource and aid in guiding management.



Figure 12. AMME vegetation map with proposed 2014 vegetation sampling plots and non-native species transects.

Detailed analysis of each map review point collected:

- Map review plots 3 and 19(southend) are mapped correctly.
 - 3 - Field call and map label are CASEQU/PLUIND.
 - 19(southend) - Field call and map label are HIBTIL/ASPNID swamp woodland. Crew notes indicate that they are in an area labeled as CASEQU, however in GIS the point is in the HIBTIL/ASPNID polygon. This is likely due to the poor GIS coverage often with >10m error.
- Map review plot 16 has coordinates out of the park boundary which may indicate the large GPS error common in Saipan.
- Map review plot 20 had a field call of CASEQU/PASSPP woodland while the map label is CASEQU/PLUIND. The field crew gives a good description of the vegetation within the polygon-which matches the adjacent polygon boundaries (maintained lawn, building). It is likely that the lawn is now larger than it was in 2006 when the imagery was taken, but without newer imagery or a specific line for the lawn we are unable to change this polygon. This may also be attributable to GPS error.
- Map review plot 2 suggested a new map label (a forested type rather than a lawn type). However, in the imagery there are no trees (and looks like a lawn) and the notes from the field indicate only a single tree. This mapping product is not designed to map at the scale of single trees and may also represent changing lawn maintenance since 2006.
- Map review plot 19(northend) is mapped as CASEQU/PLUIND and field crew suggests changing it to BRUGYM. Notes say that the area is a matrix of vegetation, and they describe how the polygon should be mapped. However, there are no photos from this revisit due to camera error and with the GPS error it is difficult to determine how much of this polygon if any should change types. The final report does highlight these two types mentioning that they are somewhat difficult to distinguish in the imagery and may be confused within the map.
- 4 map review plots (4, 5, 6, and 17) suggest creating a new vegetation classification (CASEQU over vines or grass). Unfortunately, we are beyond the stage of generating new vegetation classifications or even map units for this product. Additionally, classifications tend to be weighted more heavily by native species resulting in underrepresentation of non-native species as seems to be the case here and has also been an issue in other Pacific Island parks. We did request alternative best-fit suggestions for these plots (8/5/2013) from WAPA/AMME staff but did not receive any response and thus left polygon's as mapped.
 - 4 - Point lies near boundary with other vegetation types. Point is very close to field plot 906 which is labeled Ipomoea type (which is how it is mapped).
 - 5 - Do not see CASEQU in 2006 imagery as the field call suggests. Map label is grass type. Map review point is within 10m of several polygon boundaries (HIBTIL, CASEQU/PLUIND) and difference between review visit and map may

be due to changes in grass since 2006 or GPS error attributed to the lack of WAAS in the area.

- o 6 - Crew suggests this be a CASEQU/vine type which does not occur within our classification. Map label is CASEQU/PLUIND.

Appendix G: Mapping Conventions and Visual Key

American Memorial Park- Map Classes

This appendix describes the map classes for the American Memorial Park (AMME) 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 AMME were based on a combination of NVC 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 AMME 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 woodland types. Each map class is fully described by a variety of characteristics and features. First the NVC 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 2006 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 2008. The sample ground photographs were taken during the 2008 plot data collection or during the 2010 accuracy assessment by National Park Service staff.

Woodlands

Map Code	Mangle Lahi Mangrove Forest
W_BRGY	<i>Bruguiera gymnorrhiza</i> Mangrove Forest

Common Species

Mangle lahi (*Bruguiera gymnorrhiza*)
Gagu (*Casuarina equisetifolia*)
Hau (*Hibiscus tiliaceus*)
Langayao (*Acrostichum aureum*)
Climbing bird's nest fern (*Microsorium punctatum*)

NVC Association

-*Bruguiera gymnorrhiza* Mangrove Forest
[Provisional]

Representative Ground Photo



Description

Stands of mangle lahi were found at AMME in the central mangrove swamp area, marshes, and along the northeast coastal strand. In these areas the mangle lahi trees were intermixed with other common trees like hau and gagu forming thick forests. On the Quickbird imagery the mangle lahi trees had a characteristic, bright pink clumped appearance that contrasted with the darker foliage of the gagu trees. Due to their close proximity and similar appearance stands of this type were likely confused with hau and other deciduous, broad-leaf trees and some confusion likely occurred between them during the mapping. More ground-truthing and mapping on the ground would likely help refine the delineation of the mangle lahi association at AMME.

Range and Distribution

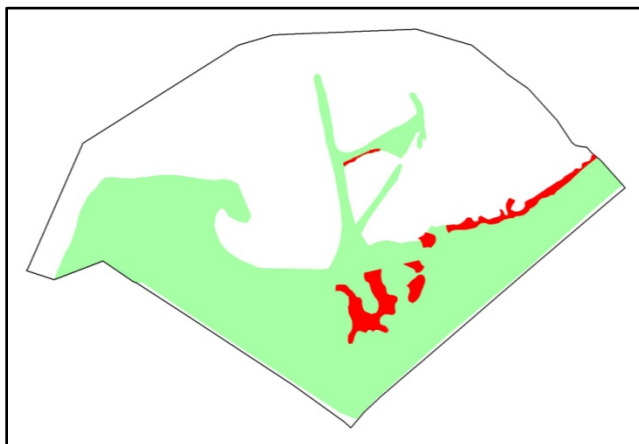
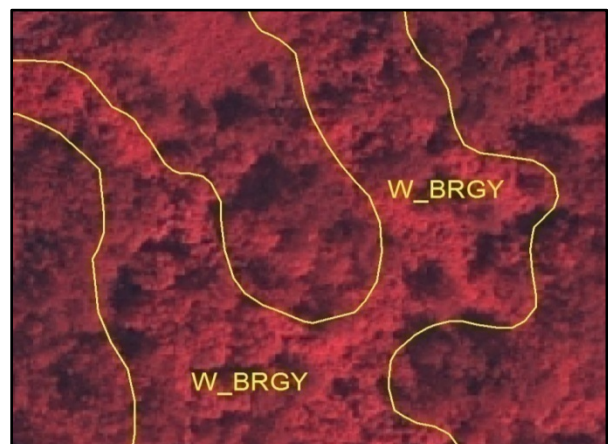


Photo Signature Example



Map Code	Gagu / Artificial Reef Woodland
W_CAAR	<i>Casuarina equisetifolia</i> / Artificial Reef Woodland

Common Species

Gagu (*Casuarina equisetifolia*)
Mangle lahi (*Bruguiera gymnorrhiza*)
Milo (*Thespesia populnea*)
Beach wiregrass (*Dactyloctenium aegyptium*)
Royal poinciana (*Delonix regia*)
Inifuk (*Chrysopogon aciculatus*)

NVC Association

-*Casuarina equisetifolia* / Artificial Reef Woodland
[Park Special]

Representative Ground Photo



Description

Evergreen gagu trees were very common at AMME and occurred in various settings ranging from coastal strand to manicured uplands. This map class was used when gagu was established on new coastal reefs and reclaimed ocean lands. The W_CAAR map class reflects both the dominant tree species and the habitat that it is growing on. W_CAAR was found exclusively along the shoreline extending into the Pacific Ocean along both sides of the harbor road and on small islands in the bay. Understories ranged from robust with short trees, tall shrubs and mixed herbaceous vegetation along the margins to almost barren in the interior. The gagu trees in this map class exhibited a consistent dark red color on the Quickbird imagery due to its evergreen physiogomy. Canopies for this type were mostly closed and had a mottled appearance. Since gagu was mapped using four different map classes much overlap likely exists and some confusion may have occurred during the mapping of this type at AMME.

