National Park Service
U.S. Department of the Interior
Natural Resource Stewardship and Science

Natural Resource Condition Assessment

American Memorial Park

Natural Resource Report NPS/AMME/NRR—2019/1976

ON THIS PAGE
A traditional sailing vessel docks in American Memorial Park's Smiling Cove Marina
Photograph by Maria Kottermair 2016

ON THE COVER
American Memorial Park Shoreline and the Saipan Lagoon, looking north to Mañagaha Island.
Photograph by Robbie Greene 2013

Natural Resource Condition Assessment

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Natural Resource Report NPS/AMME/NRR—2019/1976

Robbie Greene[1], Rebecca Skeele Jordan[1], Janelle Chojnacki[1], Terry J. Donaldson[2]

[1] Pacific Coastal Research and Planning
Saipan, Northern Mariana Islands 96950 USA

[2] University of Guam Marine Laboratory
UOG Station, Mangilao, Guam 96923 USA

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

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Executive Summary

The purpose of the Natural Resource Condition Assessment (NRCA) for American Memorial Park (AMP) is to provide park managers and National Park Service (NPS) staff with an accurate and complete compilation of all relevant data, research, findings, and literature related to AMP natural resources. The NRCA provides a broad evaluation of this data and assesses the condition of focal resources within the Park's boundaries and among adjoining areas. The report is intended to assist in identifying priority issues related to the monitoring, maintenance, and conservation of park resources. Data gaps and research needs are acknowledged as part of the assessment, as is an inventory of threats and stressors to park resources, both of which should further assist in delineating future focal points for park management.

This project was completed as a cooperative partnership between American Memorial Park and the University of Guam Marine Laboratory and its project partner, Pacific Coastal and Regional Planning (PCRP). The project was a collaborative effort, with coordination through an NPS point of contact on Guam and assistance from University of Guam Marine Laboratory, NPS staff on Saipan, and a multitude of other local contacts within the CNMI government and natural resource organizations on Saipan. While much of this project consisted of synthesizing existing research and literature, supplemental analyses of specific resources were conducted using publicly available datasets, and local expertise was consulted in areas or subject matter characterized by data gaps.

This report begins with a detailed background on NRCAs, including their purpose and implementation. The document follows with an introduction to American Memorial Park, structured by a discussion of the geographic setting of Saipan, the legislation which created the Park, and the regulatory and land tenure environment of the park. Study design and methods are then detailed in chapter three, including the means of obtaining data, relevant information repositories, and the methods used for classifying resource (component) conditions.

Five resource components were identified to represent the most prominent natural assets within American Memorial Park: mangroves and wetlands, coastal scrub and secondary forest, shore and near-shore environment, developed green space, and hydrological features. For each of these components the NRCA provides an introduction explaining the importance of the resource to the park followed by the means used for measuring the resource, an explanation of reference or baseline conditions for each measure, methods for resource assessment, and a description and graphic depiction of the condition assigned to each component. A discussion chapter concludes the report with a summary of resource condition assessments, a list of threats and stressors, and the identification of data gaps and research needs that could be prioritized in ongoing management and stewardship.

The NRCA for American Memorial Park highlights a park surrounded by rapid changes in the natural, built, and cultural landscape. Shifts in environmental stressors continue to impact the Park at varying temporal scales. Long-term alterations in climate and ocean conditions create uncertainties for future natural resource conditions, while immediate and short-term concerns related to spillover effects from the adjacent urban environment have a more discernable influence.

Extreme weather events such as typhoons continue to impact the Park's resources but remain largely unstudied. This report discusses the impacts of the Category 4 Typhoon Soudelor to the Park after it made a direct hit to Saipan in August 2015. Soudelor caused widespread damage in the Park, felling up to 90% of the trees in some areas. However, little is known about the full impact of the storm on Park resources other than personal observation of NPS staff. This data gap is noted as a research need in this report. Unfortunately, the lack of a full biological assessment after Soudelor means there is a lack of baseline data before other disturbances, such as the Category 5+ Super Typhoon Yutu, which made a direct hit to Saipan and the neighboring island of Tinian on October 24–25, 2018 at the time of the finalization of this report. Super Typhoon Yutu had sustained winds of over 180 mph and devastated Tinian and the southern villages of Saipan. Initial observations from park staff indicate that American Memorial Park suffered moderate damage but was less impacted by Yutu than by Soudelor three years earlier. Most of the mangrove seedlings recently planted in the Park appear to have survived, and most of the trees that withstood Soudelor remain standing. However, the impacts from these storms remain largely unstudied. Because Yutu hit just before this report went to publication, this report does not discuss Yutu other than to again highlight the need for extreme weather event response plans and storm damage assessments in order to better understand the impact that extreme weather events will have on park resources.

American Memorial Park's mangroves and wetlands are among the Park's most notable natural features, providing critical ecosystem services in a stressed area of Saipan. These features were assigned a resource condition score of 'moderate concern', acknowledging declining water quality indicators in some areas as well as widespread presence of invasive species and increasing threats from urban development. Likewise, the shoreline and near-shore resources of AMP were assigned a condition score of 'moderate concern' due to the prevalence of chronic shoreline erosion in some areas, historic loss of park assets due to troubling beach morphology, and the exacerbation of these issues that is expected to accompany rising sea levels.

Conversely, the Park's coastal scrub and secondary forest habitat, as well as recreational green spaces and landscaped areas were assigned assessment scores of 'limited concern', with improving resource conditions. AMP's value as a cultural and recreational asset for both visitors and the local community has been maintained over time, evidenced by land cover transitions from bare or impervious surface to green spaces or landscaped areas, as well as quantifiable increases in secondary forest.

Underlying the condition assessments and trends for the Park's wetlands, forest, open space, and shoreline is an over-arching influence of hydrological processes, both within the park and in the adjoining watershed. The Park's situation in the lowest reaches of Saipan's most threatened drainage means that the health of surface ecological features and the quality of visitor experience are closely tied to the condition of water flowing into, underneath, and out of the Park. While there is limited data and research pertaining to changes in hydrological conditions over time, the impairment of waters that cross park boundaries poses a major challenge and merits additional focus in ongoing management efforts.

In the process of synthesizing information pertaining to these NRCA elements, substantial data gaps were revealed with respect to certain park features. In some cases, this prevented the comprehensive assessment of several natural resource components and placed limitations on the accuracy of other component ratings. In several instances reference conditions or a baseline condition could not be determined and existing data were limited. In turn, trends among resources were not able to be established. These resources were still assessed to the greatest extent possible, albeit with low confidence. These limitations should be kept in mind throughout the NRCA, not just as an overarching caveat, but also as an impetus for enhanced research and monitoring within this small, remote, and constantly changing unit of the National Park Service.

Acknowledgments

The Natural Resource Condition Assessment for American Memorial Park, Saipan would not have been possible without the contributions and expert knowledge of a wide range of individuals and organizations. Given the Park's unique geographic and cultural context and relatively rapid rate of change, a diverse field of input was required with data initiating from multiple scales of government, research emanating from multiple academic institutions, and insight from a variety of local experts.

At the federal level, the U.S. National Park Service, National Oceanic and Atmospheric Administration, U.S. Forest Service, and U.S. Geological Survey all deserve recognition as the stewards of valuable public datasets that enable ongoing assessment of park resources. Staff from these agencies warrant further gratitude for devoting resources to this remote region of the Pacific. Likewise, CNMI government agencies proved indispensable in providing access to locally-relevant literature and ongoing monitoring data. In particular, the CNMI Bureau of Environmental and Coastal Quality and the Historic Preservation Office were critical to the project team's search for elusive reports.

On the island of Saipan, the following individuals served as crucial sources of information in circumstances where data gaps existed or nuanced knowledge was needed: Brooke Nevitt (NPS), Theo Chargualaf (NPS), Nathan Johnson and John Gourley (Micronesian Environmental Services), James Pruitt (CNMI Historic Preservation Office), Ana Agulto, and Kathy Yuknavage (CNMI Bureau of Environmental & Coastal Quality).

Successful project coordination and management is attributed to the hard work of various University of Guam faculty, staff, and student assistants. In particular, Maria Kottermair and the University of Guam Marine Laboratory were instrumental in launching the NRCA and served as a much-needed organizational hub throughout the project.

List of Acronyms

AMP:	American Memorial Park
BECQ:	Bureau of Environmental and Coastal Quality
C-CAP:	Coastal Change Analysis Program
CALM:	Consolidated Assessment and Listing Methodology
CAP:	Conservation Action Plan
CNMI:	Commonwealth of the Northern Mariana Islands
CUC:	Commonwealth Utilities Corporation
DCRM:	Division of Coastal Resources Management
DEQ:	Division of Environmental Quality
DFW:	Division of Fish and Wildlife
DLNR:	Department of Land and Natural Resources
DOD:	Department of Defense
DPS:	Department of Public Safety
DPW:	Department of Public Works
ENSO:	El Niño Southern Oscillation
GMP:	General Management Plan
MPA:	Marine Protected Area
NPS:	National Park Service
NRCA:	Natural Resources Condition Assessment
USACE:	U.S. Army Corps of Engineers
USFS:	U.S. Forest Service
USGS:	U.S. Geological Survey
USFWS:	U.S. Fish and Wildlife Service
VA:	Vulnerability Assessment

Chapter 1. NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks." NRCAs also report on trends in resource condition (when possible), identify critical data gaps, and characterize a general level of confidence for study findings. The resources and indicators emphasized in a given project depend on the park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators, and availability of data and expertise to assess current conditions for a variety of potential study resources and indicators.

> ***NRCAs Strive to Provide…***
>
> - *Credible condition reporting for a subset of important park natural resources and indicators*
> - *Useful condition summaries by broader resource categories or topics, and by park areas*

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement, not replace, traditional issue-and threat-based resource assessments. As distinguishing characteristics, all NRCAs

- Are multi-disciplinary in scope;[1]
- Employ hierarchical indicator frameworks;[2]
- Identify or develop reference conditions/values for comparison against current conditions;[3]
- Emphasize spatial evaluation of conditions and Geographic Information System (GIS) products;[4]
- Summarize key findings by park areas;[5] and
- Follow national NRCA guidelines and standards for study design and reporting products.

Although the primary objective of NRCAs is to report on current conditions relative to logical forms of reference conditions and values, NRCAs also report on trends, when appropriate (i.e., when the underlying data and methods support such reporting), as well as influences on resource conditions. These influences may include past activities or conditions that provide a helpful context for

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[1] The breadth of natural resources and number/type of indicators evaluated will vary by park.

[2] Frameworks help guide a multi-disciplinary selection of indicators and subsequent "roll up" and reporting of data for measures ⇨ conditions for indicators ⇨ condition summaries by broader topics and park areas

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-up response (e.g., ecological thresholds or management "triggers").

[4] As possible and appropriate, NRCAs describe condition gradients or differences across a park for important natural resources and study indicators through a set of GIS coverages and map products.

[5] In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on an area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested.

understanding current conditions, and/or present-day threats and stressors that are best interpreted at park, watershed, or landscape scales (though NRCAs do not report on condition status for land areas and natural resources beyond park boundaries). Intensive cause-and-effect analyses of threats and stressors, and development of detailed treatment options, are outside the scope of NRCAs.

Due to their modest funding, relatively quick timeframe for completion, and reliance on existing data and information, NRCAs are not intended to be exhaustive. Their methodology typically involves an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in existing data and knowledge bases across the varied study components.

The credibility of NRCA results is derived from the data, methods, and reference values used in the project work, which are designed to be appropriate for the stated purpose of the project, as well as adequately documented. For each study indicator for which current condition or trend is reported, we will identify critical data gaps and describe the level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject-matter experts at critical points during the project timeline is also important. These staff will be asked to assist with the selection of study indicators; recommend data sets, methods, and reference conditions and values; and help provide a multi-disciplinary review of draft study findings and products.

NRCAs can yield new insights about current park resource conditions, but, in many cases, their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is both credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Important NRCA Success Factors

- *Obtaining good input from park staff and other NPS subject-matter experts at critical points in the project timeline*
- *Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ⇨ indicators ⇨ broader resource topics and park areas)*
- *Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings*

However, it is important to note that NRCAs do not establish management targets for study indicators. That process must occur through park planning and management activities. What an NRCA can do is deliver science-based information that will assist park managers in their ongoing, long-term efforts to describe and quantify a park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning[6] and help parks to report on government accountability measures.[7] In addition, although in-depth analysis of the effects of climate change on park natural resources is outside the scope of NRCAs, the condition analyses and data sets developed for NRCAs will be useful for park-level climate-change studies and planning efforts.

NRCAs also provide a useful complement to rigorous NPS science support programs, such as the NPS Natural Resources Inventory & Monitoring (I&M) Program.[8] For example, NRCAs can provide current condition estimates and help establish reference conditions, or baseline values, for some of a park's vital signs monitoring indicators. They can also draw upon non-NPS data to help evaluate current conditions for those same vital signs. In some cases, I&M data sets are incorporated into NRCA analyses and reporting products.

NRCA Reporting Products…

Provide a credible, snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

- *Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations*
  (near-term operational planning and management)
- *Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values*
  (longer-term strategic planning)
- *Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public*
  ("resource condition status" reporting)

Over the next several years, the NPS plans to fund an NRCA project for each of the approximately 270 parks served by the NPS I&M Program. For more information visit the NRCA Program website.

[6] An NRCA can be useful during the development of a park's Resource Stewardship Strategy (RSS) and can also be tailored to act as a post-RSS project.

[7] While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

[8] The I&M program consists of 32 networks nationwide that are implementing "vital signs" monitoring in order to assess the condition of park ecosystems and develop a stronger scientific basis for stewardship and management of natural resources across the National Park System. "Vital signs" are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values.

Chapter 2. Introduction and Resource Setting

2.1. Introduction

2.1.1. Park Purpose and Enabling Legislation

American Memorial Park (AMP) was authorized in 1978 by the United States Congress to honor the American and indigenous people who died in the 1944 Mariana Island campaign of World War II. The Park's Foundation Document states that "American Memorial Park serves as a place to reflect on the history and to remember the fallen, so that those who died in the Marianas Campaign during World War II are not forgotten" (NPS 2017). Additionally, statements for the Park declare that it is "uniquely situated to introduce the national park idea to diverse, non-English speaking, international visitors from the Pacific and Asia" (NPS 2017).

American Memorial Park is referred to as a "living memorial" because of the opportunities for visitors today to partake in some of the same recreational activities that WWII service men and women participated in during wartime (NPS 2017). These activities occur amidst a biological and physical setting that is certainly unique within the National Park Service (NPS) system. While the Park's mission statement does not explicitly state maintenance of present biophysical resources as a park goal, it is inferred that maintaining these natural areas also maintains the integrity of the Memorial (B. Nevitt, pers. comm., 2017). Both the Foundation Document and the General Management Plan (GMP) for the park emphasize the Park's goal of attracting Saipan residents to picnic areas, athletic areas, and a large amphitheater for hosting cultural events. The founding documents state that one of AMP's major goals was to be a cultural center for the island (NPS 1989).

Given American Memorial Park's emphasis on features that highlight cultural heritage, these elements are significant enough to warrant a brief inventory here. Within the park are three war memorials:

- The memorial court and flag circle, which includes the names of over 5,000 U.S. service personnel who lost their lives in the campaign;
- The Marianas Memorial, which lists the names of 933 Chamorro and Carolinians who lost their lives in the war;
- The Carillon Bell Tower, which plays patriotic songs and anthems dedicated to both service members and civilians who perished in the war.

These memorials were erected in 1994, 2004, and 1995, respectively. While the park was not used during battle, war-era artifacts remain in the park including Japanese pillboxes, Japanese bunkers, and fuel storage tanks.

American Memorial Park contains culturally significant areas for Chamorro and Carolinians as well, including a beach once used for celestial navigation training which is disrupted now due to light pollution (Snyder 2006). Micro Beach, located along the Park's western shoreline, was also the first landing location for the Carolinian people when they reached Saipan in the 1800s and served as a primary site for Carolinian elders to teach burial rituals (NPS 2017). Archaeological surveys revealed additional pre-historic artifacts within park boundaries including prehistoric pottery sherds and midden material, a cultural deposit dated to 0–500 AD (Thomas and Price 1979). A prehistoric fire pit dated to 1025–1275 AD (McIntosh and Cleghorn 2000), and human skeletal remains (Shun and Moore 1989) were also present. However, most pre-historic artifacts within park boundaries likely were destroyed due to earlier development during Spanish, German, or Japanese rule, destructive war-time activities, and subsequent American development. The combination of these activities essentially leveled park land and filled it with coral rubble (Thomas and Price 1979, Eblé et al. 1997).

2.1.2. Geographic Setting

American Memorial Park is located on the island of Saipan, the largest and most populated island within the Commonwealth of the Northern Mariana Islands (CNMI) with an area of 119 km^2 (45.95 mi^2, JALBTCX 2007) and a population of around 48,220 (U.S. Census Bureau 2010). Centered at 15.2°N, 145.8°E approximately 2,200 km (1,367 mi) south-southeast of Japan, Saipan is part of a volcanic archipelago created by the subduction of the Pacific plate beneath the Mariana plate, putting the island in an area of frequent tectonic movement (Figure 1).

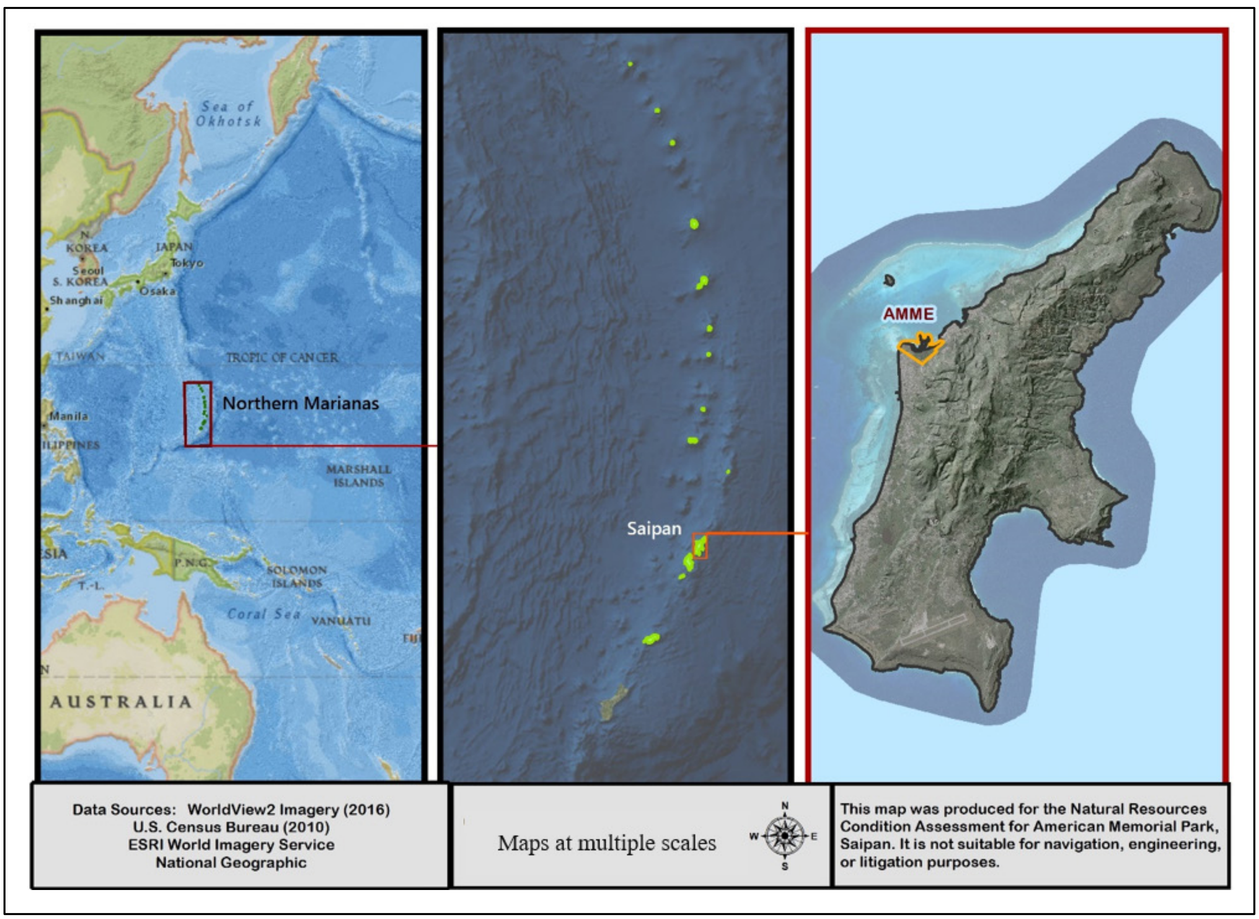


Figure 1. Location of Marianas Archipelago and Saipan. (USCB 2010).

Though Saipan is no longer volcanically active, the geologically younger islands in the north continue to experience volcanic eruptions, with substantial activity occurring as recently as 2003, 2004, and 2005 on nearby Anatahan. Saipan's western coastal plain and terraced topography surround a single peak, Mt. Tapochau, which reaches 471 m (1545 ft) above mean sea level (JALBTCX 2007; Figure 2).

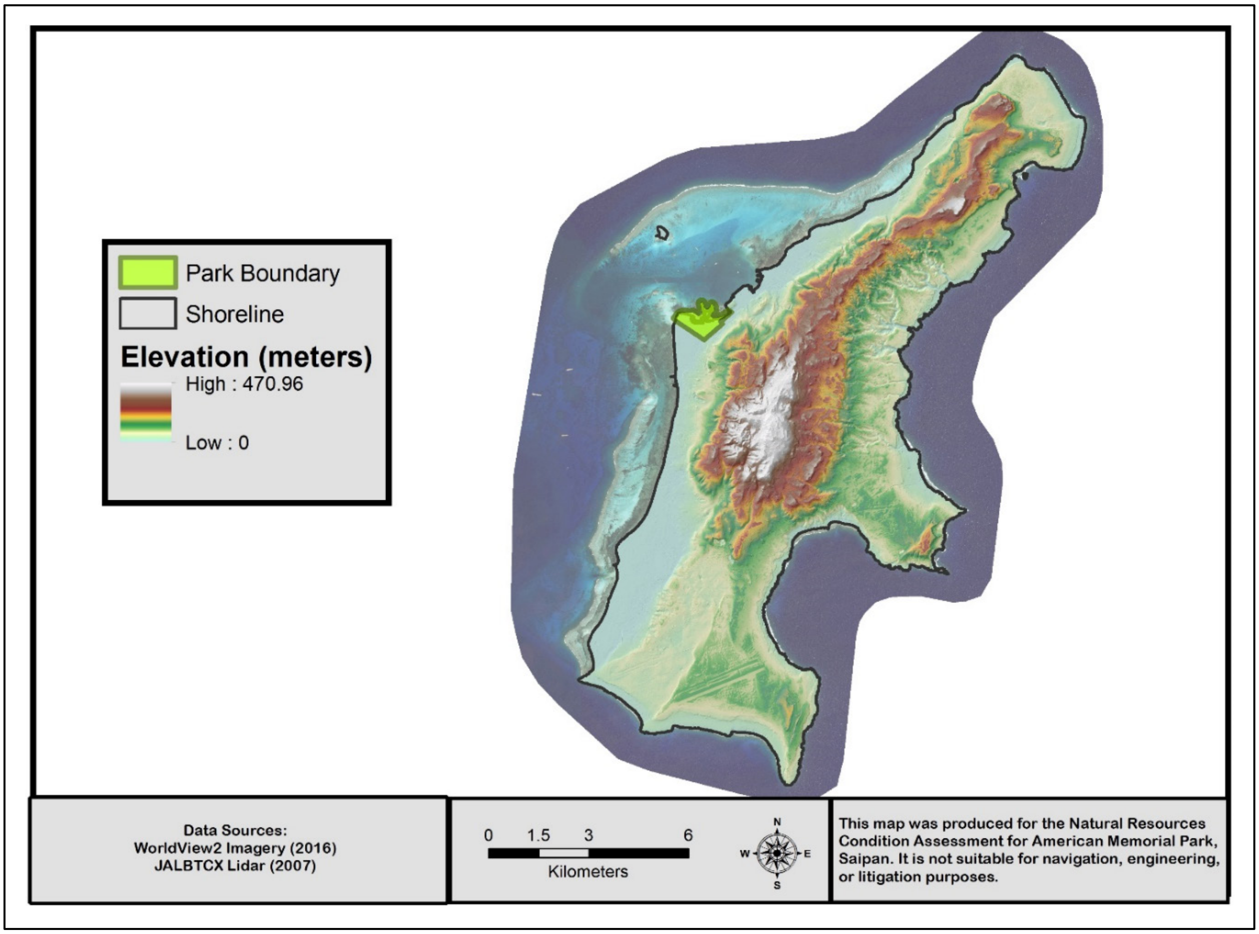


Figure 2. Map of Saipan elevation and hillshade with American Memorial Park boundary. (Lidar 2007).

While volcanic in origin, approximately 90% of Saipan's surface is terraced coral limestone (Carruth 2003), the oldest of which dates to 23 million years ago (Perreault 2007). Volcanic rock makes up the remaining 10% of the island's geologic composition. Coastal areas are dominated by either calcareous sandy beach deposits or exposed limestone (Weary and Burton 2011), but some coastal areas were flattened and filled with limestone rubble during periods of Japanese and American development (Thomas and Price 1979). The unique karst (exposed limestone) topography found in many areas also often overlaps with Saipan's remaining undisturbed native forest patches. These same geological characteristics translate into highly permeable surfaces, facilitating relatively rapid recharge of the sub-surface freshwater lens (Carruth 2003, EMO 2010). A map of park-specific geological features is provided in later discussion.

Saipan’s climatology is representative of a small Western Pacific island within the range of the inter-tropical convergence zone, where northeast trade winds converge with equatorial low pressure, and seasonal variation in rainfall, temperature, storm activity, and dominant winds result from a north-south migration of that low pressure trough. Little seasonal temperature variation exists on Saipan; average daily temperatures hover around 83°F with less than 3.5°F of seasonal variation (Lander 2004; EMO 2010). Humidity is also fairly stable throughout the year, ranging between 80–90% (Snyder 2006).

Annual and inter-annual precipitation is characterized by a bit more variability, with distinct dry (January through May) and wet (July through November) seasons relating to the annual movement of a regional low pressure trough and associated monsoon activity. The months of May-June and November-December generally comprise transition months between these two modes (Lander 2004). During the wet season Saipan obtains two thirds of its annual 80 inches (2.03 m) of rainfall, predominantly from tropical cyclones or convective cloud clusters. The wet season generally corresponds with calmer winds, while the dry season is associated with consistent trade winds and frequent light to moderate showers. Spatial variation in rainfall also exists on Saipan, with the highest levels of precipitation occurring around the high-elevation center of the island, and smaller annual averages around the southern and western villages (Lander 2004) (Figure 3).

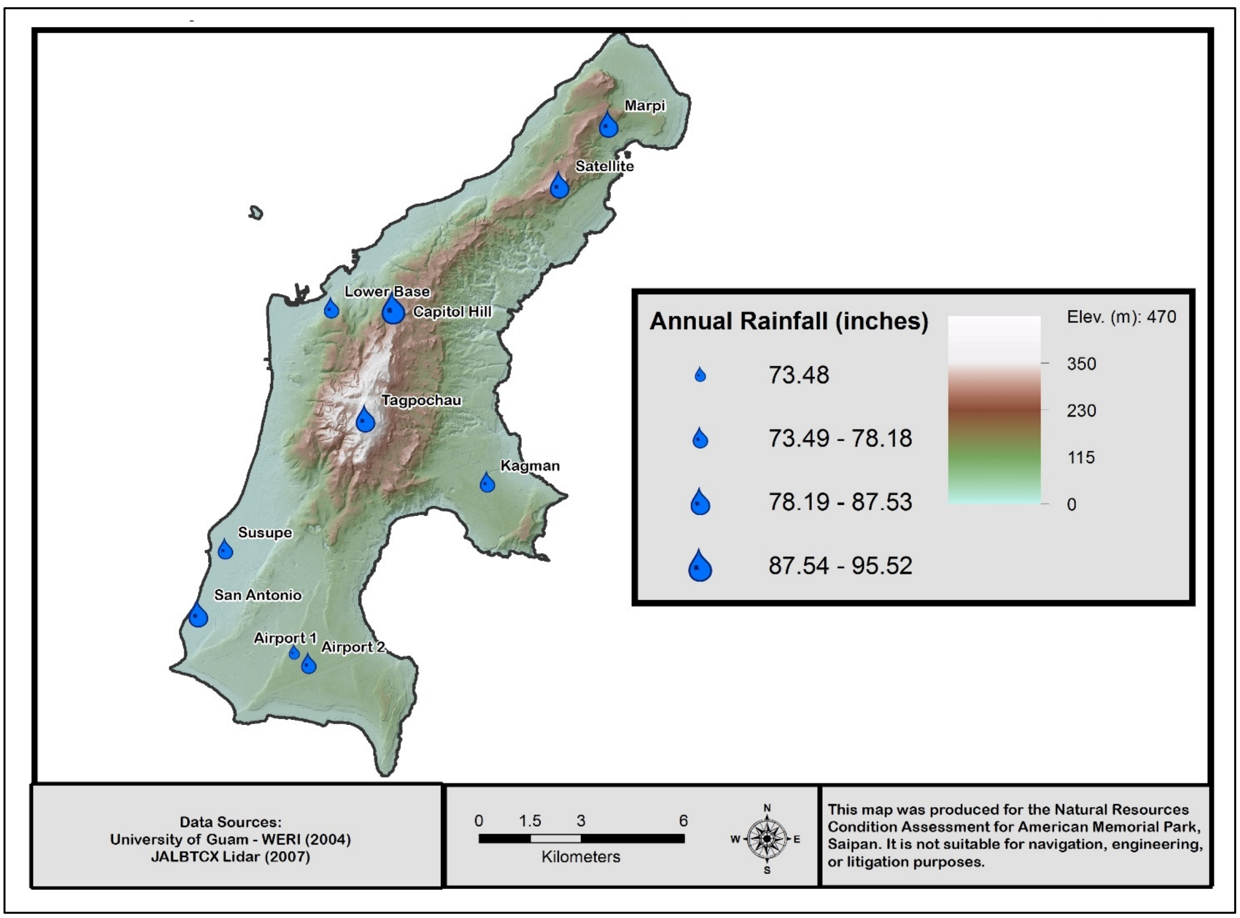


Figure 3. Map of Saipan annual rainfall distribution (Lander 2004).

Saipan's inter-annual and annual rainfall is also strongly affected by large-scale meteorological phenomenon that occur on multi-year and decadal cycles, such as the El Niño Southern Oscillation (ENSO). The cooler waters created by ENSO positive conditions (El Niño) in the western Pacific bring drought conditions for the Marianas in the latter half of El Niño years, which tend to occur every four to seven years. Saipan's driest years on record are all associated with the tail-end of large ENSO positive events. Wetter, windier years associated with La Niña often follow a strong El Niño (Lander 2004; EMO 2010). It should also be noted that Saipan's location in the most prolific tropical cyclone basin on the planet translates into immense local variation in meteorological records due to data spikes from extreme downpours. Direct passage of a typhoon over Saipan might significantly raise the annual precipitation record for that single location while having far less impact on precipitation records for islands to the south such as Guam.

Sea levels also correspond to ENSO-driven meteorological conditions across the Pacific. Lower sea levels are associated with El Niño due to relaxed trade winds in the central and western basins, while higher sea levels are associated with La Niña's enhanced trade winds which tend to "push" seas from the Eastern Pacific into the Western Pacific and Marianas. Table 1 illustrates monthly and annual sea levels associated with ENSO positive (1997–1998 El Niño)(Table 1.a.) and negative (1998–1999 La Niña)(Table 1.b.) conditions. This phenomenon is elaborated upon here due to the implications it poses for a great majority of American Memorial Park resources. The Park's low-lying situation on Saipan's western coastal plain leaves it susceptible to the threats of coastal erosion, sea level rise, and storm activity. The rise in sea level associated with a transition from El Niño to La Niña conditions (0.3–0.6 m, or 1–2 ft) could simulate several decades of projected sea level rise due to climate change while creating short-term hazards for park resources.

Table 1.a. Sea levels in the Marianas during ENSO positive (El Niño) conditions (NOAA CO-OPS 2017).

Month.Year	Feet, relative to Mean Sea Level	ENSO Index (positive)
4.1998	(data missing)	0.9
3.1998	(data missing)	1.4
2.1998	(data missing)	1.8
1.1998	(data missing)	2.2
12.1997	(data missing)	2.3
11.1997	-0.70	2.4
10.1997	-0.52	2.3
9.1997	-0.54	2.1
8.1997	-0.31	1.8
7.1997	-0.25	1.5
6.1997	-0.29	1.2
5.1997	-0.19	0.7
1997–1998	**-0.397**	**1.776**

Table 1.b. Sea levels in the Marianas during ENSO negative (La Niña) conditions (NOAA CO-OPS 2017).

Month.Year	Feet, relative to Mean Sea Level	ENSO Index (negative)
12.1999	0.28	-1.5
11.1999	0.28	-1.4
10.1999	0.37	-1.3
9.1999	0.41	-1.1
8.1999	0.51	-1.1
7.1999	0.52	-1
6.1999	0.55	-1
5.1999	0.57	-0.9
4.1999	0.64	-0.9
3.1999	0.52	-1
2.1999	0.48	-1.3
1.1999	(data missing)	-1.5
12.1998	(data missing)	-1.5
11.1998	(data missing)	-1.4
10.1998	(data missing)	-1.3
9.1998	(data missing)	-1.2
8.1998	(data missing)	-1
7.1998	(data missing)	-0.7
1998–2001	**0.432**	**-1.081**

This complex regime of climatic and oceanic conditions creates a unique setting for terrestrial ecology, in particular the succession of land cover and landscapes following disturbances, both natural (e.g., tropical cyclones) and anthropogenic. The latter category of disturbance is especially relevant for an assessment of Park resources as Saipan has a complicated history of Spanish, German, Japanese, and American occupation and development. Landscape alteration around most of the island has translated into heavy ecological instability over the last hundred years. Approximately 60% of the island consists of secondary forest and invasive vegetation, with some reports estimating that Saipan has retained only 4% of its native forest and 2% of original wetlands (Gourley 2006).

Disturbed areas are largely composed of a single invasive tree species, tangan tangan (*Leucaena leucocephala*), which was introduced by Americans following World War II to stabilize the soil. Invasive vines are also highly prevalent in Saipan's vegetated areas, especially in areas disturbed by historic agriculture or wartime bombing. The island's remaining native vegetation exists largely in protected areas in the northern quarter of the island which is characterized by steep slopes, karst geology, and shallow topsoil. These native forests are still highly fragmented, separated by patches of invasive growth. The vast majority of unprotected lands and urban areas remain dominated by invasive species.

From a perspective of ecological integrity, Saipan's aquatic and marine resources are more intact than its terrestrial environments. The island's nearshore waters and lagoons are rich in marine biodiversity. Fringing coral reefs border most of Saipan's coast and contain a multitude of coral, turtle, dolphin, fish, and seagrass species, many of which are endemic and/or endangered. Saipan hosts 99% of seagrass found in the CNMI (Gourley 2006), almost a third of marine benthic algal species (Starmer et al. 2008), and endangered sea turtle species (Starmer 2005). Recent surveys observed spinner dolphins (*Stenella longirostris*), bottlenose dolphins (*Tursiops truncatus*), pantropical spotted dolphins (*Stenella attenuata*), short-finned pilot whales (*Globicephala macrorhynchus*), pygmy killer whales (*Feresa attenuata*), sperm whales (*Physeter macrocephalus*), and a dwarf sperm whale (*Kogia sima*) just outside of the island's lagoon (Hill et al. 2013).

The 31 km2 (12.35 mi2) Saipan Lagoon that sits adjacent to the island's west coast ranges in depth between one and seventeen meters (USACE 2004), and these relatively shallow waters contain a significant proportion of the 522 coral and 1,000+ reef fish species found in the Marianas (Figure 4) (Snyder 2006). In 2014, three coral species found in the Saipan Lagoon were federally listed as threatened or endangered under the Endangered Species Act. Saipan is also home to two endemic fish species: a wrasse (*Pseudojuloides* sp.) and a goby (*Amblyeleotris* sp.) (Myers and Donaldson 2003).

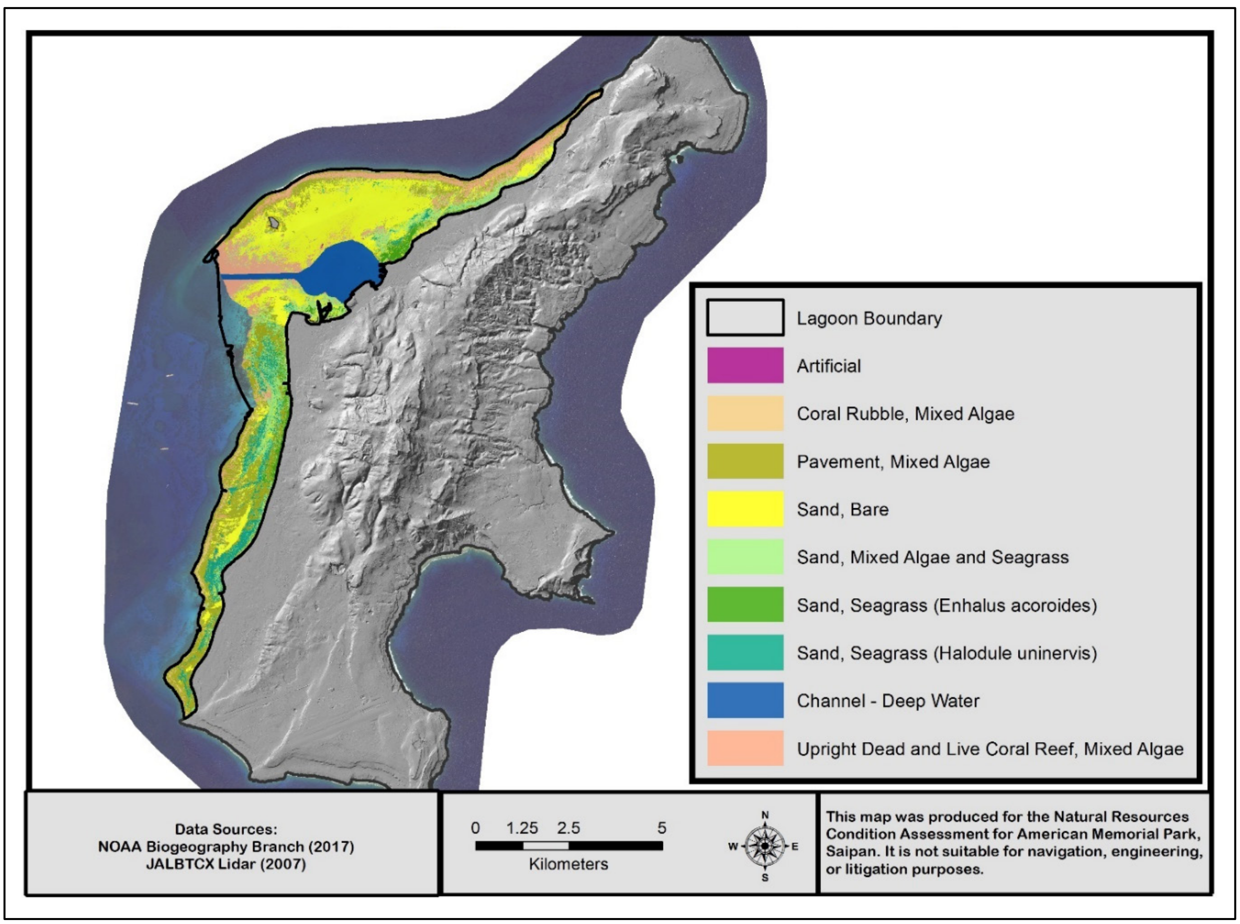


Figure 4. Map of Saipan Lagoon benthic habitat (NOAA 2017).

While the marine environment harbors far more ecological diversity than Saipan's terrestrial habitat, this is to be expected of a small island ecosystem thousands of miles removed from large, contiguous land masses. Still, fifty species of resident and migratory birds were documented on Saipan in 2016 (National Audubon Society 2010), as well as dozens of other vertebrate species and several hundred vascular plant species (Sherley 2000, Cogan et al. 2013). The island hosts many endemic species. Due to the severe population decreases of native vertebrates on Guam caused by the brown tree snake (*Boiga irregularis*) invasion, Saipan now hosts a significant proportion of these species' global populations (MAC Working Group 2013, Rogers et al. 2017).

The geographic context for American Memorial Park could be considered small in comparison to many other NPS units, yet the Park itself occupies a particularly important position on Saipan and within the Marianas Archipelago as a whole. American Memorial Park is situated on the central west coast of Saipan, directly adjacent to the tourism core of the CNMI. The Park contains some of the last remaining mangrove habitats in the Northern Marianas. Bordered to the east and south by Saipan's primary roads, and to the north and west by the Saipan Lagoon and the island's only marina (Figure 5), the Park sits at the nexus of some of the CNMI's most critical economic and environmental assets.

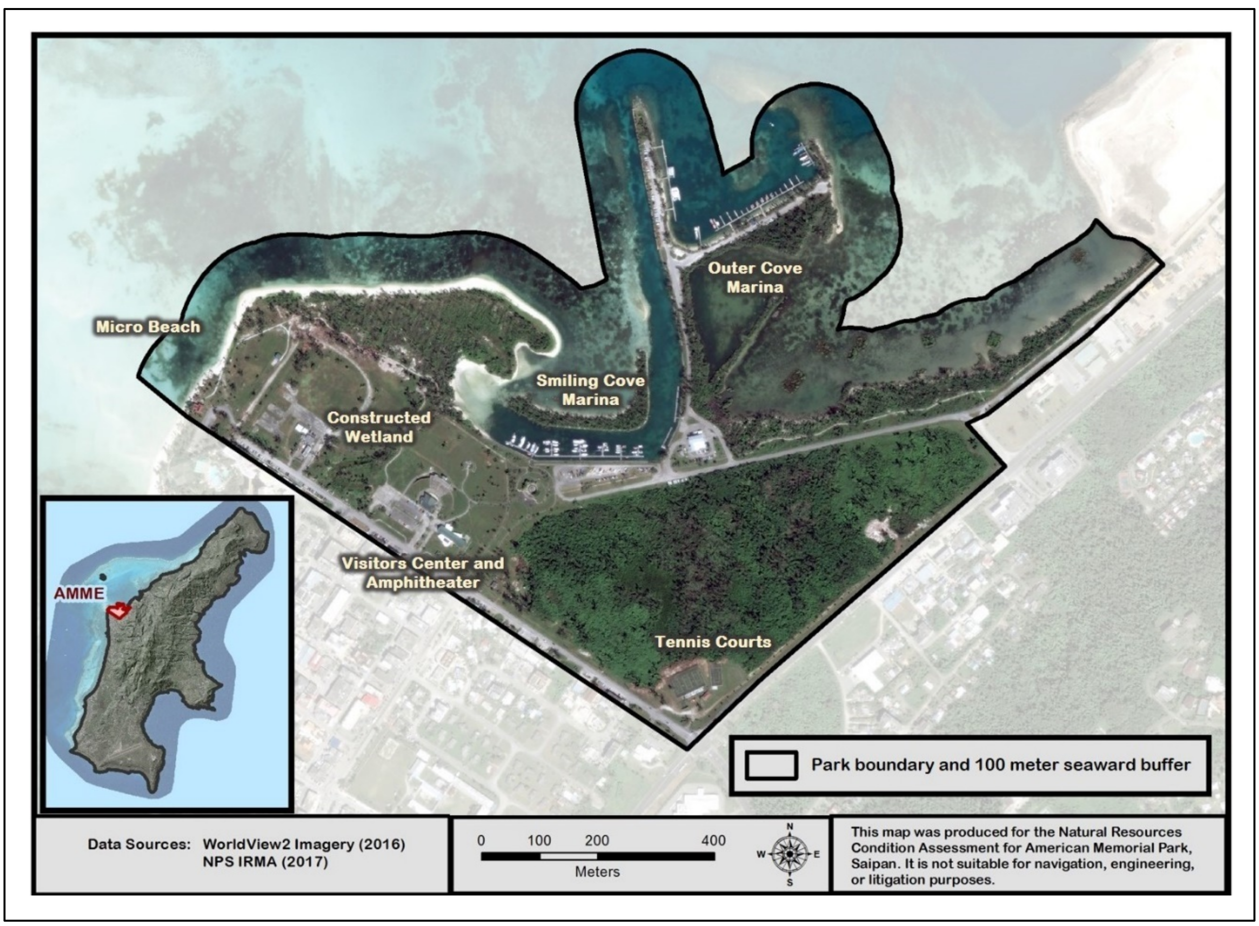


Figure 5. Park boundaries and 2016 satellite imagery with 100 m (328.08 ft) seaward buffer and inset location on Saipan. (NPS 2017).

Within this 54 hectare (133 acre) park sits a high concentration of historic memorials, some of the most popular sandy beaches in the Archipelago, and a 12 hectare (30 acre) mangrove wetland – one of only three mangrove habitats remaining in the entire CNMI. The park offers many recreational activities including a bike path, tennis courts, picnic and barbeque areas, a visitor center with cultural and historic WWII exhibits, three distinct outdoor WWII memorials, and an amphitheater. These features are partially surrounded by the Saipan Lagoon, which plays an important role in attracting visitors to and through the park and is perhaps the most significant feature for the Commonwealth's economy as it forms the natural arena for a large proportion of commercial and recreational activity in the CNMI.

2.1.3. Visitation Statistics

American Memorial Park attracts local and foreign visitors through the presence of recreational activities including tennis courts, barbeque and picnic areas, a bike and walking path, open grassy areas for sports, an amphitheater, a visitor center and museum with interpretation in four languages, historic war memorials, the island's only marina, and sandy shoreline. The park serves as a venue for large and small community events and hosts youth summer internships such as the natural resource-focused Youth Conservation Corps. Near-shore areas and the lagoon are popular areas for fishing and recreational water sports, and the marina is frequently used as a launching spot for tourist cruises and boating activities. Most of the park is accessible to visitors with no-access areas limited to the mangrove and wetland area and, following the destruction of Typhoon Soudelor in 2015, some heavily damaged patches of secondary forest (Figure 6).

In 2016 American Memorial Park recorded 81,171 visitors, a 25% increase from the previous year. Several large, annual events which have historically been held in AMP, such as the *Taste of the Marianas* and the Saipan Environmental Expo were held outside of the park in alternate locations in 2017, which will likely affect visitation statistics for that year. Documenting more nuanced aspects of visitation proves difficult as the Park's boundaries meld into the adjacent recreational and tourism landscape of Garapan Village and Smiling Cove Marina. This presence of nebulous boundaries makes any sort of effort to conduct a visitation census quite difficult. The Park's Foundation Document (NPS 2017) notes the need for a visitor use study which documents demographics, use, and preferences. Such a study would provide much-needed insight into the Park's function not only as a tourism asset but also as a community resource. In addition to visitation numbers to AMP's museum and visitor center, the Park's central location makes it a popular location for the local population to engage in daily recreational activities. The numbers of residents that transit through the park via jogging routes or on bicycle are likely quite large, as are weekend picnics and barbeques held in the Park by residents from around the island. Coastal processes have led to a northward shift in a large sand spit, facilitating accretion and subsequent beach growth. The new stretches of sandy beach have significantly enhanced the Park's potential for hosting beach-side barbeques and community gatherings.

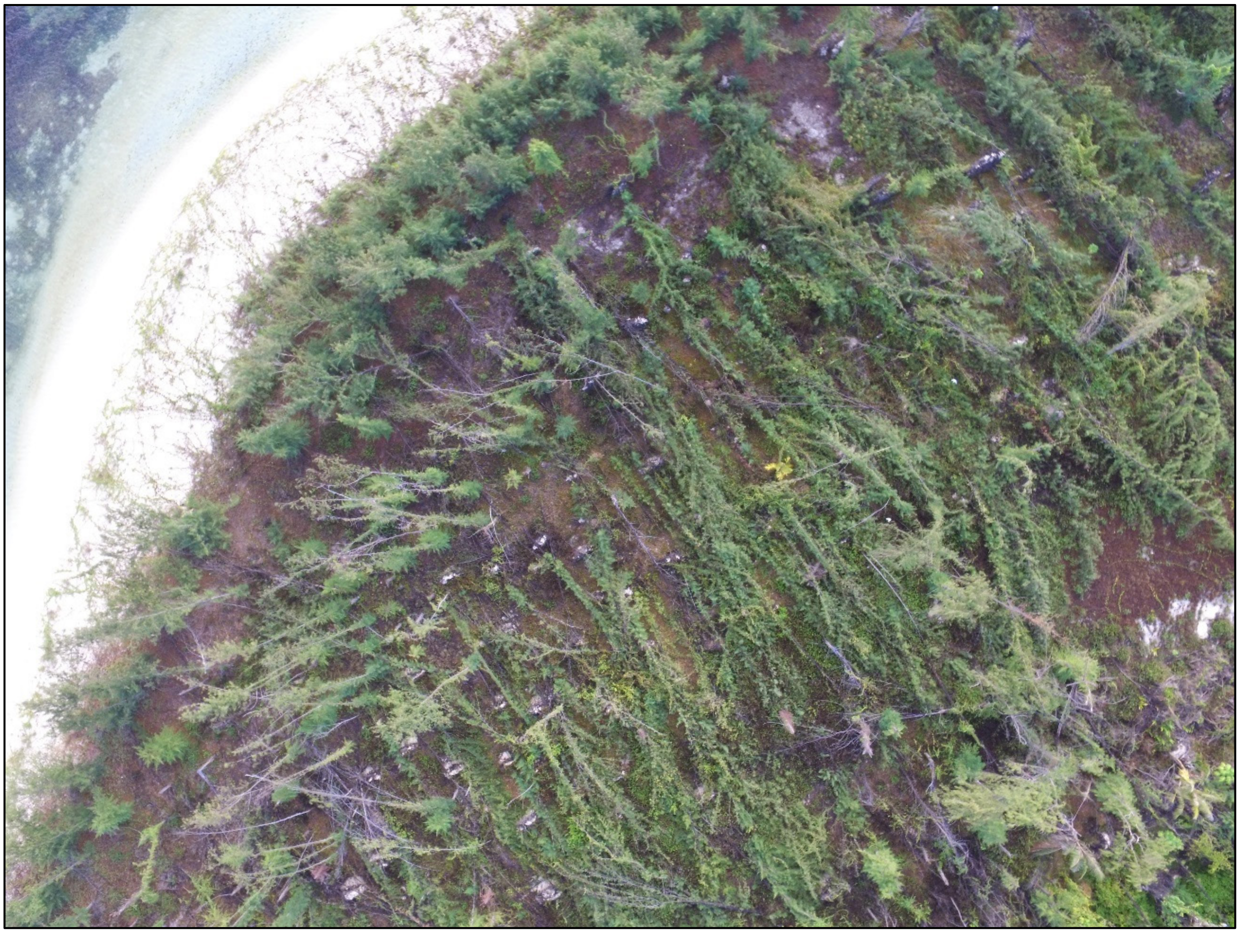


Figure 6. Aerial photo of felled secondary forest in American Memorial Park after Typhoon Soudelor (Photo by M. Kottermair 2016).

Given its prominence as a community asset, American Memorial Park is also the recipient of ongoing support and stewardship from island residents. Over 300 park volunteers performed 1,200 hours of community service in 2016 (Nevitt 2017), providing assistance in clearing vegetation and refuse after Typhoon Soudelor (B. Nevitt, pers. comm., 2017).

2.1.4. Land Ownership and Regulatory Environment

The National Park Service has leased park land from the CNMI government in a 50-year block. The original lease was established in 1976 and will consequently expire in 2026, at which point NPS and the CNMI can either renew the lease or terminate the tenure arrangement, though there is no indication as of 2017 that the lease will not be renewed. American Memorial Park was established by Public Law 94-241, which is the same document that formally established the Northern Marianas' Commonwealth Government. In this document a single, concise paragraph founds the park:

> *"Section 803. (a) The Government of the Northern Mariana Islands will lease the property described in subsection 802 (a) [177 acres (72 hecatares) on Saipan containing Tanapag Harbor (Saipan Lagoon)] to the Government of the United States for a term of fifty years, and the Government of the United States will have the*

> *option of renewing this lease for all or part of such property for an additional term of fifty years if it so desires at the end of the first term… (e) From the property to be leased to it at Tanapag Harbor (Saipan Lagoon) on Saipan Island the Government of the United States will make available to the Government of the Northern Mariana Islands 133 acres (54 hectares) at no cost. This property will be set aside for public use as an American memorial park to honor the American and Marianas' dead in the World War II Marianas Campaign. The $2 million received from the Government of the United States for the lease of this property will be placed into a trust fund, and used for the development and maintenance of the park in accordance with the Technical agreement" (U.S. Cong. 1976).*

Identified in the American Memorial Park Foundation Document (NPS 2017), several special mandates have since been applied to management of the park. Public Law 95-348 (August 1978) requires that:

- CNMI residents be trained and employed by the park to the maximum extent possible;
- Interpretation of park resources be available in English, Chamorro, Carolinian, and Japanese;
- Entrance fees are prohibited; and,
- The Governor of the CNMI can request for park administration to be transferred to local (CNMI) government management, wherein all future development, maintenance, and administration would fall on CNMI government.

The CNMI Constitution (1977) also established that the US government cannot own land within the CNMI; property ownership is restricted to people "with at least some degree" of Chamorro or Carolinian ancestry (NPS 2017).

The Foundation document outlines which organizations, in addition to the National Park Service, have responsibilities related to the management of specific resources within the park, described below in Table 2.

Table 2. Stakeholders and management agreements for American Memorial Park (NPS 2017).

Org. Name (start and expiration dates)	**Agreement Type**	**Stakeholders**	**Purpose**	**Notes**
U.S. Fish and Wildlife Service (USFWS) (Sep. 2014 renewed annually)	Department of Interior interagency agreement	USFWS office of law enforcement, NPS	Satellite office for USFWS	–
Commonwealth Utilities Corporation (CUC) (preexisting, life of lease)	Easement	US Army Reserve Command, CUC, CNMI Department of Public Safety (DPS), CNMI Division of Fish and Wildlife (DFW), local community, NPS	Easement for electricity	Includes power poles and overhead power lines, preexisting for the park
Micro Beach sewage line (preexisting, life of lease)	Easement	CUC, CNMI DPS, CNMI DFW, local community, NPS	Municipal sewage	Includes CUC sewage line, main line servicing the park, preexisting for the park
Hyatt resort (2003 – TBD)	Contract	Hyatt, NPS	Provision of reliable, potable water to park	CUC was unable to provide reliable, continuous water for AMP and was more expensive
AMP, CNMI-DPS, CNMI Department of Land and Natural Resources (DLNR) (2005 – TBD)	Memorandum of understanding	CNMI-DPS, CNMI-DFW, NPS	Administrative office space in AMP building for DLNR-DFW and CNMI-DPS	Admin. offices for Smiling Cove marina, CNMI-DLNR, operations building for CNMI-DPS boating safety division, memorandum to be updated
Mgmt. and admin. of Outer Cove docks (Nov. 1988 – NA, Jan. 2005 – NA)	–	CNMI-DLNR, NPS	CNMI commercial use of docks	NPS does not manage Outer Cove docks (CNMI-DLNR does), docks and road are used commercially and fees are paid to CNMI, access is through NPS leased lands
Mgmt. and admin. of Smiling Cove marina (Nov. 1988 – NA, Jan. 2005 – NA)	–	CNMI-DLNR, NPS	CNMI use of piers	Piers and docks under mgmt. of CNMI-DLNR funded by USFWS sport fishing grant, fees ass. with dock go to CNMI, access is through NPS leased lands

Table 2 (continued). Stakeholders and management agreements for American Memorial Park (NPS 2017).

Org. Name (start and expiration dates)	Agreement Type	Stakeholders	Purpose	Notes
Marianas Public Land Trust (1983 – life of lease)	–	CNMI, NPS	Maintenance and park upkeep	Funds from $2 million Tanapag Harbor lease set aside, income from this to be used solely for park maintenance and development
Concurrent jurisdiction (TBD – TBD)	Memorandum of understanding	CNMI-DPS, NPS	Gives jurisdictional authority and law enforcement working relations	Jurisdictional inventory does not yet exist – to be completed and memorandum of understanding to be established
Lease between military and CNMI, renewable (Jan. 1983 – Jan. 2033)	Lease agreement	US Navy, CNMI, NPS	Lease to military pursuant to Covenant	Renewable for another 55 years
Leased land use (Feb. 1975 – life of lease)	Technical agreement	US Navy, CNMI, NPS	Est. of acceptable uses	Required per Article VII of Covenant
NPS and historic parks (April 2011 – April 2016)	Cooperating association agreement	Pacific Historic Parks (PHP), NPS	Est. of NPS and PHP roles and responsibilities	Est. parameters for sales and interpretation activities, facilities, equipment, donations, fundraising, and aid

2.2. Natural Resources

2.2.1. Ecological Units and Upland Watershed

For the purposes of the NRCA and organization of the assessment, four ecological zones are identified within American Memorial Park: mangroves and wetlands, coastal scrub and non-native forest, shoreline and near-shore, and developed green space. Figure 7 illustrates the configuration of these zones within the park, followed by descriptions of each unit.

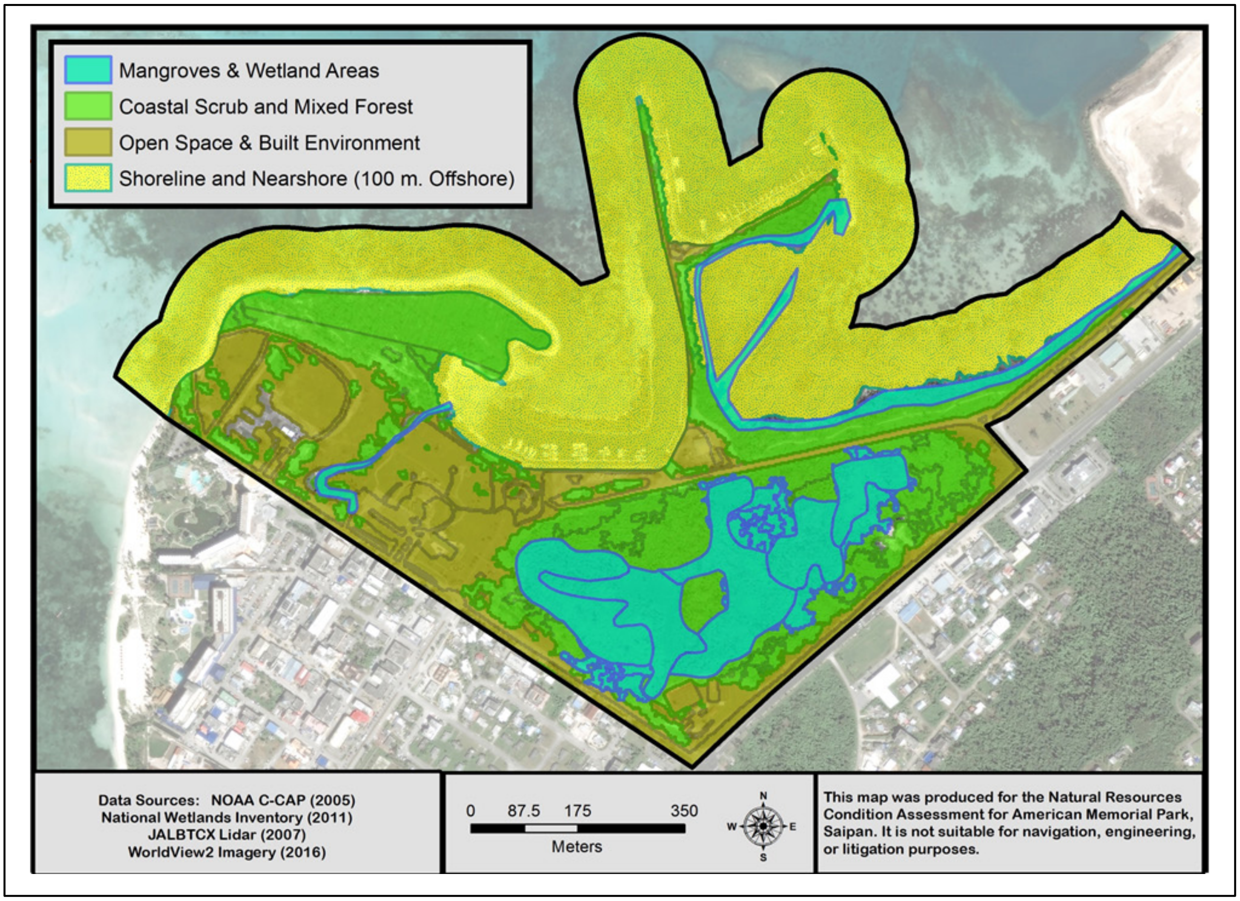


Figure 7. Map of American Memorial Park primary ecological zones within park boundary and 100 m (328.08 ft) seaward buffer beyond the park. (NOAA 2005; National Wetlands Inventory 2011).

<u>Mangroves and wetlands</u>

Saipan hosts the only remaining mangroves in the Marianas Archipelago, most of which are located within the 12 hectare (30 acre) wetland within the Park. The mangrove and wetland areas in American Memorial Park are primarily comprised of the mangrove species *Bruguiera gymnorrhiza*. This ecosystem is ecologically significant due to its role in mitigating nutrient loading in nearshore waters from upland and urban storm water runoff, providing coastal erosion control, serving as juvenile fish habitat and nurseries, and offering protected habitation for the endangered nightingale reed warbler (*Acrocephalus luscinius*), Mariana moorhen (*Gallinula chloropus guami*), and humped tree snail (*Partula gibba*) (Starmer 2007).

During Japanese administration (1919–1945), significant areas of Saipan's wetlands were cleared for sugarcane plantations. Much of the remaining mangrove wetland was spared damage from wartime bombing (Perreault 2007), but areas of the wetland were later used as a landfill through 1978 (Cogan et al. 2013, Raulerson and Rinehart 1989). Today the wetland area within American Memorial Park is protected under federal and local law and resource managers are working to restore the mangrove wetlands. Most recently, the Puerto Rico dump closure plan included the planting and continuous monitoring of 200 mangrove seedlings in the AMP wetland as mitigation for removal of wetlands during the creation of the Governor Eloy S. Inos Peace Park above the former Puerto Rico dump site (N. Johnson, pers. comm., 2017). The wetlands and mangroves ecological zone also includes a constructed wetland, created in 1997–1998 along a drainage leading into Smiling Cove Marina to filter urban runoff and brine waste water from nearby resorts. This entire ecological zone is illustrated in Figure 8 and was delineated for the NRCA using data from the National Wetlands Inventory (USFWS 2011) and National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP; NOAA 2005).

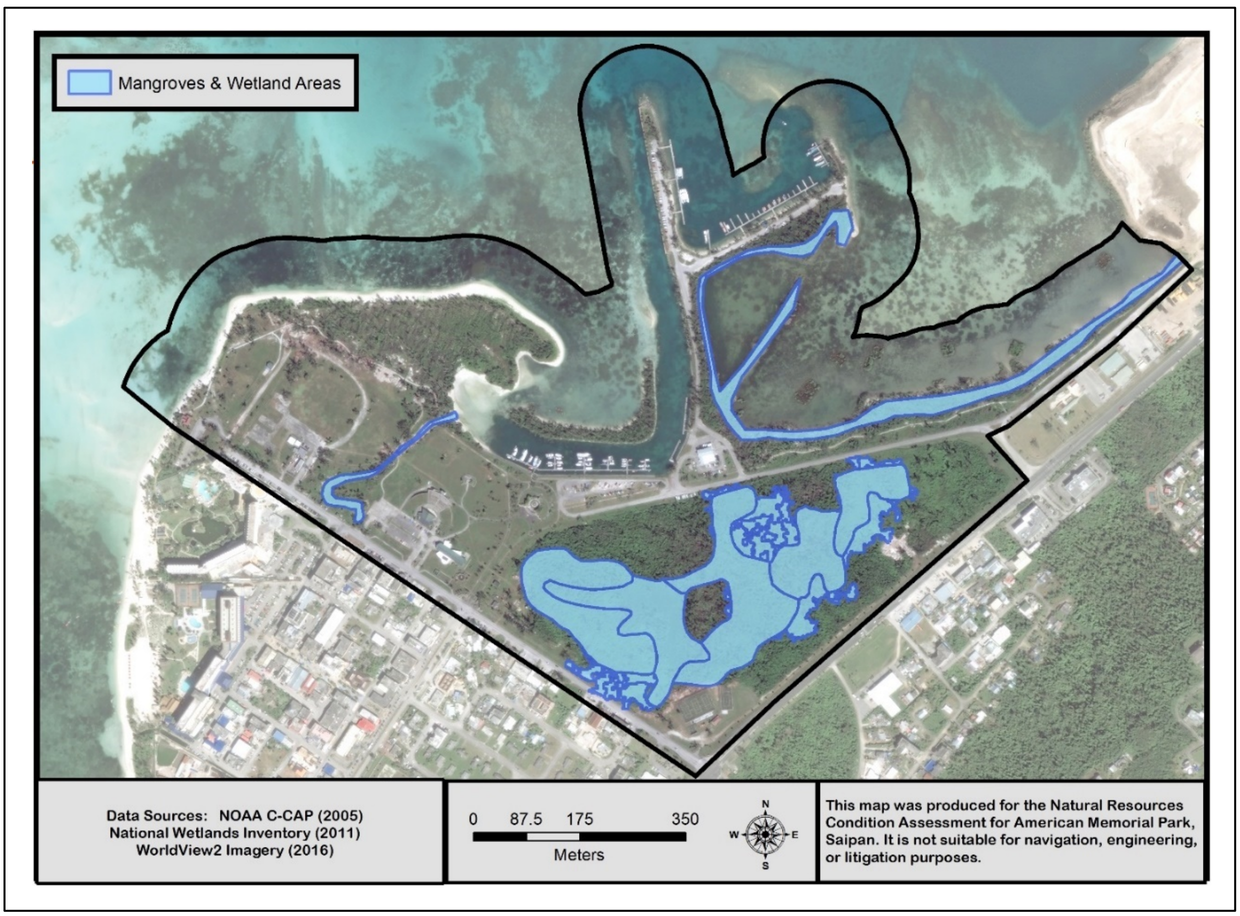


Figure 8. Map of American Memorial Park wetlands and mangroves ecological zone within park boundary (NOAA 2005; National Wetlands Inventory 2011).

Coastal scrub and non-native forest

These areas were identified based on the presence of dry, weedy, scrubby habitat consisting mostly of non-native vegetation mixed with the native Australian pine tree species (*Casuarina equisetifolia*), locally known as ironwood (Cogen et al. 2013, Jarzen and Dilcher 2009). The zone includes ironwood forests along Micro Beach and adjacent to park paths as well as environmentally degraded areas. The vegetation is configured in strands and patches within the park and corresponds with vegetation classifications in NOAA (2005) and USDA Forest Service (2006) land cover datasets (Figure 9).

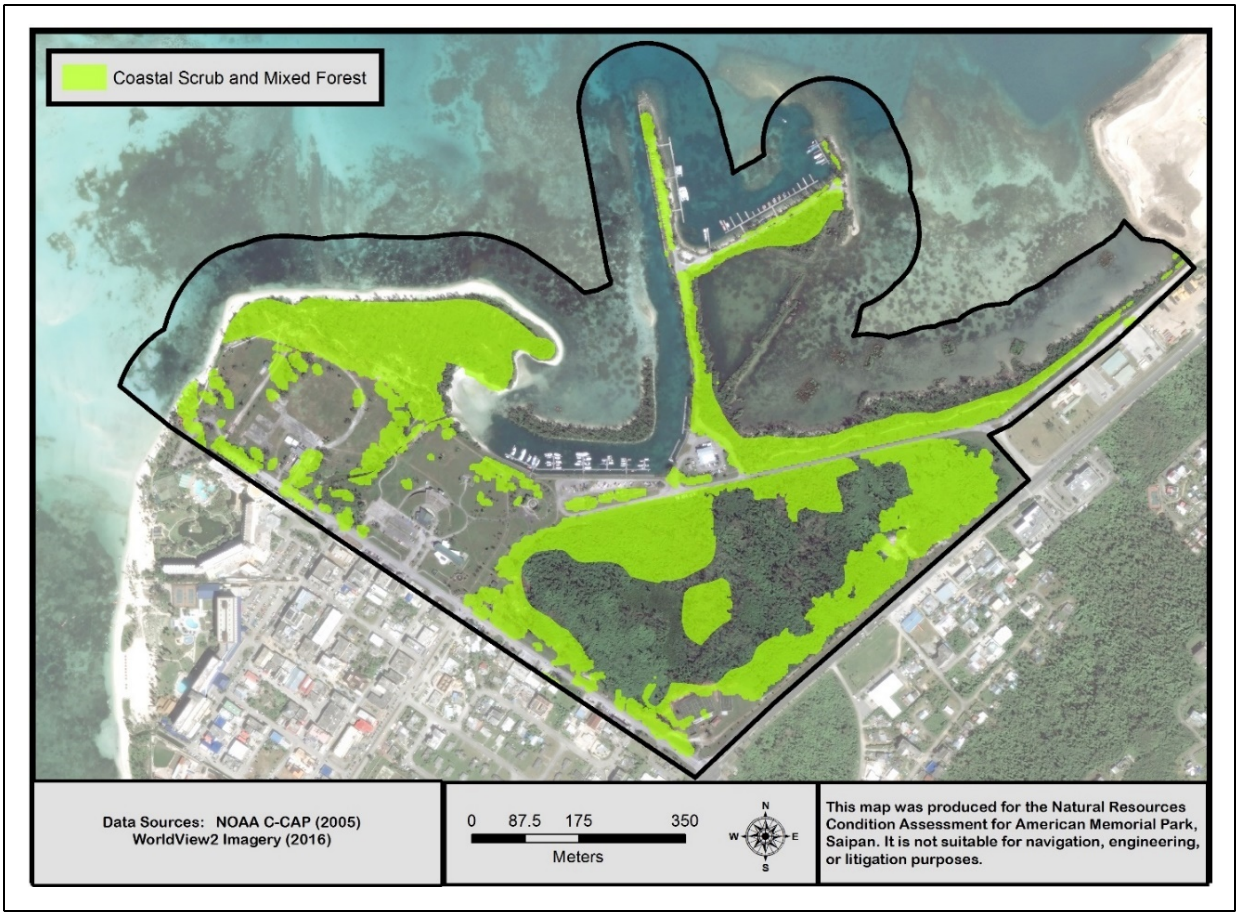


Figure 9. Map of American Memorial Park coastal scrub and non-native forest ecological zone within park boundary (NOAA 2005).

Shore and near-shore

American Memorial Park contains roughly 1.31 km (.81 mi) of sandy shoreline, though this metric fluctuates over time due to dynamic coastal processes and annual to decadal patterns of erosion and accretion. Park boundaries terminate at the mean high-water mark, however, near-shore areas in the Saipan Lagoon are included in the NRCA as their ecological function is directly tied to the status of the Park's shoreline resources, especially with respect to erosive trends. For the purposes of this assessment, the near-shore area is defined as the area from the shoreline to 100 m (328.08 ft) seaward into the adjacent Saipan Lagoon. The shoreline component is limited to areas from mean high-water shoreward to the start of strand vegetation and coastal scrub. This area is composed of unconsolidated material (sand of multiple grain sizes) and artificial shoreline composed of rubble and hardened, engineered structures. The near-shore benthic areas within the 100 m (328.08 ft) seaward buffer consist largely of sand, coral rubble, seagrass, and algae (Kendall et al. 2017). Figures 10 and 11 highlight the shoreline and near-shore ecological zone.

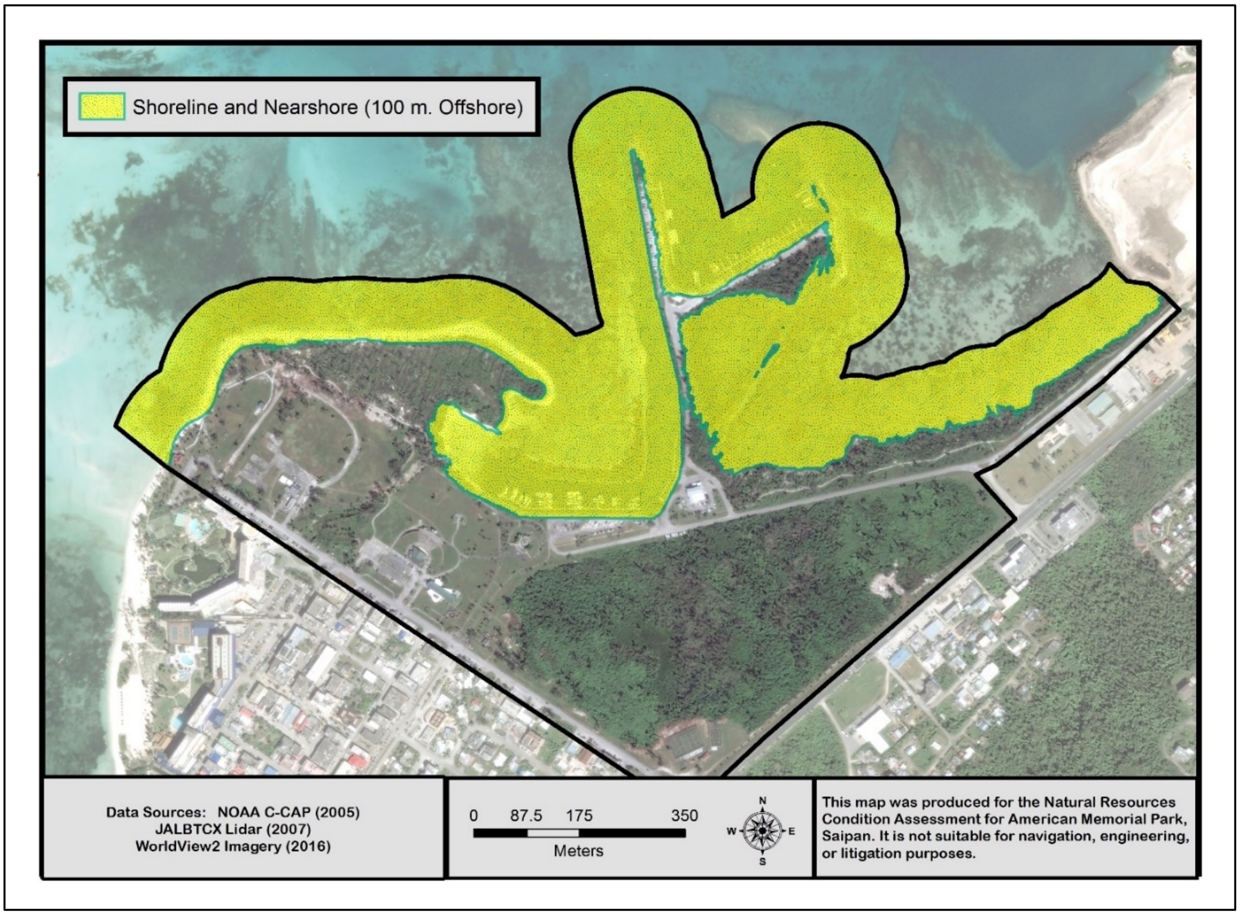


Figure 10. Map of American Memorial Park shoreline and near-shore ecological zone extending out to 100 m (328.08 ft) offshore. (NOAA 2005).

Figure 11. Aerial photo of American Memorial Park shoreline and the Saipan Lagoon (Photo by R. Skeele Jordan 2015).

Developed green space

Developed green spaces within American Memorial Park include picnic and barbeque areas, grass fields, and vegetation that border parking lots, bathroom facilities, major and minor roads, Smiling Cove Marina, the amphitheater, and three war memorials that cover .54 hectares (2.47 acres). While these areas have a heavy human influence through landscaping and maintenance and are not necessarily prime habitat for park flora and fauna, they are included in the NRCA as they often serve as the primary recreational draw for both visitors and community members (Cogen et al. 2013) and allow access to the Park's shoreline and near-shore zone. Figure 12 depicts the areas that represent developed green space. These areas correspond with the NOAA C-CAP land cover classifications of 'Open Space Developed' and 'Impervious Surface' (NOAA 2005).

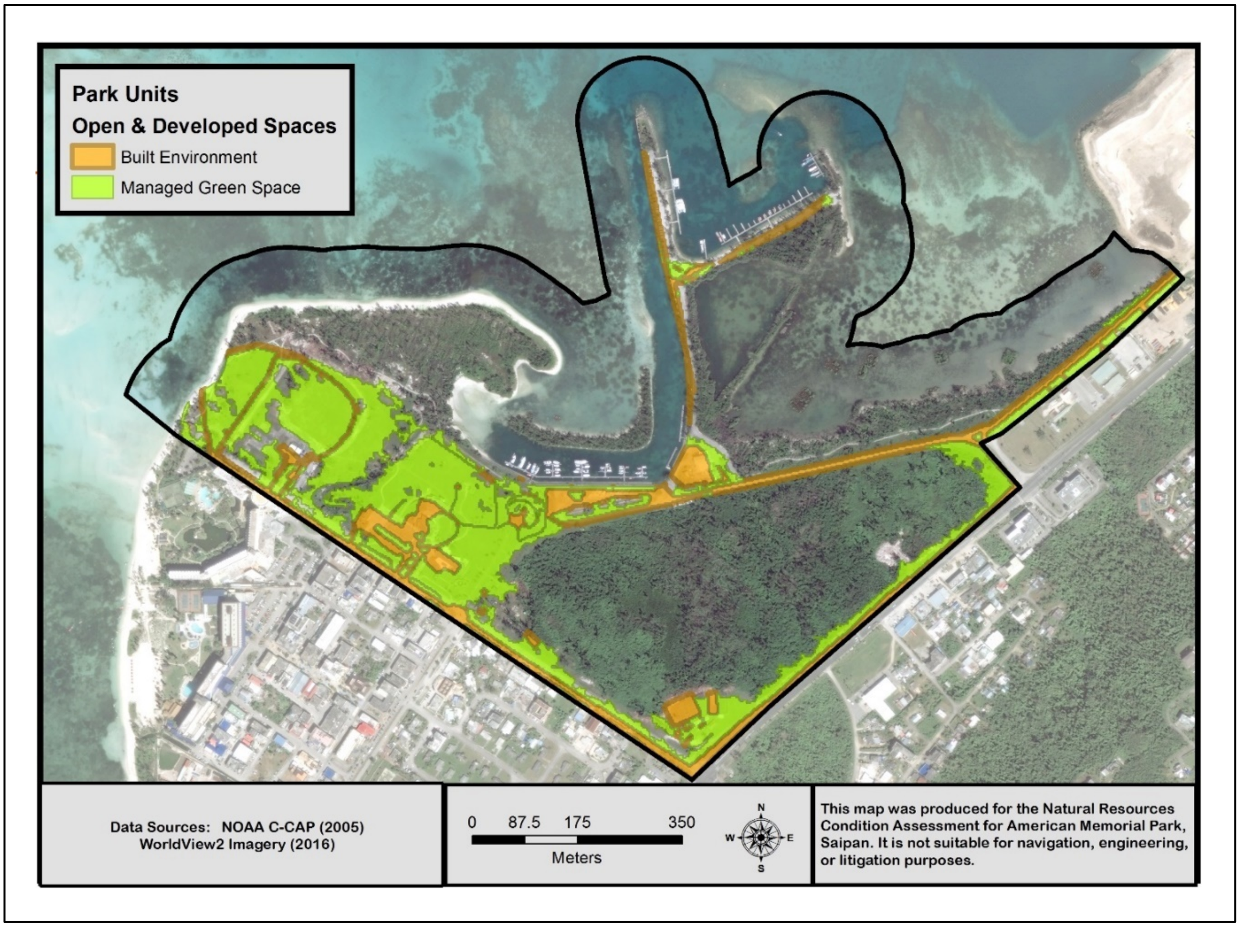


Figure 12. Map of American Memorial Park developed green space zone within park boundary. (NOAA 2005).

<u>Upland watershed and adjacent drainage units</u>

The Park does not completely encompass any significant drainage areas or sub-watersheds given its small size and relatively flat topography (Figure 13). However, a discussion of the broader drainage areas that flow into and through the Park is warranted due to the threats of storm-water run-off and non-point source pollution that these drainages pose.

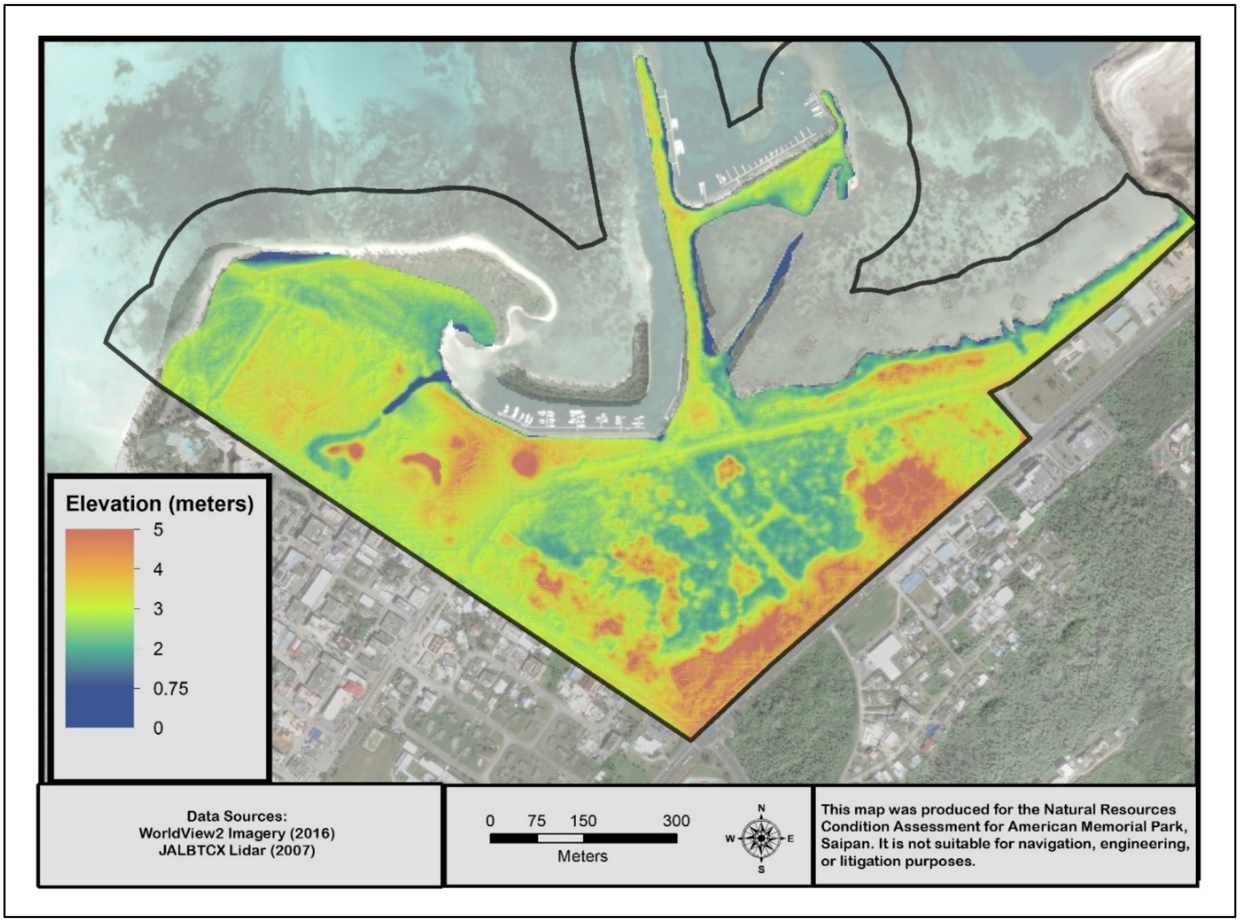


Figure 13. American Memorial Park digital elevation model within park boundary. (Lidar 2007).

American Memorial Park is situated within Saipan's West Takpochau watershed, which is the third largest drainage basin on Saipan and contains more impervious surface than any of the island's 11 other watersheds (Figures 14, 15). Given the island's limestone terraces and karst, relatively steep slopes dominate the upland sections of the West Takpochau watershed leading to high flow velocity and run-off accumulations in the lower, flatter sections of the basin. The latter areas contain the vast majority of impervious surface, reducing the infiltration capacity and permeability of the lands surrounding the Park.

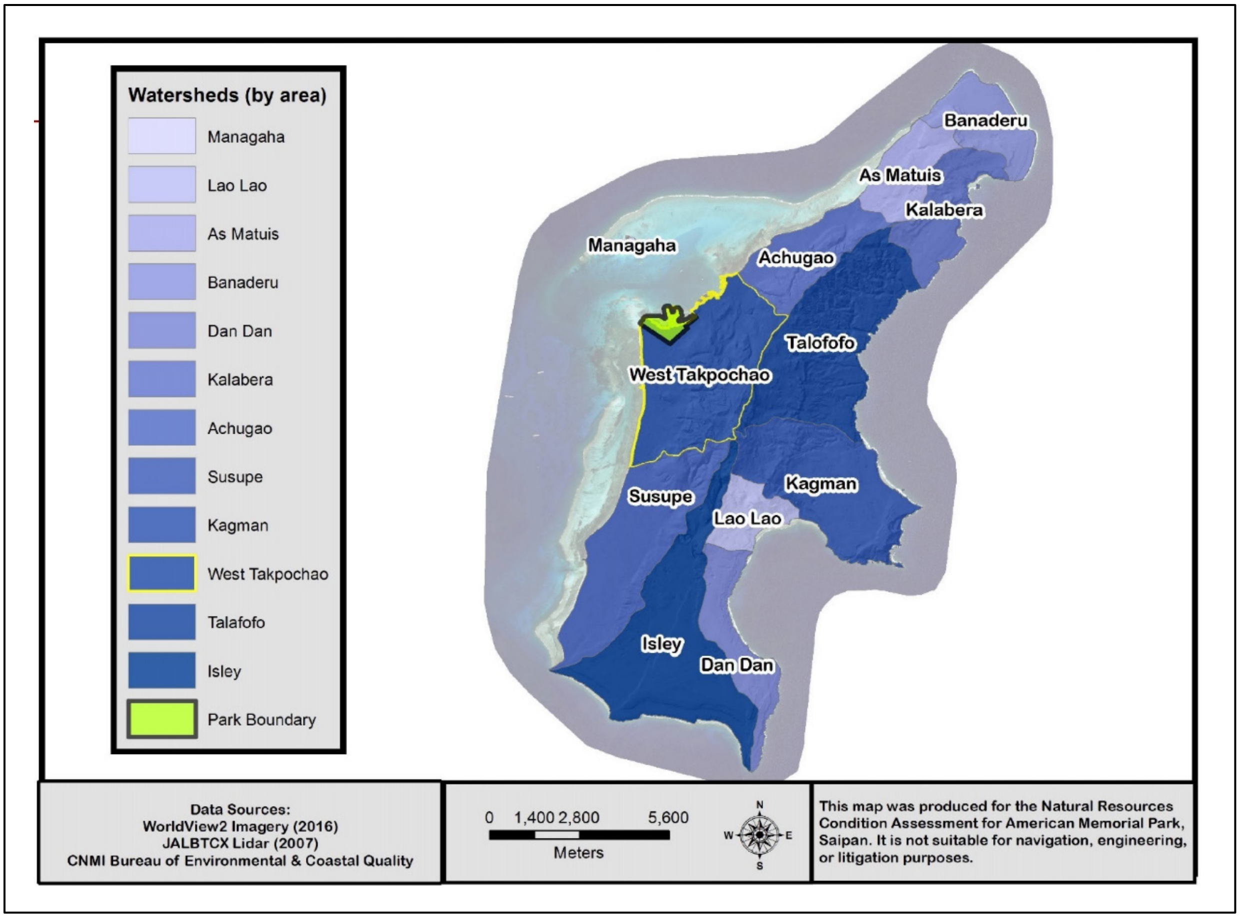


Figure 14. Map of Saipan watershed delineations and areas. (Lidar 2007).