Range and Distribution

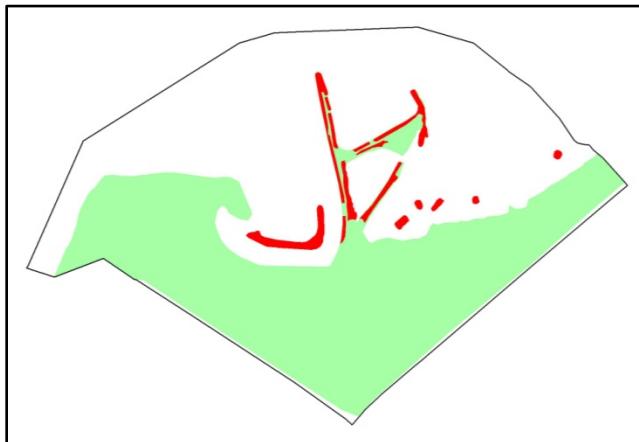
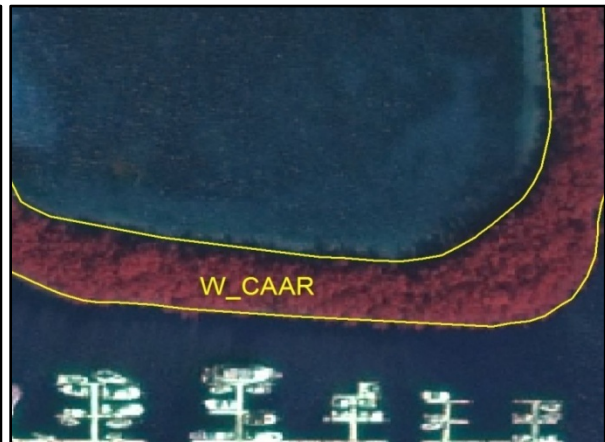


Photo Signature Example



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

Common Species

Gagu (*Casuarina equisetifolia*)
 Australian beardgrass (*Bothriochloa bladhii*)
 Inifuk (*Chrysopogon aciculatus*)
 Tropical fimbry (*Fimbristylis cymosa*)
 Mexican fireplant (*Euphorbia heterophylla*)
 Yervas babui (*Ruellia blechum*)
 Pacific Island thintail (*Lepturus repens*)
 Ivy gourd (*Coccinia grandis*)
 Papaya (*Carica papaya*)
 Hilo grass (*Paspalum conjugatum*)

NVC Association

-*Casuarina equisetifolia* Woodland [Provisional]

Representative Ground Photo



Description

The W_CAEQ woodland map class was used for coastal strand areas of gagu occurring primarily in the northwest corner of park on flat ground next to the Pacific Ocean. In this location the gagu trees were medium 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 stands of gagu trees from the other gagu map classes that occurred on artificial reef, in the mangrove swamp, and as open woodlands in the picnic grounds. The gagu trees in this map class exhibited a dark red 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 four different map classes much overlap likely exists and some confusion may have occurred during the mapping of this type at AMME.

Range and Distribution

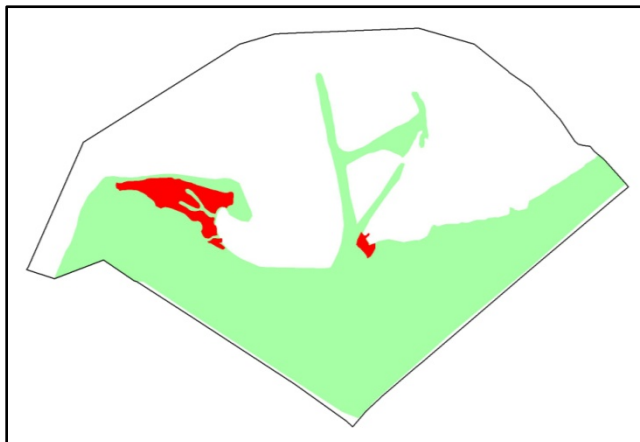
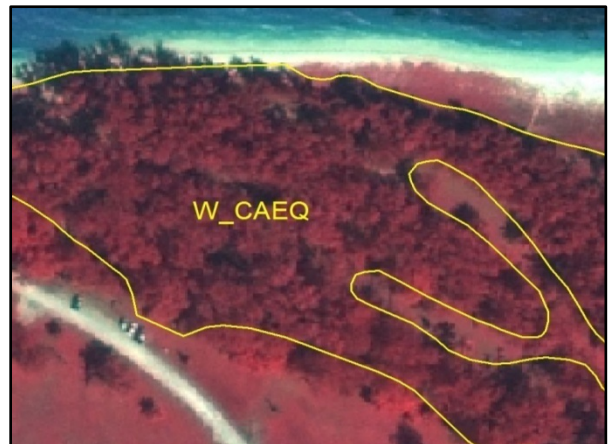


Photo Signature Example



Map Code	Gagu / Paspalum Wooded Herbaceous Vegetation
W_CAPA	<i>Casuarina equisetifolia</i> / <i>Paspalum</i> spp. Wooded Herbaceous Vegetation

Common Species

Gagu (*Casuarina equisetifolia*)
 Australian beardgrass (*Bothriochloa bladhii*)
 Hilo grass (*Paspalum conjugatum*)
 Alalag-tasi (*Ipomoea pes-caprae*)

NVC Association

-*Casuarina equisetifolia* / *Paspalum* spp. Wooded Herbaceous Vegetation [Park Special]

Representative Ground Photo



Description

Mature gagu trees were found throughout AMME occurring in open settings around the picnic area and along the various trails and roads that intersect the park. In these locations the open nature of the canopy allows for the establishment of thick, manicured lawn-like understories of various grass species. The W_CAPA map class was used to distinguish stands of tall gagu trees with grass understories from the other gagu map classes that occurred on artificial reef, in the mangrove swamp, and along the coastal margins. The gagu trees in this map class exhibited a dark red color on the Quickbird imagery due to its evergreen physiogomy. Canopies for this type were open and had a mottled appearance with smooth red undertones (grasses) beneath the trees. Since gagu was mapped using four different map classes much overlap likely exists and some confusion may have occurred during the mapping of this type at AMME.