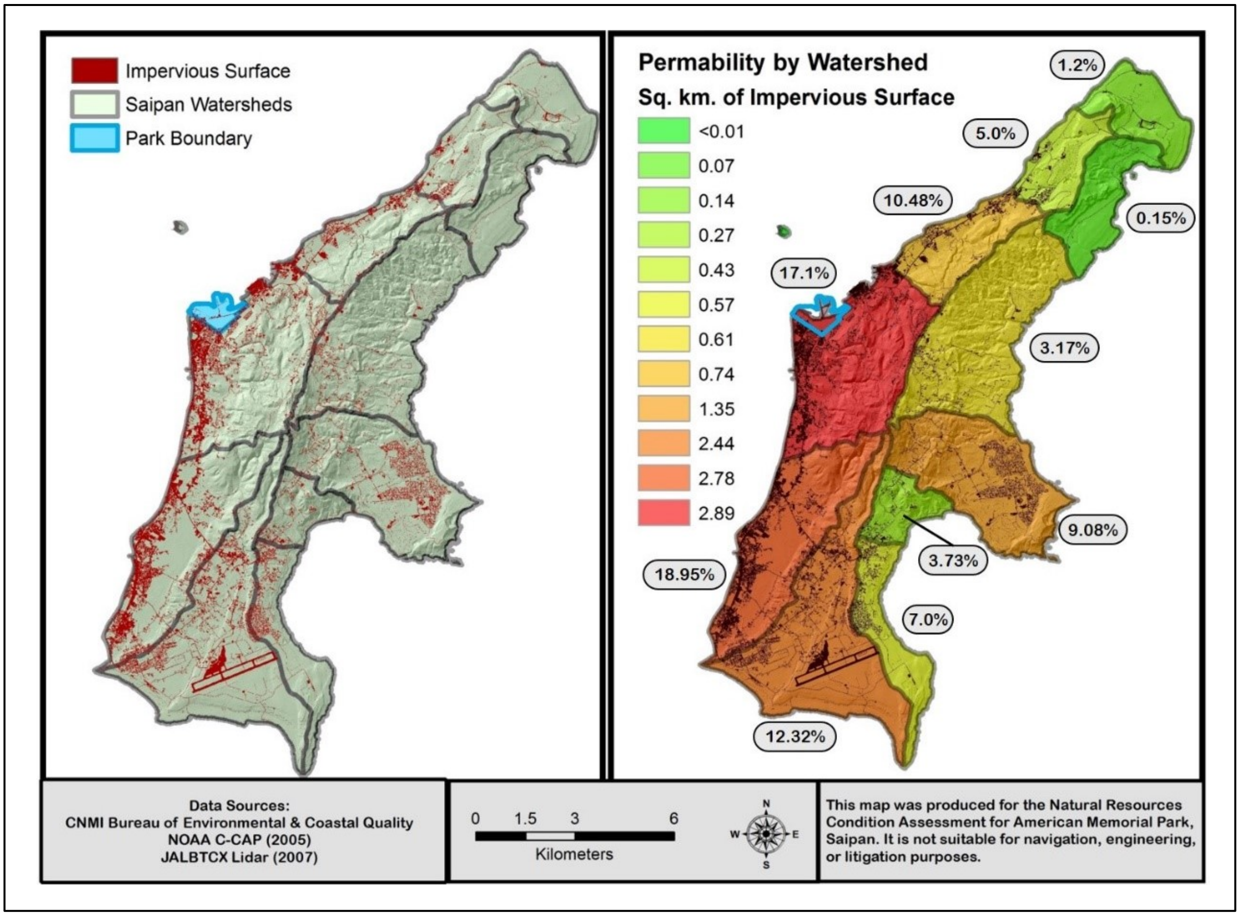


Figure 15. Map of Saipan impervious surfaces and land cover permeability by watershed. (NOAA 2005; Lidar 2007).

Given these conditions, the Park serves as one of the only natural parcels within the watershed that retains the ability to mitigate storm-water pollution and nutrient loading before surface drainage and overland sheet flow reach the Saipan Lagoon. In particular, AMP's wetlands, mangroves, and vegetated areas near Smiling Cove Marina offer a significant ponding area for storm water that would otherwise flow relatively unobstructed into the waters around Smiling Cove. Figure 16 highlights Smiling Cove Marina's sub-watershed and impervious cover within it. These threats, and the Park's role in mitigation, are discussed further in this report's discussion of threats and stressors.

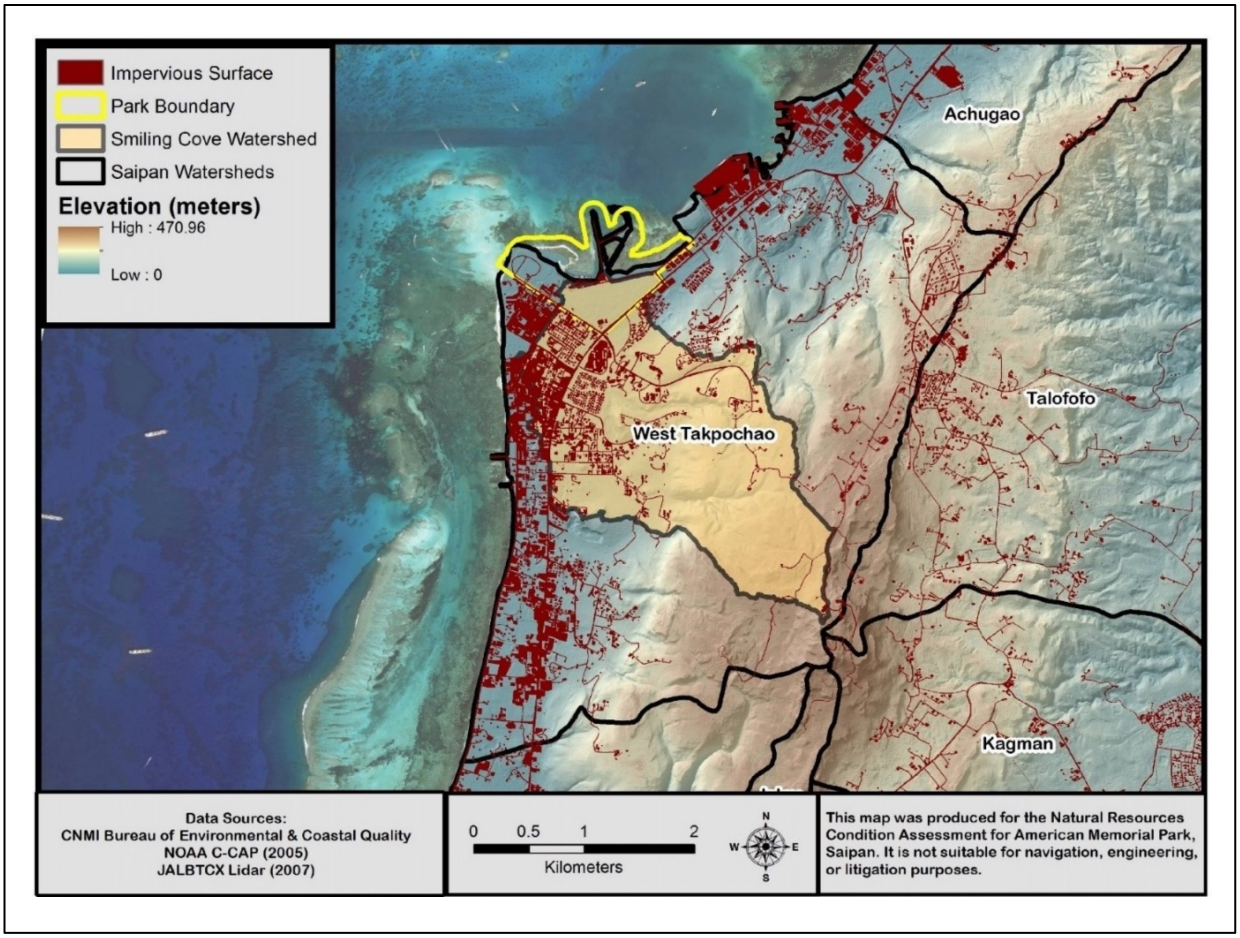


Figure 16. Map of American Memorial Park and Smiling Cove Marina sub-watershed and impervious surfaces. (NOAA 2005; Lidar 2007).

2.2.2. Land Cover and Landscape Processes

Description

The NRCA leverages a mix of broad scale (island-wide) land cover data and park-specific vegetation or habitat maps to assess baseline conditions and change over time. While some of the land cover data and classifications are more generalized than the species-level habitat or vegetation mapping efforts within the park (e.g., wetland delineation versus wetland plant species), the land cover datasets have the added capacity of including classifications for all land use in a given area. In the case of American Memorial Park, this includes parking lots, restrooms, tennis courts, the museum and visitors center, roads, the amphitheater, historic memorials, and other artificial structures that would otherwise be omitted from vegetation inventories. For the Park and its surrounding urban environs this provides a much more comprehensive picture of land configuration and edge effects between developed spaces and natural resources.

Temporally, the land cover datasets are also useful in that classification methodology employed by the data originators may stay consistent over time and therefore allow for spatio-temporal analysis. The land cover datasets and habitat maps described in the following section are critical for managers and researchers to be able to monitor changes due to the effects of climate change, the spread or decline of invasive vegetation, erosion and accretion along shorelines, impacts from drought or flood conditions, effects of large storms, and other landscape-level changes over extended periods of time. It is important to note that these crucial sets of spatially-explicit data generally derive from updates in satellite imagery and are therefore often produced within 1–2 years of the distribution of new imagery datasets. Figure 17 depicts a timeline showing a broad categorization of land use changes on Saipan along with some of the causes of change, and the satellite imagery that has been used to develop land cover datasets at various points along the timeline.

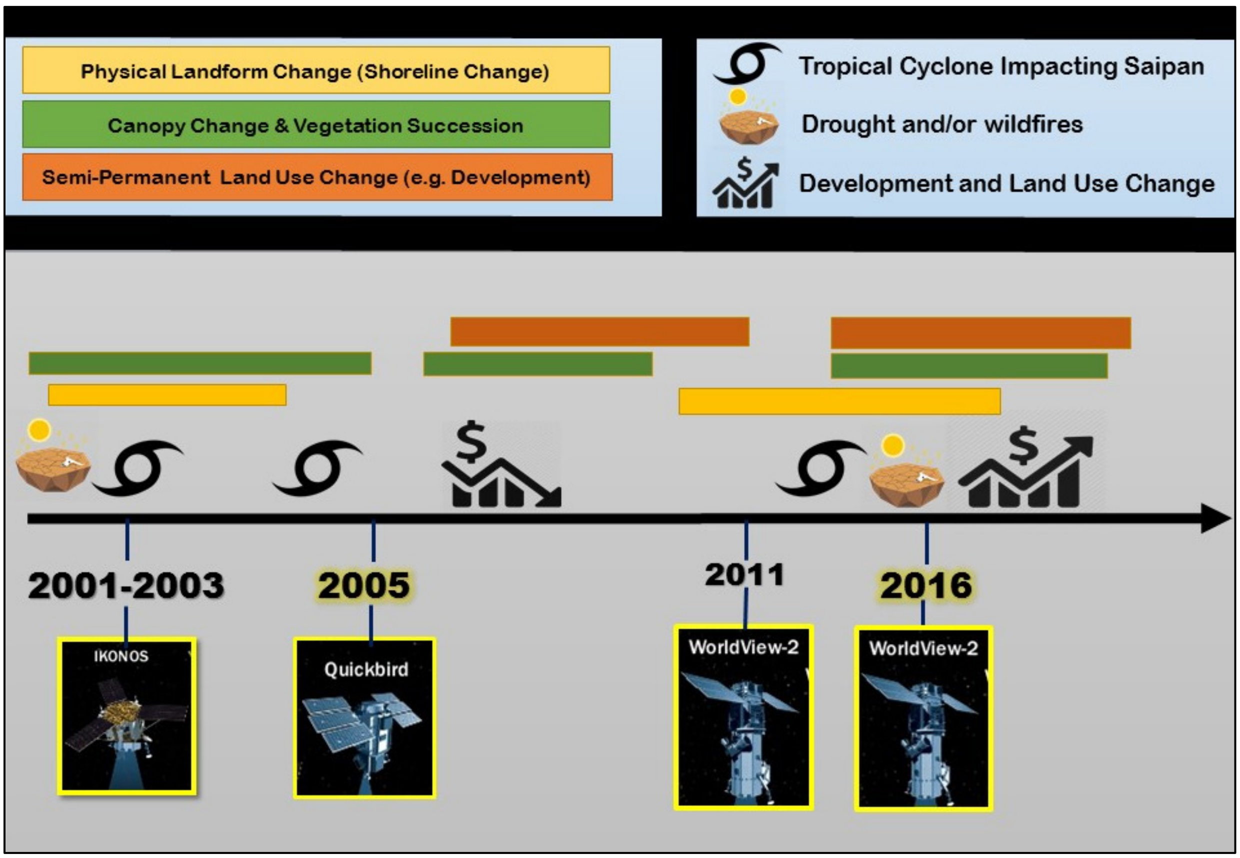


Figure 17. Timeline of land cover changes and satellite imagery used in publicly available datasets.

<u>Available Habitat Maps and Land Cover Datasets</u>

The most park-specific vegetation mapping was completed in 2013 based on species-specific field surveys, classification of Quickbird (2005) and Ikonos (2003) satellite imagery, and subsequent ground-truthing. Cogan et al. (2013) completed the vegetation inventory of the park and nearby benthic habitat, dividing the park into species-dominated habitat type (mangrove forest, reef, woodland, ornamental trees, etc.) and locating roads, park facilities, and other artificial structures.

Two decades prior, Raulerson and Rinehart (1989) developed the first vegetation inventory for the park before many structures and roads were built. Field surveys collecting plants from all areas of the wetland, as well as analysis of 1987 aerial imagery and ground-truthing allowed for the creation of this map. By comparing the two maps from 1989 and 2013 we can track land use changes within the park, including vegetation composition and the presence of roads and structures. This comparison is highlighted in Chapter 4 (“Natural Resource Conditions”) and Appendix A of the NRCA. Unfortunately, these studies were not part of an ongoing mapping program such as the NOAA C-CAP or U.S. Forest Service (USFS) Land Use datasets (NOAA 2005; USDA FS 2006), so future comparative analysis may be limited.

In contrast, island-wide land cover datasets were developed in 2005–2006 by the USFS and NOAA C-CAP. Both datasets were based primarily on the first cloud-free, high-resolution satellite imagery of the island which was captured by the Quickbird Satellite in 2005. Given the broader scale of this mapping effort, greater emphasis was placed on remote-sensing of vegetation and land cover in wide classifications (e.g., “Palustrine Wetland” or “Scrub-Shrub”) as opposed to species-specific bins that require further in-situ observations or sampling.

While the broader efforts by USFS and NOAA have limitations with regard to park-specific analysis and appear not to match actual land cover in some sites, the data has proven useful in assessing landscape-scale processes within adjacent watersheds and large portions of the island. Public access to the data renders it a valuable resource for various planning purposes. Examples of this are illustrated in Chapters 4 and 5 of the NRCA.

The Inventory and Monitoring Program (I&M) of the NPS carried out vegetation transects and mapping in the Park in 2009 and will repeat the data collection and mapping at five year intervals using a more complex and unique classification of vegetative habitats. This mapping is based on satellite images and ground truthing. These maps and data should be applied in future assessments of vegetative changes after the maps and data are certified.

For the purposes of this section of the NRCA, USFS and NOAA C-CAP data were clipped to the American Memorial Park boundary to highlight the limitations posed by coarse categorization of land cover while also demonstrating the value of such data as a snapshot in time of a constantly changing park. Of particular interest is the relatively large growth of the Park’s sand-spit and coastal scrub on the west side of the Marina, easily identified in Figures 18 and 19 through the overlay of 2005 land cover on 2016 WorldView imagery.

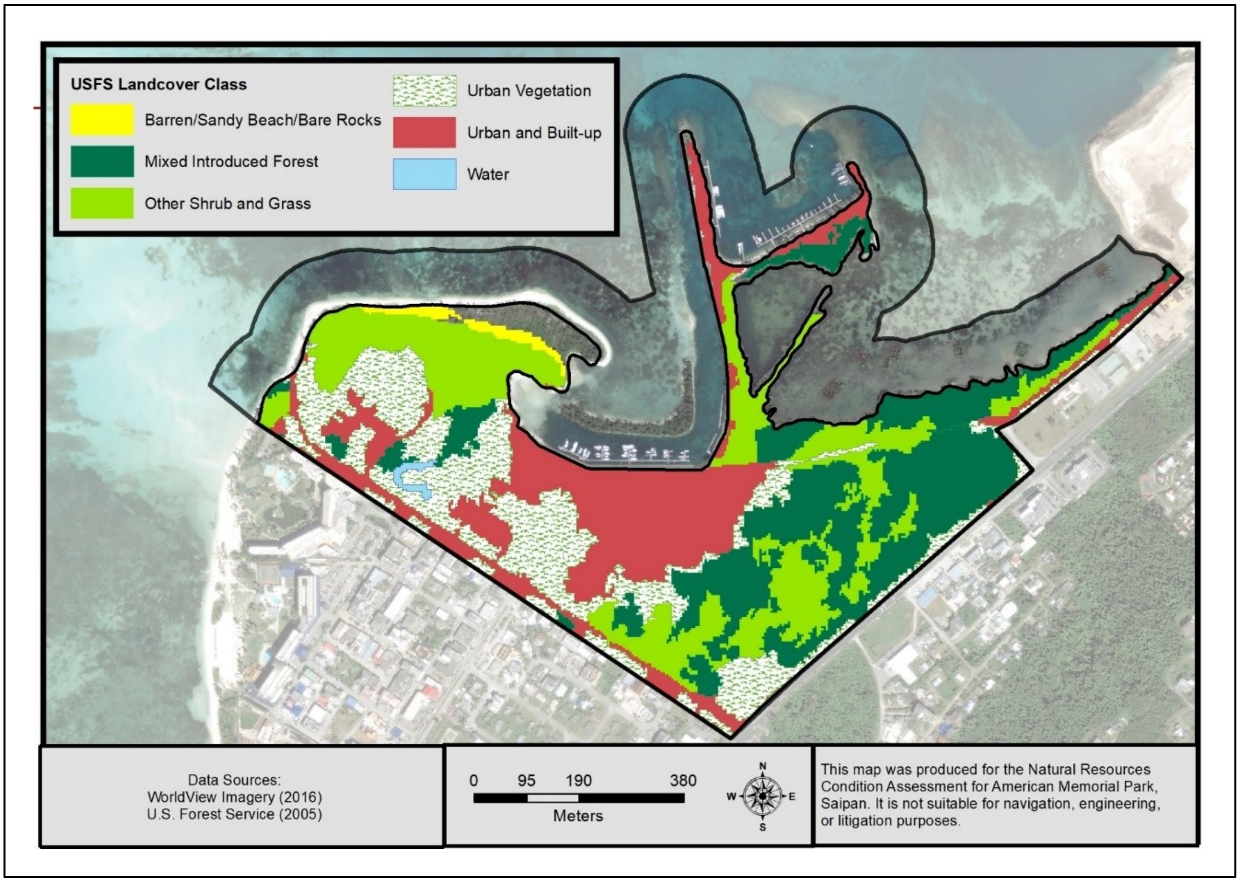


Figure 18. Map of American Memorial Park landcover within park boundary (USDA FS 2006).

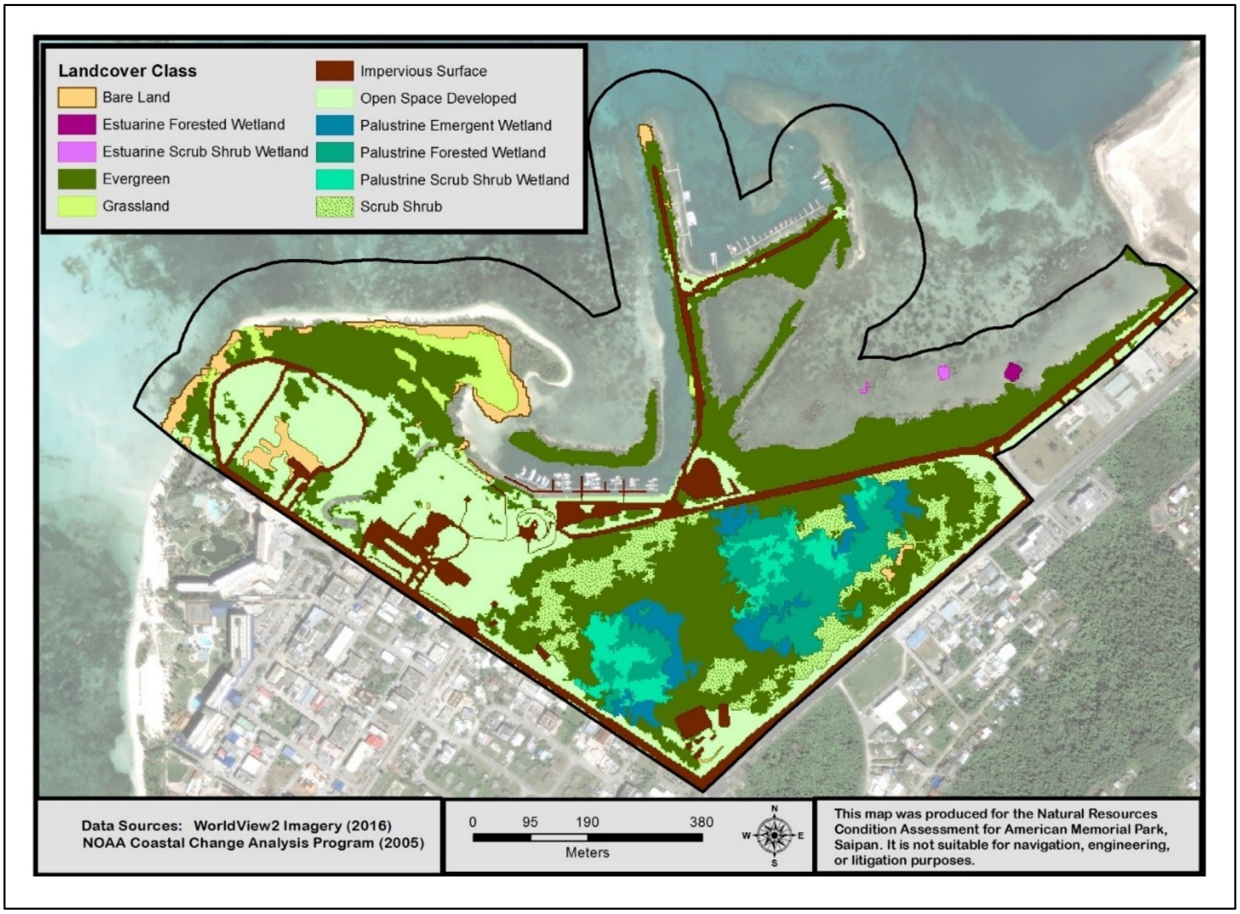


Figure 19. Map of American Memorial Park landcover within park boundary (NOAA 2005).

While American Memorial Park's land cover data are primarily focused on terrestrial spaces, the land-sea interface is quite dynamic with portions of the park growing and receding in response to coastal processes and shifts in nearshore benthic habitat. In light of this, benthic habitat mapping efforts in the Saipan Lagoon can be quite relevant to AMP when viewed in tandem with terrestrial data. For example, some early studies of shoreline change within the park hypothesized a connection between the extent of seagrass patches in the near-shore zone and the rate of shoreline change and erosion among adjacent beach areas (Dean 1991). Therefore a brief synopsis of benthic habitat mapping is warranted.

A seminal lagoon mapping study was conducted by Houk and van Woesik (2008), combining remote sensing techniques on Ikonos Satellite imagery from the early 2000s with field sampling via a "moving window analysis" and additional ground-truthing. In 2016–2017, scientists from NOAA's Biogeography Branch established a series of updated benthic habitat maps and benthic change maps for the Lagoon (Kendall et al. 2017). This study employed an extensive mixed-methods approach, using remote sensing of 2016 WorldView imagery with hundreds of sample points in the field and comparative analysis with the 2005 lagoon mapping results. This project yielded habitat maps at a two-meter resolution. While the classification schemes differed slightly between these two studies, the results do provide useful datasets for examining change over time. Figures 20 and 21 illustrate benthic habitat characteristics of the lagoon within and adjacent to the AMP near-shore zone (100 m, 328.08 ft, seaward buffer) as a result of these two studies.

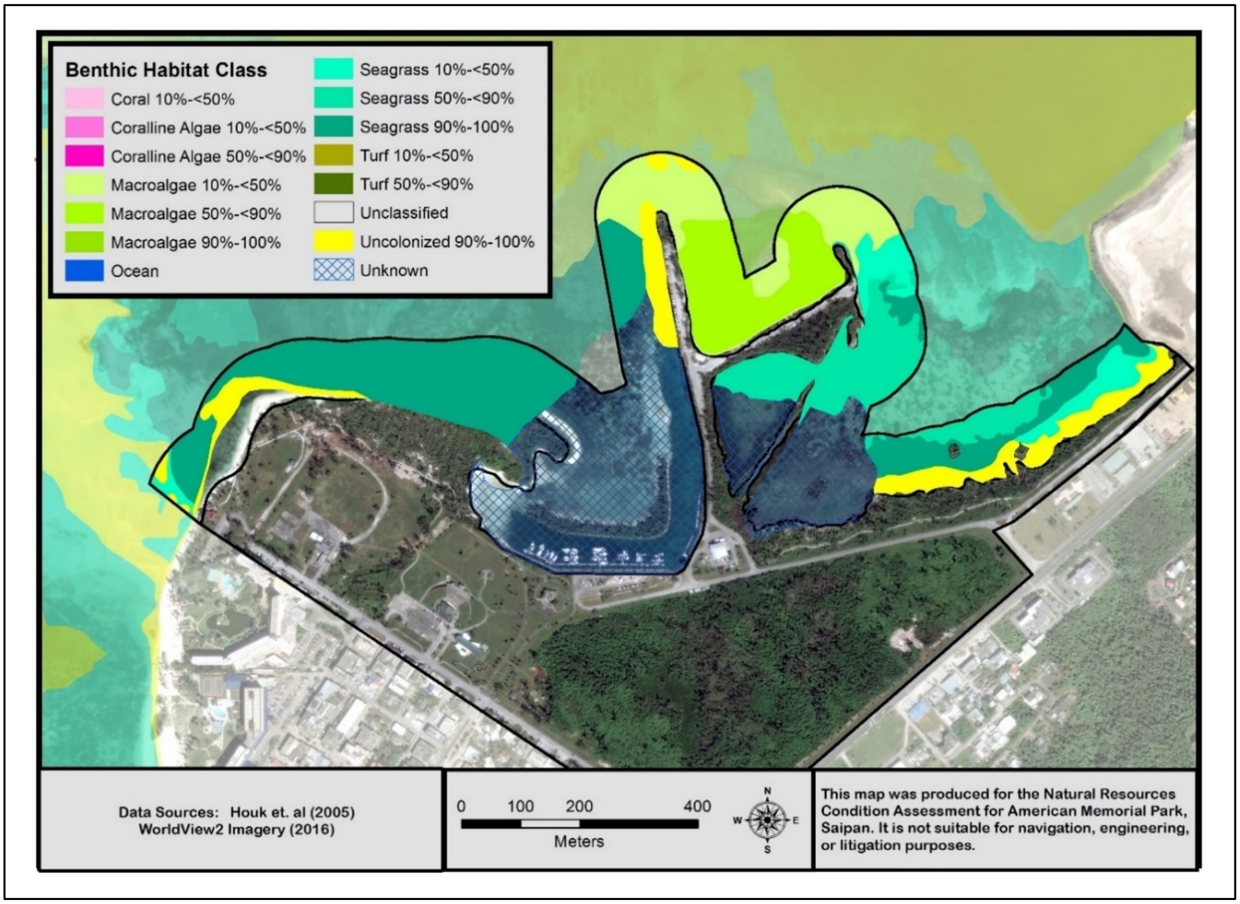


Figure 20. Map of benthic habitat adjacent to American Memorial Park, with park boundary and 100 m (328.08 ft) seaward buffer delineated, according to Houk and van Woesik 2008.

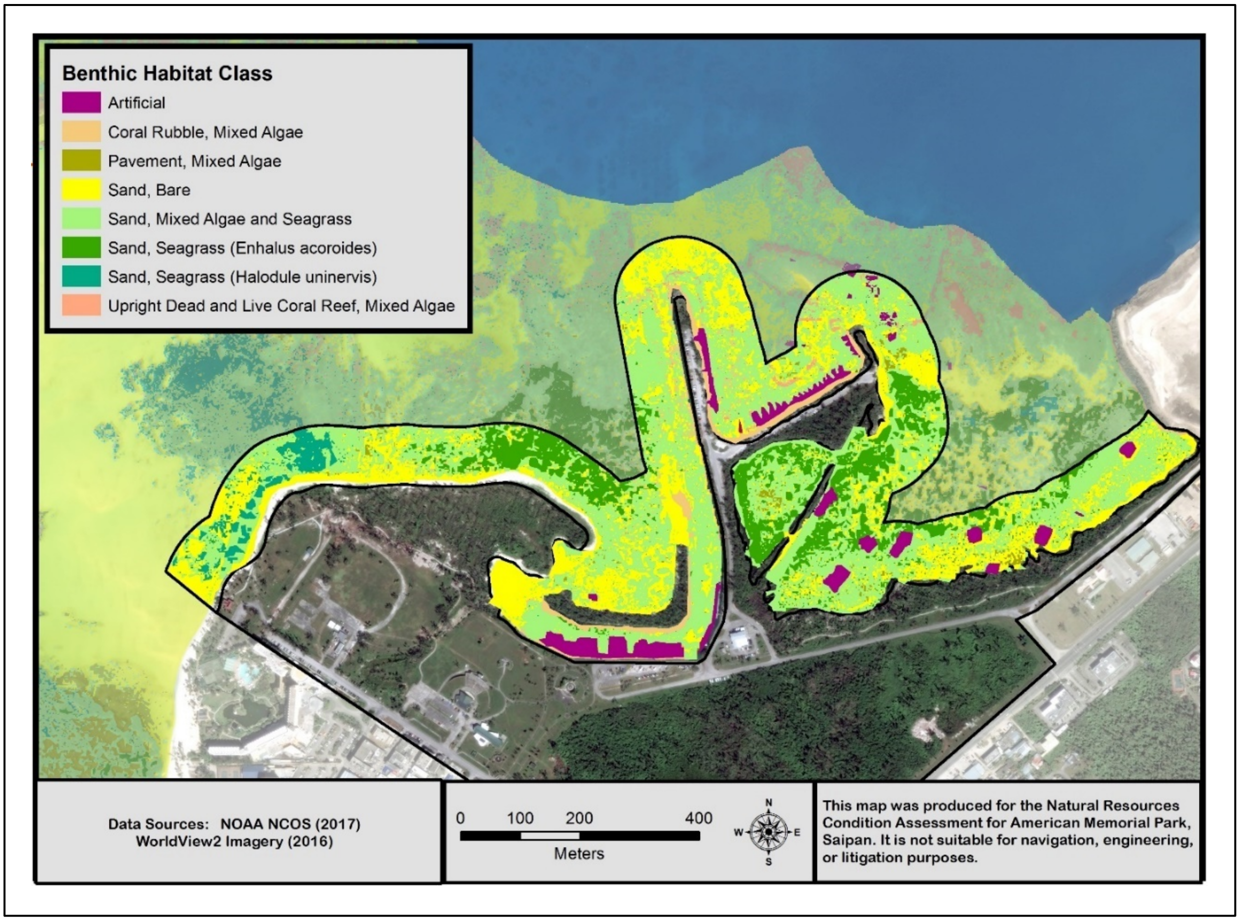


Figure 21. Map of benthic habitat adjacent to American Memorial Park, with park boundary and 100 m (328.08 ft) seaward buffer delineated according to Kendall et al. 2017.

<u>Land Cover Change</u>

Land cover change in American Memorial Park occurs due to both natural and anthropogenic causes. In August 2015, Typhoon Soudelor felled over 90% of trees in sections of the park (NPS 2017) and the predicted increase in intensity of future large storm events due to climate change, combined with ongoing threats of introduced and invasive vegetation, will compound efforts to re-vegetate areas of the park with native species after these future disturbances.

Likewise, long-term sea level rise due to anthropogenic climate shifts will pose great challenges in predicting future shoreline positions and managing infrastructure located in the lowest elevations of the park. Figures 22–24 illustrate potential temporary coastal flooding in the Park assuming a rapid rate of sea level rise over a 50-year period (NOAA 2017, USACE 2017) and 100-year recurrence sea level extremes calculated for Saipan Harbor for the months of October through December based on Saipan sea level records from 1978–2003 (Chowdhury et. al. 2010). These scenarios, which are detailed in Table 3 and further described in later portions of the NRCA, are based on a combination of historic data and future projections and should therefore be considered as purely hypothetical. Nevertheless, they would be disastrous to many of the Park’s primary recreational and cultural features. Even less drastic increases in sea level could also lead to permanent changes to the landscape including potential migration of wetland land cover into portions of the park with higher elevations.

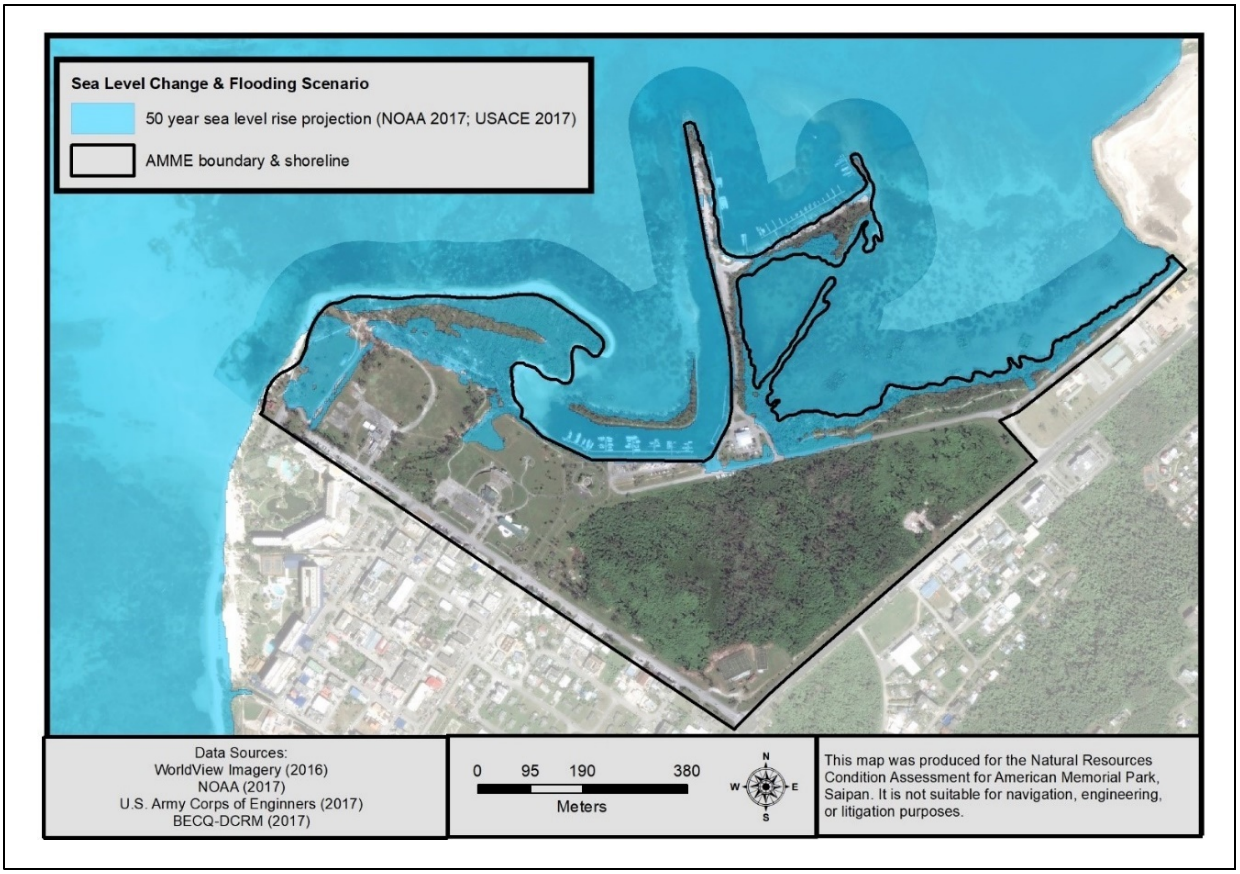


Figure 22. Coastal flooding scenario at American Memorial Park based on a 50-year (2067) sea level rise projection (+1.31 m) for Apra Harbor, Guam (NOAA 2017; USACE 2017).

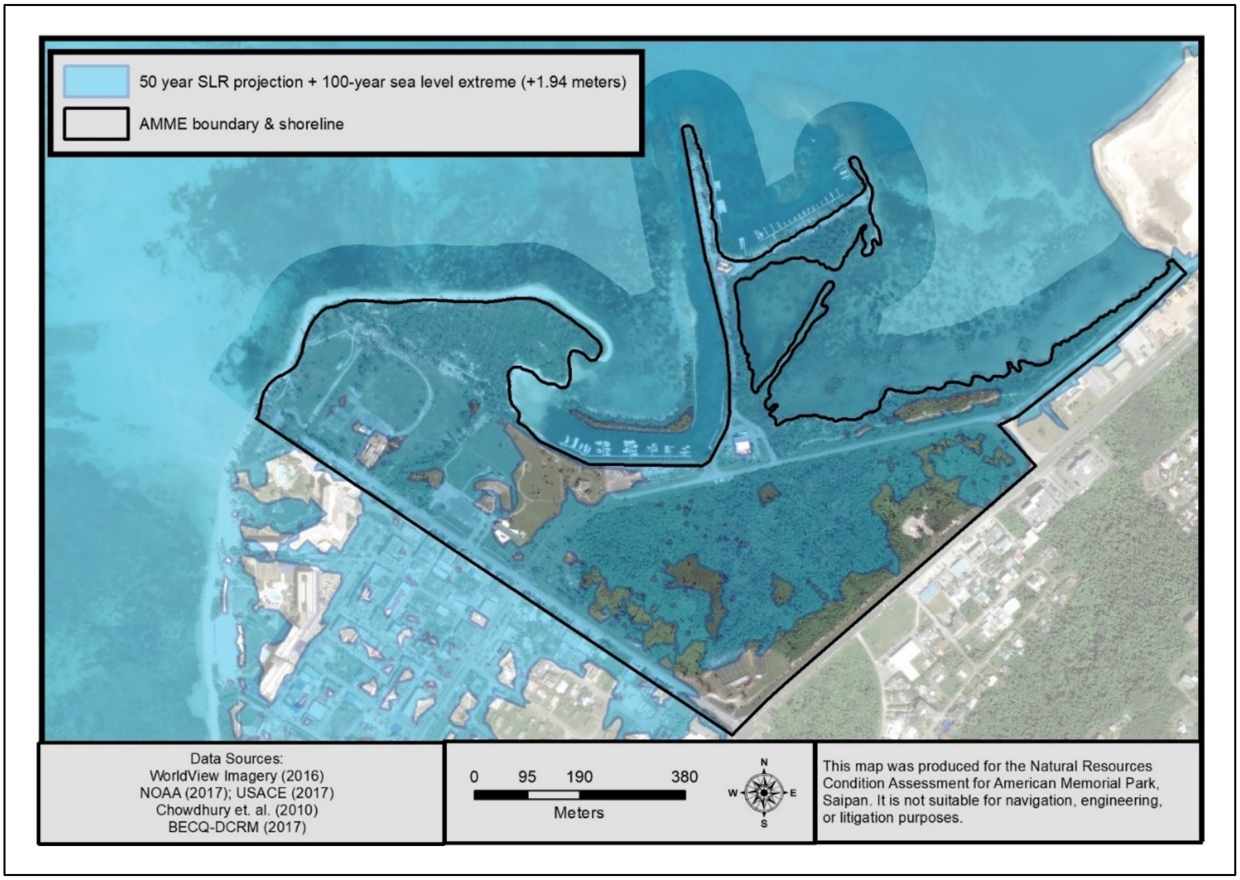


Figure 23. Coastal flooding scenario at American Memorial Park based on a 50-year (2067) sea level rise projection for Apra Harbor, Guam (NOAA 2017; USACE 2017), and 100-year return period sea level extreme for Saipan Harbor (+1.94 meters) (Chowdhury et. al. 2010).

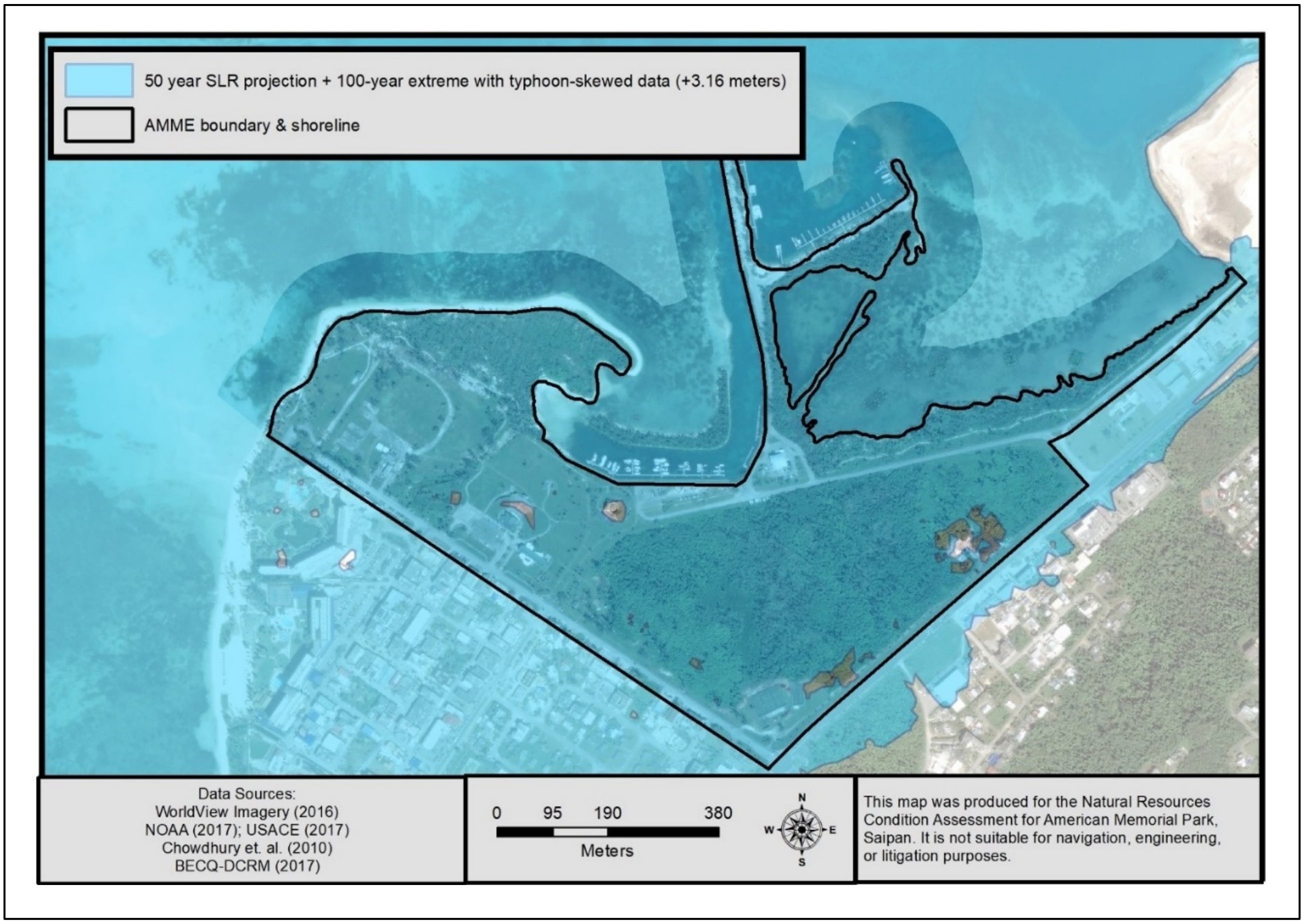


Figure 24. Coastal flooding scenario at American Memorial Park based on a 50-year (2067) sea level rise projection for Apra Harbor, Guam (NOAA 2017; USACE 2017), and 100-year return period sea level extreme for Saipan Harbor, including data from years with typhoon passage (+3.16 meters) (Chowdhury et. al. 2010).

Table 3. Coastal flooding scenarios for American Memorial Park based on a combination of historically derived sea level extremes at Saipan Harbor and sea level rise trends and projections for Apra Harbor, Guam (BECQ-DCRM 2017).

Scenario	Data Code	Seasonal Extreme (m)	Seasonal Extreme Description	Sea Level Rise (m)	Sea Level Rise Description**	Cumulative Sea Level Change (m)
OND Seasonal Extreme (Typhoon Year)	OND_TY	1.85	Historically derived (1978–2003) maximum sea level for 100-year recurrence at Saipan Harbor, during the months of October - December including data from years with typhoon passage.	0.00	Climate change-related sea level rise not factored into this scenario.	1.85
50 years SLR	SLR50	0.00	No seasonal extreme estimates factored into this scenario.	1.31	Sea level rise projection for 2067 based on NOAA 2017 "High" curve and U.S. Army Corps sea level curve calculator for Apra Harbor tide gauge (local vertical land movement)	1.31
30 years SLR + OND Seasonal Extreme	SLR30_OND	0.63	Historically derived (1978–2003) maximum sea level estimate for 100-year recurrence at Saipan Harbor for months Oct.-Dec., with Typhoon-affected data removed.	0.74	Sea level rise projection for 2047 based on NOAA 2017 "High" curve and U.S. Army Corps sea level curve calculator for Apra Harbor tide gauge (local vertical land movement)	1.37
50 years SLR + OND Seasonal Extreme	SLR50_OND	0.63	Historically derived (1978–2003) maximum sea level estimate for 100-year recurrence at Saipan Harbor for months Oct.-Dec., with Typhoon-affected data removed.	1.31	Sea level rise projection for 2067 based on NOAA 2017 "High" curve and U.S. Army Corps sea level curve calculator for Apra Harbor tide gauge (local vertical land movement)	1.94
75 years SLR + OND Seasonal Extreme	SLR75_OND	0.63	Historically derived (1978–2003) maximum sea level estimate for 100-year recurrence at Saipan Harbor for months Oct.-Dec., with Typhoon-affected data removed.	2.14	Sea level rise projection for 2093 based on NOAA 2017 "High" curve and U.S. Army Corps sea level curve calculator for Apra Harbor tide gauge (local vertical land movement)	2.77

Table 3 (continued). Coastal flooding scenarios for American Memorial Park based on a combination of historically derived sea level extremes at Saipan Harbor and sea level rise trends and projections for Apra Harbor, Guam (BECQ-DCRM 2017).

Scenario	**Data Code**	**Seasonal Extreme (m)**	**Seasonal Extreme Description**	**Sea Level Rise (m)**	**Sea Level Rise Description****	**Cumulative Sea Level Change (m)**
50 years SLR + OND Seasonal Typhoon Year	SLR50_OND TY	1.85	Historically derived (1978–2003) maximum sea level for 100 year recurrence interval at Saipan Harbor, during the months of October - December including data from years with typhoon passage.	1.31	Sea level rise projection for 2067 based on NOAA 2017 "High" curve and U.S. Army Corps sea level curve calculator for Apra Harbor tide gauge (local vertical land movement)	3.16

Additional information and implications regarding these coastal flooding scenarios are described in later sections of the NRCA to highlight potential future impacts on land cover as well as park infrastructure.

The presence of invasive species and the amount of resources devoted to invasive species mitigation will also continue to impact land cover within the park. The coconut rhinoceros beetle (*Oryctes rhinoceros*) is not yet established on Saipan but has been found on nearby islands such as Rota and Guam. If introduced, this beetle has the potential to decimate palms on park land as it is currently doing on Guam. The brown tree snake is also not yet established on Saipan but could devastate terrestrial vertebrate populations on Saipan as it has on Guam. The introduction of this snake and the cascading ecological impacts that would result would significantly alter park vegetation due to the loss of seed dispersal services that local avifauna perform (Rogers et al. 2017).

Tectonic activity also has the potential to affect park land cover, including developed spaces, through shifts in geologic configuration and impacts to the built environment. In-depth field investigation and mapping of Saipan's tectonic features was last conducted by the U.S. Geological Survey (USGS) in 2006 and 2007 (Figure 25; Weary and Burton 2011), but very little detail exists regarding the actual behavior of the nearby Matansa fault or whether the Park's geologic composition of marsh deposits, artificial fill, and carbonate sands would experience liquefaction in a large earthquake. Saipan sits in a tectonically active area, with frequent minor tremors (<4.0 magnitude), so the potential effects from high-magnitude earthquakes remains a topic that requires further investigation.

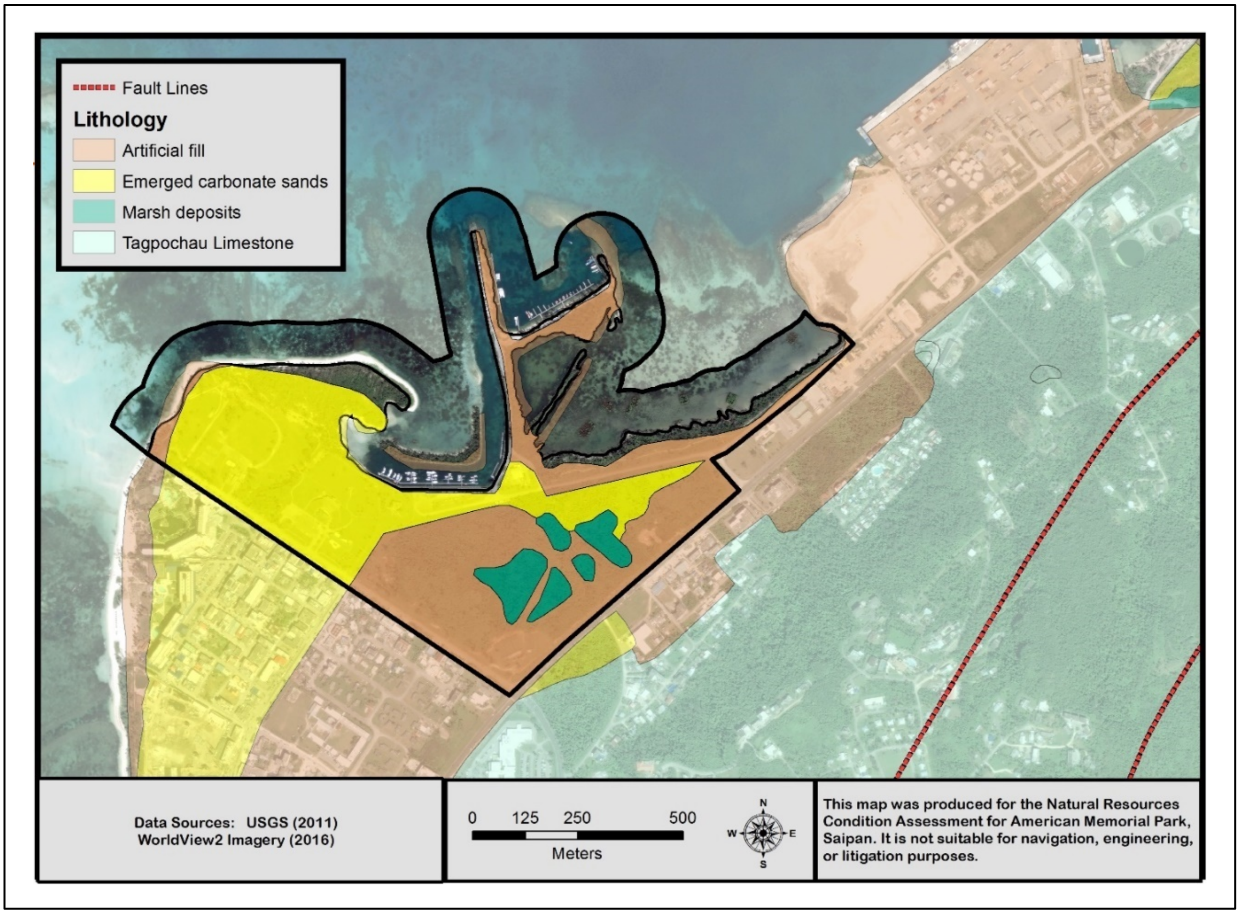


Figure 25. Geological composition within American Memorial Park and location of Matansa fault line (Weary and Burton 2011).

2.2.3. Park Specific Resource Descriptions

In addition to the broader environmental context discussed in the previous section, American Memorial Park contains high concentrations of culturally and ecologically significant resources, warranting a focused discussion on some of the rare features specific to the park. While there are highly visible historic WWII relics, three war memorials, and noteworthy Chamorro cultural deposits, the Park also provides habitat for three endangered species, the moorhen, reed warbler, and humped tree snail, and contains mangrove wetland habitat that is rare in the CNMI. A full list of plant and animal species that are present or probably present in the park has been compiled on NPSpecies and is included in Appendix B of this report (NPS Irma Portal).

With respect to avian fauna, seventeen terrestrial avian species are found within the park, fourteen of which are indigenous to the Marianas. Of these seventeen species, most have been observed foraging for food, collecting nesting materials, building or caring for nests, or feeding young within the park (Rauzon 2010). Additional pelagic and migratory shorebirds have been observed flying near or above the park and in adjacent mudflats (Rauzon 2010; Snyder 2006). The endangered Mariana gray swiftlet (*Aerodramus bartschi*) has been reported foraging above park shores but is seen infrequently.

Two endangered species of sea turtle, the green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*), have also historically nested within park boundaries (Summers et al. 2018). In recent years there has been limited nesting activity by green sea turtles in AMP, with nesting activity being reported only in 2015 and 2017 (DLNR unpublished data).

One species of orchid (*Zeuxine fritzii*) found within the Park is rare in the CNMI. The endangered humped tree snail was present in the Park's wetlands but may be locally extinct there since the recent typhoon damage to habitats in 2015 and again in 2018 (M. Gawel, pers. comm., 17 December 2018). No critical habitats have been designated within the Park. Threatened and endangered species, as noted by USFWS, are listed in Table 4.

Table 4. Endangered fauna found within American Memorial Park (USFWS 2017).

Fauna type	Species common name (*scientific name*)	Status (date listed)
Avifauna	Bridled white-eye (*Zosterops conspicillatus*)	Endangered (1984)
	Mariana moorhen (*Gallinula chloropus guami*)	Endangered (1984)
	Nightingale reed warbler (*Acrocephalus luscinius*)	Endangered (1970)
	Mariana gray swiftlet (*Aerodramus vanikorensis bartschi*)	Endangered (1984)
Reptiles	Green sea turtle (*Chelonia mydas*)	Endangered (2016)
	Hawksbill sea turtle (*Eretmochelys imbricata*)	Endangered (1970)
Invertebrates	Humped tree snail (*Partula gibba)*	Endangered (2015)

2.2.4. Resource Issues Overview

Numerous issues currently face American Memorial Park posing an array of management problems as well as the potential for future complication due to anthropogenic forces. Threats and stressors affecting the Park as identified by local resource managers and park officials include invasive species, illegal or excessive harvest, storm-water runoff, coastal erosion, pathogens, point-source pollutants, unchecked adjacent development, stochastic events (natural disasters), and the complications that a changing climate may create for these issues.

Invasive species

Invasive species are already present in the Park. Invasive vegetation on Saipan is prevalent throughout AMP's natural landscape and invasive fauna are outcompeting native species and posing a significant threat to critical populations of endemic and endangered species. For example, the flowering plant *Lantana camara* was not invasive on Saipan until after 1974 but is now widespread throughout the island and outcompeting native flora, especially in disturbed areas (Sharma et al. 2005). Feral cats (*Felis catus*) predate on many of Saipan's native species, especially birds. There are also additional species not yet established on Saipan that pose significant threats because of their establishment in neighboring islands. Most notable are the brown tree snake and the coconut rhinoceros beetle, both of which are found on nearby Guam where their presence is decimating sensitive vertebrate and palm populations.

Coastal erosion and sea level rise

With respect to the physical landscape, the shoreline of American Memorial Park is a focal point in the CNMI for the study and management of coastal erosion and the compounding effects of sea level variability and storm activity. The beaches and nearshore waters along the Park's western and northern boundaries are dynamic, as evidenced by comparative analysis of historic shoreline positions as well as documentation of tangible impacts (Figure 26).

Figure 26. A section of collapsed sidewalk and adjacent eroded shoreline during a high tide and large west swell at American Memorial Park (Photo by R. Greene 2013).

The coastal morphology and shoreline trends of the park are one of the more visible threats to the Park, prompting several reports over the last thirty years (Dean 1991; USACE 2004; Yuknavage and Palmer 2010). Perhaps most notably, a bathroom facility near the shore was lost due to wave erosion and was rebuilt further inland. In addition, portions of the popular recreational paths are crumbling as the adjacent shoreline recedes during storm events and large swells out of the west. Despite a number of direct observations, documentation, and intermittent reports that affirm the chronic nature of these changes, there is a relative lack of studies that quantify these changes and no modeling has been conducted to provide projections or estimates of future shoreline positions. Subsequently there is a general deficiency in the data and information that could support management planning or decisions regarding mitigation or adaptation options.

Based on NOAA's most recent report on global and regional sea level trends and scenarios (NOAA 2017) and calculations of local sea level scenarios using the U.S. Army Corps of Engineers (USACE) Sea Level Curve Calculator (USACE 2017), shifts in global, regional, and sub-regional climate conditions are expected to cause sea level change rates at American Memorial Park in exceedance of the global rates. Using these updated resources, Figure 27 and Table 5 highlight a range of potential sea levels at American Memorial Park. These sea levels and associated rates of change are partially based on sea level records from the tide gauge in Apra Harbor, Guam. This station holds the most consistent, long-term records for the Marianas Archipelago and serves as the basis for NOAA's Center for Operational Oceanographic Products and Services' sea level trend calculations for the Marianas. It is therefore used as a proxy for sea level trends at AMP in this report. Revised intermediate to extreme projections based on the Apra Harbor gauge range from 0.67 m (2.2 ft.) to 1.58 m (5.2 ft.) by 2070, roughly 50 years from the date of publication of this NRCA (NOAA 2017; USACE 2017).

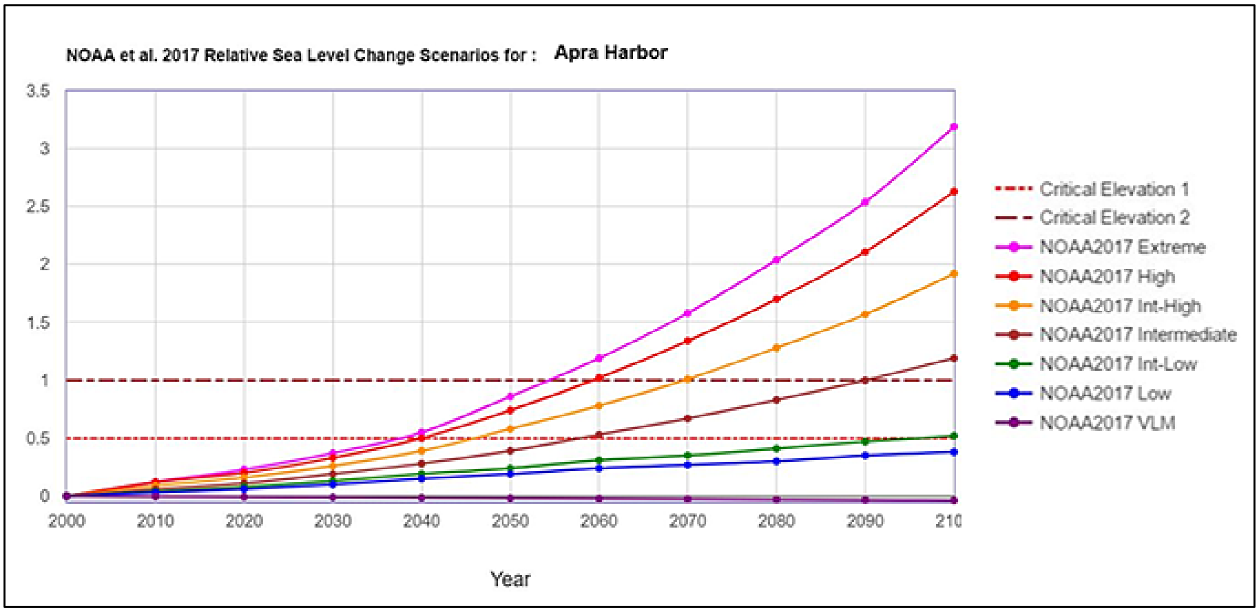


Figure 27. Sea level curves (meters) for the Apra Harbor Tide Gauge on Guam (NOAA 2017).

Table 5. Sea level change projections at American Memorial Park up to 2100 at 10 year intervals (NOAA 2017). VLM: -0.00037 m/yr (all values expressed in meters).

Year	NOAA2017 VLM	NOAA2017 Low	NOAA2017 Int-Low	NOAA2017 Intermediate	NOAA2017 Int-High	NOAA2017 High	NOAA2017 Extreme
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	-0.00	0.03	0.04	0.06	0.09	0.12	0.12
2020	-0.01	0.06	0.08	0.11	0.16	0.20	0.23
2030	-0.01	0.10	0.13	0.19	0.26	0.33	0.37
2040	-0.01	0.15	0.19	0.28	0.39	0.50	0.55

Table 5 (continued). Sea level change projections at American Memorial Park up to 2100 at 10 year intervals (NOAA 2017). VLM: -0.00037 m/yr (all values expressed in meters).

Year	NOAA2017 VLM	NOAA2017 Low	NOAA2017 Int-Low	NOAA2017 Intermediate	NOAA2017 Int-High	NOAA2017 High	NOAA2017 Extreme
2050	-0.02	0.19	0.24	0.39	0.58	0.74	0.86
2060	-0.02	0.24	0.31	0.53	0.78	1.02	1.19
2070	-0.03	0.27	0.35	0.67	1.01	1.34	1.58
2080	-0.03	0.30	0.41	0.83	1.28	1.70	2.04
2090	-0.03	0.35	0.47	1.00	1.57	2.11	2.54
2100	-0.04	0.38	0.52	1.19	1.92	2.63	3.19

With the majority of the park situated between 0–6 m (0–19.69 ft) in elevation, most climate change scenarios and associated sea levels suggest frequent, large-scale flooding during storm events by the end of the century (Greene and Skeele 2014), while 'high' and 'extreme' scenario curves would permanently inundate lower-lying portions of the park in the next 50 years. Changes in annual, inter-annual, and decadal climate patterns, such as ENSO and the Pacific Decadal Oscillation, will also likely affect park ecosystems through variations in storm frequency and associated precipitation, as well as sea level extremes, both high and low.

Pathogens

Introduced pathogens also pose an issue at American Memorial Park as they can be particularly harmful to the terrestrial animals of an isolated island ecosystem such as Saipan. Impacts from pathogens could subsequently compound the habitat loss and presence of invasive species already taking place on the island and within the Park. Avian malaria, which is decimating native bird populations on other Pacific islands (e.g., Hawai'i) could have similar detrimental effects if introduced to the CNMI (Wikelski et al. 2004). The mangrove and wetland areas are also a breeding ground for mosquitoes, so any mosquito-borne virus introduced to Saipan would have ample opportunity to propagate within the park.

The Park is adjacent to Saipan's urban center and tourism core, Garapan, and is also situated at the outfall of a highly-developed area with substantial patches and corridors of impervious surface. This translates into urban runoff filtering through the park during storms, carrying with it pollutants from automobiles, mechanic shops, gas stations, septic tanks, and other forms of urban contamination. With the additional issue of outdated sewer and storm water infrastructure as well as frequent raw sewage discharge at the artificial wetland, Saipan residents have consistently noted the smell of sewage near park boundaries. Water monitoring performed by local government officials at the Bureau of Environmental and Coastal Quality (BECQ) has repeatedly documented bacteria representing fecal contamination in the near-shore waters and artificial wetland (Bearden et al. 2014).

Stochastic events

In terms of the relationships between these issues, stochastic events (natural disasters) can offer a glimpse into the manner in which threats may compound each other. Most recently, in 2015 Typhoon

Soudelor not only disturbed the terrestrial ecosystems within the park but also destroyed adjacent infrastructure and natural filtration systems. This opened opportunities for increased presence of pathogens, invasive species, and impacts from storm water runoff. Other stochastic events such as earthquakes, volcanic eruptions in the Northern Islands, wildfires, and even ship groundings and associated spills, pose additional threats to park resources. Adaptive management and resource stewardship within the Park will be critical in the coming years as the potential for some of these threats increases substantially.

2.3. Resource Stewardship

2.3.1. Management Directives and Planning Guidance

American Memorial Park was created by Public Law 94-241 in March, 1976 with the same legislation that established the CNMI. In 1978 a master plan was created for the Park which outlined development guidelines including a mixture of passive and active recreational opportunities aimed at encouraging both local and foreign visitation (NPS 1989). The general park design was intended to promote a “passive, intimate, and contemplative” environment (NPS 1989).

The Park’s general management plan (GMP) has not been updated since 1989. Twenty-eight years later, NPS acknowledges a high priority to update this GMP as it “does not reflect current visitor use, changes in visitor demographics, the park’s unique natural resources, and the current staffing needs” and does not adequately address the evolving threats posed by climate change (NPS 2017). Construction for several facilities described in the GMP are identified as too costly and conflicting with the park purpose (such as the implementation of large athletic fields), and this disparity between the outdated park management plan and current needs causes confusion in park management.

This 1989 GMP states planning focus areas that include the following:

- Recreational activities which emphasize sports and swimming facilities and marine, botanic, and cultural facilities;
- Development which exclusively addresses WWII memorialization, recreation, environmental, and cultural activities which will be confined to those that afford the protection and preservation of historic, natural, terrestrial, and marine park resources;
- Activity locations are confined to locations compatible with such activities (marine recreation will be limited to a zone 200 ft. inland of the shoreline, the forested swamp will stay as natural as possible, development will occur in already disturbed areas, structures will not be erected at elevations below 4 ft. above sea level);
- At the time of writing, $3 million of federal funding was available for development within the park, and highest priority would be given to projects totaling $3 million or less;
- Local (CNMI) government and Department of Defense (DOD) coordination would take place to determine which artifacts needed preservation and interpretation, and for the exchange of professional, technical, and operating expertise;
- Training and employment of local staff to the highest extent possible;

- The design and construction of structures by competent and qualified professionals and, later in the document, humidity and typhoon damage-related prevention measures would be taken overall.

Comprehensive park planning at the time intended to include through-traffic access for Micro Beach, the amphitheater, WWII memorials, and open fields and parking areas. The latter features would be positioned to best serve sport and cultural centers, with the marina and museum parking lots accommodating tour bus turnouts. Additionally, all roads would be paved and parking lots would be either paved or filled with concrete pavers or soil stabilizers. Pedestrian walkways would either be paved or filled with compacted earth/coral fill and would be designed in a manner that connected sports fields and portions of natural areas.

Sewage, connected to the island's larger sanitation system, as well as electricity and running water provision would be incorporated into park facilities, with power lines and all possible other utility carriers placed underground to limit visual obstructions. Recreational facilities, especially picnic areas which were identified as culturally important for Pacific Islander communities, would be established and maintained with capacity to accommodate large groups.

The GMP also identified shoreline stabilization measures, and shoreline improvement was identified as the most probable high-cost alternative, including the removal of dangerous structures and the addition of vegetation and other structures to protect the shoreline while still allowing visitor access. The development of a Northern Marianas Cultural and Performing Arts Center building is outlined in the GMP as well, which would include spaces for banquets, cultural events, education and social programs, and was ultimately intended to "become a focal point of civic, business, and community life on Saipan" (NPS 1989).

Phases of park development are also outlined in the GMP, though in fairly broad terms. Phase one includes utilization of the federally allocated \$3 million for projects such as access roads, the cultural center building, a monument, plaza, public utilities, and the museum. Stabilization of the shoreline as well as the removal of debris were determined to be costs shared by other government organizations and would not be covered with the initial \$3 million. Additionally, nine Japanese historic features would be maintained with interpretation provided for the more prominent components (NPS 1989).

The preservation of natural resources is addressed in the 1989 GMP. Specifically, "Preservation and management of the park's natural resources will differ in each of the indicated management zones" (NPS 1989). Preservation includes the removal of harmful native or invasive species, the prohibition of activities which disturbs park resources (such as mining), soil and slope stabilization, and the provision of windbreaks, shade, and groundcover where relevant. Restoration efforts were to be geared towards the wetlands, with a pedestrian walkway and self-guided nature trails through the area to encourage study and observation of native flora and fauna. A nature center located near the wetlands is also described in the GMP to serve as an educational center for the island's unique ecology and natural resources.

With regard to specific natural resources, the GMP notes the presence of two endangered avian species, the nightingale reed warbler and Mariana moorhen. However, many species have been added to the endangered species list since 1989 and a new park management plan needs to address these additional species. Likewise, changes to overall land-cover, hydrology, and near-shore resources all warrant updated management strategies.

In addition to the GMP, the Park's foundation document (updated in 2017) identifies several management plans or guidance documents necessary for park maintenance, most of which are currently underway (denoted with an asterisk) or already completed (year completed in parentheses):

- Landscape vegetation recovery plan to repair damage caused by Typhoon Soudelor*
- Staffing plan*
- National Resource Condition Assessment*
- Invasive species monitoring*
- Strategic plan (2015)
- Park asset management plan (2014)
- Cultural resources inventory
- Climate change scenario planning, identified as a living plan incorporating a variety of assessments, trends, and scenarios*
- Climate change action plan, resulting from climate change scenario planning*
- Digital geologic map of the park and vicinity (2013, NPS Geologic Resource Inventory, unpublished)
- Paleontological resource inventory (2007)

2.3.2. Status of Supporting Science

Efforts to monitor American Memorial Park's natural resources or establish datasets related to ecological systems in the park have been somewhat inconsistent and sporadic. Most resource inventories and research projects that are not funded by NPS are either funded as part of a limited-term effort or are part of broader data collection initiatives that cover the whole island of Saipan or in some cases the entire archipelago. Based on consistency and availability of historical baseline studies, the most well-documented natural resource issues are avifauna, near-shore water quality monitoring performed by BECQ, and shoreline erosion. NPS I&M water quality monitoring has been carried out quarterly from 2009 to present in the created wetland and mangrove areas and I&M vegetation and invasive vegetation monitoring was done in 2009, in 2014, and will be repeated every five years. Certified data reports are not available at the time of this writing. NPS I&M monitored groundwater conductivity, depth, and temperature from 2010 to 2017 at two shallow wells. The results are being reviewed by USGS in a Focused Condition in 2019 following problems with the monitoring instruments and damage to the wells. The NPS I&M program has monitored meteorological data from the AMP weather station since 2014.

Research, monitoring, and environmental datasets for most other park resources are either non-existent (e.g., invasive animal monitoring, effects of visitor use on park resources, invertebrate monitoring, presence and effects of pathogens and pollutants in the park, herpetological surveys), outdated (e.g., post-typhoon species populations, shoreline change analyses, land cover classifications), or have insufficient historic data to enable comparative analyses (e.g., park-specific vegetation studies). The determination of whether a study or inventory is "outdated" is largely dependent on the temporal variation and volatility of the resource being examined. For example, underlying geologic strata are not expected to change significantly over time (though shoreline configuration and morphology may shift), but vegetation and animal populations may change over a period of several years or in response to major disturbances. Given the relatively rapid changes in physical configuration of the shoreline, succession of mixed-forest landscape along the northern stretches of the Park, and the frequency of natural disturbances impacting the entire park, temporal considerations should be weighted heavily in prioritizing future scientific efforts.

As of 2017 the following scientific studies, plans, and data development efforts were either underway (denoted by asterisk) or recently completed (year noted in parentheses). Most of these efforts are focused more broadly on Saipan (as opposed to just American Memorial Park) but are assumed to include relevant coverage of the park and its near-shore environment.

- Saipan Lagoon Benthic Habitat Mapping (2017; Kendall et al. 2017)
    - Project resulted in multiple high-resolution (2 m) spatial datasets for the Saipan Lagoon's benthic characteristics including habitat composition, rugosity, slope, and depth. Composition of seagrass beds and bare sand habitat poses implications for shoreline processes at AMP, making this project critical for completing studies of related coastal systems.
- High-Resolution (2.4 m) Land Cover Update for Saipan* (NOAA 2005)
    - This development in Saipan's C-CAP data series is leveraging 2016 WorldView satellite imagery, providing the first update to the island's land cover data since 2005. Land cover products are scheduled for release in the last quarter of 2017.
- Saipan Shoreline Enhancement Study and Digital Shoreline Analysis* (USACE and BECQ)
    - Study will result in graphic output of a historic shoreline change analysis covering the entirety of Saipan's lagoon shoreline (including AMP) and involves development of shoreline stabilization alternatives for stretches of beach threatened by coastal processes. Project completion is expected in first quarter of 2018, with park-specific assessments of shoreline management options.
- National Hydrography Dataset Update* (USGS; University of Guam)
    - Dataset will include revised boundaries and delineations of all surface hydrology and water features on Saipan (and in AMP) based on high-resolution Lidar data, WorldView imagery, National Wetlands Inventory data, and field investigations. The dataset is expected to be published in the last quarter of 2017.

- CNMI Tsunami Evacuation Study and Planning* (CNMI Dept. of Homeland Security and BECQ)
  - Tsunami inundation models developed by NOAA's Pacific Marine Environmental Laboratory in 2013 are being used in spatial planning exercises to specify "worst-case" scenarios, delineate evacuation zones, identify highly vulnerable areas such as AMP, and establish evacuation routing. Plans are expected to be complete by 2018.
- Ecology and Bird Loss Study* (Iowa State University)
  - Study has examined distance-dependent and gap-dependent survival of native seedlings on Saipan and Guam since 2010 and is expected to continue as a long-term initiative given its consistent funding.
- TMAPS – Tropical Monitoring Avian Productivity and Survivorship* (Institute for Bird Populations, Point Reyes, CA; CNMI DFW)
  - Collaborative effort among public agencies, non-governmental groups, and individuals to assist the conservation of tropical birds and their habitats through demographic and morphological monitoring. The nation-wide program was first implemented on Saipan in 2008, with ongoing monitoring activities since then.
- BECQ Water Quality Monitoring Program* (CNMI BECQ)
  - An EPA-funded water quality monitoring program has been run out of CNMI BECQ for over two decades allowing for trend analysis of water quality parameters at sample points throughout the CNMI, including within and adjacent to AMP.
- Atmospheric Conditions Monitoring & Data Services (2014; Western Regional Climate Center; NOAA)
  - A weather station was installed by NPS in AMP in 2014 and established data streaming to online services through the Western Regional Climate Center and NOAA partners in February of that year. These data services enable park-specific climate record keeping.
- Environmental Pollution
  - NPS and the Water and Environmental Research Institute of the Western Pacific (WERI) completed a study in 2018 on toxicity of shore infauna by Dr. Gary Denton. The results were not available for this report.
- National Park Service Inventory and Monitoring Program (I&M)*
  - The National Park Service Inventory and Monitoring Program has been conducting surface water quality surveys and vegetation surveys within the Park since 2009. Surface water quality monitoring is conducted quarterly in the mangroves (four permanent sites) and in the created wetland (four permanent sites), while vegetation surveys and invasive vegetation surveys are conducted every five years at both permanent and temporary sites within AMP boundaries. Groundwater conductivity, depth, and temperature was also monitored from 2010 to 2017, but the project was temporarily suspended due to continual equipment failure,

damage to wells, and the determination that existing wells were inadequate for the project. Certified data reports are not yet available and therefore will not be reported on.

These initiatives will either contribute valuable datasets that offer direct support in guiding park management and project prioritization (e.g., USACE Shoreline Enhancement Study), or add to a growing data series that can be referenced with increasing confidence in determining change over time (e.g., NOAA C-CAP and BECQ Water Quality Monitoring Program).

The evolving threats of adjacent urban development, exponential growth in tourism, and a changing climate will undoubtedly warrant additional research of impacts to natural systems within the park. In particular, threats to cultural and recreational features and infrastructure due to dynamic coastal morphology require a more sophisticated approach than what has been implemented in the past. Shoreline change requires both examination of historic trends, as well as projections of future positions based on multiple climate scenarios. These same scenarios justify an investigation of potential wetland migration and landcover change resulting from rising sea levels and associated changes in hydrology. The data and information that fill gaps such as these will be necessary to support the adaptive management that is required on an island characterized by rapid change.

In order to secure resources for implementing these scientific studies and research projects, American Memorial Park may benefit from continuing its relationship with local government partners and stakeholders. These entities often initiate island-wide programs that are inclusive of the Park. Furthermore, the Park's physical position on Saipan at both the core of economic activity and encompassing some of the CNMI's most treasured natural resources makes it an inherent focal point in broader studies where the park may not be explicitly targeted as the primary area of interest.

Chapter 3. Study Process and Design

3.1. Study Process

To accomplish the goals of the NRCA (outlined on the following page), initial meetings were held to describe and assign project roles and responsibilities among team members. Team composition included a Saipan-based group consisting of a Project Lead responsible for aggregating existing research and compiling written deliverables and two Technical Personnel to handle geospatial analysis, mapping output, and editing services. The Saipan-based team coordinated with the primary partners at the University of Guam who administered project logistics and provided oversight on project deliverables.

The study was based upon three sources of input: (1) Compilation of existing literature and research results, (2) consultation of local experts and solicitation of resource stewards' knowledge, and (3) processing and assessment of publicly-available environmental datasets relevant to the park. Literature review was conducted in concert with consultation of local knowledge sources and authorities as clarification and validation of historic studies or outdated information was often necessary.

Following significant background research and data collation, park management zones and focal ecological units were identified based on presence of discrete habitat or land-use and concentrations of unique natural resources. Given the Park's small size, pre-existing "zones" and "management units" had not been previously established, thus consensus building based on consultation with local experts and the team's pre-existing knowledge was necessary.

Following the delineation of focal resource zones, the team returned to the compiled literature and existing research to identify data gaps and formalize a set of threats and stressors. The technical team's familiarity with park context and relevant resource managers allowed easy access to confirming the sets of threats, stressors, and data gaps.

Subsequent stages of NRCA drafting adhered to the most recent NPS guidance on assessment structure and indicator rating systems. The team consulted the Kenai Fjords National Park NRCA (Stark et al. 2015) as a reference point when fitting American Memorial Park content to standard NPS structure while assuming greater autonomy in framing a discussion of the Park's unique threats. Notably, content that was generated for this NRCA was not constricted to resources solely within park boundaries which constitutes a slight departure from NRCAs of larger NPS units. This flexibility was necessary in order to capture the influences of adjacent resource conditions and trends that directly impact the park.

Geographic information systems (GIS) and geospatial data comprised a substantial component of the NRCA design. In describing current resource conditions and general configuration of natural systems in and around American Memorial Park, the most recent releases of publicly available spatial data were utilized. Data related to soils, geology, hydrology, landcover and land use, and near-shore resources have been distributed through U.S. federal agencies, which provided the team with some baseline data and a basic means of describing the Park and its resources. Coverage of the Marianas with respect to dataset development tends to be delayed in comparison to the coterminous U.S., thus some information has not been updated in over a decade. The team acknowledged this caveat in working to establish confidence in trends.

In addition to providing a spatially-explicit representation of existing (or recent) park resource conditions, these datasets were also used to the greatest degree possible in describing change over time. This effort was primarily limited to evaluations of land cover change, shoreline positions, and nearshore habitat. The latter elements had multiple iterations of data for comparison, and in some cases publicly available products related to trend analysis.

Field work and new research projects were outside the scope of the NRCA, therefore all means of assessment relied on existing data and research results and in some cases inference of implications from the spatial data mentioned in this section.

Project expectations and goals of the NRCA were identified from the outset to include the following:

- Identify unique and significant natural and cultural resources present in the park;
- Determine the existence and extent of monitoring protocols for all relevant resources;
- Ascertain the presence or absence of historic baselines and current assessments for park resources;
- Identify threats and stressors to park resources;
- Compile complete and accurate assessments of existing literature related to park resources, or island resources when park-specific information was not available;
- Create appropriate and useful GIS-based figures to better visualize or share relevant information.

3.1.1. Indicator Framework, Focal Study Resources and Indicators

The American Memorial Park NRCA employed a simplified version of the reporting framework used in the Heinz Center's "State of the Nation's Ecosystems 2008" (Heinz Center for Science, Economics and the Environment 2008). This framework, as adapted by NPS as an approved reporting framework for NRCAs, attempts to summarize current resource conditions, risk factors, and critical data gaps by park area. The original framework provides a means of summarizing park areas based on reporting categories of (1) landscape condition, (2) the supporting environment, including park land, water and air resources, (3) biological integrity, and (4) an optional category reserved for reporting on specialized topics such as ecosystem services.

For American Memorial Park this framework was further modified to accommodate the unique context of the Park. The Park is particularly small in size and has some significant data gaps that limit the extent to which biological integrity can be assessed in some park areas. Nevertheless, the Park has a surprisingly heterogenous landscape for such a small space with several distinct ecological units, as discussed in Chapter 2.2. In light of this, the first, broad reporting category of 'landscape condition' is addressed at a park-wide level as one of five "resources", including overviews of surrounding landscape processes and the overarching configuration of park ecology and management units. The framework's reporting categories of 'supporting environment' and 'biological integrity' are addressed at a finer scale as "measures" within each resource, which are evaluated individually in order to determine the overall condition each of American Memorial Park's ecological units. The fourth, 'optional' reporting category in this framework is then addressed in Chapter 5 of the NRCA, in which the topics of stressors, risks and critical data gaps are discussed at a park-wide level. Figure 28 illustrates this adapted framework.

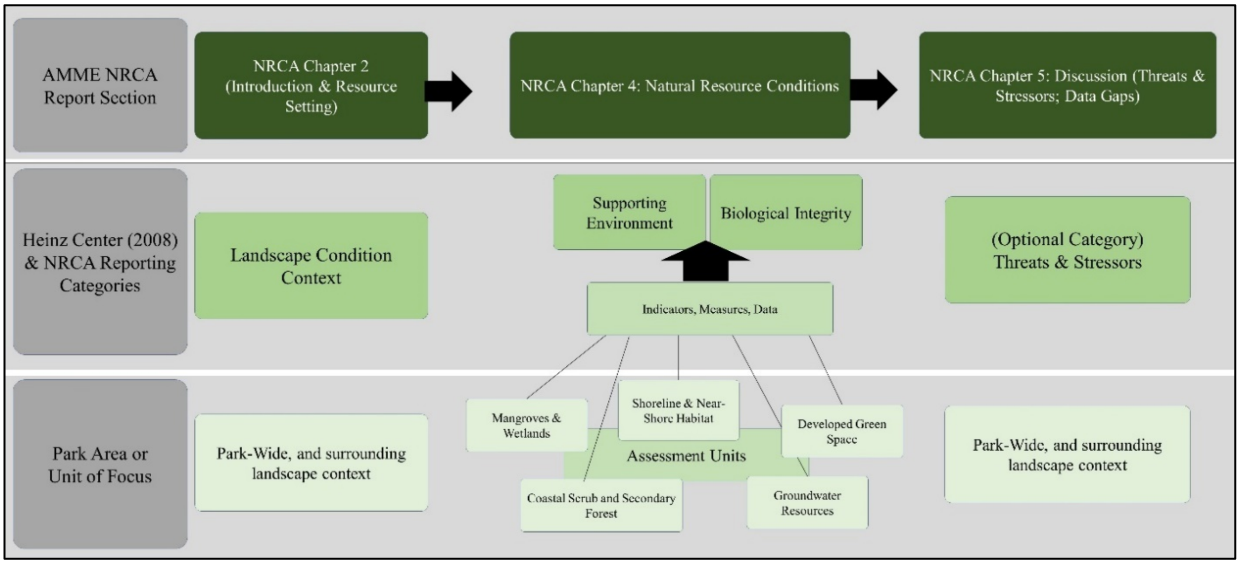


Figure 28. American Memorial Park NRCA framework showing NRCA resource assessment units and associated reporting categories and park focal units.

Table 6 describes the natural resource indicator framework of park resources that are addressed in this report. The matrix can be taken as a comprehensive overview of park resources and issues in that it encompasses all unique and significant park natural resources that have been previously identified as well as all natural systems and threats that hold implications for the park's ecological integrity.

Table 6. NCRA standard indicator framework.

Resource	Measures	Data sources	Threats and stressors
Mangrove and wetlands	• Extent of natural wetland areas • Salinity of constructed wetland and surface pools within the natural wetland • Prevalence of invasive species (plants, fish, birds, invertebrates) • Presence and abundance of native animal and plant populations	NOAA C-CAP (2005); National Wetlands Inventory (USFWS 2011); BECQ Water Quality Monitoring Program (ongoing); AMP-Specific vegetation inventories (multiple dates), hydrologic and groundwater assessments (2003 and 2011), NPS I&M water quality (2009 to Present), vegetation monitoring (2014).	Large storm events, non-point source pollutants, sedimentation from upland erosion, climate change (sea level rise, extreme precipitation events, rising air and sea surface temperatures), competition with invasive species (especially vines and the brown tree snake), over-pumping of groundwater, saltwater intrusion, adjacent urban development, underground injection wells, storm-water diversion

Table 6 (continued). NCRA standard indicator framework.

Resource	Measures	Data sources	Threats and stressors
Coastal scrub and secondary forest	• Extent of coastal scrub and secondary forest habitat • Presence and abundance of native animal and plant populations	NOAA C-CAP (2005); USFS Landcover data (2005); AMP-Specific vegetation inventories.	Large storm events, climate change (inundation during large storm events, altered atmospheric temperature-precipitation regimes, sea level rise), illegal take of fruits and seeds, feral and invasive animals, shoreline change
Shore and near-shore habitat	• Shoreline dynamics (erosion and accretion) • Configuration and coverage of seagrass and marine algae • Near-shore water quality	NOAA C-CAP (2005); CNMI Climate Assessments (2014); Shoreline change analyses and reports (2004, 2010, 2014); Benthic habitat composite maps (2005, 2017)	Erosion/accretion, large storm events, terrestrial pollutants and presence of toxins or heavy metals in lagoon from adjacent dump site, sea level rise and variability, fecal contamination of water, disruptions to natural marine assemblages, invasive species
Developed green space	• Upkeep of useable recreational green space (lawns, picnic areas) and ornamental trees	Personal communication with park staff and local resource managers; Land use change analysis and observations in adjacent urban core	Large storm events, overuse or misuse, trash and pollutants including buried UXOs, boat pollutants, climate change, history of development and unintentional destruction of cultural material
Hydrology	• Depth and spatial extent of freshwater lens • Surface water quality and salinity	Hydrologic and groundwater assessments (2003 and 2011); BECQ Water Quality Monitoring Program (ongoing), NPS I&M Water Quality (2009 to Present)	Subsurface brine injection from nearby resorts, over-pumping of freshwater wells, sea level rise and saltwater intrusion, upslope impervious surfaces and decreased soil permeability/groundwater recharge.

The first four resources listed are the habitat zones and ecosystem-based management units that were delineated explicitly for the NRCA. A fifth resource was appended to include the hydrology in and around the Park, as the features within this system are critical to American Memorial Park's provision of ecosystem services and ability to provide cohesion in maintaining the quality of other natural resources. For each resource, measures are included to indicate the health or stability of the resource or system and notes related to data sources, threats, and stressors are described. Unless noted otherwise, the threats posed by shifting climate conditions and potential proliferation of invasive species are assumed to be inherent stressors for all resources.

3.2. Standard Resource Component Methods

Original research was not performed for this report; instead, existing literature and resource assessments were examined and relevant spatial data were employed to assess the current condition of park resources. Park-specific reports were occasionally unavailable for specific resources, such as insect surveys or invasive mammals, and in these cases island-wide or CNMI-wide reports were utilized. Instances in which the NRCA refers to data or literature with broader geographic coverage or areas of interest are noted. All relevant data are included in this report except where a more current or trust-worthy report can replace an older or less dependable one, or where a park-specific report can replace one that addresses a resource at coarser resolutions.

3.2.1. Data Mining

Data mining began with an initial collection of park and island-specific natural resource reports from known projects and assessments. As literature was reviewed and specific needs were identified, online resources provided by CNMI agencies and their project contractors were leveraged. Additional local government contacts were approached as well for park-specific data. Local natural resource management agencies serve as the primary spatial data stewards for the CNMI, housing both national and regional datasets and locally-developed geospatial data resulting from analyses of public data or geo-referencing of resources at high resolutions. All available spatial data for the CNMI was provided by these local data stewards, and subsequent extraction and geoprocessing of pieces of these datasets was performed as an additional means of data mining. This included clipping of Park-specific portions of resource data, delineation of sub-watersheds and ecological zones or management boundaries, and isolation of specific classes of landcover change.