Range and Distribution

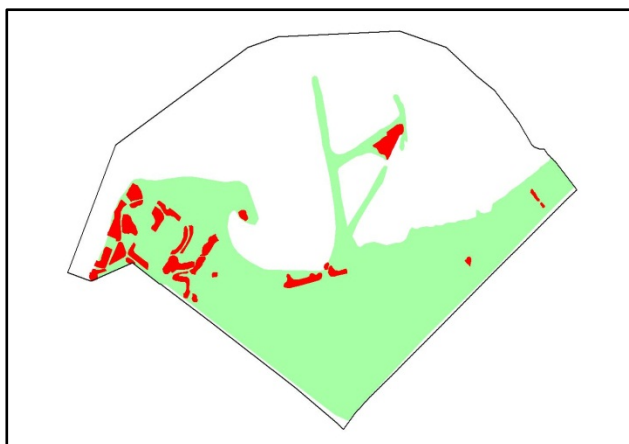


Photo Signature Example



Map Code	Gagu / Indian Pluchea Swamp Forest
W_CAPL	<i>Casuarina equisetifolia</i> / <i>Pluchea indica</i> Swamp Forest

Common Species

Gagu (*Casuarina equisetifolia*)
Hau (*Hibiscus tiliaceus*)
Indian pluchea (*Pluchea indica*)
Tangan-tangan (*Leucaena leucocephala*)
Langayao (*Acrostichum aureum*)
Sourbush (*Pluchea carolinensis*)
Kamachile (*Pithecellobium dulce*)
Pahong (*Pandanus dubius*)
Yerbas babui (*Ruellia blechum*)
Climbing hempvine (*Mikania scandens*)
Corky passionflower (*Passiflora suberosa*)
Hodda (*Ficus tinctoria*)
Mangle lahi (*Bruguiera gymnorrhiza*)

Representative Ground Photo



NVC Association

-*Casuarina equisetifolia* / *Pluchea indica* Swamp Forest [Park Special]

Description

Gagu forests with Indian pluchea understories were common in the central mangrove swamp area at AMME. In the mesic swamp the gagu trees were large and contained lush understories with climbing vines. Other tree species (especially hau and mangle lahi) intermixed and intertwined with this map class forming mixed and multi-strata stands of lush, jungle-like vegetation. The W_CAPL map class was used to distinguish stands of tall gagu trees in the swamp and marsh area from the other gagu map classes that occurred on artificial reef, in the open picnic area, and along the coastal margins. The gagu trees in this map class exhibited a dark red color on the Quickbird imagery due to its evergreen physiogomy. Canopies for this type were open and had a mottled appearance with coarse red undertones (multi-strata vegetation) beneath the trees. Due to their close proximity and intermixing, stands of this type were likely confused with the hau and mangle lahi map classes. More ground-truthing and mapping on the ground would likely help refine this map class and the other mesic types at AMME.

Range and Distribution

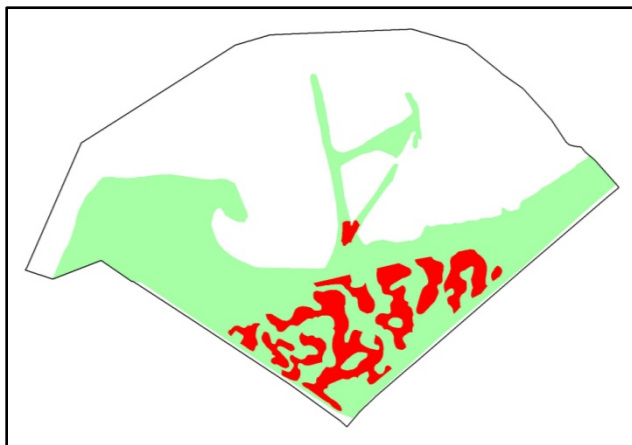
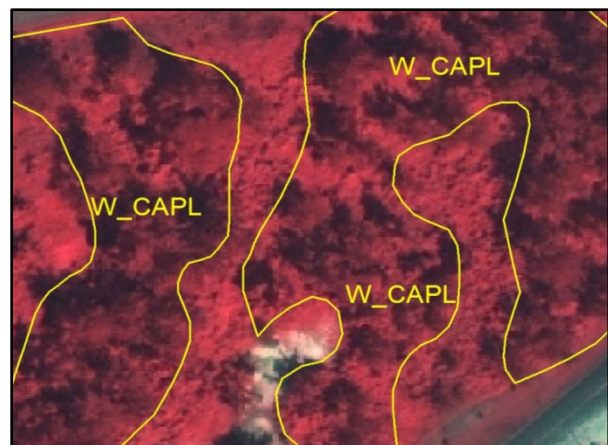


Photo Signature Example



Map Code	Tronkon niyok Stand Wooded Scrub
W_COCS	<i>Cocos nucifera</i> Stand Wooded Scrub

Common Species

Tronkon niyok (*Cocos nucifera*)
 Gagu (*Casuarina equisetifolia*)
 Australian beardgrass (*Bothriochloa bladhii*)
 Hilo grass (*Paspalum conjugatum*)
 Alalag-tasi (*Ipomoea pes-caprae*)

NVC Association

- No Association – Unclassified Map Class

Representative Ground Photo



Description

Stands of tronkon niyok were rare at AMME and primarily occurred in the northwest corner along the beach and coastal strand adjacent to the Mircobeach Road and associated development south of the park boundary. Other individual tronkon niyok trees likely occur at AMME but were mapped as part of the Ruderal Lawn / Ornamental Trees map class. Tronkon niyok trees at AMME were probably planted at one time and/or are descendants of ones planted by early island inhabitants. On the Quickbird imagery the tronkon niyok had a characteristic, dark red fan appearance due to their sparse canopy and the spreading of their fronds. The W_COCS type occurred in close proximity to the W_CAPA map class and some mixing of gagu with the tronkon niyok trees likely occurred leading to some confusion in the mapping.

Range and Distribution

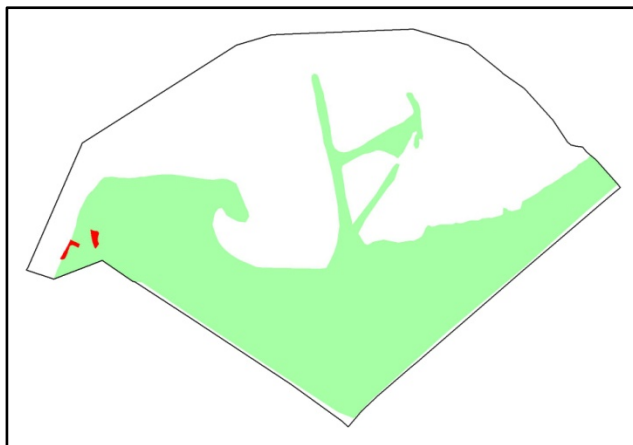
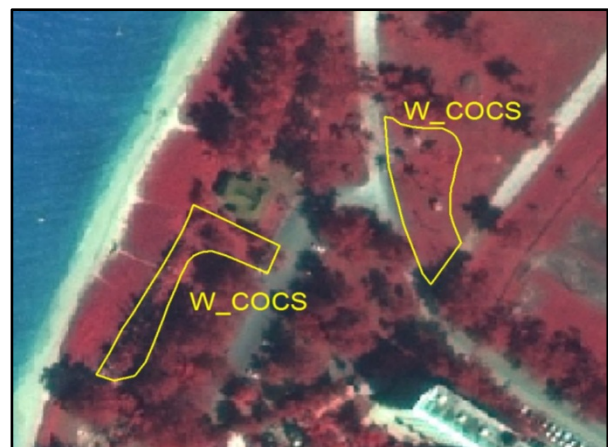


Photo Signature Example



Map Code	Royal Poinciana / Mother-in-law's Tongue Ruderal Woodland
W_DERE	<i>Delonix regia</i> / <i>Sansevieria trifasciata</i> Ruderal Woodland

Representative Ground Photo

Common Species

Royal poinciana (*Delonix regia*)
 Scaly swordfern (*Nephrolepis hirsutula*)
 Mother-in-law's tongue (*Sansevieria trifasciata*)
 Tangan-tangan (*Leucaena leucocephala*)
 Gagu (*Casuarina equisetifolia*)
 Nonag (*Hernandia sonora*)



NVC Association

-*Delonix regia* / *Sansevieria trifasciata* Ruderal Woodland

Description

The royal poinciana with mother-in-law's tongue woodland map class was added to the AMME vegetation mapping classification after the accuracy assessment field work. Prior to the accuracy assessment this map class was included in the tangan-tangan shrub map class but further analysis of the imagery allowed for the separation of these two map classes. The three polygons of this type were located primarily along the coastal areas in the northeast and along the margins of the mangrove swamp area. Trees of this type were short in stature containing a sporadic understory of various herbaceous species. Royal poinciana trees often intermixed with nonag and gagu trees and tangan-tangan shrubs and some confusion likely exists in the mapping of these types at AMME. On the color infrared imagery trees of the W_DERE map class had a characteristic dark red signature consisting of puffy clumps (tree canopies) and pink to light red undertones representing the understory species.

Range and Distribution

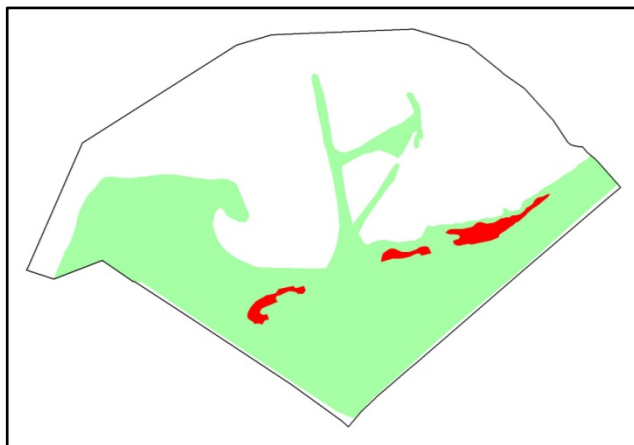


Photo Signature Example



Map Code	Nonag/ Mangle Lahi Forest
W_HESO	<i>Hernandia sonora</i> / <i>Bruguiera gymnorrhiza</i> Forest

Common Species

Nonag (*Hernandia sonora*)
 Mangle lahi (*Bruguiera gymnorrhiza*)
 Royal poinciana (*Delonix regia*)
 Scaly swordfern (*Nephrolepis hirsutula*)
 Mother-in-law's tongue (*Sansevieria trifasciata*)
 Tangan-tangan (*Leucaena leucocephala*)
 Gagu (*Casuarina equisetifolia*)

NVC Association

-No Association – Unclassified Map Class

Representative Ground Photo



Description

The nonag with mangle lahi map class was added to the AMME vegetation mapping classification after the accuracy assessment field work. Prior to the accuracy assessment the W_HESO map class was included in the W_BRGY 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 along the coastal areas in the northeast portion of AMME. Trees of this type were short in stature containing a sporadic understory of various other tree and shrub species. Nonag trees often intermixed with royal poinciana, mangle lahi and gagu trees and with tangan-tangan shrubs and some confusion likely exists in the mapping of these types at AMME. On the color infrared imagery trees of the W_HESO map class had a characteristic mottled red signature with various hues of red ranging from dark to bright pink relating to the intermix of species.

Range and Distribution

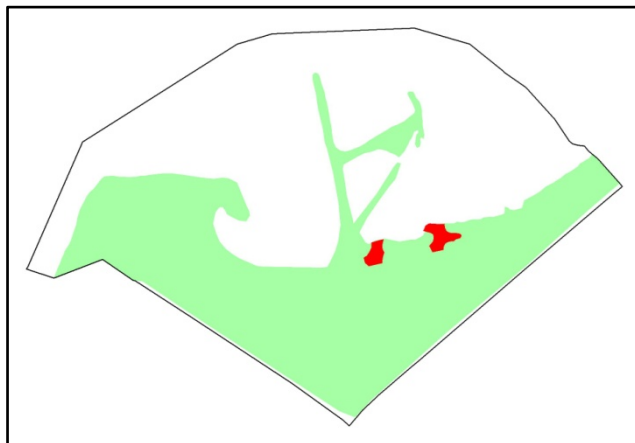


Photo Signature Example



Map Code	Hau / Bird's Nest Fern Swamp Woodland
W_HIAS	<i>Hibiscus tiliaceus</i> / <i>Asplenium nidus</i> Swamp Woodland

Representative Ground Photo

Common Species

Hau (*Hibiscus tiliaceus*)
 Bird's nest fern (*Asplenium nidus*)
 Tronkon niyok (*Cocos nucifera*)
 Gasoso (*Colubrina asiatica*)
 Langayao (*Acrostichum aureum*)
 Gagu (*Casuarina equisetifolia*)
 Yervas babui (*Ruellia blechum*)
 Indian pluchea (*Pluchea indica*)
 Crab's eye (*Abrus precatorius*)

NVC Association

-*Hibiscus tiliaceus* / *Asplenium nidus* Swamp Woodland



Description

Hau was a common species in the coastal and central swamp/ marsh portions of AMME. Stands of this type tended to have dense cover and occur in multi-layer canopies with thick to moderate cover of bird's nest fern and various non-native forbs in the understory. This type intermixed with the gagu and mangle lahi woodlands and some confusion between these types may have occurred. On the color infrared imagery trees of this type had a coarse, pink to light red signature color. More ground-truthing and mapping on the ground would likely help refine the delineation of the hau from the mangle lahi association at AMME.