NPS staff were consulted on some topics such as land tenure and the complex regulatory landscape, as well as for information pertaining to ongoing park-specific projects such as the rehabilitation of Smiling Cove Marina. The park was also visited frequently to develop an accurate picture of current vegetation, habitat distribution, and layout of developed areas and green space. Visual assessments were also made of the constructed wetland. While this information was not extracted in the form of a published dataset, it served as validation for other data mining efforts.

All data were assessed for relevancy in both time and content, accuracy based on factual alignment with other sources, and the frequency with which sources were referenced by other research and literature. Qualitative assessment of the thoroughness, scope, and resolution of reports was performed on an ad hoc basis.

3.2.2. Data Development and Analysis

The extent and quality of park or island-specific information varied for each resource of the NRCA, so data development and analysis were largely piecemeal which is addressed and highlighted by the assignment of confidence levels to each resource. More detail pertaining to analysis can also be found within respective element assessments in Chapters 4 and 5 of the NRCA.

3.2.3. Scoring Methods and Assigning Condition

The condition status for each of the five resources (outlined above in Table 6), indicated by red, yellow, or green, was assessed using several measures. The scoring method used was adopted from the method developed by St. Mary's University of Minnesota GeoSpatial Services for NPS Natural Resource Condition Assessments. This study followed the application of the method as demonstrated in the NRCA for Kenai Fjords National Park in Alaska (Stark et al. 2015).

Each measure was assigned two numbers: one based on the significance of the measure for evaluating the resource, and the other based on the condition of the measure.

Significance Level

The "Significance Level" of a measure represents a numeric categorization (integer scale from 1–3) of the importance of each measure in assessing the resource's condition, as defined below in Table 7. This categorization allows measures that are more important for determining the condition of a resources (having a higher Significance Level) to be more heavily weighted in calculating an overall condition. Significance Levels were determined for each measure through discussions with park staff and/or other outside resource experts.

Table 7. Scale for a measure's Significance Level in determining a resource's overall condition.

Significance Level (SL)	Description
1	Measure is of low importance in defining the condition of this resource.
2	Measure is of moderate importance in defining the condition of this resource.
3	Measure is of high importance in defining the condition of this resource.

Condition Level

After each focal resource assessment is complete, the "Condition Level" of each measure is assigned on a 0–3 integer scale (Table 8). This assigned number is based on all available literature and data reviewed for the resource as well as communications with park staff and/or other outside resource experts.

Table 8. Scale for a measure's Condition Level.

Condition Level (CL)	Description
0	Of NO concern. No net loss, degradation, negative change, or alteration.
1	Of LOW concern. Signs of limited and isolated degradation.
2	Of MODERATE concern. Pronounced signs of widespread and uncontrolled degradation.
3	Of HIGH concern. Nearing catastrophic, complete, and irreparable degradation.

Condition Score and Weighted Condition Score

After the Significance Level (SL) and Condition Level (CL) for each measure are assigned, a Condition Score (CS) was calculated by adding the SL and CL for each measure. All measures that were given a 0 for Condition Level are automatically assigned a 1 for Condition Score, as that measure is determined to not be a pressing issue facing the relevant resource. For all other scores, the SL and CL scores are added to result in an overall Condition Score between 1 and 6 (the lowest and highest possible Condition Scores), as further described in Table 9.

Table 9. Scale for the Condition Score for each individual measure.

Condition Score (CS)	Description
1–2	Measure is in good condition.
3–4	Measure is in moderate condition.
5–6	Measure is in poor condition and is of significant concern.

The Weighted Condition Score (WCS) for the resource was then calculated by finding the average of all of the resource's Condition Scores: dividing the sum of the resource's Condition Scores by the number of measures.

$$WCS_{resources} = \frac{\sum_{i=l}^{\#\ of\ measures}(SL_i + CL_i)}{\sum_{i=l}^{\#\ of\ measures}}$$

Table 10. Example determination of a resource condition based on condition scoring of measures.

Measure	Significance Level	Condition Level	Condition Score CS = SL + CL	Resource Weighted Condition Score
A	3	3	6	–
B	1	1	2	–
C	3	2	5	–
Resource	7	6	13 / 3	4.3

The symbolization illustrated in Tables 11 and 12 is used to create status, trend, and confidence indicator symbols for each NRCA resource. The condition status (developed by averaging scores of all available measures) attributes a color (red, yellow, or green) to each natural resource component to represent significant concern, moderate concern, or not of current concern, respectively.

Table 11. Indicator symbols used to indicate condition, trend, and confidence in the assessment.

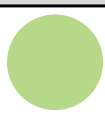
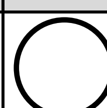
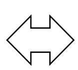
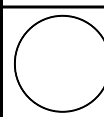
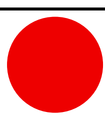
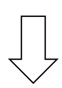
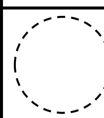
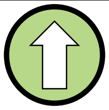
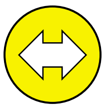
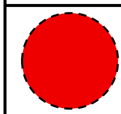
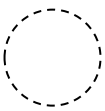
Condition Status		Trend in Condition		Confidence in Assessment	
	Resource is in Good Condition (WCS = 1–2)		Condition is Improving		High
	Resource warrants Moderate Concern (WCS = 3–4)		Condition is Unchanging		Medium
	Resource warrants Significant Concern (WCS = 5–6)		Condition is Deteriorating		Low

Table 12. Example indicator symbols and descriptions of how to interpret them in weighted condition score tables.

Symbol Example	Description of Symbol
	Resource is in good condition; its condition is improving; high confidence in the assessment.
	Condition of resource warrants moderate concern; condition is unchanging; medium confidence in the assessment.
	Condition of resource warrants significant concern; trend in condition is unknown or not applicable; low confidence in the assessment.
	Current condition is unknown or indeterminate due to inadequate data, lack of reference value(s) for comparative purposes, and/or insufficient expert knowledge to reach a more specific condition determination; trend in condition is unknown or not applicable; low confidence in the assessment.

Condition trends are assigned using arrows: '*up*' for improving, '*side to side*' for unchanging, and '*down*' for deteriorating. Trends were determined by comparing current conditions of resources with baseline or reference conditions, and no arrow is assigned if the current trend is unknown such as when baseline references are not available. Additionally, thick, thin, or dotted lines around the colored circle indicate high, medium, or low confidence in our assessment. This confidence rating is based on availability and quality of information for a given resource.

3.2.4. Preparation and Review of Resource Component Draft Assignments

Report draft reviews were a collaborative and cooperative effort among the project team, which has a combined twelve years of experience working directly with the natural resources on Saipan often within or overlapping with American Memorial Park. This local expertise, in addition to the strict adherence to peer-reviewed literature, published government reports and grey literature, or direct communication with resource specialists, is assumed to ensure the highest level of accuracy possible in preparation of the NRCA.

Local specialists were consulted whenever different literary or data sources were in disagreement or were unclear. Local experts beyond the project team were also consulted frequently to simply confirm findings from older research and reports. These consultations were conducted in informal settings and occurred primarily in-person.

3.2.5. Development and Review of Final Resource Component Assessments

After draft reviews and consistent iterations of communication with local specialists, feedback was incorporated into the final drafts of the NRCA thereby allowing the team to establish as much confidence as possible in its assessments.

3.2.6. Format of Resource Component Assessment Documents

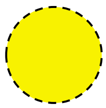
In the following chapter (4), each of the five resources for American Memorial Park are assessed in a standard format beginning with a description and measures of the resource component's health or integrity followed by reference conditions, data and methods employed, condition and trend, and culminating with a synopsis of overall condition, as described below:

- *Condition Summary Statement:* Each of the five resource sections will begin with a synopsis of the findings for current condition and trend of the assessed resource.
- *Description:* Details why each resource is included in this report, describing why this resource is essential for the natural resource health of the park and the unique features within this resource.
- *Measures:* Describes which factors were used to assess the current condition of each resource identified through research and discussion and listed as bullet points. Measures were determined for each resource after all available literature had been assessed and local contacts consulted.
- *Reference Condition/Values:* When available, reference conditions and values are presented here and serve as baseline comparisons for current and future values.
- *Data and Methods:* Analysis of current trends and resource condition is explained here, with steps and descriptions of techniques listed for how we evaluated each resource's condition and trend.
- *Condition and Trend:* Measures, reference conditions, and data/methods are synthesized in this section which assesses and interprets the status and trend of each resource. Relevant maps, tables, and figures are included here to better visualize or interpret data, if available. Condition and trend are assessed using the assignment of two scores as described above in Section 3.2.3.: the first represents level of importance of each measure and the second represents condition. Scores are then integrated to assign a color (red, yellow, or green) based on the resulting numerical score. Trend is assessed through comparison of the current standing of the resources to baseline conditions, if available, and confidence is determined by the quality of data used to evaluate condition and trend.
- *Overall Condition:* Previous sections of the NRCA that address the resource are summarized to establish an overall condition. Key findings such as significant data gaps or the presence of unique and important ecological features are highlighted here. Synthesis if provided through a figure depicting resource status, with trend and confidence intervals wherever possible.

Chapter 4. Natural Resource Conditions

4.1. Mangroves and Wetlands

The overall resource condition of mangroves and wetlands is moderate with an unknown trend; confidence in the condition determination is low. Rationale is discussed in the "Condition Summary" section and following.



4.1.1. Description

Saipan hosts the only remaining mangroves in the Northern Marianas, most of which are located within the 12 hectare (30 acre) wetland within American Memorial Park. The mangrove and wetland areas in American Memorial Park are characterized by the mangrove species *Bruguiera gymnorrhiza*. This ecosystem is ecologically significant due to its roles in mitigating nutrient loading in nearshore waters from upland and urban storm water runoff, providing coastal erosion control, serving as juvenile fish habitat and nurseries, and offering protected habitation for the endangered nightingale reed warbler, Mariana moorhen, and humped tree snail (Starmer 2007).

During Japanese administration (1919–1945), significant areas of Saipan's wetlands were cleared for sugarcane plantations. Much of the remaining mangrove wetland was spared damage from wartime bombing (Perreault 2007), but areas of the wetland were later used as a landfill through 1978 (Cogan et al. 2013, Raulerson and Rinehart 1989). Today the wetland area within the Park is protected under federal and local law and resource managers are working to restore the mangrove wetlands. Most recently, the Puerto Rico dump closure plan includes the planting and continued monitoring of 200 mangrove seedlings in the Park's wetland as mitigation for removal of wetlands during the creation of the Governor Eloy S. Inos Peace Park above the former Puerto Rico dump site. Preliminary monitoring results from this project indicate a high success rate (N. Johnson, pers. comm., 2017; J. Gourley, pers. comm., 30 January 2019). Table 13 lists the plant species, native and non-native, found with the Park's wetlands and mangroves.

Table 13. Plant species found within American Memorial Park wetlands and mangroves.

Vegetation type	Common name	Scientific name	Source
Dominant species (as described by Snyder 2006)	West Pacific mangrove	*Bruguiera gymnorrhiza*	Cogan et al. 2013, Snyder 2006
	Indian pluchea	*Pluchea indica*	Cogan et al. 2013, Snyder 2006
	Indian tulip tree	*Thespesia populnea*	Cogan et al. 2013, Snyder 2006
	Beach hibiscus, pago	*Hibiscus tiliaceus*	Cogan et al. 2013, Snyder 2006

Table 13 (continued). Plant species found within American Memorial Park wetlands and mangroves.

Vegetation type	Common name	Scientific name	Source
Dominant species (as described by Snyder 2006) (continued)	Aquatic fern	*Acrostichum aureum*	Cogan et al. 2013, Snyder 2006
	Nonak	*Hernandia sonora*	Cogan et al. 2013, Snyder 2006
Invasive (as noted by Cogan et al. 2013)	Water hyacinth	*Eichhornia crassipes*	Cogan et al. 2013
Also present	Nest fern	*Asplenium nidus*	Cogan et al. 2013
	Ironwood	*Casuarina equisetifolia*	Cogan et al. 2013
	Tangan tangan	*Leucaena leucocephala*	Cogan et al. 2013
	Mother-in-law's tongue	*Sansiveria trifasciata*	Cogan et al. 2013, Starmer 2007
	Orchid tree	*Bauhinia monandra*	Cogan et al. 2013, Starmer 2007
	Alexandrian laurel balltree, da-ok	*Calophyllum inophyllum*	Cogan et al. 2013, Starmer 2007
	Papaya	*Carica papaya*	Cogan et al. 2013, Starmer 2007
	Haitian catalpa	*Catalpa longissima*	Cogan et al. 2013, Starmer 2007
	Coconut palm	*Cocos nucifera*	Cogan et al. 2013, Starmer 2007
	Flame tree	*Delonix regia*	Cogan et al. 2013, Starmer 2007
	Melanolepis	*Melanolepis multiglandulosa*	Cogan et al. 2013, Starmer 2007
	Lada (noni)	*Morinda citrifolia*	Cogan et al. 2013, Starmer 2007
	Pandanus	*Pandanus dubius*	Cogan et al. 2013, Starmer 2007
	Pandanus	*Pandanus tectorius*	Cogan et al. 2013, Starmer 2007
	Pisonia	*Pisonia grandis*	Cogan et al. 2013, Starmer 2007
	Manila tamarind, monkeypod	*Pithecellobium dulce*	Cogan et al. 2013, Starmer 2007
	Pouteria	*Pouteria obovate*	Cogan et al. 2013, Starmer 2007
	Trumpet tree	*Tabebuia* sp.	Cogan et al. 2013, Starmer 2007
	Tropical almond	*Terminalia catappa*	Cogan et al. 2013, Starmer 2007

Table 13 (continued). Plant species found within American Memorial Park wetlands and mangroves.

Vegetation type	Common name	Scientific name	Source
Also present	Mile-a-minute vine	*Mikania micrantha*	Cogan et al. 2013, Starmer 2007
	Paper rose (vine)	*Operculina ventricosa*	Cogan et al. 2013, Starmer 2007
	Ipomea (vine)	*Ipomea indica*	Cogan et al. 2013, Starmer 2007
	Sea bean (vine)	*Mucuna gigantea*	Cogan et al. 2013, Starmer 2007
	Ivy gourd (vine)	*Coccinia grandis*	Cogan et al. 2013, Starmer 2007

Also within American Memorial Park is an artificial wetland, which was built in 1998 to filter storm runoff and highly saline wastewater from nearby hotel and resorts' reverse osmosis facilities. Beginning in the early 2000s nearby resorts switched to using underground injection wells to pump brine wastewater directly into the lagoon and so the wetland's purpose is now limited to filtering storm runoff. Visitors to the park often comment on the smell emanating from this man-made wetland, which is aggravated by frequent leaks and overflows of raw sewage from the overwhelmed nearby utility system. The area is also plagued with pathogens and invasive vegetation and fish.

4.1.2. Measures

- Extent of natural wetland areas
- Salinity of constructed wetland and surface pools within the natural wetland
- Prevalence of invasive species (plants, fish, birds, invertebrates)
- Presence and abundance of native animal and plant populations

4.1.3. Reference Conditions/Values

<u>Extent of natural wetland areas</u>
Palynological samples from two areas within the wetland determined the native status of the single mangrove species, *Bruguiera gymnorrhiza*. This species' presence in the area is estimated to date back to at least the start of the Holocene epoch, 11,700 years before present (Jarzen and Dilcher 2009). Current urban boundaries in and around the park were established in the decades following WWII. A baseline reference date of 1978 was selected to coincide with the Park's creation date and the resulting cessation of illegal dumping and development within the wetland area (Raulerson and Rinehart 1989).

<u>Salinity of constructed wetland and surface pools within the natural wetland</u>
Reference conditions for some water quality indicators within the constructed wetland and surface pools of the natural wetland were not available at the time of this assessment, though substantial information regarding salinity is available. For management and monitoring purposes, additional information is important for determining water quality such as turbidity, acidity, and temperature.

Information related to water quality indicators within American Memorial Park wetlands would provide for a more robust set of reference conditions in future assessments of park resources.

<u>Prevalence of invasive species (plants, fish, birds, invertebrates)</u>
Land cover maps from 1987 (Raulerson and Rhinehart 1989) and aerial and satellite imagery from 2006 (Cogan et al. 2013) provide details regarding the extent of cover for native plant and invasive plant species. The 1987 land cover also shows the presence of a natural wetland-like area where the constructed wetland is currently located.

It is important to note that aerial imagery from 1945 for all of Saipan is available along with a high resolution land cover dataset corresponding with those images. This information could be particularly useful in instances where land use and land cover change are the subjects of a study with a larger temporal scope. For the purposes of investigating wetlands and mangroves, this information was omitted due to radical changes in land use that altered the area decades before American Memorial Park was established. A comparison of conditions over this time period would not align well with the assessment of some other resources in the Park. Additional details and figures related to the 1945 data are highlighted in section 4.4 ('Developed Green Space').

<u>Presence and abundance of native animal and plant populations</u>
Presence and abundance of native animal and plant populations was included as a measure for the mangroves and wetlands resource assessment, although data assessing the condition of this resource was extremely limited. Reference conditions for the endangered Mariana moorhen were compared using 1991 (Stinson et al.) and 2010 (Rauzon) reports, and for the nightingale reed warbler using 1992 (Reichel et al. 1992) and 2009 (Camp et al.) data. Quantitative data were not available for the endangered humped tree snail so reference conditions were not created for this species. Reference data for other avian species were gleaned from Camp et al. (2009), which presents an island-wide avian population assessment based on 1982, 1997, and 2007 data, and Rauzon (2010) who conducted extensive park avian surveys. Quantitative reports describing fish species specifically in park habitats are not yet available, but data are available in reports that address the entire marine environment of Saipan. Vegetation data from NPS I&M plots may also be useful for future studies. Vegetation surveys and invasive vegetation surveys are conducted every five years at both permanent and temporary sites within Park boundaries.

4.1.4. Data and Methods

<u>Extent of natural wetland area</u>
In order to determine the historical presence of mangrove and other pollen producing plant species, Jarzen and Dilcher (2009) took palynological core samples to examine pollen from 35, 25, 15, and 5 cm depths, the oldest of which accesses samples from the Holocene (11,700 years BP). Pollen cores were taken from two areas within the Park's mangrove and wetland complex, and one area 2 km (1.24 mi) to the north. Families, or species when possible, were identified based on the shape of pollen spores preserved in the soil.

Two land cover maps were utilized to assess trends in vegetation cover: Raulerson and Rinehart (1989) and Cogan et al. (2013). These maps were extracted from their respective publications and are included in this report as Appendix A for reference.

Data collection methods for both maps were similar, involving field data collection of all plant species followed by use of aerial (Raulerson and Rinehart 1989) and satellite (Cogan et al 2013) imagery to delineate habitats present and concluding with ground-truthing to ensure map accuracy. Raulerson and Rinehart collected plant specimens in 1986 and 1988 along established transects from within the mangrove wetland and used a 1987 USGS aerial image to map habitat. Cogan et al. employed ecologists familiar with Pacific Island species and aimed to collect three to five classification plots per plant association. This study included the entire park, and field plots where collection occurred were distributed relatively evenly throughout. A habitat classified image was created using 2006 Quickbird imagery (cloud-free, 4-band, 0.6-meter resolution) and followed by extensive ground-truthing, yielding a map with 92% accuracy.

<u>Salinity of constructed wetland and surface pools within the natural wetland</u>
Water quality can be measured through several means including salinity, turbidity, temperature, nutrients, acidity, and by the presence or absence of pathogens. Salinity of park surface pools is addressed in a reconnaissance study of the Park's hydrology (Perreault 2007). This report found that surface pools in the natural wetland generally decrease in salinity with proximity to the ocean. This is in contrast to groundwater samples, which increase in salinity with proximity to the lagoon. The strange pattern of salinity may be due to the main road Chalan Pale Arnold ("Middle Road") preventing overland freshwater flow from entering the natural wetland or from spatial variation in the underground distribution of freshwater, but more study is required to accurately assess the cause (Perreault 2007).

<u>Prevalence of invasive species (plants, fish, birds, invertebrates)</u>
The prevalence of invasive plant species can be derived from land-cover maps. Park-specific non-native fish are not addressed in a quantitative manner but are mentioned in several reports. Snyder (2006) notes the presence of mosquito fish (*Gambusia affinis*) and Mozambique tilapia (*Sarotheradon mossambicus*) but source or original data are not provided. Mattos (2013) notes the presence of sailfin mollies (*Poecilia latipinna*) in stormwater drainages in Garapan, citing a local resource specialist. Starmer (2005) notes the risk of red tilapia (*Oreochromis mossambica*) breaking out of aquaculture ponds into the Saipan Lagoon, and the NPS species checklist for the park also notes walking catfish (*Clarias batrachus*), though neither of these reports present original data or sources.

<u>Presence and abundance of native animal and plant populations</u>
Avian surveys for the island of Saipan are relatively abundant, but park-specific surveys are minimal. These park-specific studies focus on the endangered Mariana moorhen (Rauzon 2010) and nightingale reed warbler (Johnson 2003, Starmer 2007). Additional surveys looked at island-wide trends in avian populations (Takano and Haig 2004, Camp et al. 2009) but will not be evaluated here as they are not park-specific. Rauzon (2010) studied the Mariana moorhen and performed fieldwork on July 19–30, 2009. A total of six hours were spent conducting point counts (72-five minute

surveys) at 47 survey stations along established transects and 25 novel stations. A total of 30 hours were spent outside of point counts listening, orienting, and surveying. Tape playback was used for detecting Mariana moorhens.

Johnson (2003) focused on the nightingale reed warbler and followed an established route designed to ensure thorough surveying of the area. Audio or visual observations were marked on an aerial photograph carried in the field. As nightingale reed warblers are highly territorial, playback was not used. In total, 24 surveys were conducted, all before 10 am or after 4 pm, between June 11 and October 8, 2002. Three males were captured and color banded. These three birds were re-sighted over a period of 64 surveys in the subsequent ten months which were used to determine territory sizes and locations.

Starmer (2007) followed six previously established survey transects in the wetland area and performed point counts in five minute intervals.

Rauzon (2010) collected data for all species of birds including the introduced species. Sherley (2000) is a technical review which compiled existing literature to assess the presence of invasive species on Saipan and when and how each species arrived.

Starmer (2007) also addresses invertebrates within the wetlands, providing what the report describes as an "initial understanding of the terrestrial arthropod and mollusk diversity and distribution of this diversity among forest types" at American Memorial Park (Starmer 2007). Six transects were followed through the wetland and plastic cups filled with isopropyl alcohol were buried until the tops were even with the ground at points along each transect 10 m (32.81 ft) in from the road and every 50 m (164 ft) following. Specimens were collected 24 hours later and identified using a microscope. Surface litter was also examined for shells at random locations using 25 cm (9.84 in) disk stencils to which litter and 1 cm (.39 in) of soil was cut and then collected and searched. Shells collected were sent to the Florida Museum of Natural History for identification.

4.1.5. Condition and Trend

<u>Extent of natural wetland area</u>
The condition and trend regarding the areal extent of the wetland can be assessed through a comparison of land cover maps from Raulerson and Rinehart (1989) and Cogan et al. (2013), which addresses the prevalence of native and introduced plant species. Based on imagery and data collected between 1987 and 1989, the wetland area historically consisted of a large patch of mesic non-native tangan tangan scrub with vines dominating the south, southeast, and southwest of the wetland area. Smaller patches in the central and north-central portion of the wetland contained mixed vegetation type. This area consists of less than half the total wetland area and contains open mesic grassland with morning glory vines (*Ipomea pes-caprae*), closed wet mixed forest with mangroves, open wet ironwood forest with other native trees and an understory of *Acrostichum aureum*, closed hibiscus forest, closed wet mixed forest with mangroves, open wetland with *Acrostichum aureum*, and the smallest patch of open wetland with native herbs. This 1989 map depicts a wetland surrounded by a thick border of open dry area with mixed grasses and a small patch of ironwood in the corner.

In contrast, the 2013 map shows a wetland area with a greater mix of vegetation, substantially less tangan tangan, more ironwood, and larger patches of the native mangrove, though most of the same species are noted in both maps (excepting *Delonix regia*, noted only in the 2013 map). In summary, the extent of wetland vegetation grew between 1989 and 2013 and these wetland species appear to have largely replaced the non-native tangan tangan (Raulerson and Rinehart 1989, Cogan et al. 2013).

<u>Salinity of constructed wetland and surface pools within the natural wetland</u>

Salinity of the wetland surface pools and the constructed wetland is the second measure of resource condition. The salinity of these pools and the underlying water table respond to sea level variability and tidal fluctuations, with increased salinity in nearby coastal wells documented during years with higher sea levels such as La Niña events (Perreault 2007; Carruth 2003). Likewise, periods of lower sea levels such as those observed during the 1997–1998 El Nino event have led to less saline well water on Saipan's coastal plain. The degree of saltwater mixing among the Park's hydrologic features likely impacts the ecological features around the wetlands.

The artificial wetland has been found to be significantly more saline than any of the natural wetland's surface waters. This is likely attributable to the intentional release of brine into the wetland from nearby hotels' reverse osmosis facilities. Nearby resorts and businesses disposing of highly saline water have since implemented underground injection wells to avoid sending the brine directly into the lagoon. As of 2013 there were eight wells implemented (Mattos 2013); however, anecdotal information from local resource managers and government agencies suggest that significant spillover from the adjacent urban area continues to impact the artificial wetland.

<u>Presence and abundance of native animal and plant populations</u>

Diversity and population dynamics of native species could provide an important additional measure of wetland health if sufficient data were available. In total, Rauzon (2010) counted 946 individuals of 17 avian species throughout the wetland area of the Park. Of these seventeen species, 8 were endemic, 6 indigenous, and the other 3 were introduced.

Of particular concern und are the populations of the wetland's endangered species: the nightingale reed warbler, Mariana moorhen, and humped tree snail. The mangrove wetlands within American Memorial Park were formally listed as critical habitat for the Mariana moorhen (Stinson et al. 1991, Rauzon 2010) and six territorial pairs of nightingale reed warblers (Johnson 2003), but populations have not been assessed since Typhoon Soudelor struck the island in 2015. As 90% of the Park's trees were affected by the typhoon, animal populations were likely impacted as well (NPS 2017).

The humped tree snail was listed federally as endangered in 2015 (USDOI 2015). Starmer (2007) noted the presence of two individuals encountered while performing avian surveys in the natural wetland, though field surveyors were consciously searching for endangered and rare species during all times of data collection for this report. The report notes this infrequent observance of the humped tree sail as an apparent decline in the population compared to 2001, when the snails were "relatively abundant" (Starmer 2007).

The same document includes a separate study surveying terrestrial invertebrates in the wetland area of the park. Invertebrate diversity was found to be somewhat low in the park. Pan traps collected an average of 0.5 to 4 morphospecies in a 24-hour period and cup traps caught an average of 2 to 4 morphospecies in the same 24-hour period. Leaf litter collection collected 13 species of snail but the endangered humped tree snail was not detected (Starmer 2007).

4.1.6. Condition Summary

Measures for the mangroves and wetlands resource are listed here, accompanied by respective scores for significance (1–3) and condition (0–3).

<u>Extent of natural wetland area</u>

The wetland complex provides habitat for three endangered species, and therefore wetland extent is given a significance level of 3. Based on aerial and satellite imagery, the areal extent of the wetland has increased over time, so a condition level of 1 is assigned, giving an overall condition score for this measure of 4.

<u>Salinity of constructed wetland and surface pools within the natural wetland</u>

This report recognizes that salinity is only one of a handful of indicators for water quality. However, as it is the only data we have available we will use it for the purposes of being able to assign a condition with the caveat that this is an area where more research would be beneficial. The quality of the surface pools has a significant impact on wetland ecology but the constructed wetland does not, so a significance level of 2 is assigned. Though brine water input to the constructed wetland has stopped, the area still collects storm runoff. The constructed wetland also has had frequent exposure to raw sewage associated with the adjacent CUC sewage pump and past leakage from damaged sewers to or illegal connections to the Garapan storm drains discharging into the park. BECQ recorded the presence of *Escherichia coli* and low levels of oxygen within the wetland as well.

As the surface water salinity in the natural wetlands is not following a pattern of higher salinity closer to the lagoon, Perreault (2007) notes that something must be obstructing it. For these two reasons, we assign a condition level of 2, for a measure condition score of 4.

<u>Prevalence of invasive species (plants, fish, birds, invertebrates)</u>

Invasive plants have come to dominate the constructed wetland, though they are receding in the natural wetland. New species of introduced birds were noted in the last few years, and invasive fish are also being found in the wetlands. Invasive species can have a wide range of effects on an ecosystem ranging from minimal to catastrophic damage, thus the significance level of this issue is 3. As condition appears to be deteriorating over time, the condition level is 2, for an overall measure condition score of 5.

<u>Presence and abundance of native animal and plant populations</u>

Based on habitat maps and land cover data, it seems as though native plant species are increasing within the wetland, possibly providing opportunities for restoration. However, the endangered humped tree snail is noted to be declining and was listed federally as endangered in 2015, though limited data is available for this species. Data is also limited for the populations of the nightingale reed warbler or the Mariana moorhen. Greater effort toward population studies is warranted. Examining the diversity and population dynamics of endangered, resident, and rare species in the Park would play an important role in ensuring thoroughness and integrity in future assessments.

In the face of this extremely limited data, based on the nature of endangered species and the threats facing endemic species' populations on nearby islands, a significance level of 3 is assigned for this measure. Abundance of native plant species appears to be increasing, although it is uncertain what the condition of most of the native animal species populations is. However, Typhoon Soudelor in 2015 and Super Typhoon Yutu in 2018 likely caused significant damage to native habitat that is not yet documented. Therefore, a condition level of 2 is assigned giving this measure a total condition score of 5. However, there is not enough reference information to determine a trend, so confidence in this assessment is quite low.

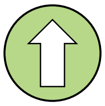
The weighted condition score, or mean value, of the four scores is 4.5, giving the wetlands and mangroves resource an assessment of moderate concern. The lack of an arrow indicates that some measures may be improving, others may be declining, but most lack sufficient baseline data to determine a trend. Due to a lack of data regarding water quality and the populations of endangered species, we have assigned this weighted condition a dashed outline indicating a low level of confidence in this condition (Table 14).

Table 14. Mangroves and wetlands weighted condition score.

Measures	Significance Level	Condition Level	Resource Weighted Condition Score
Extent of wetland	3	1	
Salinity	2	2	
Prevalence of invasive species	3	2	
Abundance of native species	3	2	
Cumulative condition score	**11**	**7**	**18/4 = 4.5**

4.2. Coastal Scrub and Secondary Forest

The overall resource condition of coastal scrub and secondary forest is good with a positive trend; confidence in the condition determination is moderate. Rationale is discussed in the "Condition Summary" section and following.



4.2.1. Description

The coastal scrub and secondary forest within American Memorial Park consists largely of one native tree species, Australian pine (*Casuarina equisetifolia*), known locally as ironwood. Numerous non-native plant species occupy the remainder of the scrub-forest landscape. Pollen core samples determined that this ironwood species pre-dates human arrival on Saipan, dispelling a common misconception that the tree is an introduced, invasive species (Jarzen and Dilcher 2009). The same is true for the coconut palm (*Cocus nucifera*) on Saipan, which was found in lake sediments dating to 7800 BC (Jarzen and Dilcher 2009). Despite the ironwood's native status, the species is most dominant in disturbed areas and is absent in native forest (Cogan et al. 2013).

The general distribution of coastal scrub and secondary forest consists of multiple patches throughout the Park, and ironwood-dominated stands alone make up 14% of AMP (Cogan et al. 2013). The most extensive patches exist in four separate locations:

- Along the constructed wetland, paralleling the wetland's stream-like route to the lagoon;
- In a large, closed access area northeast of the bike path;
- Surrounding the parking lot near Micro Beach;
- And alongside the road leading to Smiling Cove marina, and adjacent to the marina causeway.

The largest patch of secondary forest northeast of the bike path was heavily damaged by Typhoon Soudelor in 2015, which killed many ironwoods and felled nearly 90% of trees within the park (NPS 2017, see Figure 6). Figure 29 shows this patch prior to typhoon damage via oblique imagery taken by CNMI Coastal Resources Management Office in 2009 during a period of rapid beach growth along the sand spit at Smiling Cove Marina and subsequent vegetation succession.

Figure 29. Oblique image of American Memorial Park's ironwood forest in 2009 (Photo courtesy of CNMI CRMO).

The ironwoods have been the primary successors following establishment of shoreline strand vegetation in this part of the Park, as accretion caused the shoreline to shift seaward to 6.5 m (21.33 ft) per year between 2003 and 2011 (Greene and Skeele 2014). Figure 30 illustrates this succession, showing parallel stands of ironwoods along the accreting sand spit in 2013, with older, taller pines on the left, and more recently established, shorter pines on the right (closer to the growing shoreline).

Figure 30. Parallel ironwood stands illustrating forest succession in American Memorial Park (Photo by R. Greene 2013).

Coastal scrub and secondary forest within the park has not been documented as a host habitat for endangered species, though a group of foraging endangered Mariana gray swiftlets (*Aerodramus bartschi*) were noted in avian surveys of the park (Rauzon 2010). Ironwood trees are also attractive as nesting or roosting trees to several indigenous seabird species, including the white tern (*Gygis alba*) which nest in the trees, the black noddy (*Anous minutus*), and brown noddy (*Anous stolidus*).

4.2.2. Measures

- Extent of coastal scrub and secondary forest habitat
- Presence and abundance of native animal and plant populations

4.2.3. Reference Conditions/Values

Land cover maps from Raulerson and Rinehart (1989) can be compared with Cogan et al. (2013) to serve as reference points in assessing changes to areal extent and abundance of native vegetation in the park. Animal populations have not been formally surveyed in the coastal scrub habitat so no reference conditions for this resource exist.

4.2.4. Data and Methods

Vegetation and land cover within this habitat is taken from Raulerson and Rinehart (1989) and Cogan et al. (2013), the methods for which were both described previously in Section 4.1. Data on avifauna is incidental, and at times anecdotal, but Rauzon (2010) reports species presence in the park by habitat and observed activities within that habitat, such as foraging or building nests. Survey and data collection methods for Rauzon (2010) are also previously described in Section 4.1.

4.2.5. Condition and Trend

Changes in areal extent of this habitat over time can be determined by comparing the land cover maps of Raulerson and Rinehart (1989, based on 1987 aerial imagery) and Cogan et al. (2013, based on 2005–2006 Quickbird satellite imagery). Table 15 describes differences found between the two maps.

Table 15. Comparative table of American Memorial Park's secondary forest, 1989 and 2013 (Raulerson and Rinehart 1989 and Cogan et al. 2013).

Location	1989	2013
Between Micro Beach and bike path	Open dry area with mixed grasses (mowed areas), small patch of open mesic grassland with morning glory vines directly adjacent on eastern side of bike path.	Ironwood (*Casuarina equisetifolia*) wooded herbaceous vegetation with a small patch of coconut palm (*Cocos nucifera*).
Point to the northwest of Smiling Cove Marina	This area is a product of accretion and didn't exist in 1989.	Ironwood woodland and small patches of *Pithecellobium dulce* (semi-natural woodland).
Smiling Cove and Outer Cove Marina	Closed mesic native shrubs.	Ironwood-dominated woodland on isolated dredging spoils, except for small patch. Ironwood/*Pluchea indica* swamp forest at the base of the marina entrance and ironwood/*Paspalum spp.* wooded herbaceous vegetation south of the western outer point. Smaller patch of *Hibiscus tiliaceus/Asplenium nidus* swamp woodland southeast and adjacent to the herbaceous patch.
Vegetation around constructed wetland and drainage area	Open wetland with native herbs.	Stream bordered by ironwoods.
Vegetation around bike path	Open dry area with mixed grasses (mowed areas), with small patch directly adjacent to northern third of bike path. Open mesic ironwood forest with grassland and morning glory understory.	Several new facilities (transitional), with a lawn dominated by *Bothriochloa bladhi* and *Chrysopogon aciculatus*. Ironwood is adjacent to the majority of the bike path.

There are multiple similarities between the vegetation comparisons of secondary forest and developed green space zones, as many areas noted in 1989 as “mowed lawn” have since grown into ironwood forest. This transformation characterizes areas between the bike path and Micro Beach, areas immediately bordering the bike path, vegetated areas adjacent to the constructed wetland drainage, and alongside Outer Cove Marina road.

Additionally, the most substantial patch of ironwood forest did not exist in 1989 because the underlying soil is a product of rapid beach growth that has persisted since the early 2000s. The area was formerly submerged. Adjacent stands of trees in a range of growth stages can be seen in this large patch of secondary forest (Yuknavage and Palmer 2010; Figure 30), showing a clear successional pattern of the forest following accretion and growth of new shoreline.

Species identified by Cogan et al. (2013) in coastal scrub and secondary forest are identified in Table 16, including trees, grasses, shrubs, and vines.

Table 16. Plant Species in American Memorial Park's scrub and secondary forest patches. Native species are denoted with an asterisk (Cogan et al. 2013).

Common name	Scientific name	Plant type
Ironwood*	*Casuarina equisetifolia*	Tree
Pacific mangrove*	*Bruguiera gymnorrhiza*	Tree
Indian tulip tree*	*Thespesia populnea*	Tree
Manila tamarind, monkeypod	*Pithecellobium dulce*	Tree
Flame tree/royal poinciana	*Delonix regia*	Tree
Coconut palm*	*Cocos nucifera*	Tree
Tangan tangan	*Leucaena leucocephala*	Tree
Nonag*	*Hernandia sonora*	Tree
Papaya	*Carica papaya*	Tree
Lesser spear grass	*Chrysopogon aciculatus*	Grass
Australian beardgrass	*Bothriochloa bladhii*	Grass
Tropical fimbry	*Fimbristylis cymosa*	Grass
Hilo grass	*Paspalum conjugatum*	Grass
Beach wiregrass	*Dactyloctenium aegyptium*	Grass
Pacific Island thintail	*Lepturus repens*	Grass
Scaly swordfern	*Nepholepis hirsutula*	Shrub
Mother-in-law’s tongue	*Sansevieria trifasciata*	Shrub
Mexican fireplant	*Eurphorbia heterophylla*	Shrub
Browne’s blechum	*Ruellia blechum*	Shrub
Ivy gourd	*Coccinia grandis*	Vine
Beach morning glory*	*Ipomea pes-caprae*	Vine

Information regarding animal species' use of coastal scrub and secondary forest habitat within the park has largely been anecdotal inclusions in reports on other topics. During Rauzon's 2010 avian surveys within the wetland complex of the park, for example, a collared kingfisher (*Todiramphus chloris*) nest was observed in an arboreal fern clump. This feature was coincident with the coastal scrub area delineated for the NRCA. Rauzon also noted non-native Philippine turtle doves (*Streptopelia bitorquata*) foraging in weedy areas and ironwoods, as well as the presence of yellow bitterns (*Ixobrychus sinensis*), white terns, Pacific reef herons (*Egretta sacra*) and Micronesian starlings (*Aplonis opaca*) in other ironwood patches within the park. A single endangered green sea turtle was observed nesting in the coastal scrub habitat along Micro Beach, with nesting activity being reported only in 2015 and 2017 (Summers et al. 2018). This particular nesting sea turtle has since been poached (DLNR unpublished data).

Additional avifauna that have been noted in the Park's secondary forest include the Micronesian honeyeater (*Myzomela rubratra*), rufous fantail (*Rhipidura rufifrons*), and the non-native, recently established orange-cheeked waxbill (*Estrilda melpoda*). Endangered Mariana swiftlets were seen foraging above the coastal scrub and near-shore terrestrial area.

The coastal scrub and secondary forest patches host many of the terrestrial non-native or invasive fauna present in the park, including rats (*Rattus* spp.), mice (*Mus musculus*), feral cats (*Felis silvestris*) and dogs (*Canis familiaris*), cane toads (*Bufo marinus*), and Eurasian tree sparrows (*Passer montanus*). Zoological surveys specific to this habitat within the park have not yet been formally conducted (M. Gawel, pers. comm., 2017).

4.2.6. Condition Summary

Measures for the coastal scrub and secondary forest are listed here, accompanied by respective scores for significance (1–3) and condition (0–3).

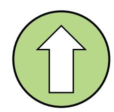
<u>Extent of coastal scrub and secondary forest habitat</u>
Habitat extent was given a significance level score of 3 (high significance) due to the services these areas can provide with respect to both aesthetics and habitat for native fauna. This size substantially increased in the 20-year reference period, therefore a condition level of 0 (least concern) has been assigned. The recent disturbance to the forest caused by Typhoon Soudelor is not weighted heavily as the area is already showing signs that succession and re-vegetation is occurring. Visual inspection (2017) reveals steady growth of new ironwood stands in areas where canopy coverage was reduced; however, there is insufficient data to evaluate whether this disturbance has ultimately led to positive or negative effects. Monitoring the growth and change in the disturbed area over the coming years could be key to understanding restoration opportunities following future disturbances.

<u>Presence and abundance of native animal and plant populations</u>
The presence of a significant number of non-native species in this park habitat has been observed for decades without reducing ecological integrity. This situation renders the presence of strictly native species less crucial to overall habitat health than would otherwise be the case in a larger, more fragile environmental setting. In light of this circumstance, a significance level of 2 is assigned. Conditions for animal species are very poorly understood, but presence and abundance of plant species have

either improved or remained consistent within the historic reference period, resulting in a condition level of 0. This score is accompanied by the caveat that fauna populations are mostly undetermined and therefore the confidence level is low.

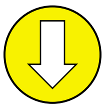
Because both of these measures were given condition level of 0, both are assigned an overall condition score of 1. Therefore, the mean value of the two scores is 1 and so the weighted condition score for this resource is assigned a green circle, indicating that this coastal scrub and secondary forest habitat is in good condition based on assessments made (Table 17). The arrow inside indicates that conditions have been improving within the reference period (based on historic and current land cover maps). Due to the paucity of information regarding animal species, we have assigned this graphic a thin outline indicating a modest level of confidence in the comprehensiveness of the data and any resulting assessments.

Table 17. Coastal scrub and secondary forest weighted condition score.

Measures	Significance Level	Condition Level	Resource Weighted Condition Score
Extent of coastal scrub and secondary forest habitat	3	0	
Presence and abundance of native animal and plant populations	2	0	
Cumulative condition score	**5**	**0**	**1**

4.3. Shore and Near-shore Habitat

The overall resource condition of shore and near-shore habitat is moderate with a negative trend; confidence in the condition determination is moderate. Rationale is discussed in the "Condition Summary" section and following.



4.3.1. Description

American Memorial Park contains 1.31 km (0.8 mi) of sand shoreline, though this area has a dynamic pattern of erosion and accretion so the exact dimensions fluctuate in response to coastal processes and climate variation. Historic aerial photographs and land cover datasets for 1945 and 2005 demonstrate the effects of these changing patterns of erosion and accretion, with the most notable change being extensive accretion of sand along the northeast stretch of unconsolidated beach adjacent to Smiling Cove. This area was also described in Section 4.2 with respect to secondary forest succession and growth of ironwood stands.

Although the park boundary terminates at mean high water, the near-shore areas and benthic habitat of Saipan Lagoon are also included in the NRCA conditions ratings for the services they provide to park resources, especially erosion mitigation and recreational attractions (Figure 31). The NRCA near-shore resource is defined as the water column and benthos within 100 m (328.08 ft) of the shoreline, which consists largely of bare sand, seagrass, macro algae, and coral rubble (Kendall et al. 2017). Additionally, pelagic avian species and migratory shorebirds such as the Pacific golden plover (*Pluvialis fulva*) use some areas of the shoreline for foraging, especially the tidal flats near the marina.

Figure 31. Unconsolidated shoreline and strand vegetation at the north end of Micro Beach in American Memorial Park (Photo by R. Greene 2012).