Range and Distribution

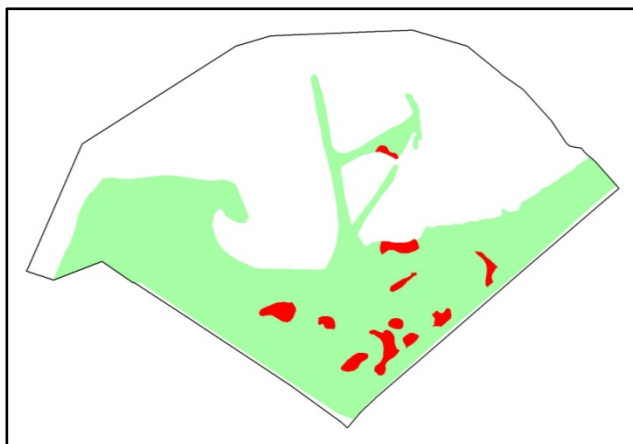
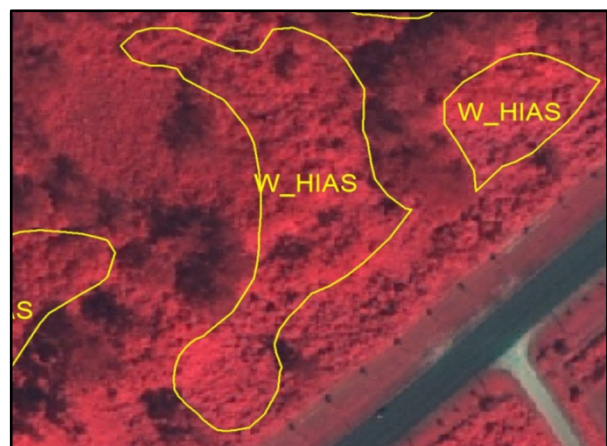


Photo Signature Example



Map Code	Kamachile Semi-natural Woodland
W_PIDU	<i>Pithecellobium dulce</i> Semi-natural Woodland

Common Species

Kamachile (*Pithecellobium dulce*)
 Gagu (*Casuarina equisetifolia*)
 Australian beardgrass (*Bothriochloa bladhii*)
 Inifuk (*Chrysopogon aciculatus*)

NVC Association

Pithecellobium dulce Semi-natural Woodland
 [Park Special]

Representative Ground Photo



Description

Kamachile trees occurred as a minor component to the gagu and hau map classes and an attempt was made to split this short statured tree class out during the mapping at AMME. Two areas north of the picnic grounds were identified as likely candidates based on plot data collection comments. In this location, short deciduous trees were found growing in the margins of the larger gagu coastal woodlands. Since no accuracy assessment data was collected at these polygons it is unknown if the trees are actually kamachile. More ground-truthing efforts are needed to verify these trees and determine if the W_PIDU is a vaild class at AMME. If not, another more appropriate species name could be inserted in this map class name. However, kamachile trees were verified in the swamp/marsh areas at AMME growing in the understory of hau and gagu map classes and more ground-truthing in this mesic area may allow for the expansion of this type in the future.

Range and Distribution

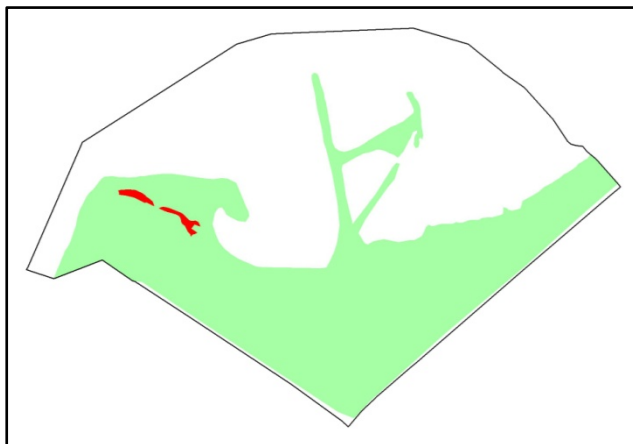


Photo Signature Example



Map Code **Ruderal Lawn / Ornamental Trees**
W_RUOR

Common Species

Tronkon niyok (*Cocos nucifera*)
Gagu (*Casuarina equisetifolia*)
Kamachile (*Pithecellobium dulce*)
Peregrina (*Jatropha integerrima*)
Lada (*Morinda citrifolia*)
Da'ok (*Calophyllum inophyllum*)
Seagrape (*Coccoloba uvifera*)
African tulip tree (*Spathodea campanulata*)
Royal poinciana (*Delonix regia*)
Australian beardgrass (*Bothriochloa bladhii*)
Inifuk (*Chrysopogon aciculatus*)

NVC Association

- No Association – Unclassified Map Class

Representative Ground Photo



Description

Various species of trees were planted over the years at AMME in the picnic grounds, along trails, and around the monuments/memorials. Common species include: tronkon niyok, gagu, African tulip tree, royal poinciana, and da'ok with various lawn grasses in the understory. This catch-all category was used to help separate landscaped areas with trees from the open lawn areas. The trees in this map class exhibited a range of signatures related to sparse canopies or single large, spreading trees. Most of the canopies appeared as dark red stipples on a smooth red background (lawn) 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

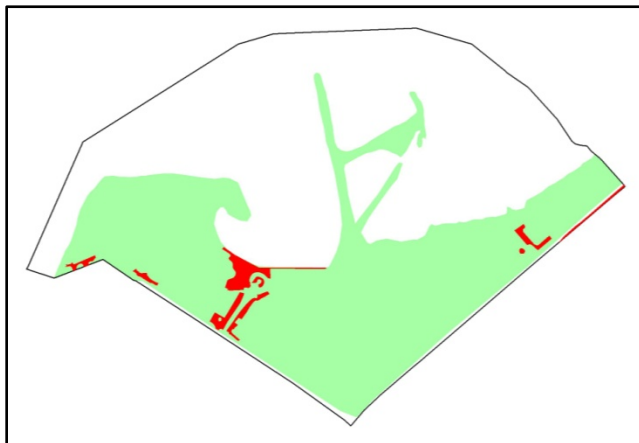
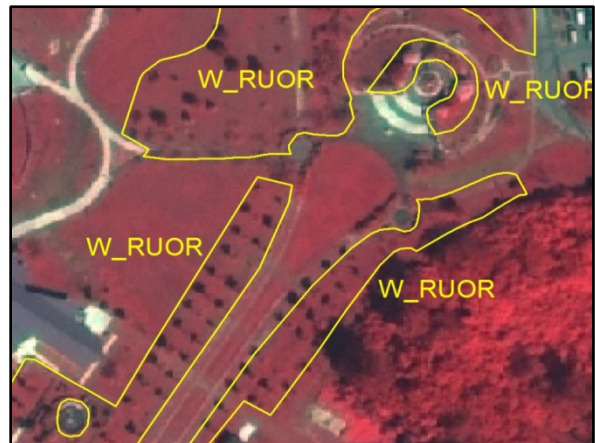


Photo Signature Example



Shrublands

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

Common Species

Tangan-tangan (*Leucaena leucocephala*)
Nonag (*Hernandia sonora*)
Mangle lahi (*Bruguiera gymnorrhiza*)
Royal poinciana (*Delonix regia*)
Gagu (*Casuarina equisetifolia*)

NVC Association

-*Leucaena leucocephala* Lowland Dry Semi-natural Shrubland

Representative Ground Photo



Description

Tangan-tangan shrublands were rare at AMME, only occurring as mappable stands near the margins of the central mangrove swamp/marsh area. In the two polygons mapped as S_LELE the tangan-tangan shrubs formed thick stands with an average height of about 2 - 3 meters. The S_LELE polygons were usually surrounded by stands of hau and gagu and likely represent disturbance gradients or ecotones. Other areas of AMME likely contain tangan-tangan and more ground-truthing may allow for other small polygons of this type to be delineated in the future. On the Quickbird imagery this map class had a characteristic smooth, red signature that contrasted with the dark red gagu and bright pink hau signatures.

Range and Distribution

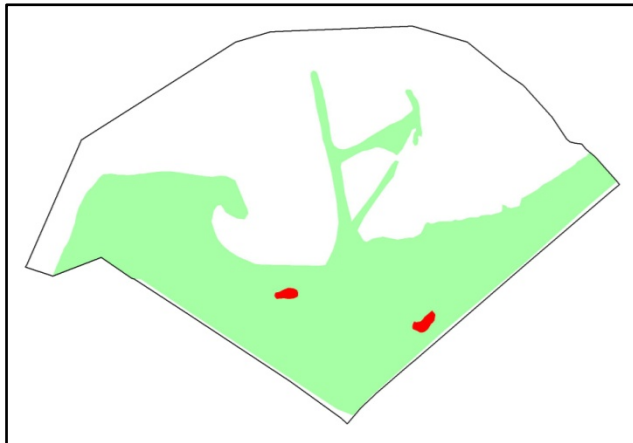


Photo Signature Example



Herbaceous Vegetation

Map Code	Langayao - Fern Open Wetland Herbaceous Vegetation
H_ACRO	<i>Acrostichum aureum</i> - <i>Microsorium</i> spp. Open Wetland Herbaceous Veg.

Common Species

Langayao (*Acrostichum aureum*)
Fern (*Microsorium* spp.)
Bird's nest fern (*Asplenium nidus*)
Limeberry (*Triphasia trifolia*)
Corky passionflower (*Passiflora suberosa*)
Gasoso (*Colubrina asiatica*)
Crab's eye (*Abrus precatorius*)
Yerbas babui (*Ruellia blechum*)
Rabbit foot fern (*Davallia solida*)
Indian pluchea (*Pluchea indica*)

NVC Association

- No Association – Unclassified Map Class

Representative Ground Photo



Description

The langayao with ferns map class was added to the AMME classification based on accuracy assessment efforts. Most of this map class was found in two polygons located in the center of the mangrove swamp/marsh in central AMME. In this location, short herbaceous vegetation was found growing on very mesic soils with some standing water. Thick forests of gagu and hau framed these polygons and the presence of water may have prevented these trees from growing at these sites. On the Quickbird imagery this map class had a characteristic smooth, red signature that contrasted with the dark red gagu and bright pink hau signatures. More ground-truthing and updating of this type should occur in the future to better inventory this rare type.

Range and Distribution

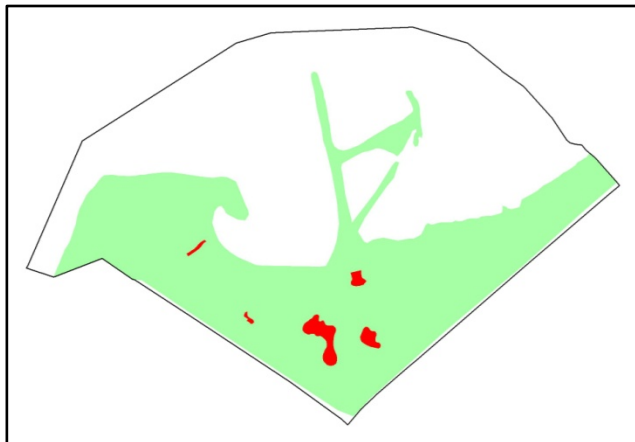
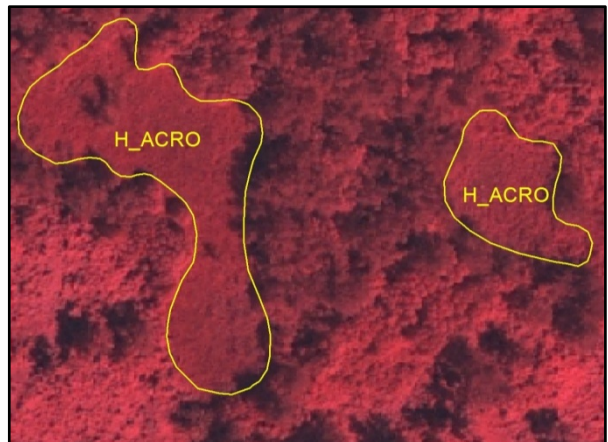


Photo Signature Example



Map Code	Mission Grass – Napier Grass Ruderal Herbaceous Vegetation
H_CENC	<i>Cenchrus (polystachios, purpureus)</i> Ruderal Herbaceous Vegetation¹

Common Species

Mission grass (*Cenchrus polystachios*)
 Napier grass (*Cenchrus purpureus*)
 Climbing hempvine (*Mikania scandens*)
 Fugfu (*Ipomoea indica*)
 Noni (*Morinda citrifolia*)

NVC Association

- *Pennisetum (polystachion, purpureum)* Ruderal
 Herbaceous Vegetation [Provisional]

Representative Ground Photo



Description

Mission grass and Napier grass were two grass species found in a couple of locations near the central mangrove swamp/marsh at AMME. In these semi-mesic locations the grasses were taller than the nearby manicured lawns and occurred both in the understory of the nearby forest and woodlands and in some of the larger canopy openings. At AMME this map unit was lush and low-growing, traits that translated into a smooth, 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_ARCO and the H_IPIN map units during the mapping.