4.3.2. Measures

- Shoreline dynamics (erosion and accretion)
- Configuration and coverage of seagrass and marine algae
- Near-shore water quality

4.3.3. Reference Conditions/Values

Shoreline dynamics

Historic aerial photographs and satellite imagery dating from WWII to present demonstrate dynamic coastal morphology along most of American Memorial Park's beaches, but older aerial imagery from the 1940s would serve as a skewed baseline reference due to dredging, the creation of the marina, and shifts in hardened shoreline which had already been occurring during that time. Thus, there is no reliable historic reference for a stable, pre-development shoreline for the entire park. In light of this, the NRCA utilizes studies of shoreline behavior extending from the sand spit at Smiling Cove Marina to the southern extent of Micro Beach beginning in 1991 (Dean). This reference condition is followed by analyses of shoreline positions in 2004 (USACE), 2010 (Yuknavage and Palmer), and 2014 (Greene and Skeele). Figure 32 highlights some of the various reference points that exist for the shoreline, including imagery-derived shorelines from 2003, 2005, and 2011, overlain on 2005 Quickbird imagery.

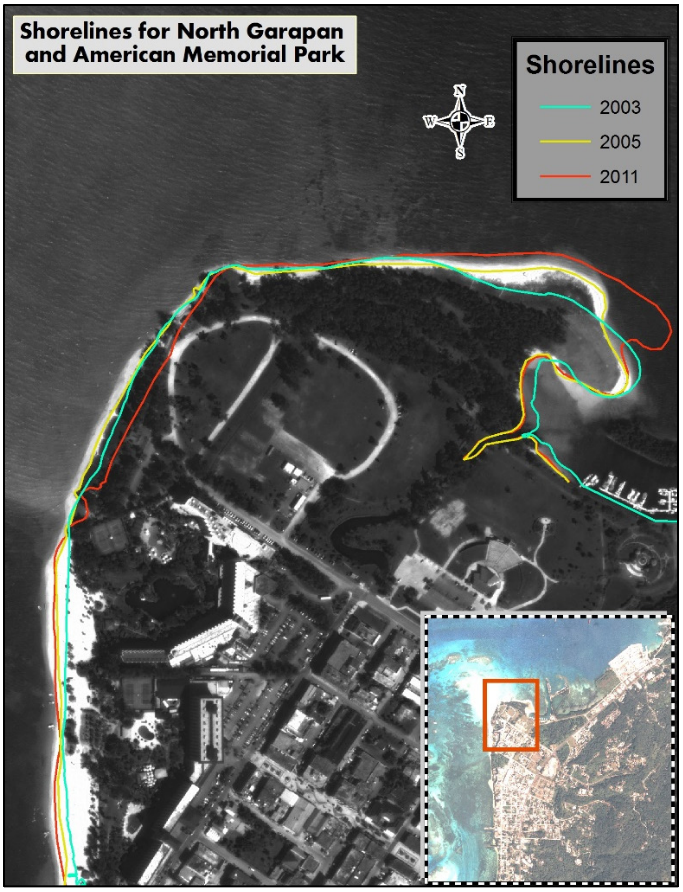


Figure 32. Shoreline delineations for 2003, 2005, 2011 overlain on 2005 satellite imagery.

<u>Configuration and coverage of seagrass and marine algae</u>

Near-shore marine habitat around the park was extensively mapped in 2016 (Kendall et al. 2017; Figure 33). Prior to this effort, the only detailed benthic mapping around the park's near-shore area was performed by Houk and van Woesik (2008) and utilized a different classification scheme. While relative configurations of seagrass beds and unconsolidated sand can be observed in the data products from both studies (maps in Section 2.2.2.), the two datasets are not directly compatible for analysis, and therefore confidence is low in using the 2005 and 2017 published data as a reference period. The benthic classification below includes three bins for seagrass: 'Mixed Algae and Seagrass', 'Seagrass (*Enhalus*)', and 'Seagrass (*Halodule*)'. The latter two classes tend to constitute a healthier seagrass habitat with less macro-algal cover. The *Enhalus* and *Halodule* habitat is significant for provision of juvenile fish habitat and wave energy attenuation, thus particular emphasis should be placed on the extent of these classes as a metric for assessing resource condition.

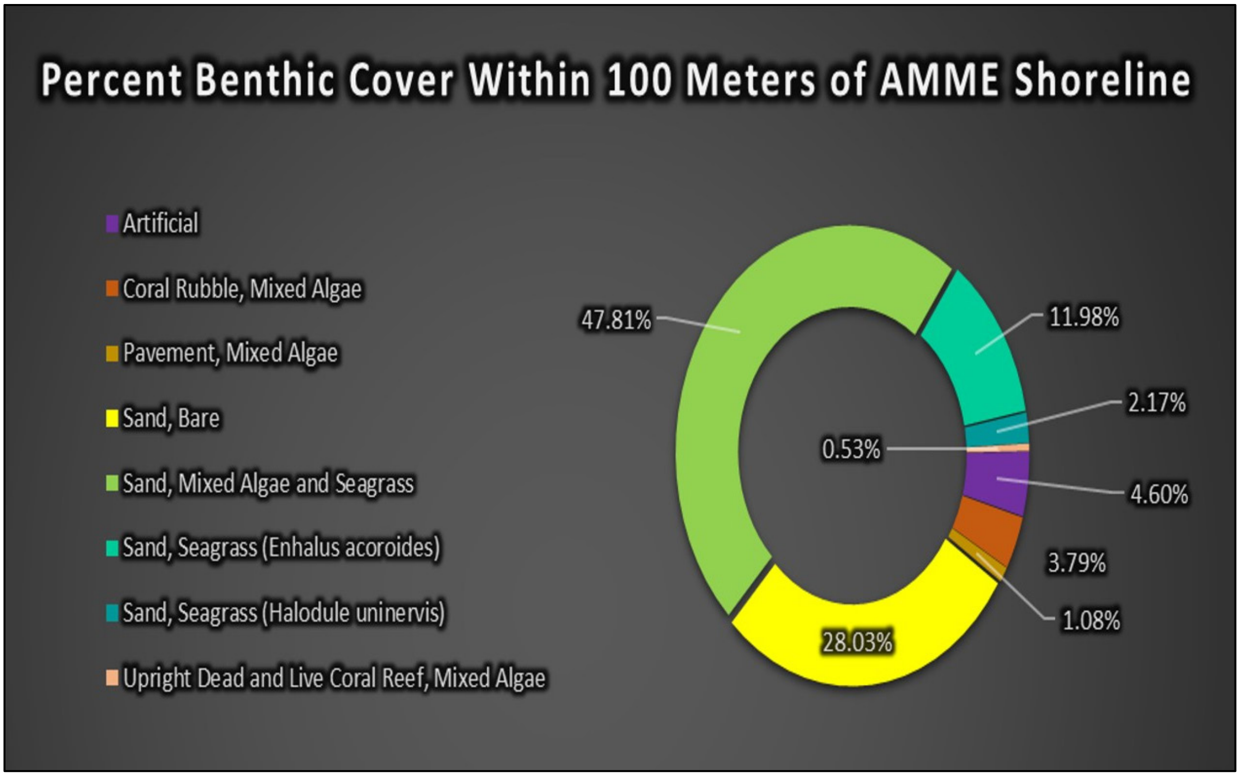


Figure 33. Benthic habitat composition in American Memorial Park near-shore zone (Kendall et al 2017).

Near-shore water quality

Regular water quality sampling of beaches adjacent to the park has been conducted by the CNMI BECQ's Division of Environmental Quality (DEQ) since mid-1993 and is ongoing as part of the U.S. EPA BEACH grant requirements. These sites are WB13 (outer cove marina N15 13.106; E145 46.024), WB12 (Smiling Cove Marina N15 13.018; E145. 43.466), WB12.1 (American Memorial Park), and WB14 (Micro Beach N15 13.020; E145 42.998). Sampling and lab analysis has consistently revealed fecal bacterial contamination from enterococci. These bacteria can occur naturally, and studies have not been performed to determine the source of the bacteria or the extent to which the bacteria are naturally. Thus a reference for this measure is difficult to establish. Regardless, trends in red flag events (water quality unsafe for human recreation) were examined and reveal that higher occurrences of these bacteria have been noted over time, posing implications for both habitat health and park recreational opportunities (Bearden et al. 2014).

4.3.4. Data and Methods

Shoreline dynamics: Shoreline morphology has been the primary focus of four studies from 1990 to present: Dean (1991), USACE (2004), Yuknavage and Palmer (2010), and Greene and Skeele (2014). The 1991 assessment utilized aerial photographs to examine historic shoreline positions, comparing these with in situ measurements of the shoreline, visual inspections of benthic and grain size conditions of adjacent beaches, and estimates of impacts from near-shore currents, wind, and wave patterns. The 2004 USACE study was a systematic analysis of shoreline change using standard transect measurements and monitoring protocol. This project assessed shoreline conditions for the

Park by evaluating the effects of wind, waves, current, tide, tropical storms, sand size, and vegetation on sand movement patterns in the park, with a primary focus on analysis of shoreline transects at various points along the stretch of shoreline between Smiling Cove and the tourist resorts to the south. While this project included coverage of the entire Saipan Lagoon, the largest areas of change and consequent discussion fall within park boundaries.

Yuknavage and Palmer (2010) digitized shorelines based on satellite imagery, and recorded shoreline transect measurements on a quarterly basis from 2004 to 2008. Transects were selected from 19 pre-established reference points along Saipan's lagoon shoreline as well as Mañagaha, a small islet off the coast. These measurements included multiple transects within the park. This long-term monitoring established useful metrics for erosion and accretion trends and allowed a basis for hypothesizing relationships between changes in shoreline conditions and seasonal or stochastic events.

Greene and Skeele (2014) utilized GIS and the USGS Digital Shoreline Analysis System to calculate shoreline trends in the park and along adjacent beaches to the south. One-hundred transects were cast over the shoreline at regular intervals, with over seventy of these falling within American Memorial Park. Changes in the position of shoreline between 2003, 2005, and 2011 were measured at each transect, to identify the areas of greatest concern, and potential for management priorities. This same study also applied methodology from NOAA inundation models to map coastal flooding and potential future inundation boundaries within and adjacent to the park, providing a visualization of future threats due to climate change. The latter part of this study is not a specific metric for current and historic shoreline change, but nevertheless addresses a relevant issue that may impact future shoreline positions and is therefore elaborated on in Chapter 5 of this NRCA.

<u>Configuration and coverage of seagrass and marine algae</u>
Near-shore marine habitat data for the Saipan Lagoon was developed by Houk and van Woesik (2008) and Kendall et al. (2017) using combinations of field-based observations and remote-sensing techniques, performed with 2001–2003 Ikonos imagery and 2016 WorldView imagery, respectively. Spatial data produced by each of these projects was clipped to the American Memorial Park near-shore zone that was delineated for the NRCA, and broad differences between the two resulting maps are described as part of the NRCA condition assessment. Kendall et al. also included a cursory assessment of change in benthic composition between 2003 and 2016, noting several areas of significant change including shifts in seagrass and sandy habitat adjacent to the Park. Conclusions based on both the NRCA team's comparison of spatial data as well as Kendall et al.'s observations are briefly outlined in the following section.

<u>Near-shore water quality</u>
Water quality monitoring data were obtained from the CNMI BECQ-DEQ, which has four long-term monitoring sites along the Park shoreline. Sampling generally occurs at these four sites on a weekly basis. The sampling includes measurements of pH, salinity, temperature, and occasionally total suspended solids. For the purposes of the NRCA, analysis focused on the frequency of enterococci, a fecal indicator bacteria, and the resulting red-flag events (hazardous to human health) for beaches within and adjacent to American Memorial Park.

4.3.5. Condition and Trend

Shoreline dynamics

The shoreline research and data described above resulted in a range of conclusions regarding the morphology and possible future beach conditions at American Memorial Park. In general, changes have been quite rapid within the park when compared to the rest of Saipan's fairly stable beaches. Portions of the Park's bike path have been undercut and in some cases completely destroyed, while a major bathroom had to be relocated 150 m (0.09 mi) inland due to impending erosion and damage to the foundation. This was a costly and time-consuming process, yet given the continuing loss of shoreline, funding was sought for a second bathroom relocation (Yuknavage and Palmer 2010). Specific results of relevant studies are discussed below.

Almost all research related to shoreline change at American Memorial Park concluded that erosion threatens facilities on the western side of the park, while accretion has been expanding the park's landscape to the north and east of this area. This pattern is potentially attributable to a combination of a decline of nearby seagrass beds, periods of elevated storm activity, enhanced trade winds, and westerly wave action. Dean (1991) determined that eroding areas would continue to experience a shoreline loss of as much as 6 m (20 ft) per year in some locations. However, subsequent studies diverged, concluding that stretches of shoreline to the south bordering the adjacent public lands and hotel beaches were to be the focal points of ongoing beach loss, while accretion would persist at the northeast end of the unconsolidated shore, filling in marine habitat in Smiling Cove Marina.

The USACE suggested a possible cause of this pattern might be the 600 m (1,968.5 ft) hardened shoreline and marina infrastructure, which began blocking the transport of sand from northeast to southwest upon construction and dredging (USACE 2004). This explanation may require significant research to substantiate, as some indication of structure in the shape of the current marina and jetty is indicated as early as 1945 in land cover data produced by NOAA's C-CAP. That dataset suggests that several iterations of change and shoreline modifications over the last 70 years may need to be investigated to determine the impact of the marina on the Park's shoreline dynamics.

More recently, monthly shoreline monitoring between 2004–2008 suggested that portions of the Park's shoreline were stabilizing, taking on a position comparable to pre-dredging and before structures altered deposition patterns. Yuknavage and Palmer concluded that park facilities were no longer severely threatened by erosion in 2010.

Three years later park infrastructure along the western shoreline near Micro Beach was destroyed by steady erosion and wave action during a series of highly active tropical cyclone seasons. The use of GIS and the USGS Digital Shoreline Analysis System to measure shoreline position shifts between 2003 and 2011 revealed focal points of erosion at end-point rates of -2.5 m (8 ft) per year, and accretion rates of up to 6.5 m (21 ft) per year (Greene and Skeele 2014). Data from this study was provided by BECQ and is summarized in Figure 34, as well as in the discussion of threats and stressors in Chapter 5.

Shoreline Classification and Rating

Values	Behavior	Rating
-2.97 to -1.1	Erosion – High Rate	At Risk
-1.0 to -0.51	Erosion – Slow Rate	Poor
-0.50 to 0	Stable, Slight Erosion	Fair
0. 1 to 3.0	Stable, Accretion	Good
3.1 to 7.89	Accretion – High Rate	Fair

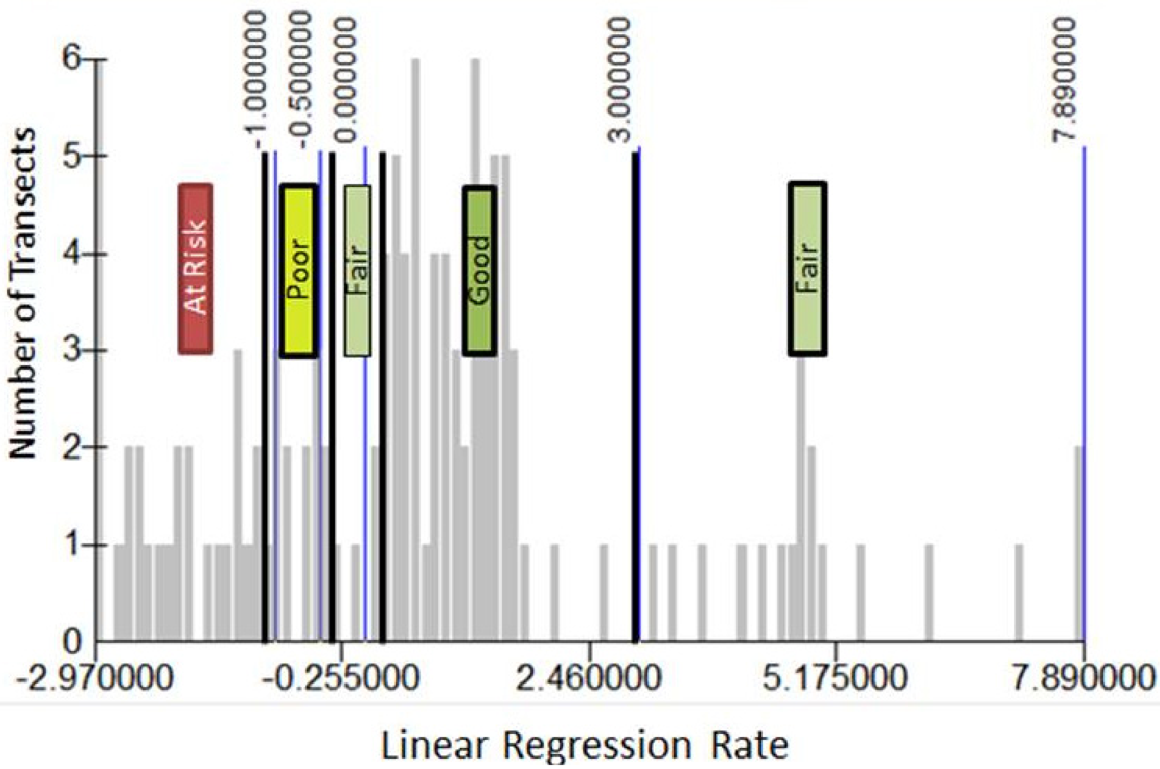


Figure 34. Shoreline change classification (m/yr.) for beach transects at American Memorial Park (Greene and Skeele 2014).

Figure 34 illustrates a shoreline rating scale based on classification of rates of change at beach transects throughout the Park. Five classes and associated ratings of change resulted, ranging from ‘At Risk’ (-2.97 - 1.1 m/yr.) to ‘Good’ (0.1 – 3.0 m/yr.). These ratings corresponded with relatively rapid loss of beach and fairly stable or slowly accreting areas, respectively. Rates of change that fell between these two classes were considered ‘Poor’ to ‘Fair’, while extreme rates of accretion (3.1 – 7.89 m/yr.) were assigned a rating of ‘Fair’ instead of ‘Good’ due to the uncertain impact that this growth of land would have on recreational features at Smiling Cove Marina. These ratings were originally established as a contribution to BECQ’s conservation action planning process for the beaches within and adjacent to American Memorial Park and are included here as a partial basis for the NRCA condition rating.

While all reports on shoreline stability reinforce the conclusion that the Park's shoreline is dynamic, cycles of change appear to occur in a manner that is still not well understood and this poses issues for prediction of future shoreline configuration. This problem is compounded by a lack of modeling of the direction and mechanisms of sand deposition (USACE 2004) and the effects of sea level variability on rates of change (Greene and Skeele 2014).

A cursory examination of historic and current satellite imagery (up to 2016) allows for an updated visualization of major changes to the shoreline, the most substantial of which continue to sustain growth of coastal scrub and secondary forest near the marina while deposition and northward migration of unconsolidated sediment and sand is now mitigating some of the previous focal points of erosion. The latter phenomenon is highlighted further in Chapter 5. Aerial imagery from 1948, 1970, 1999, and 2003 was compared in Yuknavage and Palmer's study (2010), yet the trends that appear to dominate in these images are contrary to observations made between 2015 and 2017 with an apparent reversal of sediment transport and longshore drift in parts of the park. While the condition rating of American Memorial Park's shorelines primarily reflects data that have been published through 2014, additional changes since then should be noted as both a limitation in assessment confidence as well as a justification for further study.

Beyond the sand beaches and soft shoreline, the sea wall protecting Smiling Cove marina is facing erosion, with visible, costly damage to hardened mitigation features. An environmental assessment was performed in 2008, after a 2007 study determined construction needs and costs. However, available funding was not able to cover costs of stabilizing the entire marina. Repairs are estimated to be around $10 million, thus the area will not likely be repaired soon (T. Chargualaf, pers. comm., 2017). Furthermore, Typhoon Soudelor exacerbated the crumbling concrete on the eastern side of the marina (T. Chargualaf, pers. comm., 2017). If no changes occur to the portion of sea wall that was not reconstructed, periodic wave action will continue to adversely impact the area and will threaten the integrity of the causeway, potentially limiting access to the marina. Eroding material would also intensify sedimentation in the near-shore zone and increase water turbidity in the area (NPS 2008).

<u>Near-Shore Habitat</u>

Kendall et al. (2017) describe the near-shore benthic composition of the lagoon area adjacent to American Memorial Park which consists largely of bare sand, seagrass, and marine algae with trace amounts of coral rubble. Spatio-temporal analyses comparing benthic composition and adjacent shoreline positions are needed to examine potential relationships between the two. This would provide a more valid means of determining if the presence or absence of seagrass significantly affects erosion/accretion patterns.

Despite the absence of a metric for this relationship, benthic habitat composed of large seagrass beds has been documented as effective in mitigating wave energy. In light of this, a simple assessment of presence, absence, or shifting of *Enhalus* and *Halodule* beds in the near-shore zone serves as the primary means of establishing a current resource condition for the NRCA. Comparison of benthic habitat maps from 2005 and 2017 illustrate an increase in bare sand cover in the near-shore areas adjacent to the park's western shoreline, covering former patches of seagrass. While this might appear to translate into a reduction in the wave attenuation capacity of the benthic environment, the expansion of sandy habitat has corresponded with a reduction in lagoon depth offshore from the Park's western beaches. The raised sand deposits may be providing *more* capacity for wave energy reduction than the original seagrass beds, consequently allowing for the current re-stabilization and growth of beach in that area of the park.

Figure 35, extracted from Kendall et al. (2017), illustrates the conversion of seagrass meadows to sand-dominated habitat in three locations adjacent to American Memorial Park, outlined in green. Kendall et al. (2017) note that prior habitat dominated by seagrass was relatively continuous in coverage with high shoot density among the individual seagrass colonies. The changing benthic habitat configuration may warrant additional study as the transport of sand likely impacts the sediment budget along the Park's shoreline, and consequently changes in shoreline position.

Figure 35. Conversion of seagrass meadows to sand-dominated habitat adjacent to American Memorial Park from 2001–2016. Figure extracted from Kendall et al. 2017.

Seagrass beds on the north and northeast sides of the park remain fairly consistent in coverage, but confidence is low in terms of specific changes in species composition in part due to different classification systems between the 2005 and 2017 data. Rating the condition or trend of the benthic environment in this section of the lagoon is therefore infeasible until additional study is conducted.

<u>Near-shore water quality</u>

The final measure of the shoreline and near-shore zone consists of results of water quality monitoring. This measure employs BECQ water quality data from the early 2000s to present. Between September 2011 and March 2017 weekly monitoring of an American Memorial Park beach produced 50 red flag events from a total of 239 sampling days. This translates into 21% occurrence of marine conditions that could be hazardous to human health if there is extended exposure (i.e. swimming and snorkeling). No obvious trends in the exact timing or occurrence of red flag events with respect to seasonal atmospheric or oceanic conditions were apparent.

BECQ has assigned the marine waters adjacent to American Memorial Park a “category five” listing based on the Consolidated Assessment and Listing Methodology (CALM), indicating that these waters are “impaired or threatened for one or more designated uses by a pollutant(s)” (Bearden et al. 2014). In addition to presence and abundance of enterococci, BECQ data documents temperature, salinity, pH, turbidity, nitrate, and the presence/abundance of several other parameters of water quality. Analysis of these variables was beyond the scope of the NRCA. For the purposes of this assessment, the relatively high frequency of red flag events constitutes a sufficient basis for assigning a fairly high score for concern.

4.3.6. Condition Summary

Measures for the shore and near-shore resource are listed here, accompanied by respective scores for significance (1–3) and condition (0–3).

<u>Shoreline change</u>

Shoreline erosion and accretion patterns are relatively well-documented, but the possible future conditions are still not well-understood or agreed upon. The Park’s shoreline is dynamic and changes to it have created new habitat as well as caused destruction to several park facilities. Given the critical role in the ecological, recreational, and cultural functions of the Park and the impacts that changes to this resource can have, shoreline morphology is assigned significance level rating of 3. The most recent shoreline observations suggest that the shoreline appears to be re-establishing in some areas of prior concern; however, the resource remains unstable and is expected to continue erosive trends given impacts of changing sea levels. In addition, the marina is experiencing continued deterioration. A condition level of 3 is warranted in light of these concerns, for an overall condition score for this measure of 6.

<u>Configuration and coverage of seagrass and marine algae</u>

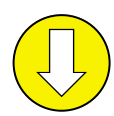
The significance of this resource is built largely on the premise that benthic habitat directly impacts wave energy along the AMP shoreline. In the absence of a thorough comparative analysis of benthic and shoreline change, the NRCA assessment is limited to simple identification of change in presence/absence of seagrass over time and the assumption that loss of healthy seagrass to macro algal cover could be cause for concern. A significance level of 1 is assigned to this feature, largely due to a lack of evidence to justify a higher ranking. Further research could demonstrate otherwise. In a similar manner, the documented shift from mixed seagrass-algal cover in 2005 to bare sand in 2016 appears to have complex implications that could impact the shoreline in positive or negative ways. A condition level of 1 is assigned due to the relatively innocuous impacts observed thus far, for an overall condition score of 2.

<u>Near-shore water quality</u>
Marine water quality affects all biotic life within the lagoon, including Park visitors engaging in aquatic recreation. Thus, this resource has direct implications for park visitor experience and safety, which justifies a significance level of 3. Continued monitoring of fecal indicators has revealed a 21% rate of impairment in these waters, and local government assessments further confirm poor water quality, thus a condition level of 2 is assigned for an overall condition score for this measure of 5.

The weighted condition score of the shoreline and near-shore zone at AMP is 4.3 and therefore of moderate concern overall. Shoreline morphology as a stand-alone indicator of condition status is rated much higher, warranting additional concern with respect to park resource management.

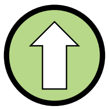
The yellow color of this circle indicates that the resource is of moderate concern, and the thin line around the circle indicates moderate confidence in this assessment (Table 18). The confidence level is based on the presence of fairly extensive data related to erosion and water quality monitoring but acknowledges the addition of uncertainties regarding impacts from benthic habitat change. As water quality is not improving, and shoreline change patterns remain troublesome, the resource trend is negative.

Table 18. Shore and near-shore weighted condition score.

Measures	**Significance Level**	**Condition Level**	**Resource Weighted Condition Score**
Shoreline dynamics	3	3	
Composition and health of seagrass and marine algae	1	1	
Near-shore water quality	3	2	
Cumulative condition score	**7**	**6**	**13/3 = 4.3**

4.4. Developed Green Space

The overall resource condition of developed green space is good with a positive trend; confidence in the condition determination is high. Rationale is discussed in the "Condition Summary" section and following.



4.4.1. Description

The developed green space within American Memorial Park consists largely of open lawn, fields, landscaping around built structures, and patches of non-native species (Figure 36). The delineation of these areas roughly corresponds with the NOAA C-CAP land cover class 'Open Space, Developed', which includes areas with a mixture of constructed materials and vegetation, primarily in the form of low-lying vegetation, recreational areas, aesthetic additions, and managed grasses. Constructed surfaces account for less than twenty percent of the cover in these areas, and they are distinguished from the Park's other habitats and ecological zones by the deliberate intervention of humans in maintaining the landscape. Aside from the park's shorelines, the developed green space areas likely have the most significant impact on visitor experience. This zone contains the recreational pathways, barbeque and picnic areas, visitor facilities, and war memorials.

Figure 36. Oblique image of American Memorial Park visitor center, amphitheater, and developed open spaces (Photo by M. Kottermair 2016).

In addition to lawns consisting almost exclusively of introduced mowed grass and shrub species, ornamental (introduced) trees and flowers adorn the built landscape. Archaeological findings from areas that are now developed green space have revealed pre-historic artifacts, including midden, a fire pit, and pottery sherds, suggesting a high level of cultural significance for the Chamorro people. Pre-war and war-time development flattened and filled most of the non-wetland area within the park, so it is likely that many historic cultural artifacts were destroyed in this process (Thomas and Price 1979, Shun and Moore 1989, Eblé et al. 1997, McIntosh and Cleghorn 2000).

Little documentation exists concerning the animal species present in this area, but based on the highly fragmented, non-native, and maintained nature of the vegetation, it likely receives minimal attention from native species. Insects such as butterflies, spiders, and bees can be observed around the ornamental plants (pers. obs.), but species-specific surveys are lacking. Based on herpetology surveys in other areas of Saipan it is also likely that at least non-native geckos (*Gehyra spp.*), skinks (*Carlia fusca*), and anoles (*Anolis carolinensis*) can be found in the lawns and around park facilities (Wiles and Guerrero 1996). Migratory shorebirds are observed seasonally in the mowed lawn areas of the park.

4.4.2. Measures

- Upkeep of useable recreational green space (lawns, picnic areas) and ornamental trees.

4.4.3. Reference Conditions/Values

Reference conditions for developed green space within American Memorial Park consist of two sets of land cover data. The primary reference condition is based on a 1989 vegetation map of the park (Raulerson and Rinehart), which utilized 1987 aerial imagery and plant collections from 1986 and 1988. Data for this reference condition was developed prior to publication of the General Management Plan, rendering it a suitable historic baseline. Current land cover conditions for comparison purposes are derived from Cogan et al. (2013).

Additional reference conditions are available through the NOAA C-CAP land cover datasets for Saipan from 1945 and 2005. Comparisons of land cover composition between these two datasets provide perspective on long-term progress in the green space resource, particularly with respect to the amount of impervious surface and bare land versus open spaces and landscaped areas. These datasets are not sufficient as a stand-alone reference frame for establishing a condition trend as they fail to capture a current snapshot (within the last decade) of land cover. The C-CAP data are added here as a supplement in light of its limitations.

4.4.4. Data and Methods

USDA classification of soils data and the soils survey database (USDA NRCS 2016) enable visualization of the soil types present in developed green spaces (see Section 4.5 for soils maps), while sub-surface soil conditions were also documented in archaeological reports (Thomas and Price 1979, Shun and Moore 1989, Eblé et al. 1997, McIntosh and Cleghorn 2000, Maigret 2015). These studies included the development of soil profiles from trenches, excavations, and examinations of root balls from fallen trees. In general, the majority of this data are either too coarse in resolution or classification (e.g., USDA), or too specific to particular sites (archaeological reports) to be used as a primary means of rating resource conditions or trends. Land cover is favored as a form of data that is more telling of the conditions and patterns in green spaces or developed landscapes.

Cogan et al. (2013), whose methods are detailed in Section 4.1, provide a land cover map for developed green spaces as well as an inventory of plant species presence. This map was compared to that of Raulerson and Rinehart (1989). The comparison provides the primary basis for assessing land cover change. This is supplemented by mapping of land cover conversions in the park between 1945 and 2005.

Rauzon (2010) also lists avifauna species found within the park, their favored habitats, and the activities these birds were engaged in within specific habitats. Several species were noted in developed green space within the park, which provides a very rudimentary foundation for suggesting an avian habitat condition for the developed green space zone, though confidence in such an assessment would be very limited due to lack of additional study.

4.4.5. Condition and Trend

Developed green spaces within the park consist of mowed lawns surrounding the visitor center and other facilities, picnic areas adjacent to Micro Beach, and ornamental trees and plants along trails and walkways. The only measure identified for this resource component is the upkeep of these largely non-native plant species, the baseline for which is Raulerson and Rinehart's 1989 land cover map of the park, and land cover change, which is represented through comparison of the aforementioned data from 1945, 1989, 2005, and 2013. The 1945 dataset reflects WWII era conditions that differ drastically from the park's current configuration, and the 1989 map was created before any of the memorials, museum, or parking lots were built. The comparison between the 1989 land cover map and Cogan et al.'s 2013 maps outlined in Table 19 suggests modest changes to developed green space within the park. Additional change has occurred to these developed areas in the past several years, especially following Typhoon Soudelor, though no published datasets are available to quantify this change. Land cover data for the NOAA C-CAP program based on 2016 imagery are currently under development, but preliminary products were not available prior to the NRCA.

Table 19. Comparison of 1989 and 2013 vegetation maps of American Memorial Park open spaces.

Location	1989 (Raulerson and Rinehart)	2013 (Cogan et al.)
Strand vegetation between Micro Beach and the bike path	Open dry area with mixed grasses (mowed areas), small patch of open mesic grassland with morning glory vines directly adjacent on eastern side of bike path.	Ironwood (*Casuarina equisetifolia*); wooded herbaceous vegetation.
Area encircled by bike path	Open dry area with mixed grasses (mowed areas) with small patch directly adjacent to northern third of bike path with open mesic ironwood forest and morning glory understory.	Several new built facilities (transitional), lawn consisting mostly of *Bothriochloa bladhi* and *Chrysopogon aciculatus*. Ironwood fringing the majority of the bike path.
Area between the bike path and constructed wetland	Open dry area with mixed grasses (mowed areas).	*Bothriochloa bladhi* and *Chrysopogon aciculatus* lawn with ironwoods thickly bordering the stream.

Table 19 (continued). Comparison of 1989 and 2013 vegetation maps of American Memorial Park open spaces.

Location	**1989 (Raulerson and Rinehart)**	**2013 (Cogan et al.)**
Drainage from constructed wetland	Open wetland with native herbs.	Stream bordered by ironwoods and young mangroves planted before 2010.
Area east of drainage extending to natural wetland	Open dry area with mixed grasses (mowed areas).	Large parking lot, visitors' center, and other facilities, surrounded by *Bothriochloa bladhi* and *Chrysopogon aciculatus* lawn with ornamental trees adjacent to walkways, including rows of Mahogany. A small patch of ironwood at the north end of the drainage.
Green space fringing the natural wetland	Open dry area with mixed grasses (mowed areas) encircling entire wetland area. Small patch of closed hibiscus forest near marina.	Wetland is entirely bordered by *Bothriochloa bladhi* and *Chrysopogon aciculatus* lawn except for small patch of ornamental trees near the flag circle.
Along road to Outer Cove marina	Closed mesic native shrubs.	*Pluchea indica* swamp forest at the base of the entrance and ironwood/*Paspalum spp.* Wooded herbaceous vegetation south of the outer point, and smaller adjacent patch of *Hibiscus tiliaceus/Asplenium nidus* swamp woodland.

Substantial changes between 1986 and 2006 consist largely of ironwood forest growth, which has replaced large patches of lawn between Micro Beach and the bike path. Ironwood proliferation is also apparent in areas adjacent to the constructed wetland, the adjoining drainage to Smiling Cove Marina, along the bike path, and in patches leading to the outer cove. The coverage of ornamental trees and ruderal lawn has also grown, replacing corridors of open space near the natural wetland and Smiling Cove, but these ornamental trees are largely restricted to walkways, and the ruderal lawn is difficult to distinguish from other mowed lawns from an aesthetic perspective. Nevertheless, these transformations constitute a diversification of vegetation in open and developed spaces, providing a richer landscape (and shade) to visitors.

Land cover conversions between 1945 and 2005 illustrate a sweeping transformation of American Memorial Park, with the majority of the Park's lawns and landscaped areas evolving from what was previously bare ground, impervious surface, and artificial fill (Figure 37).

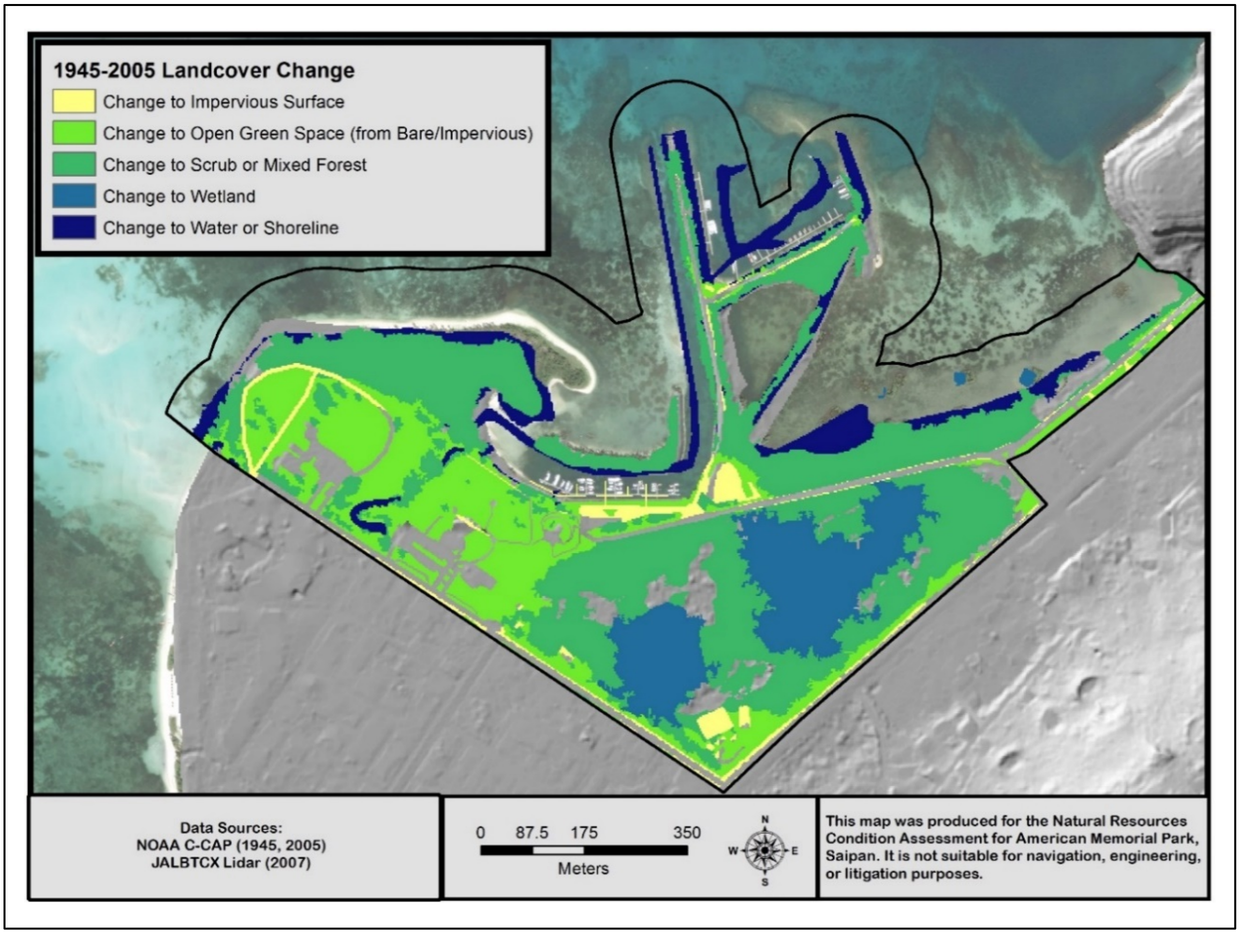


Figure 37. Map of land cover conversions in American Memorial Park from 1945–2005 within park boundary and 100 m (328.08 ft) seaward buffer beyond the park (NOAA 2005, Lidar 2007).

4.4.6. Condition Summary

The measures for the developed green spaces resource are described here, accompanied by respective scores for significance (1–3) and condition (0–3).

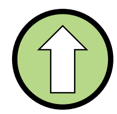
Impervious surfaces and extensive swaths of built environment have largely disappeared from the park area since 1945, giving way to grass-dominated open spaces and lawn coverage. These open spaces have transformed further since 1987, being replaced with ornamental trees and ironwood forest. This land cover change, in combination with green space maintenance and landscaping efforts, has provided favorable shade to bike paths, picnic areas, and parking lots, and resulted in diversified vegetation within the developed green space zone. In addition, ornamental trees are typically selected for their aesthetics, thus an increase in ornamental presence and abundance can be interpreted as an enhancement to visitor experience.

Because the purpose of developed green spaces within American Memorial Park is to provide local and foreign visitors with space for recreational and cultural celebrations and is not aimed at providing habitat for wildlife, less value is placed on the ecological integrity of this resource. Rather, the long-term transformation of open and bare spaces to aesthetically pleasing recreational areas and landscaped visitor features constitutes an improvement in conditions. However, delays in the removal of trees and recovery of vegetation damaged in Typhoon Soudelor have impacted visitor use.

Given that the measures of land cover transformation and maintenance of recreational green spaces address some of the most prominent goals established in the park's GMP and foundation document, a significance level of 3 is assigned. Due to the relatively positive transformations in this resource over time, a condition level of 0 is assigned, resulting in an overall weighted condition score of 1 for this resource.

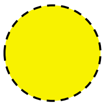
The green color of the condition indicator suggests that the resource is in good condition, while the arrow indicates that condition is improving. Around the circle is a thick, solid line, which symbolizes high confidence in this assessment (Table 20).

Table 20. Developed green space weighted condition score.

Measures	Significance Level	Condition Level	Resource Weighted Condition Score
Upkeep of useable recreational green space (lawns, picnic areas) and ornamental trees	3	0	
Cumulative condition score	**3**	**0**	**1**

4.5. Hydrology

The overall resource condition of the Park's hydrology is moderate with an unknown trend; confidence in the condition determination is low. Rationale is discussed in the "Condition Summary" section and following.



4.5.1. Description

Understanding and monitoring surface and subsurface park hydrology is critical for the health and maintenance of American Memorial Park. The Park's hydrologic conditions directly affect surface ecology (Perreault 2007), and consequently the extent of resource allocation for maintenance of various natural resources. Surface water within the park is present in both the natural and artificial wetlands and is replenished by rain, groundwater discharge (which is especially relevant for portions of the wetland below sea level), and storm water runoff. Four distinct surface freshwater pools exist within the park. These pools generally decrease in salinity with proximity to the ocean, unlike groundwater samples which increase in salinity with proximity to the ocean. The extent and salinity of surface pools in the wetlands is discussed extensively in the wetlands and mangroves resource condition assessment (Section 4.1).

The NPS I&M Groundwater Monitoring Program began after Perrault's study and sampled three sites seaward of the Park's natural wetland using shallow temporary monitoring wells that had been created previously for the study of subsurface pollutants. Staff made quarterly data collections from continuous-recording conductivity-temperature-depth (CTD) probes for sampling water level and conductivity. However, instrument failure, change of wells, data omission, and destruction of one well has triggered a NPS Focused Condition Assessment by USGS to determine the validity of the data collected from 2010 to 2015.

Similar to surface water, groundwater is replenished by direct infiltration from rainfall but also by delayed infiltration from surface water and the flow of groundwater towards the ocean from higher elevations in the West Takpochau watershed. The latter drainage unit is characterized by roughly 25% impervious surface, and therefore has significant portions of land cover that are unable to achieve full saturation and retention of water. This results in a higher concentration of overland water flow reaching the park during storms and a lower amount of slower, delayed infiltration replenishing groundwater after storm events (Mattos 2013). The higher rate of overland flow caused by impervious surfaces also brings increased sediment and pollutant loading directly through the park and into the lagoon, whereas slower infiltration to the island's basal lens in other watersheds allows for filtration of urban pollutants.

Infiltration rates also partially depend on the configuration of soils within the park, and the associated USDA drainage classifications that accompany the soil types that are present. Data for the CNMI are available via the USDA soil survey database (USDA NRCS 2016). The USDA determines soil type by assessing vegetation, slope, drainage patterns, and bedrock, as well as soil color, texture, size, and shape of soil aggregates. Figures 38 and 39 illustrate USDA soil classifications within American Memorial Park.