Range and Distribution

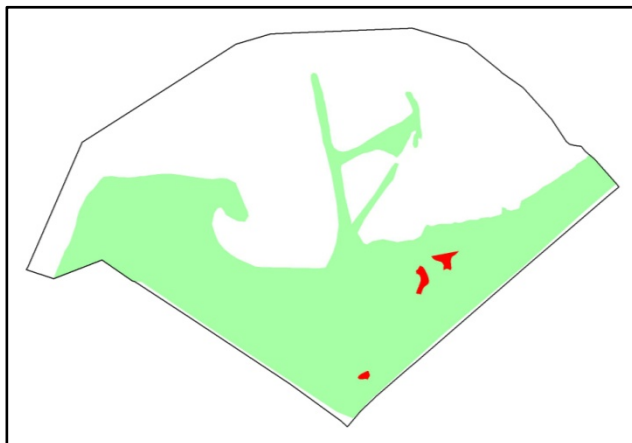
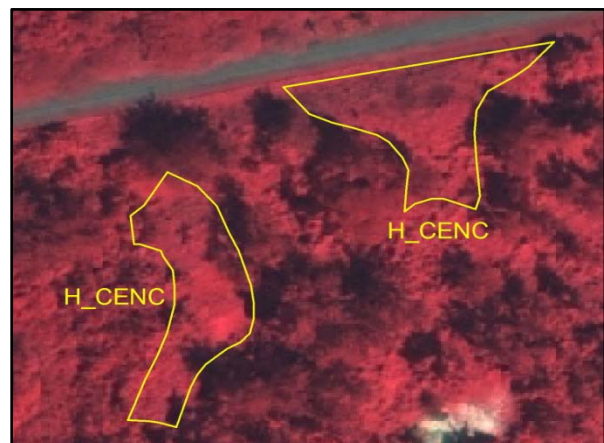


Photo Signature Example



Map Code	Fufgu Herbaceous Vegetation
H_IPIN	<i>Ipomoea indica</i> Herbaceous Vegetation

Common Species

Fufgu (*Ipomoea indica*)
 Scaly swordfern (*Nephrolepis hirsutula*)
 Guinea grass (*Urochloa maxima*)
 Tangan-tangan (*Leucaena leucocephala*)
 Romerillo (*Bidens alba*)
 Napier grass (*Cenchrus purpureus*)
 Lantana (*Lantana camara*)
 Lada (*Morinda citrifolia*)
 Climbing hempvine (*Mikania scandens*)
 Bittermelon (*Momordica charantia*)

NVC Association

- *Ipomoea indica* Herbaceous Vegetation

Description

Fufgu is a climbing vine found throughout the mangrove swamp/marsh area of central AMME. Fufgu was found growing on the ground, over shrubs, and on trees. The various strata and species that fufgu can grow on made it challenging to map and describe accurately. For AMME, sites were only mapped as H_IPIN when the vine had greater than 60% cover; otherwise they were mapped based on the dominant underlying trees and shrubs. The lush and broad-leaf nature of this species was apparent on the Quickbird imagery as bright pink colors with various textures depending on what the vine was growing on.

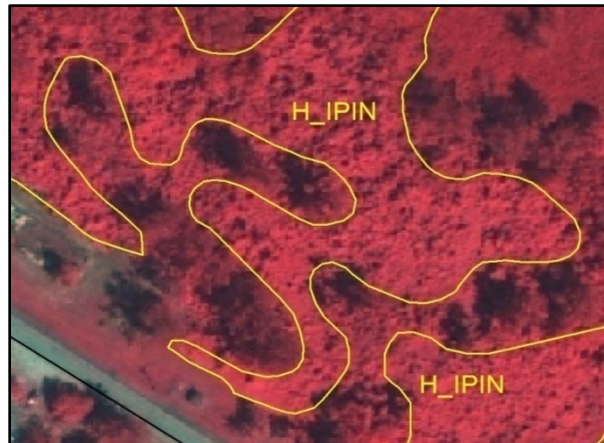
Representative Ground Photo



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*),
Inifuk (*Chrysopogon aciculatus*),
Threeflower ticktrefoil (*Desmodium triflorum*),
White moneywort (*Alysicarpus vaginalis*),
Hilo grass (*Paspalum conjugatum*)

NVC Association

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

Representative Ground Photo



Description

Lawns are common at AMME along trails, in the picnic area, around the memorials/monuments, and surrounding the various park facilities. In addition, manicured coastal areas next to the coastal strand and beaches were included in this map class. 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 AMME. On the Quickbird imagery the H_LAWN map class had a characteristic signature of smooth red colors with pink (forbs) and gray (bare ground) hues. Since this map class was also used to map herbaceous areas along the coastal strand, future ground-truthing work may warrant the addition of a coastal scrub or similar map class for these unique areas.

Range and Distribution

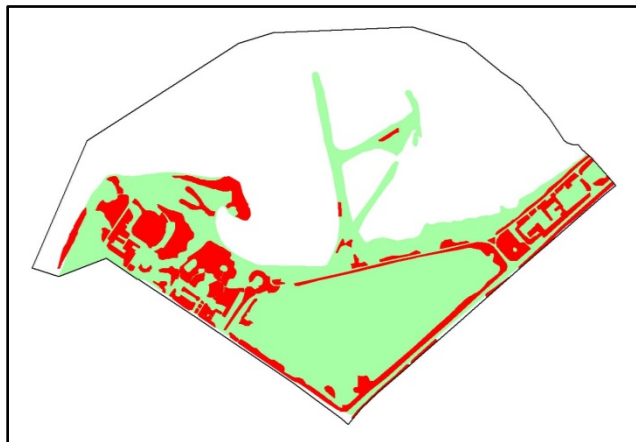
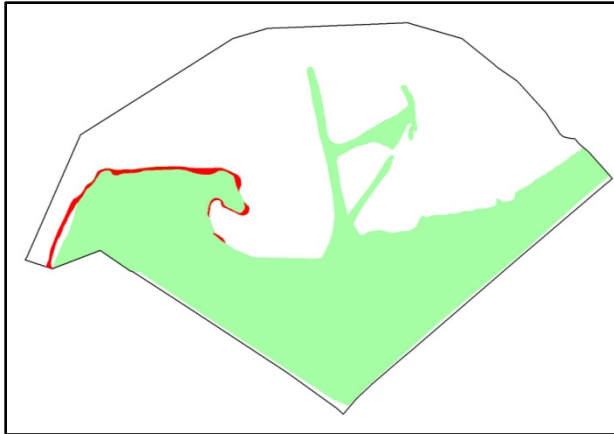


Photo Signature Example



GEOLOGY – BARE GROUND

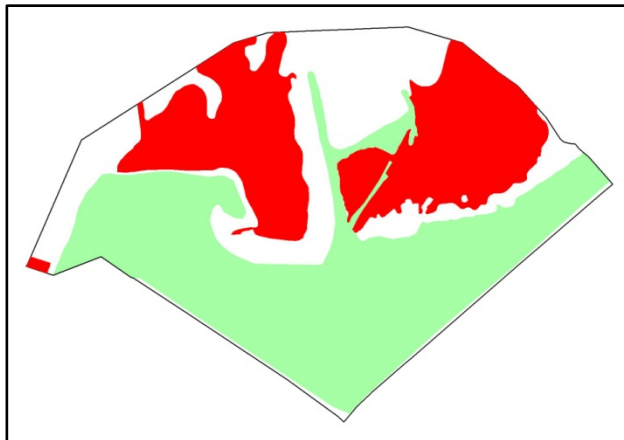
B_BE Beaches



B_SA Submerged Sand and Rock

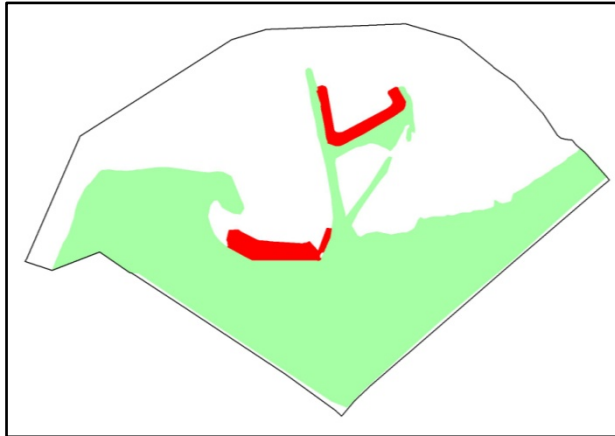


B_ER Exposed Reef and Tidal Pools

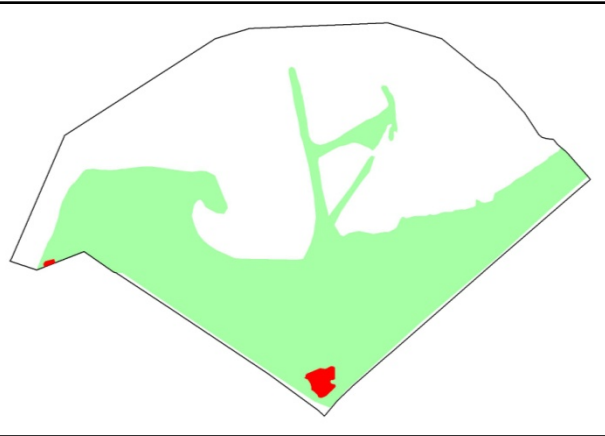


LAND COVER – LAND USE

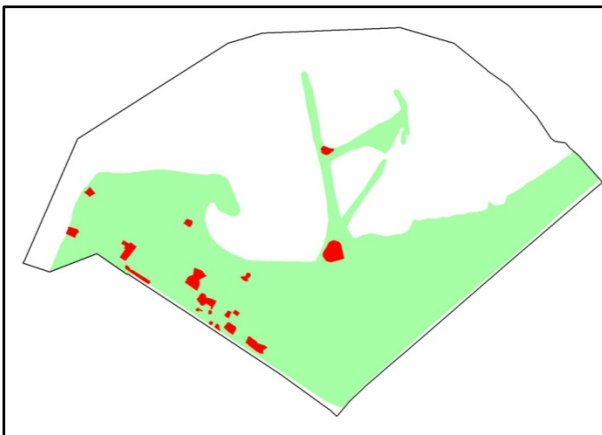
L_BAY Bay / Estuary



L_RECR Entertainment / Recreation



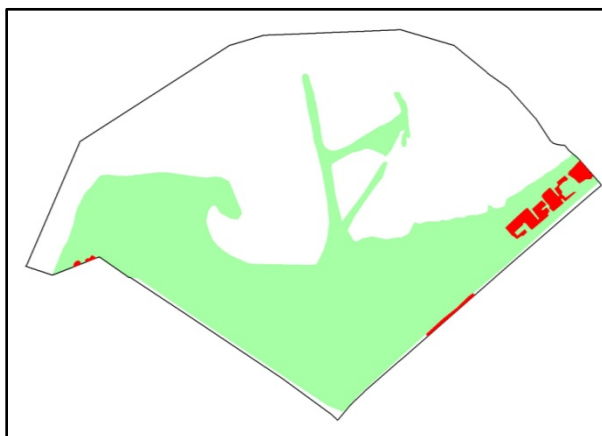
L_FACL Facilities



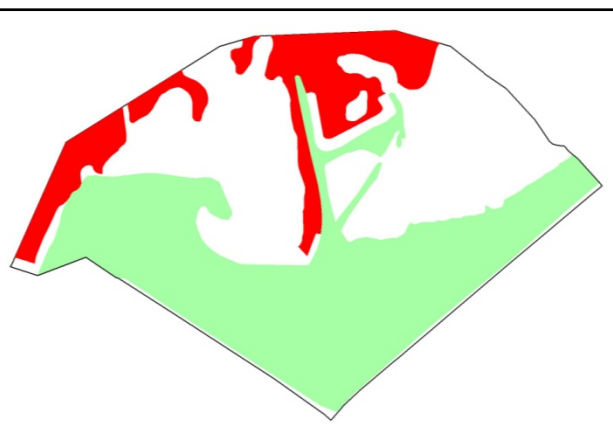
L_ROAD Transportation



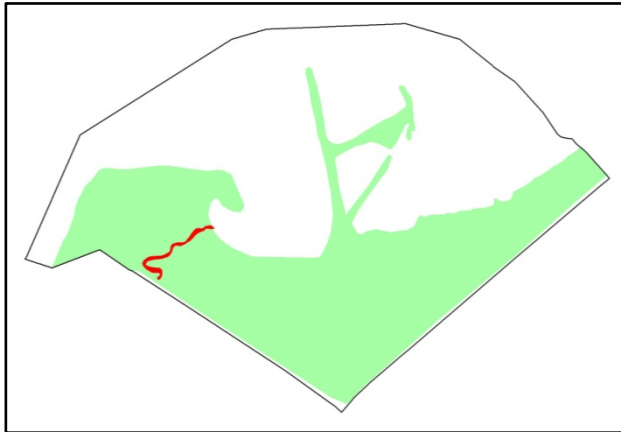
L_LIIN Commercial / Light Industry



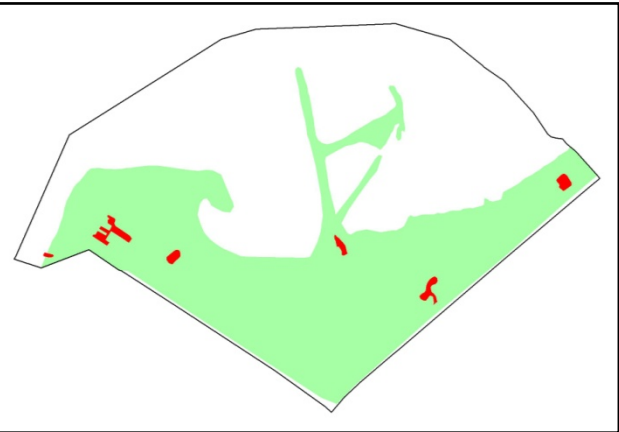
L_SEA Sea / Ocean



L_STRM Stream / River



L_TRAN Transitional



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 483/123174, December 2013

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

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