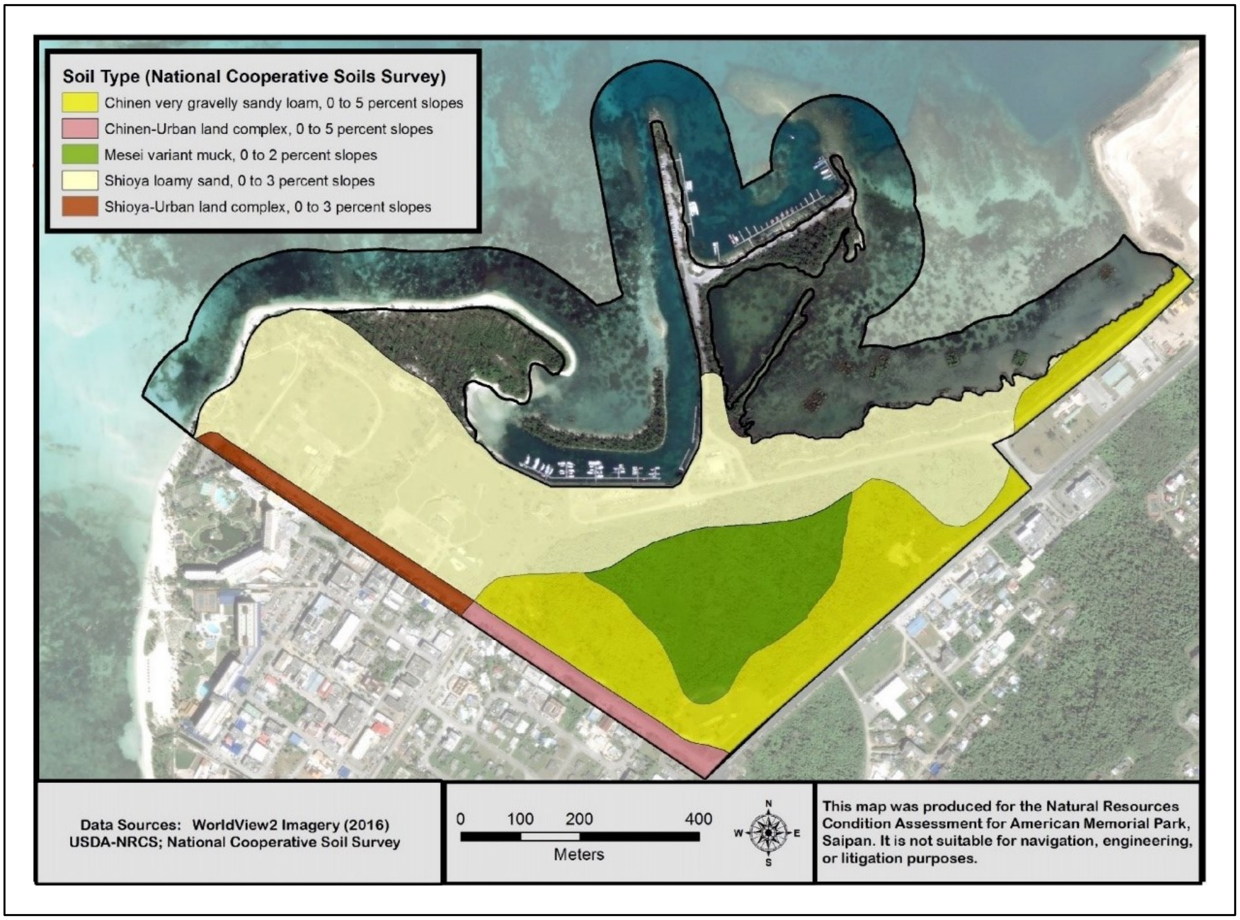


Figure 38. Soil composition in American Memorial Park according to USDA NRCS (2016).

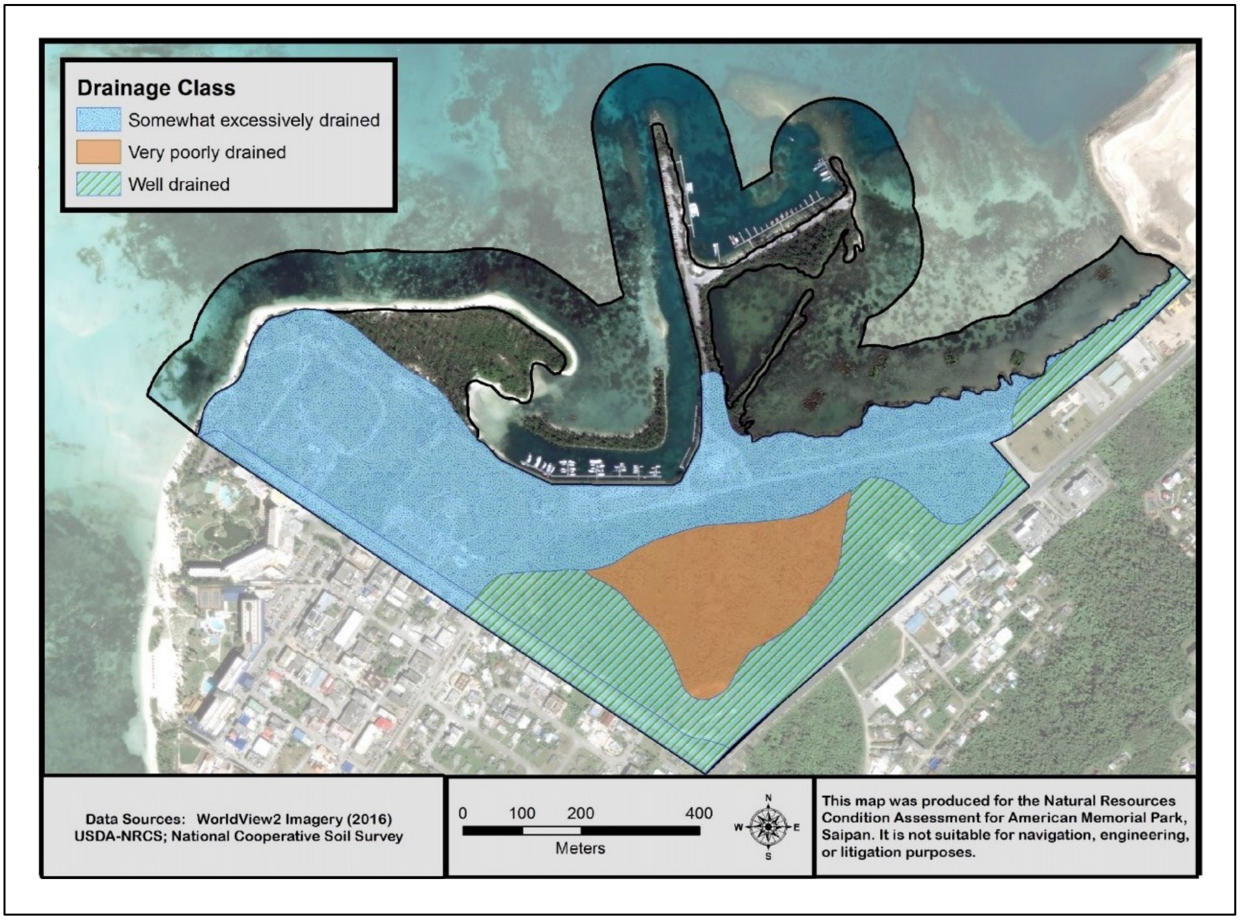


Figure 39. Drainage classification in American Memorial Park according to USDA-NRCS (2016).

With the exception of American Memorial Park's primary natural wetland, most of the Park's soils are well drained or excessively drained, consisting largely of sand and gravel deposits. While the soils data are useful in visualizing one factor that influences the Park's hydrology, that information is not sufficient to fully address both surface and sub-surface hydrologic processes and is therefore not included as a stand-alone measure.

4.5.2. Measures

- Depth and spatial extent of freshwater lens
- Surface water quality and salinity

4.5.3. Reference Conditions/Values

Most hydrologic data were taken from a single source (Perreault 2007) due to the scarcity of literature addressing park hydrology, therefore reference conditions cannot yet be established.

4.5.4. Data and Methods

Perreault (2007) is the primary source for park-specific hydrology. In this report, salinity (through conductivity) was measured for surface water pools and ground water using a hand-held conductivity meter at direct access for surface pools and 13 wells for ground water. Water level was assessed through three different methods: by installing transducers in 3 wells, through synoptic surveys for the other 10 wells, and from readings of the nearby tide gauge which collected tidal data at five-minute intervals.

Additional information was gleaned from a previous USGS report (Carruth 2003), which examined groundwater geology of the entire island of Saipan. The study focused on the occurrence, movement, and availability of groundwater resources for the island. This report was a collaborative effort between the USGS and the CUC. Carruth used existing data from USGS and CUC meters and groundwater pumps to describe Saipan's ground-water withdrawal, chloride concentrations and salinity (also collected by CUC using titration), ground-water flow direction, long-term monitoring of the freshwater lens, elevation of the water table, and thickness and boundary of the freshwater lens. At the time of this report, Saipan had 140 municipal wells and several monitoring wells.

While the Park's soil configuration includes some areas of low permeability fill and fine sediment deposits, supporting wetlands and limited areas of surface water, the broader West Takpochau watershed is characterized by the highly permeable Tapochau Limestone and steep terrain (Figure 40). Areas outside the park boundary, with the exception of urban Garapan, have high infiltration rates, and do not support surface stream flow or springs (Carruth 2003). An exception to this is the adjacent urban area with high percentages of impervious surface, where groundwater recharge is prevented, and surface flow over paved areas and stormwater infrastructure channels runoff toward the park during heavy precipitation events.

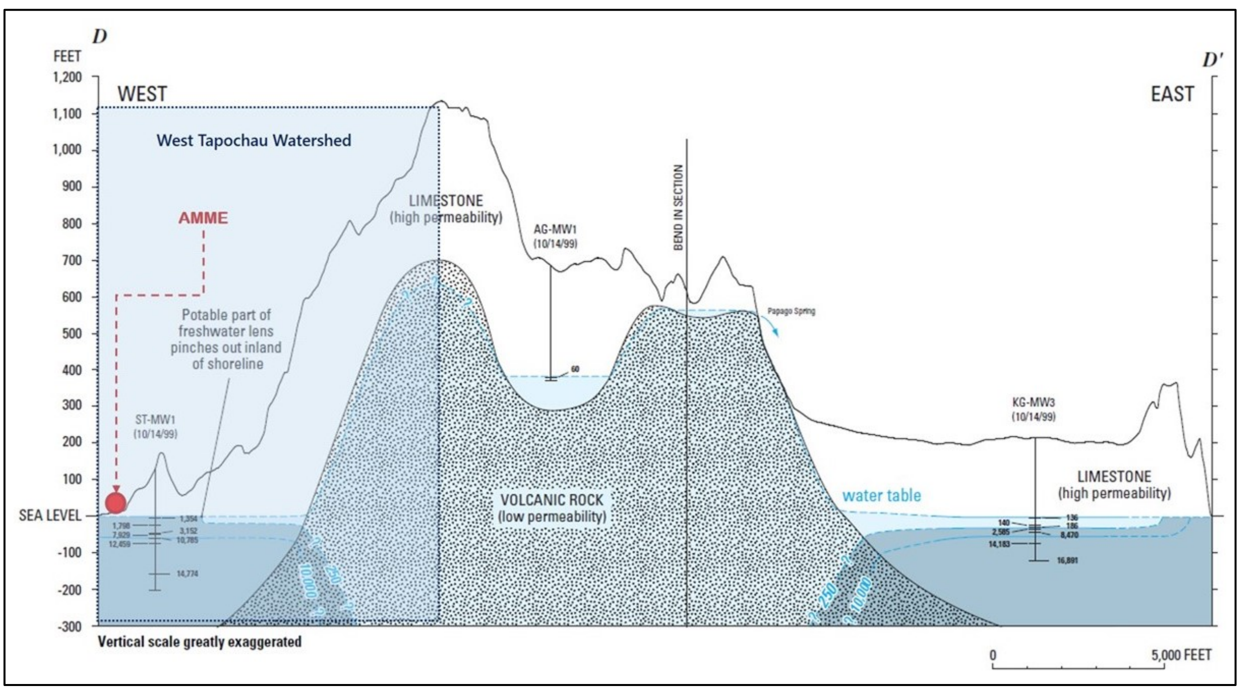


Figure 40. Cross section of hydrogeology along a west-east axis across central Saipan, including American Memorial Park and West Takpochau watershed (figure adopted from Carruth 2003).

The Garapan Conservation Action Plan (CAP) (Mattos 2013) contains an analysis of the threats and issues facing the 17.14 km^2 (6.62 mi^2) West Takpochau watershed including American Memorial Park. Water quality is identified as one of the nine priority conservation targets. This CAP is a product of a four-day workshop and follow-up meetings involving local stakeholders and decision-makers. This report also contains a literature review of relevant material which includes ten reports from 1997 to 2010. Geologic, biologic, cultural, and socioeconomic features of the watershed are described, as are threats and stressors. The CAP brought together the CNMI's resource managers and scientists to compile best available knowledge and research in the area surrounding the Park and therefore includes extensive discussion of many of the issues impacting the Park, particularly its hydrologic resources.

NPS I&M water quality monitoring since 2009 consists of quarterly YSI sonde measurements and surface water collection to measure four core parameters – temperature, conductivity/salinity, pH, and dissolved oxygen. The program also monitors turbidity, total nitrate, total nitrogen, total phosphorous, and chlorophyll.

4.5.5. Condition and Trend

Hydrologic health within American Memorial Park can be measured using two variables: the depth and spatial extent of the freshwater lens, and surface and subsurface water quality and salinity. As surface water quality is addressed in the mangroves and wetlands section (4.1) it is partially omitted here to avoid redundancy. However, wetlands and park hydrology are strongly connected in American Memorial Park, and surface water is an important indicator for hydrologic health. Therefore, surface water will still be included in the resource score for the hydrology metric.

Saipan's freshwater lens is defined by the area of sub-surface freshwater underneath the island, including saturated limestone geology and a mixing zone of varying depth in which the layer of freshwater is situated atop higher density saltwater. The thickness of the freshwater lens depends upon several factors, including rates of groundwater recharge from seasonal rainfall, soil permeability, and pumping rates of the island's wells. The location of the freshwater lens was documented in 2007 as extending beneath the park (Perreault), though exact edges were not determined. Freshwater lens edges can fluctuate over time naturally, extending during periods of heavy rainfall (input) or shrinking during droughts. Thinning of the lens can also occur if nearby wells are over-pumped, while groundwater mounding can result from sub-surface injection wells, such as those used by Garapan's tourist resorts to release brine wastewater. In these mounding scenarios, concentrated input of wastewater or stormwater into the groundwater system at specific points leads to localized increases in the height of the water table. This reduces the area of unsaturated soil in which contaminants would normally be attenuated, thus introducing additional pollutants into the freshwater lens.

The extent of potable water within the coastal aquifer does not reach the park and adjacent shoreline as this area is defined by a mixing zone. Tidal fluctuations conduct seawater through the highly permeable limestone underlying the park, rendering the groundwater non-potable. Fluctuations in salinity of well water along the western coastal plain correspond with sea level variability (Carruth 2003), indicating that American Memorial Park is situated entirely within a mixing zone.

Freshwater lens edges can fluctuate over time naturally, extending during periods of heavy rainfall (input) or shrinking during droughts.

Eight injection wells were implemented in Garapan beginning in the mid-2000s in order to discontinue using the constructed wetland for brine wastewater disposal. Perreault (2007) suggests that this may be causing the mounding of groundwater on the western side of the park. Further investigation is needed to provide confirmation. Perreault (2007) also noted tidal response patterns in these surface pools after heavy rainfall from Super-Typhoon Nabi. The saturated wetland soils dehydrated in direct correlation with the outgoing tide, further confirming a connection between ground and surface water in these areas.

Perreault's reconnaissance study of the park's hydrology did not describe the boundaries of the freshwater lens, and neither previous nor subsequent hydrologic profiles for the park exist, so no reference location for this lens exists.

4.5.6. Condition Summary

Measures for the hydrologic resource are listed here, accompanied by respective scores for significance (1–3) and condition (0–3).

<u>Depth and spatial extent of freshwater lens</u>
The single report addressing the freshwater lens suggests that the lens does extend beneath the park. But lens extent is subject to spatial and temporal variation and further study is needed to determine how much of the park sits on top of the lens and how this changes over time. Thus, a trend could not be established. Significance of this measure was valued at 3 based on the degree to which subsurface hydrology affects surface ecology. Condition level was determined to be a 1 due to ground water mounding caused by the injection wells. Therefore, this measure received a total condition score of 4.

<u>Surface water quality and salinity</u>
Surface water pools directly affect rare and valuable mangrove and wetland habitat. If salinity of the surface pools were to change dramatically the wetland vegetation may not be able to adjust. Therefore, this measure is also given a significance level of 3. Condition level was assessed as a 2. This condition rating is based on observations that adjacent raised surfaces (Chalan Pale Arnold Road) are affecting salinity in the wetland surface pools by preventing overland flow, and the constructed wetland receives very poor quality storm water overflow. The condition score for this measure is a 5.

The hydrologic resource component has a weighted condition score of 4.5, signifying moderate condition and color-coded yellow. A dashed outline is used to indicate a low level of confidence in this assessment due to a lack of data regarding the current or historical extent of the freshwater lens beneath the park and the lack of quantitative water quality data for factors other than salinity (Table 21). Based on the absence of long–term or baseline data we were unable to establish a trend for this resource and therefore no arrow is present.

Table 21. Hydrology weighted condition score.

Measures	Significance Level	Condition Level	Resource Weighted Condition Score
Depth and spatial extent of freshwater lens	3	1	
Surface water quality and salinity	3	2	
Cumulative condition score	**6**	**3**	**9/2 = 4.5**

Chapter 5. Discussion

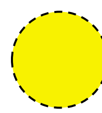
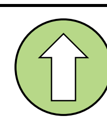
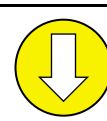
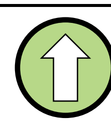
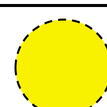
Chapter 5 serves as a concluding section for the NRCA, involving brief summaries of the assessment and an overview of concerns that resource stewards may need to address in the coming years. Specifically, the chapter is broken down into:

- A brief summary of the NRCA resource component ratings for the five ecological and management zones at American Memorial Park,
- A more extended discussion of the threats and stressors that the Park is currently facing or may need to adapt to in the future, and
- A brief synopsis of some outstanding data and research gaps that could be filled to better inform future NRCAs.

5.1. Resource Component Condition Designations and Observations

Table 22 shows each of American Memorial Park's primary natural resource components along with their assigned condition assessments. The purpose of this synoptic table is simply to translate a synthesis of all available reports and literature into indicators of the status (color) and trend (arrows) of each resource component, as well as confidence (line around circle) in those assessments. The availability and quality of data varied per resource, which is reflected in our confidence assessment. Trends were assigned when they could confidently be determined, which was only the case for three of the five resources. The remaining two resources were lacking baseline reference data and the long-term datasets required to assess trends.

Table 22. Summary of American Memorial Park resource component scores.

Resource	Weighted Condition Score	Condition
Mangroves and Wetlands	4.5	
Coastal Scrub and Secondary Forest	1	
Shore and Near-shore	4.3	
Developed Green Space	1.0	
Hydrology	4.5	

Two resources, ‘Coastal Scrub and Secondary Forest’ and ‘Developed Green Space’, were found to be in good condition and improving, with moderate and high confidence in these assessments, respectively. The remaining three resources (‘Mangroves and Wetlands’, ‘Shore and Near-shore’, and ‘Hydrology’) were all found to be in conditions that warrant moderate concern, with only moderate or poor confidence in these assessments.

5.2. Park-wide Threats and Stressors

The threats and stressors currently affecting American Memorial Park are numerous and diverse, though mitigation strategies are currently being implemented to address several of the most pressing concerns. As defined by the National Park Service, stressors are “physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive (or deficient) level. Stressors cause significant changes in the ecological resources, patterns, and processes in natural systems” (NPS 2006).

Described in greater detail throughout this section, the primary threats and stressors that currently affect or have the potential to significantly impact the natural resources of American Memorial Park include:

- invasive species;
- illegal or excessive harvest, hunt, and take;
- coastal erosion;
- climate change and variability;
- pathogens;
- contaminants, sewage, and debris;
- and stochastic events.

Each sub-section describes how each threat or stressor affects the park or, if not yet established as a current stressor, how it may affect the park in the future. Habitat-specific details are included where relevant, and historic, current, and future impacts are elaborated on to the greatest extent possible.

5.2.1. Invasive Species: Plants

Invasive plants within American Memorial Park are characterized by rapid growth, the ability to outcompete native vegetation for sunlight and nutrients, and both intentional and accidental anthropogenic introduction. Ivy gourd (*Coccinea grandis*) is a fast-growing canopy vine that shades out undergrowth and is encroaching on Park wetlands (Cogan et al. 2013). This species was labeled by the CNMI Statewide Assessment and Resource Strategy (SWARS) Council (2010) as the most dangerous invasive species threatening Saipan. As of 2010 this invasive was present among 80% of the island’s plant communities. To address the threat of ivy gourd, a non-native weevil species (*Acythopeus cocciniae*) that kills the plant by boring into stems has been introduced after an environmental assessment was conducted and assured regulators that the weevil would not also become invasive (Raman et al. 2007).

Tangan tangan is an invasive tree that was introduced to Saipan post-World War II to prevent erosion and is another fast-growing colonizer species prevalent in the Park. However, over time native tree species will likely outcompete this introduced tree, partly because tangan tangan does not create a closed canopy (Gourley 2006).

Invasive plant species noted in American Memorial Park are listed in Table 23 by both common name and scientific name. Common names contained in parenthesis are noted only in Sherley (2000) as being island-wide and therefore may not be found in the Park at this time. Sherley describes invasive plants affecting Saipan and divides them into eight dominant, four moderate, and seven potentially invasive species. A “D”, “M”, or “P” for dominant, moderate, or potentially invasive respectively is used to indicate the Sherley rating where applicable.

Table 23. Invasive plant inventory for American Memorial Park. Sources: Sherley (2000) and Gourley (2006).

Species common name	Scientific name	Type of plant
Ivy gourd	*Coccinia grandis*	Vine
Balsam pear	*Momordica balsamina*	Vine
Chain of love	*Antigonon leptotus*	Vine
Love-in-a-mist	*Passiflora foetida*	Vine
Mile-a-minute	*Mikania micrantha*	Vine
Mexican creeper[2]	*Antigonon leptopus*	Vine
Napier grass[1, 3]	*Cenchrus purpureus*	Grass
Guinea grass[1]	*Urochloa maxima*	Grass
Australian beardgrass[1]	*Bothriochloa bladhii*	Grass
Inifuk[1]	*Chrysopogon aciculatus*	Grass
(Mission grass)[3]	*Pennisetum polystachyon*	Grass
(Cotton grass)[5]	*Imperata cylindrica*	Grass
Flame tree, royal poinciana[1]	*Delonix regia*	Tree
African tulip tree[1, 5]	*Spathodea campanulata*	Tree
(Formosan koa)[3]	*Acacia confusa*	Tree
(Indian siris)[3]	*Albizia lebbeck*	Tree
Tangan tangan[3]	*Leucaena leucocephela*	Tree
(Jamaican/Panama cherry)[5]	*Muntinglia calabura*	Tree
Mimosa[2]	*Mimosa diplotricha*	Shrub
Bitterbrush[2]	*Chromolaena odorata*	Shrub

[1] Cogan et al. (2013)

[2] CNMI SWARS Council (2010).

[3] Dominant species

[4] Moderate

[5] Potentially invasive species

Table 23 (continued). Invasive plant inventory for American Memorial Park. Sources: Sherley (2000) and Gourley (2006).

Species common name	Scientific name	Type of plant
(Lantana)[3]	*Lantana camara*	Shrub
Paper rose[2]	*Operculina ventricosa*	Shrub
(Day cestrum, day-blooming jasmine)[4]	*Cestrum diurnum*	Shrub
(Mimosa)[4]	*Mimosa invisa*	Shrub
(N/A)[5]	*Melochia villossissima*	Shrub
(Limeberry, orange berry)[5]	*Triphasia trifolia*	Shrub
Velvet bean, cow itch[2, 3]	*Mucuna prurien*	Legume
(Manila tamarind, monkeypod)[5]	*Pithecellobium dulce*	Legume
Beggar's tick[2]	*Bidens pilosa*	Flowering plant
Mother-in-law's tongue[1]	*Sansevieria trifaciata*	Flowering plant
Indian pluchea[1]	*Pluchea indica*	Flowering plant
Peregrina[1]	*Jatropha integerrima*	Flowering plant
Hyacinth spp.[1]	*Hyacinthus* spp	Flowering plant
(Siam weed, triffid weed)[4]	*Chromolaena odorata*	Herb

[1] Cogan et al. (2013)

[2] CNMI SWARS Council (2010).

[3] Dominant species

[4] Moderate

[5] Potentially invasive species

5.2.2. Invasive Species: Invertebrates

Like plants, invasive invertebrates have colonized Saipan and American Memorial Park through assorted routes including intentional introductions designed to combat other invasive species or serve as a food source, as well as unintentional release through the pet or aquarium trade, agricultural products or equipment, unchecked soil on the bottoms of shoes, or by being attached to imported plants (Table 24). As invertebrate surveys are infrequent, especially those specific to the Park, this list is not comprehensive and invertebrate monitoring is noted later in this report as a data gap.

Table 24. Introduced and invasive invertebrate species on Saipan. Source: Sherley (2000).

Common Name	Species Name	Notes
Weevil sp.[2]	*Acythopeus burkhartorum*	Control of invasive ivy gourd
Western honey bee[1]	*Apis mellifer*	From Hawaii
Carpenter bee[1]	*Xylocopa brasilianorum varipuncta*	From Hawaii
New Guinea flatworm	*Platydemus manokwari*	Control of giant African snail

[1] Source: Tadauchi 1994

[2] Source: Raman et al. 2007

[3] Source: Starmer 2005

Table 24 (continued). Introduced and invasive invertebrate species on Saipan. Source: Sherley (2000).

Common Name	Species Name	Notes
Giant African snail	*Achatina fulica*	–
Cannibal snail	*Euglandina rosea*	–
Snail sp.	*Gonaxis kibweziensis*	–
Snail sp.	*Gonaxis quadrilateralis*	–
Snail sp.	*Subulina octona*	–
Snail sp.	*Paropeas achatinaceum*	–
Snail sp.	*Allopeas gracile*	–
Snail sp.	*Lamellaxis* spp.	–
Snail sp.	*Fossaria viridis*	–
Snail sp.	*Pacificella variabilis*	–
Snail sp.	*Gastrocopta servilis*	–
Snail sp.	*Gastrocopta* spp.	–
Snail sp.	*Nesopupa*	–
Snail sp.	*Gulella bicolor*	–
Snail sp.	*Bradybgenidae*	–
Commercial topshell[3]	*Tectus niloticus*	1938 for commercial harvest
Giant clam[3]	*Tridacna derasa*	1988 for commercial exploration

[1] Source: Tadauchi 1994

[2] Source: Raman et al. 2007

[3] Source: Starmer 2005

Additionally, population declines of local snails have significant ties to the intentional introduction of carnivorous land snails, especially the cannibal snail (*Euglandia rosea*) which was introduced to combat the invasive giant African snail (*Achatina fulica*) (Sherley 2000). Surveys in 1992 listed eight total bee species on Saipan, six of which were endemic and two of which were introduced, though this survey was island-wide and not specific to American Memorial Park (Tadauchi 1994).

There are also numerous invasive species that are not yet established on Saipan but have recently colonized the nearby island of Guam. Due to the close proximity of Guam and frequent air and boat transportation between the two islands, these species pose an imminent threat to Saipan and AMP. These species include the coconut rhinoceros beetle (*Oryctes rhinoceros*), little fire ant (*Wasmannia auropuntata*), nettle caterpillar (*Darna pallivitta*), red imported fire ant (*Solenopsis invicta*), erythrina gall wasp (*Quadrastichus erythrinae*), Asian cycad scale (*Aulacaspis yasumatsui*), and the Cuban slug (*Veronicella cubensis*) (CNMI SWARS Council 2010).

5.2.3. Invasive Species: Vertebrates

Invasive vertebrate species within the park are relatively numerous given the low number of competing indigenous vertebrates on Saipan. These species include birds, small mammals, reptiles, and fish (Gourley 2006, Mattos 2013, and Rauzon 2010). Common and scientific species names are listed in Table 25, as are dates of first documentation of the species on island where available.

Table 25. Invasive vertebrates documented on Saipan. Source: Sherley 2000.

Common Name	Scientific Name	Date first documented, if available
Eurasian tree sparrow	*Passer montanus*	–
Philippine turtle dove	*Streptopelia bitorquata*	–
Chestnut-breasted mannikan	*Lonchura malacca*[1]	–
Orange-cheeked waxbill	*Estrilda melpoda*[3]	2007–2009
Feral dog	*Canis familiaris*	likely mid-1700s, as on Tinian
Feral cat	*Felis silvestris*	likely 1700s
Pacific or Polynesian rat	*Rattus exulans*	likely 1500 BC
Norway rat	*Rattus norvegicus*	Late 1800s
Ship or black rat	*Rattus rattus*	Pre-1931
House mouse	*Mus musculus*	Pre-1931
Musk or house shrew	*Suncus murinus*	1962
Asian rat	*Rattus tanezumi*	at least 1995
Cane toad	*Bufo marinus*	1962
Indian monitor lizard	*Varanus indicus*	Post-WWII to control rat populations
Brown tree snake	*Boiga irregularis*	not established, noted as early as 1993
Green tree skink	*Lamprolepis smaragdina*[1]	–
Sailfin molly	*Poecilia latipinna*[2]	–
Mozambique tilapia	*Sarotherodon mossambicus*	1955
Mosquitofish	*Gambusia affinis*	at least 1981
Walking catfish	*Clarias batrachus*[1]	–
Red tilapia[4]	*Oreochromis mossambica*	1955–57 for aquaculture

[1] Source: NPS species checklist

[2] Source: Mattos 2013

[3] Source: Rauzon (2010)

[4] Source: Starmer 2005.

Many of these invasive vertebrates pose a threat to the native ecosystem. The monitor lizard may predate on native ground-nesting bird species, which historically have not had predators on Saipan. The brown tree snake is not yet established on Saipan but has devastated native bird species populations on nearby Guam. Extensive efforts are underway on Saipan to monitor and mitigate this threat. Ninety-five reported sightings and 11 captures of the snake have been recorded on Saipan since 1982 (Snyder 2006). The most likely locations from which the brown tree snake will enter the island are the international airport and the shipping port, which is adjacent to American Memorial Park. Strict monitoring protocols are followed at potential entry points including trained canine searches, live prey and pheromone traps, and rigorous, multi-week inspections by trained personnel when a snake sighting is reported.

Skink and shrew populations within the park are also being monitored because a sudden population decline could be an indicator of brown tree snake establishment (Rauzon 2010). Feral cats are also a danger to native bird species as noted by the Marianas Avian Conservation Plan (MAC Working Group 2013) which highlights cats' role in impairing endangered Mariana crow and Guam rail populations. Feral cats are a similar threat to endangered avian populations within the Park such as the Mariana moorhen, white-throated ground dove (*Gallicolumba xanthonura*), and nightingale reed warbler.

Invasive vertebrates affecting the Park are also found in the water. The NPS species checklist and Mattos (2013) discuss the threat of invasive freshwater fish, noting that additional species not already in the park have been found in storm-water drainages in nearby Garapan. Snyder (2006) reports the presence of mosquitofish and tilapia in American Memorial Park as well as invasive aquatic vascular plants and algae in the near-shore areas. Red tilapia was introduced originally into the brackish lakes of Saipan and other islands in the CNMI as a food source and now the fish is being cultivated at NMC's aquaculture center, which provides fish to private ponds. One such pond includes open-system pools next to the Saipan Lagoon, in fully marine water. This location is precarious in that escape into the lagoon is likely (Starmer 2005). The CNMI SWARS Council (2010) describes a potential emerging invasive species of concern, the coqui frog (*Eleutherodactylus coqui*).

5.2.4. Hunt, Harvest, and Take

The American Memorial Park Compendium details the amount of natural resources that may be taken by visitors as well as the circumstances under which they can be taken. Coconuts, lada (noni), papaya, soursop, and Pacific almonds may be taken at an unlimited rate so long as they are found on the ground after having fallen naturally and are not used commercially (NPS 2014). Park staff have noted the continued illegal take of lada (noni) and bananas directly from trees. The collection of shells from the shoreline is limited to ten specimens per person, per day and must be unoccupied. The wetland, however, is an absolute no-take zone.

Near-shore areas outside the Park are frequently used for rod and reel and spearfishing. Because this area is outside of park boundaries, park regulations cannot control species, size, or amount taken. The Compendium does stipulate that the most direct route through the park must be taken to transport legally caught fish and wildlife from these near-shore areas (NPS 2014). Potentially linked to the harvest of resource competitors, sea cucumber populations were increasing near American Memorial Park in the early 1990s, which may have been connected with a reduction in the amount of seagrass present and subsequently contributed to erosion on park shores (Dean 1991). Relative abundance of sea cucumbers and seagrass has not been determined in the last decade. Illegal take of fauna within the park's terrestrial area is also an issue: recent green sea turtle nesting activity was recorded within park boundaries in 2015, and this particular turtle was poached mid-nest (DLNR unpublished data).

5.2.5. Coastal Erosion

In Section 4.3 the shoreline and near-shore zone of American Memorial Park was assigned a rating of high concern. This assessment was based largely on documentation of troublesome erosive processes, loss of shoreline infrastructure, and overall instability of some park beaches. Existing research and projects analyzing these issues were summarized and utilized as reference points (Dean

1991, USACE 2004, Yuknavage and Palmer 2010, Greene and Skeele 2014), but estimates of future shoreline conditions were largely outside the scope of discussion. The future configuration and stability of the Park's shoreline is, however, one of the most significant topics for park management to consider, particularly given the current trajectory of global climate phenomena. Uncertainty in the degree to which the erosion and accretion patterns at American Memorial Park are cyclical complicates the issue. Recent rapid migration of unconsolidated sediment along sections of Park shoreline that were experiencing drastic rates of erosion up until 2016 now raise questions as to the appropriate temporal period in which to assess shoreline threats (Figures 41 and 42).

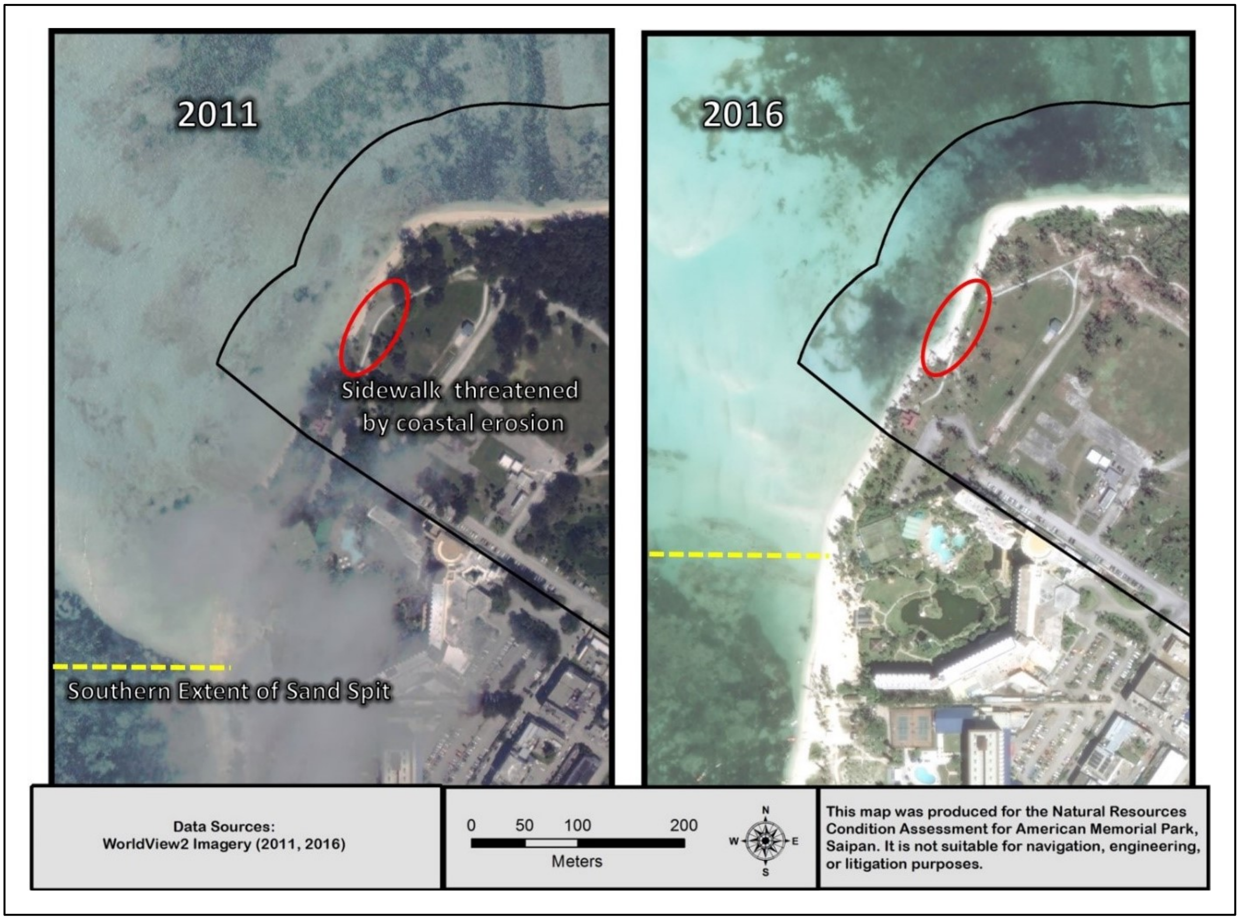


Figure 41. Satellite imagery comparison of American Memorial Park shorelines from 2011 and 2016.

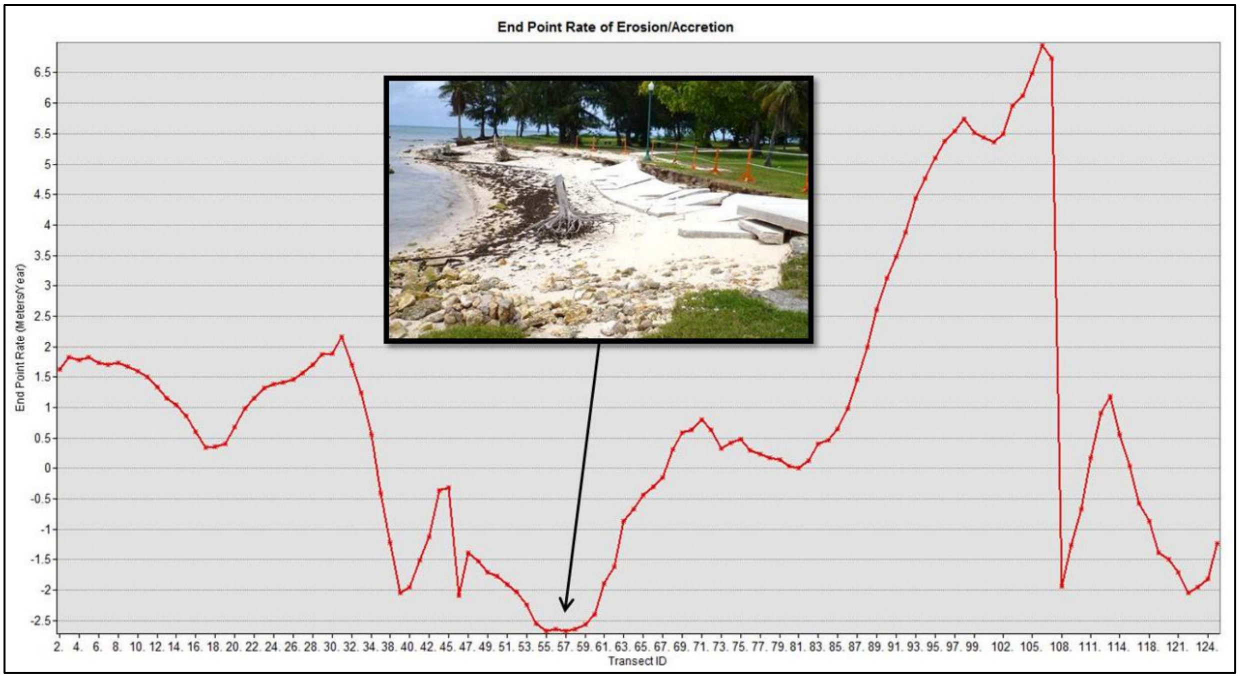


Figure 42. Results of digital shoreline change analysis, 2003–2011 (Adapted from Greene and Skeele 2014).

The threats to park facilities mentioned in the rating of the shoreline resource (Section 4.3) are expected to increase with rising sea levels (Greene and Skeele 2014), as well as possible growth in tropical cyclone intensity (BECQ-DCRM 2015). While these stressors are elaborated on in Section 5.2.6, they are conceptualized here as coefficients, increasing the magnitude of existing shoreline impacts that have already been discussed.

Previous reports indicate that the western side of the park faces the greatest risks with regard to erosion as it is the most exposed to westerly wave energy and longshore currents, and that decline of wave-attenuating seagrass beds has enabled greater wave action along the beaches. Given projected rates of sea level rise (NOAA 2017), it is likely that fringing reefs will have greater depth in the future, which could lead to increases in the amount of wave energy passing over the lagoon's protective reef and subsequently interacting with unstable beaches.

Optimal atmospheric and oceanic conditions for these erosive westerly surges tend to coincide with the presence of intense low pressure and cyclonic circulation to the north and northwest of Saipan. The southern periphery of these systems drives swell directly toward American Memorial Park. During strong El Niño events, the area of genesis for tropical cyclones in the Western Pacific Basin shifts north by several degrees of latitude (Lander 2004), increasing the chances of cyclone passages to the north of the island. Great uncertainty still exists regarding future ENSO behavior and trajectories of tropical cyclones, but any trend that mimics El Niño conditions would likely increase the frequency of coastal erosion.

In addition, the undercutting of infrastructure and strand vegetation that was previously exacerbated during higher tides (Figure 43) may become a more frequent phenomenon, demanding the timely development of adaptive management approaches.

Figure 43. A high tide submerges the root systems of ironwood trees at American Memorial Park (Photo by R. Greene 2013).

The sea wall protecting Smiling Cove Marina was also noted for the damaging erosive forces it faces. If the sea wall and Outer Cove causeway are not modified to accommodate increasing stress or rising sea levels, wave and wind action will continue to adversely affect the integrity of the causeway, and possibly limit recreational and commercial access to the marina (NPS 2008).

While little can be done to limit the coastal exposure of marina infrastructure, measures can be taken to reduce its sensitivity to continued threats of erosion. This concept applies to the Park's unconsolidated and soft shorelines as well, where implementation of living shoreline principles and soft stabilization solutions may be necessary to combat growing threats.

5.2.6. Climate Change and Variability

While regional climate variability and periodic disturbances complicate efforts to predict and plan for future climate scenarios in the Marianas, American Memorial Park is expected to experience effects of a changing climate that depart significantly from the conditions that originally shaped the park's natural systems.

The following summary of projected climate conditions for the Park is adapted from multiple studies of down-scaled climate change effects in Micronesia, including output from the *Pacific Climate Futures 2.0* tool, which was used by CNMI-BECQ in 2015 to assess climate vulnerabilities for the southern Marianas (BECQ-DCRM 2015). The tool generates downscaled (sub-regional) projections for western Micronesia based on the Australian Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Representative Climate Futures Framework (Whetton et al. 2012). Projections are derived primarily from the global climate modelling experiments that informed the Intergovernmental Panel on Climate Change's Fifth Assessment Report (IPCC 2014) and assume a "worst-case" emissions scenario (Representative Concentration Pathway 8.5 from IPCC 2014). More information concerning the model output summarized in the following figures, and consensus among those models, is available at http://www.pacificclimatefutures.net/en/.

Temperature (Annual Surface Temp. and Annual Max Daily Temp.):
Under the IPCC's worst case emissions scenario (RCP 8.5), future air temperatures in 2065 and 2090 (50 and 75 year projections at the time of Climate Futures Tool usage) may reflect the changes summarized in Tables 26 and 27.

Table 26. 50-year projections of annual and maximum daily temperatures.

Scenario 2065	Model(s)	Consensus	Surface Temp. (Annual Mean)	Max Daily Temp. (Annual Mean)
Best Case (smaller increases)	CMIP5 - GISS-E2-R-CC	Moderate	+1.58°C	+1.57°C
Worst Case (largest increases)	CMIP5 - GFDL-CM3	Moderate	+2.97°C	+2.96°C
Maximum Consensus among models	CMIP5 - CESM1-CAM5	Moderate	+2.22°C	+2.24°C

Table 27. 75-year projections of annual and maximum daily temperatures.

Scenario 2090	Model	Consensus	Surface Temp. (Annual Mean)	Max Daily Temp. (Annual Mean)
Best Case (smaller increases)	CMIP5 - GISS-E2-R-CC	Low	2.23°C	2.22°C
Worst Case (largest increases)	CMIP5 - GFDL-CM3	Low	4.3°C	4.29°C
Maximum Consensus	CMIP5 - GFDL-ESM2M	Low	3.07°C	3.08°C

Visitors to American Memorial Park can expect increases in both annual surface and maximum daily temperatures in the future, with increases over 2°C likely posing a public health concern especially when combined with seasonal extremes. Increasing temperatures will also have consequences on evapotranspiration rates throughout Saipan and in turn the park's hydrologic cycle. Specific impacts to the latter system have not been determined.

Precipitation (Annual Rainfall):

Under the IPCC's worst case emissions scenario (RCP 8.5), annual precipitation values in 2065 and 2090 (50 and 75 year projections at the time of Climate Futures Tool usage) could reflect the changes summarized in the following tables. It should be noted that there is great uncertainty in the trajectory of precipitation change in the Marianas, especially due to the overwhelming influence that stochastic events such as tropical cyclones can have on rainfall in any given year. This uncertainty is reflected in the projections highlighted in Tables 28 and 29.

Table 28. 50-year projections of annual rainfall change in western Micronesia.

Scenario 2065	Representative Model(s)	Consensus	Annual Rainfall Change
Increased	CMIP5 - ACCESS1-3	Very Low	+22.9%
Decreased	CMIP5 - MIROC5	Very Low	-8.7%
Maximum Consensus	CMIP5 - MPI-ESM-MR	Moderate	+9.9%

Table 29. 75-year projections of annual rainfall change in western Micronesia.

Scenario 2090	Representative Model(s)	Consensus	Annual Rainfall Change
Increased	CMIP5 - ACCESS1-3	Low	+31.9%
Decreased	CMIP5 - MIROC5	Very Low	-13.2%
Maximum Consensus	CMIP5 - MPI-ESM-MR	Low	+9.6%

Though there is low confidence among all models for precipitation scenarios in the Marianas, greatest model agreement involves an increase of almost 10% in annual rainfall. It should be noted that these scenarios were developed for the entire western Micronesia sub-region, and confidence in projections is lowest in the center of this region near the Marianas (Keener et al. 2012; Lander 2004). Therefore, the threats posed by decreasing precipitation trends documented in the Marshall Islands (i.e. threat of drought) and increasing precipitation trends noted in Palau are not necessarily applicable to Saipan or American Memorial Park. Regardless, any increase in precipitation could have implications for the Park if the rainfall were to occur in the form of periodic extreme events as opposed to an even annual distribution. Stormwater runoff, which already impacts water quality in the Park and among its nearshore waters, may be compounded by both future rainfall scenarios as well as ongoing land cover change adjacent to the park. While impervious surface within American Memorial Park has decreased over the last several decades, the urban core surrounding much of the park has expanded since 1945 (Figure 44), with growth spurts in the 1990s and at present. Stormwater volumes will likely pose a threat without proper mitigation or adaptation measures implemented both within the park and throughout the surrounding watershed.

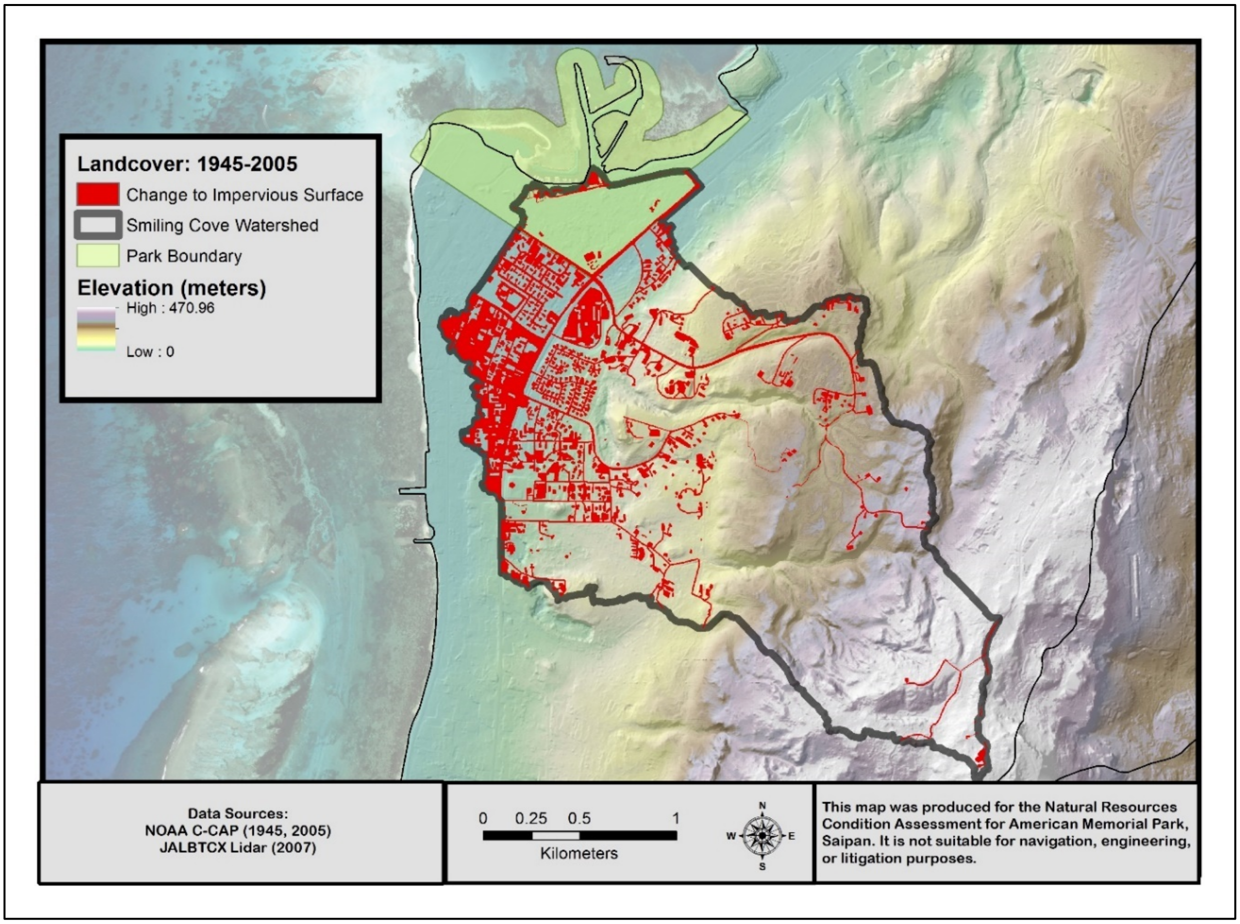


Figure 44. Map of impervious surface growth from 1945–2005 in the American Memorial Park watershed (NOAA 1945, 2005; Lidar 2007).

Sea Surface Temperatures and Threats to Near-Shore Zone:

Sea surface temperatures in the Western North Pacific exhibit significant inter-annual and decadal flux, particularly in response to El Niño events, but there has been a dominant warming trend since the mid-20th century. Global ocean temperatures from the surface to a depth of over 183 m (600 ft) have increased by over 1°C (Leong et al. 2014), but periods of elevated sea temperatures create short term thermal stress that is far more drastic than gradual long-term rise. Thermal stress events are expected to increase in frequency and severity for the foreseeable future, creating adverse conditions for recovery of any coral reefs that have bleached or been otherwise damaged. Under the worst-case emissions scenario (RCP 8.5), coral reefs in Micronesia are predicted to experience annual bleaching events beginning sometime between 2030 and 2040 (van Hooidonk et al. 2013). Given that bleaching events have impacted the reefs in the Marianas in four of the last five years, this estimate may be conservative. Coral reef mortality translates into lower capacities for vertical reef accretion, ultimately reducing the ability of Saipan's fringing reefs to keep pace with sea level rise.

Sea Level Rise and Variability:

Perhaps the greatest threat to American Memorial Park with respect to sea levels is the combination of long-term sea level rise and short-term extremes created by natural variability and storm events.

Eventually long-term sea level rise is likely to exceed critical elevations in low-lying areas. This surpassing of low-elevation thresholds is of particular importance in the Park, where significant portions of the Park's recreational spaces and cultural features are situated in the lowest elevations. The sea level curves illustrated in Section 2.2.4 of the NRCA were adjusted to fit local sea level trends based on Guam's tidal record and vertical land movement (see Figure 27 and Table 5). The highest sea level rise curves demonstrate exceedance of critical low-elevation thresholds of 0.5 and 1.0 m (1.64 and 3.28 ft) by 2040 and 2055, respectively (NOAA 2017).

In addition to permanent inundation of the lowest lying features of the park, these future sea levels combined with possible climate-related changes in storm patterns could result in frequent flooding scenarios throughout the islands. Additional documented and projected sea level extremes for the CNMI and American Memorial Park are highlighted in Table 30.

If sea turtles continue to nest on park beaches, sea level rise could permanently inundate nesting sites. Sea turtle nests are also sensitive to temperature: gender is determined in the nest by temperature, so higher temperatures projected in future climate scenarios could potentially lead to skewed gender ratio.

Additionally, regional climate phenomena such as ENSO and the Walker Circulation have the potential to change as well, though the nature and extent of this shift are uncertain. Regardless, a change in dominant regional atmospheric drivers of weather patterns in Micronesia would alter the frequency of large-scale disturbances and extremes (Greene and Skeele 2014). Such changes to seasonal extremes or disturbances can be far more disruptive than gradual transitions in climate. The latter may be far easier to adapt to but will undoubtedly be punctuated by the threats of extreme events.

Beyond the Park's boundaries changes in ocean currents may also occur, which would likely have severe consequences for nutrient upwelling, larval transport, fish stocks, species migration, and phenology of oceanic species on a global scale (Bakun et al. 2015). Change at this scale translates into more concentrated threats at a local scale where natural features such as the Saipan Lagoon will face direct impacts to ecosystem function.

Table 30. Sea level extremes for the CNMI and American Memorial Park (short term variability and long term change).

Scenario	Height (ft)	Height (m)	Cause	Source(s)	Notes
USACE Curve Low	-0.41	-0.12497	Climate Change SLC - 100 years	USACE Circular No. 1165-2-212 - https://www.dropbox.com/s/1l4zse4zdn6jlwj/USACE_SLR_policy_2011-2013.pdf and USACE Curve Generator - http://corpsclimate.us/ccaceslcurves.cfm	Low Curve - Historic, eustatic rate of SLC (1.7mm/yr.)
USACE Curve Intermediate	0.83	0.25298	Climate Change SLC - 100 years	USACE Circular No. 1165-2-212 - https://www.dropbox.com/s/1l4zse4zdn6jlwj/USACE_SLR_policy_2011-2013.pdf and USACE Curve Generator - http://corpsclimate.us/ccaceslcurves.cfm	Intermediate Curve - NRC Curve 1, with projections from IPCC and modified NRC projections. Local vertical land movement considered (Guam 2.75 mm/yr. uplift).
USACE Curve High	4.76	1.45085	Climate Change SLC - 100 years	USACE Circular No. 1165-2-212 - https://www.dropbox.com/s/1l4zse4zdn6jlwj/USACE_SLR_policy_2011-2013.pdf and USACE Curve Generator - http://corpsclimate.us/ccaceslcurves.cfm	High Curve - NRC Curve 3, with projections from IPCC and modified NRC projections. Local vertical land movement considered (Guam 2.75 mm/yr. uplift).
NOAA CO-OPS Linear	2.77	0.84430	Climate Change SLC - 100 years	NOAA CO-OPS http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=1630000	Linear trend for Guam, accounting for geologic movement. 1993–2006
NOAA-NWS Typhoon Pongsona Saipan	5.00	1.52400	Typhoon Pongsona	NOAA/NWS Assessment of Typhoon Pongsona (Guard, Chip) - https://www.dropbox.com/s/vqmjfvynacq0sdw/Pongsona_assessment_Final.pdf	Storm surge was not measured on Saipan or Tinian. However, based on lack of reports, inundation height estimated to 10 ft. or less on south and east coasts (possibly less on west side due to lack of exposure)
NOAA-NWS Typhoon Pongsona Rota	22.00	6.70560	Typhoon Pongsona	NOAA/NWS Assessment of Typhoon Pongsona (Guard, Chip) - https://www.dropbox.com/s/vqmjfvynacq0sdw/Pongsona_assessment_Final.pdf	Surge measured on Rota (extreme scenario) A significant storm surge occurred on the southwest coast at Songsong Village.
NOAA-NWS Typhoon Pongsona Guam	13.00	3.96240	Typhoon Pongsona	NOAA/NWS Assessment of Typhoon Pongsona (Guard, Chip) - https://www.dropbox.com/s/vqmjfvynacq0sdw/Pongsona_assessment_Final.pdf	Height of surge and wave run-up on western side of Guam (parts are comparable to western side of Saipan)

Table 30 (continued). Sea level extremes for the CNMI and American Memorial Park (short term variability and long term change).

Scenario	Height (ft)	Height (m)	Cause	Source(s)	Notes
USACE Typhoon Kim Guam-Saipan	10.00	3.04800	Super Typhoon Kim	USACE Saipan Lagoon Erosion Study 2004 - https://www.dropbox.com/s/p6pxzn2s4bobd0d/USACE%20Saipan%20Lagoon%20Erosion%20Study%20-%202004.pdf	Inundation levels were measured on Guam following 2002 Pongsona. Inundation on the west coast of Guam in Tumon Bay and Agana Bay ranged from 8–11 feet. Tumon and Agana have similar exposures and reef environments to west Saipan, and these levels are consistent with reports of road inundation on Saipan during Kim.
USACE 10 yr. Storm	4.90	1.49352	10 year Storm	USACE Saipan Lagoon Erosion Study - https://www.dropbox.com/s/p6pxzn2s4bobd0d/USACE%20Saipan%20Lagoon%20Erosion%20Study%20-%202004.pdf	Expected still water rise (bathtub; no wave run-up) on west coast of Saipan (San Jose to Garapan). Based on 1989 USACE study (Chou).
USACE 50 yr. Storm	6.90	2.10312	50 year Storm	USACE Saipan Lagoon Erosion Study - https://www.dropbox.com/s/p6pxzn2s4bobd0d/USACE%20Saipan%20Lagoon%20Erosion%20Study%20-%202004.pdf	Expected still water rise (bathtub; no wave run-up) on west coast of Saipan (San Jose to Garapan). Based on 1989 USACE study (Chou).
USACE 100 yr. Storm	7.70	2.34696	100 year Storm	USACE Saipan Lagoon Erosion Study - https://www.dropbox.com/s/p6pxzn2s4bobd0d/USACE%20Saipan%20Lagoon%20Erosion%20Study%20-%202004.pdf	Expected still water rise (bathtub; no wave run-up) on west coast of Saipan (San Jose to Garapan). Based on 1989 USACE study (Chou).

5.2.7. Pathogens
Introduced pathogens are a significant threat to American Memorial Park wildlife and an outbreak would likely have severe consequences. The mangrove wetlands found in the Park are favorable breeding grounds for mosquitoes which serve as disease vectors for many pathogens that affect birds and mammals such as Zika, malaria, pox, and West Nile virus. With the high number of international visitors Saipan receives, the introduction of novel pathogens remains a concern.

Little is known about endemic avian pathogens on Saipan, but those of concern include avian pox, aspergillosis, atoxoplasmosis, avian tuberculosis, malaria, and West Nile virus, most of which are spread by mosquitoes and all of which are deadly (MAC Working Group 2013). In his survey of park avifauna, Rauzon (2010) includes photos of birds found in American Memorial Park showing the wart-like growth symptoms of avian pox. Pox occurs frequently and naturally in avian populations and is largely left untreated when found in wild birds, but for endangered species with small populations focused in preserved areas a usually benign disease like pox could prove detrimental.

Other avian diseases have fortunately not yet been noted in the park. Though the effects of Zika virus on wildlife are largely unknown, the threat of virus establishment on Saipan is real: in August 2016 the CNMI Bureau of Environmental Health (BEH) received $400,000 in federal funding from the Center for Disease Control (CDC) to monitor and assess the impact of the mosquito-borne virus locally (CDC 2016).

Large storm events also pose pathogenic risks because they can cause the release of sewage and waste into open areas, potentially leading to contamination of ground and surface water. The additional standing water can provide more breeding ground for disease-carrying mosquitoes and the contamination can affect both wildlife and humans. Unconfirmed cases of E. coli have been noted in sewage trenches around the park and the surrounding urban area of Garapan has received attention for its need for storm water and sewer infrastructure upgrades (Greene and Skeele 2014). Additionally, invasive rats on Saipan have been documented carrying leptospirosis (Weil's disease), the disease that bacteria in the genus *Leptospira* cause. It is possible that rats within the park may be carrying the same bacteria (Maraya 2000). The CNMI SWARS Council (2010) also notes two emerging invasive pathogens of concern that threaten terrestrial vegetation: eucalyptus rust (*Puccinia psidiii*) and root rot fungus (*Phellinus noxious*).

5.2.8. Contaminants, Sewage, and Debris
American Memorial Park is located in close proximity to the urban center of Garapan, the recently closed Puerto Rico dump, Saipan's only marina, and the industrial port. It is also located in the West Takpochau watershed which contains the highest amount of impervious surface on the island. These factors lead to a high risk of contamination from pollutants and sewage as well as litter and other types of debris.

Large amounts of aerobic bacteria in lagoon waters outside the park are likely a partial product of runoff carrying wastewater from outhouses and piggeries upstream from the park (Bearden et al. 2014). BECQ-DEQ has been monitoring shoreline sites within the Park since 1993 for enterococci, a fecal indicator bacteria. When enterococci levels exceed local water quality standards, the BECQ water quality team issues a red flag warning swimmers and fishermen to stay away from the area. Numerous red flag events have occurred since monitoring began in 2004, particularly after storm events. As a result of this monitoring, the 2014 Water Quality Assessment Report has the coastal waters of the Central West Takpochau watershed, which covers Micro Beach, American Memorial Park, and the Garapan tourist district, rated as a CALM Category 5, the most impaired rating, meaning that the "waters are impaired or threatened for one or more designated uses by a pollutant(s)" (Bearden et al. 2014).

Denton et al. (2014) found that trace metals in lagoon sediments were highest at storm drain outlets. Due to the high amount of paved, impervious surface surrounding the park, the volume of water passing through the park during rainstorms is especially high. Much of this stormwater settles into the wetlands and saturates park soils. The West Takpochau watershed surrounding the Park contains five sewage treatment facilities (Mattos 2013). Greene and Skeele (2014) identify these facilities as well as gas stations, septic tanks, industrial waste, and agriculture/livestock as the highest sources of storm-water runoff contamination for American Memorial Park.

Snyder (2006) describes illegal dumping of waste and oil directly onto park lands which continues despite federal and local regulations banning the practice. Smiling Cove Marina also likely produces a significant amount of pollutants from fuel, oil, anti-fouling paint, and other boat-related chemicals that are released directly into the lagoon and likely have heavy impacts on life in and adjacent to the marina. Specific examinations of the effects of these chemicals on the Park's shoreline or wetlands have not yet been carried out.

Directly adjacent to American Memorial Park is the Puerto Rico dump site, which opened as one of the island's primary landfills after World War II for the disposal of metals and unexploded ordnances. Post-war, the dump continued to serve as the island's main waste-disposal site until it was closed in 2003. The 8-hectare dump site was labeled Saipan's most pressing environmental problem due to the poor design/regulation, the potential disposal of toxic substances that occurred there, and the leaching of dump material into nearby areas including Saipan Lagoon and the wetlands of American Memorial Park (Denton et al. 2001). Dominant flow patterns in Saipan Lagoon suggest that leached toxins and other plumes of pollutants originating from the Puerto Rico dump site will spread toward the Park (Damlamian and Krüger 2010), though leaching may be partially mitigated by recent remediation efforts that have capped the site.

Years after the dump's closure, Denton et al. (2009) sampled for trace metals in nearby coastal waters and noted that "aqueous contaminants impacting this site are principally derived from the dump itself (in leaching streams), the Port, and road surface water drainage," referring to a site just north of American Memorial Park. Trace metals and toxins result in harm to local marine life, which can harm near-shore marine and mangrove animals as well as cause harm to consumers of these fish and crustaceans.

5.2.9. Stochastic Events

A variety of stochastic events potentially threaten the park, including earthquakes, tsunamis, typhoons, volcanic eruptions, wildfire, and the grounding of ships on nearby reefs. Saipan's Standard

State Mitigation Plan (EMO 2010) addresses natural disasters and notes that little can be done to avoid stochastic events, but mitigation measures can decrease the negative effects these events have. This hazard mitigation plan provides extensive details on the history of these events on Saipan, the different types of damage they have and can cause, and the probability of each event occurring. The plan also describes what, if any, warning systems are in place for each event.

Earthquakes

Mueller et al. (2012) details the seismic history of the Mariana archipelago. Saipan has dozens of faults, one of which, the Matansa Fault, borders the park (Figure 25; Perreault 2007). The U.S. Geological Survey has catalogued 860 earthquakes with magnitude 4.5 or greater within a 175-km radius of Saipan (USGS 2017) since 1936. The earthquake epicenters shown in Figure 45 date back to 1936 and are current through December 2017. Many additional minor earthquakes have occurred in this area, though the USGS notes that records of earthquakes with a magnitude of less than 4.5 may be incomplete. The various sources contributing to the catalog at earthquake.usgs.gov may not always capture or contribute data in some remote areas (USGS 2017).

The high earthquake activity of the island as well as the fault's presence so close to the Park poses a potential risk for the damage or destruction of park facilities. Natural areas are not highly likely to face severe or direct harm from earthquakes except in the case of liquefaction. Liquefaction is a side-effect of earthquakes that occurs when vigorous shaking causes soils that are saturated with water to act as liquids, consequently destabilizing all resources within or on top of that soil. Due to the saturated nature of the wetlands within American Memorial Park, this ecologically important area may suffer heavy disturbance in the event of a large earthquake.

To mitigate earthquake risk through monitoring and data-gathering, seismographs were installed for Saipan and four other islands in the CNMI (EMO 2010). Beyond ongoing data collection and general geological inventory, not much is known about the potential risk of liquefaction on Saipan or near the Matansa Fault. The Standard State Mitigation Plan (EMO 2010) recommends mapping fault characteristics to learn which are the most active and dangerous, identifying land units that are at high risk of liquefaction, and installing strong-motion instruments that can support the development of seismic hazard models.

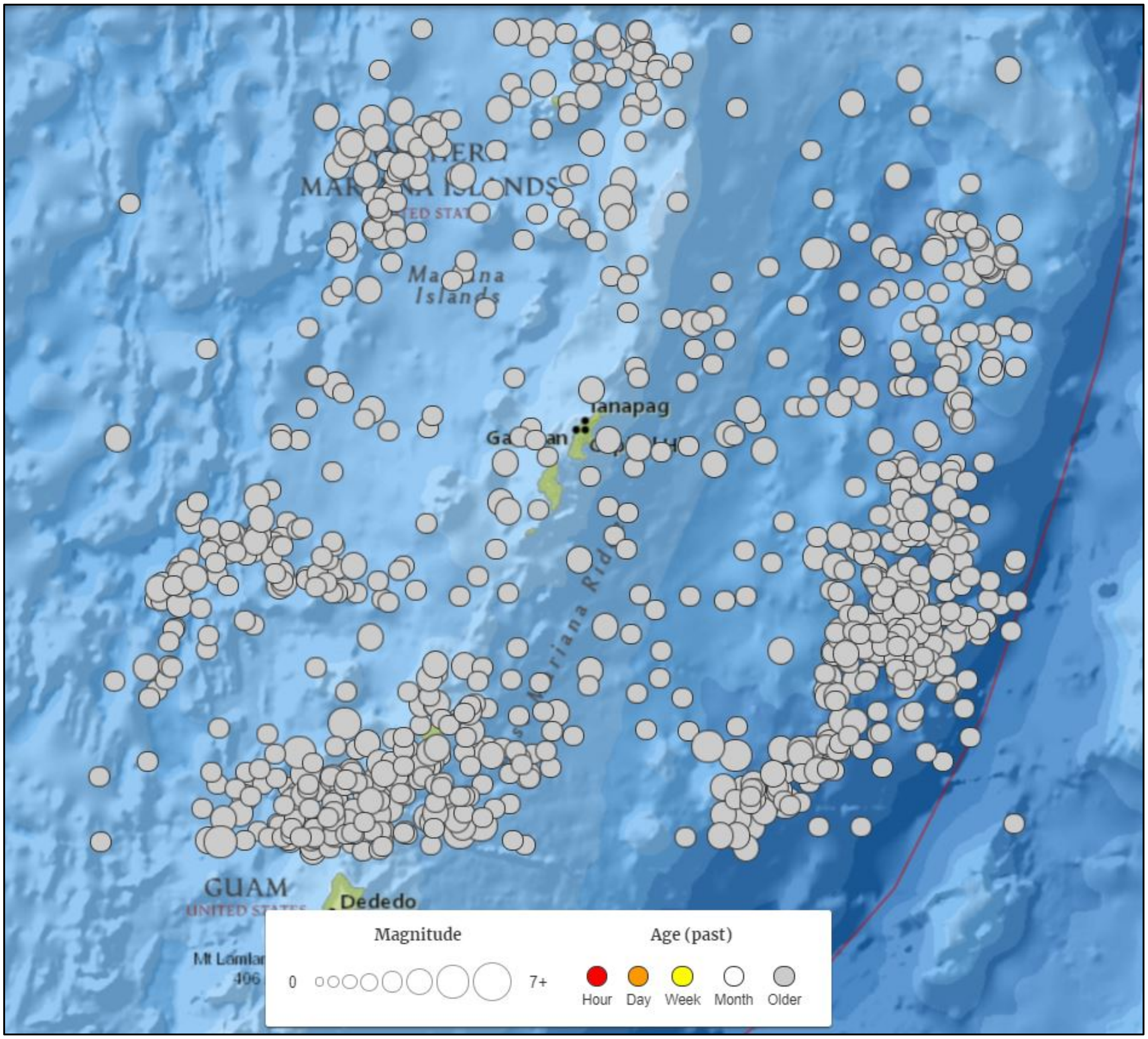


Figure 45. USGS map of earthquake epicenters within 175 kilometers of Saipan with a magnitude of 4.5 or higher, occurring from 1936 through 2017.

Tsunamis

Tsunamis are large, destructive oceanic waves resulting from enormous amounts of displaced water following explosions, earthquakes, landslides, and volcanic eruptions. Tsunamis can be characterized by wavelengths of up to 500 km (310.69 mi) and can move as fast as 640 km/hour (397.68 mi/hr), reaching locations far from an earthquake epicenter or point of disturbance in minimal amounts of time. The cumulative volume and energy of these waves can cause copious amounts of destruction to both the built and natural environment, especially in low-lying areas such as American Memorial Park.

In 2013 the NOAA Pacific Marine Environmental Laboratory completed a tsunami vulnerability modelling study for the CNMI, identifying tsunami hazards on Saipan, Tinian, and Rota for 725 probable earthquake scenarios in the Pacific region (Uslu et al. 2013). While only 26 of these scenarios pose a potential hazard for American Memorial Park, the Park would face some of the greatest impacts relative to the rest of Saipan and CNMI. Of greatest concern would be a magnitude 9.0 earthquake originating from the Ryuku-Nankai Trench (south of Japan), which would generate wave amplitudes in excess of 11 meters. Due to the relative unpredictability of earthquakes in the region, the existing tsunami models do not include probability of occurrence with temporal constraints (e.g., “return periods”).

The results of this work are currently being integrated into a revision of the CNMI’s Tsunami Evacuation Plan, led by the CNMI Department of Homeland Security and Emergency Management. While there are several tsunami hazard zone and evacuation route signs scattered in the neighboring urban area, there are none within the Park. The Park will need to be included in ongoing tsunami preparedness efforts and planning as a primary stakeholder due to its exceptional exposure and vulnerability.

Typhoons

Typhoons occur frequently in the Western North Pacific, which is the most prolific tropical cyclone basin in the world. Unlike other global ocean basins which have comparatively discrete seasons for hurricanes or typhoons, tropical cyclones (depressions, storms, and typhoons) have been documented in Micronesia in every month of the year. Tropical cyclone passage through the Marianas is most common between August and December (Lander 2004; EMO 2010).

The loss or damage or natural and built resources in American Memorial Park from a typhoon could cause direct impacts on human health and infrastructure as well as secondary impacts such as habitat degradation, increased water turbidity, salt-water intrusion into groundwater, and the release of toxic contaminants and sewage into the environment. Historical trends for over-wash from storm surge in relation to topography were used to identify the most at-risk areas on the island, and the entirety of the Park has been determined to lie in the island’s most vulnerable zone (EMO 2010).

Typhoon tracks have intersected Saipan on numerous occasions since the creation of the Park in 1978. In August 2015 Typhoon Soudelor passed directly over Saipan and with it brought sustained winds of over 200 km/hr (124.27 mi/hr) and approached Category 4 intensity at times during the later stages of its passage. Villages on Saipan were without power or running water for weeks, with some areas lacking basic services and infrastructure as long as 3–4 months.

The typhoon caused forty injuries, the loss or severe damage of almost four hundred homes, spillage of five-hundred-gallons of diesel fuel into the port, and a total of $20 million in damages. American Memorial Park sustained immense damage to the Park's ironwood forest (see Figure 6). The playground was destroyed, many large trees were felled, and large portions of the park were closed to the public for months. The root balls of the felled ironwood trees prompted archaeological studies of the area (Maigret 2015). Park-specific ecological effects have yet to be studied and measured; however, the nearshore environment and shoreline configuration has shifted significantly since the storm.

Even without the implications that a changing climate poses, tropical cyclones will remain a consistent threat to the park. Spillover effects from flooding of adjacent areas, wind-borne debris, altered habitat, and impaired sewer or storm water infrastructure will continue to impact the Park following extreme storm events. Given the uncertainty involved with typhoon genesis and behavior in Micronesia under future climate conditions, revised mitigation planning may be necessary to prepare for an exacerbated "worst case" scenario.

Volcanic eruptions

While Saipan itself is not volcanically active, the younger Northern Islands continue to experience periodic eruptions, tremors, and venting. Most recently the neighboring island to the north (Anatahan) erupted three separate times in 2003, 2004, and 2005. Other islands farther north - Asuncion, Agrihan, Pagan, and Alamagan - were last active in 1906, 1917, 1981, and 1998, respectively. Damage to the Park from volcanic action on Anatahan or the other Northern Islands could result from excessive ash and sulfur emissions, which can choke out local biota through air toxicity or blockage of sunlight. The eruption of Anatahan in 2004 resulted in the closure of the Saipan International Airport due to ash fall and poor visibility. Stronger winds out of the north could have intensified the scenario by transporting additional tephra to Saipan, creating health hazards through prolonged fall of ash.

Wildfire

The risk of wildfire increases during drought years, which coincide with the tail end of El Niño events. Most wildfires on Saipan in recent history were anthropogenic in origin and were either intentional burns that became uncontrollable or were related to arson, which includes burning for hunting purposes (EMO 2010). American Memorial Park has not been identified as one of the high-risk areas for wildfire, potentially because the park is composed of large swaths of wetland and surrounded by non-vegetated land uses (including a fire station directly opposite the park). However, damage from wildfires can also include indirect effects. Fires that occur upland of the park can enhance erosion processes, bringing sediment to the wetlands, marina, and lagoon. Repeated wildfires may cause upland soils to become hydrophobic, increasing long-term runoff and reducing overall saturation capacity (EMO 2010).

Ship grounding and anchoring

Grounded ships can cause direct harm to reefs and near-shore habitat through collisions, the release of oil or other pollutants contained on the ship, the release of ship debris as the vessel degrades, and the scouring of benthic habitat if movement during storms occurs (Starmer et al. 2008). American Memorial Park's close proximity to Saipan's only marina, industrial port, and shipping channel increases the chances that vessel groundings could potentially impact park resources. In addition, the Park is situated down-current from the majority of commercial and industrial shipping activities, meaning any spillage from damaged vessels, particularly in the port turning basin, would likely make contact with the Park's shoreline and impair the near-shore waters.

In 2014 the M/V Paul Russ, a 160 m (524.93 ft) container vessel, grounded while coming into port about a mile off of the Park's northwest shoreline. No damage was sustained by the Park, but the grounding caused significant damage to the surrounding reef and temporarily closed the shipping channel (Johnston et al. 2016). Typhoon Soudelor caused two fishing vessels, the Lady Carolina and the Miss Saipan, to break free of their moorings and run aground in the lagoon nearby to American Memorial Park. Again, neither of these vessels caused direct damage to the Park or its infrastructure, but a shift in wind or currents could have brought either vessel in much closer proximity to the park (Johnston et al. 2016).

5.3. Resource Component Data Gaps

The American Memorial Park NRCA revealed numerous instances in which data and research gaps exist for the resources that were assessed (Chapter 4), as well as the threats facing those resources (Chapter 5). Gaps in data and knowledge can effectively limit the capacity of ongoing park management to adapt to various stressors or emergent issues, especially given the relatively rapid changes in land use and land cover that the island of Saipan is experiencing. Several data gaps and research needs were identified for each resource component in the Park. Especially lacking were:

- Sophisticated, predictive assessments of the Park's shoreline and coastal resources (e.g., beach morphology), including estimates of future shoreline positions and impacts of possible mitigation or adaptation options;
- Datasets to analyze up-to-date *and* future impacts of land cover change in the Park and the adjoining watershed;
- Research focusing on analysis of park visitation, usage types, frequency of use, and use impacts;
- Insect, herpetology, and mammal surveys.

As noted in previous sections, coastal morphology constitutes one of the Park's most dynamic assets, facilitating high concentrations of visitor use in some areas where accretion has been observed while posing threats to infrastructure and habitat in areas characterized by chronic erosion. While there have been several studies documenting historic changes to the Park's shoreline position, there has only been one effort to visualize future impacts of climate phenomena on the Park's resources and this did not include estimates of future shoreline positions. Managers and local resource stewards continue to emphasize the need for predictive models or other quantitative studies of future conditions so that informed mitigation decisions can be made.

Regarding land cover change, it was noted that the NOAA C-CAP is finalizing a new data set (2016 land cover) to partially address the lack of current land cover data. However, additional analysis will be necessary to estimate the impacts of proposed changes in the areas directly surrounding American Memorial Park, which appear to include exponential growth in tourism infrastructure, loss of vegetative cover, and expansion of impermeable cover.

The growth in tourism and adjacent urban land use on Saipan also holds potential implications for the Park's ability to sustain human uses. While park stewards and local resource managers may have an intuitive sense of visitor activities, numbers, and impacts, these components of human use require more formal study. Research into human use and impacts could provide a reliable basis for appropriate planning and regulation within the park while providing managers a replicable framework with which human uses could continue to be monitored and studied in the future.

Finally, information for herpetology and mammals was available only from island-wide information, which likely differs from park-specific species presence and populations. Insect species presence (Bourquin 2002), specifically for butterfly(s) and bee (Tadauchi 1994) species, are available island-wide as well, but recent park-specific reports are currently absent.

This report concludes with a simple summary table (Table 31) of data gaps and research needs, organized by NRCA resource component. The points outlined in the table below each constitute an opportunity to enhance park stewardship, and guide management and planning efforts in the face of numerous challenges and external stressors.

Table 31. Data gaps and research recommendations by NRCA Resource Component.

Resource	Data Gaps/Research Recommendations
Mangrove and Wetland	• Post-storm (Soudelor, Yutu) wildlife monitoring, especially for endangered avifauna • Invertebrate species presence and population assessments • Invasive animal species presence and population estimates • Herpetological surveys, especially for indigenous species • Constructed wetland species assemblage • Continuous water quality monitoring of surface pools and constructed wetland • Additional palynological and sediment accretion cores to determine historic extent and identify rates of historic elevation change for mangroves in park • Evaluation of mangrove wetland complex as fish nursery • Post-disturbance (e.g., typhoon) assessments • A study of the history of storm events and their impact on Park resources.
Coastal Scrub and Secondary Forest	• Native zoological surveys and monitoring (mammals, avifauna, invertebrates, reptiles, amphibians) • Invasive species (plants, animals) presence and abundance • Post-disturbance (e.g., typhoon) assessments • A study of the history of storm events and their impact on Park resources.
Shore and Near-shore	• Continued monitoring of erosion/accretion patterns, including longshore transport and deposition in the Smiling Cover area • Modelling of future shoreline positions and inundation scenarios • Monitoring of sea levels with respect to both long-term rise and short-term extremes • Assessment of land-based and marina pollutants, including noise pollution, effects on near-shore and benthic areas • Continued monitoring of benthic habitat to track changes in fauna and in seagrass/algae assemblages • Determine if illegal ballast water dumping is occurring as this is a potential significant source of invasive species • Monitoring of surface elevation change and other sedimentation processes. • Post-disturbance (e.g., typhoon) assessments • A study of the history of storm events and their impact on Park resources.

Table 31 (continued). Data gaps and research recommendations by NRCA Resource Component.

Resource	Data Gaps/Research Recommendations
Developed Green Space	• Animal species assemblages and population estimates (insects, reptiles, amphibians, birds, other invertebrates) • Assess the extent to which illegal take/harvest occurs in this (or other) areas • Post-disturbance (e.g., typhoon) assessments • A study of the history of storm events and their impact on Park resources.
Hydrology	• Monitoring of freshwater lens to determine degree of fluctuation beneath park • Regular monitoring of surface and groundwater for salinity, acidity, temperature, turbidity, and pollutants • Effects of Matansa Fault on groundwater flow • Further study of ground and surface water interactions, especially relating to surface ecology • Monitor release of brine wastewater from resorts to ensure it’s not causing subsurface mounding of water • Measure of volume and direction of storm water flow from upslope areas • Determination of impacts on surface hydrology and flow patterns from the presence of Middle Road • Post-disturbance (e.g., typhoon) assessments • A study of the history of storm events and their impact on Park resources.

Figure 46. Sunrise along American Memorial Park's sandy shoreline (Photo by R. Greene 2012).

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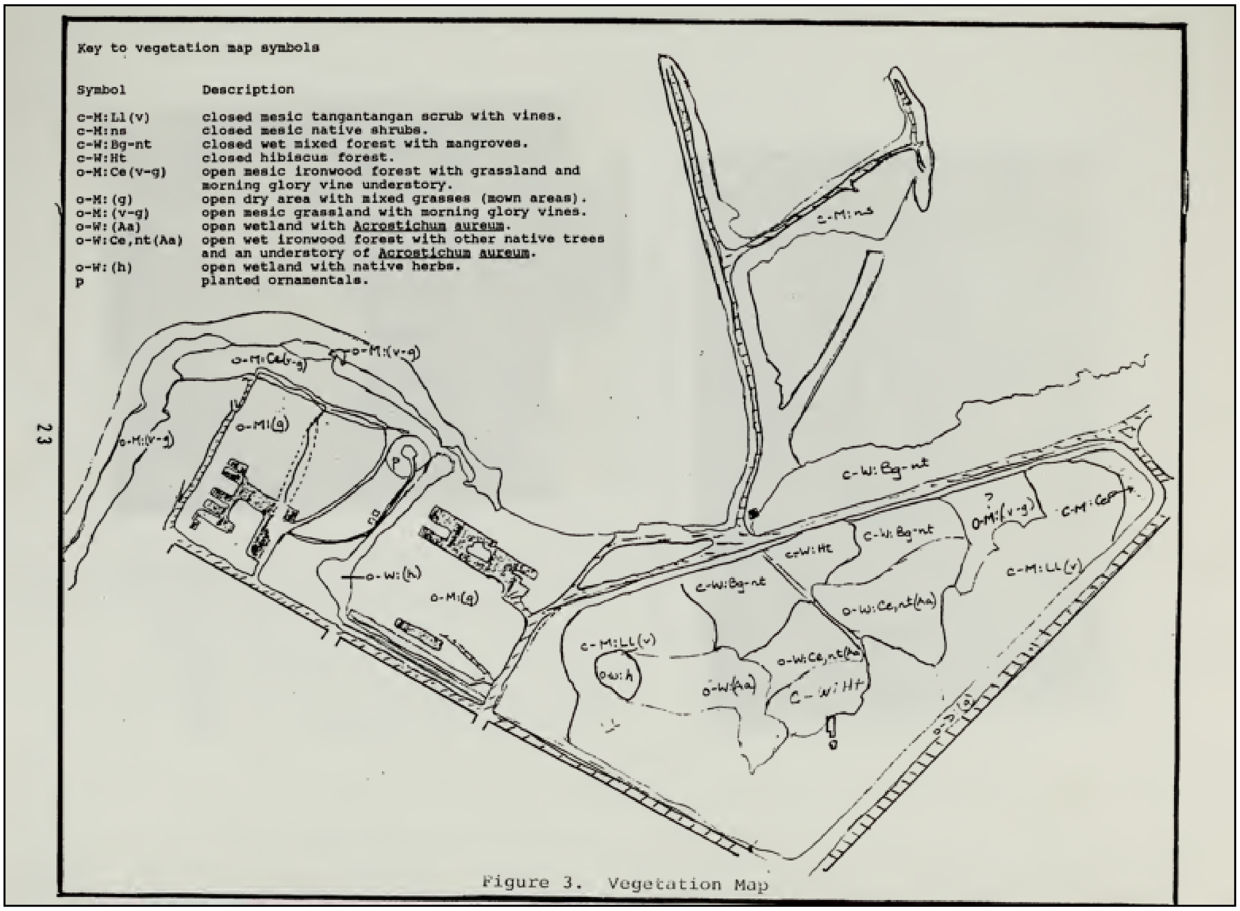
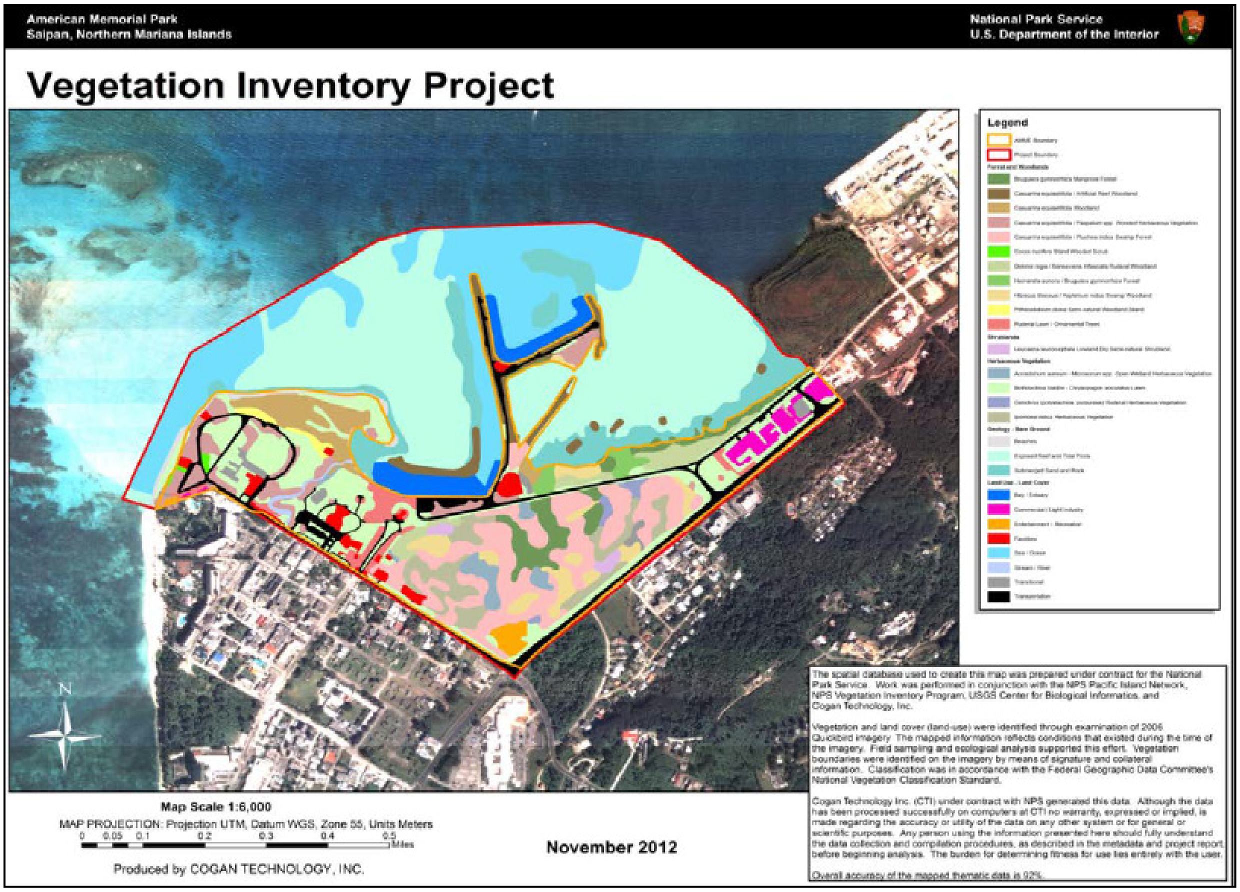
Appendix A. Historical Extent of Wetland Landcover

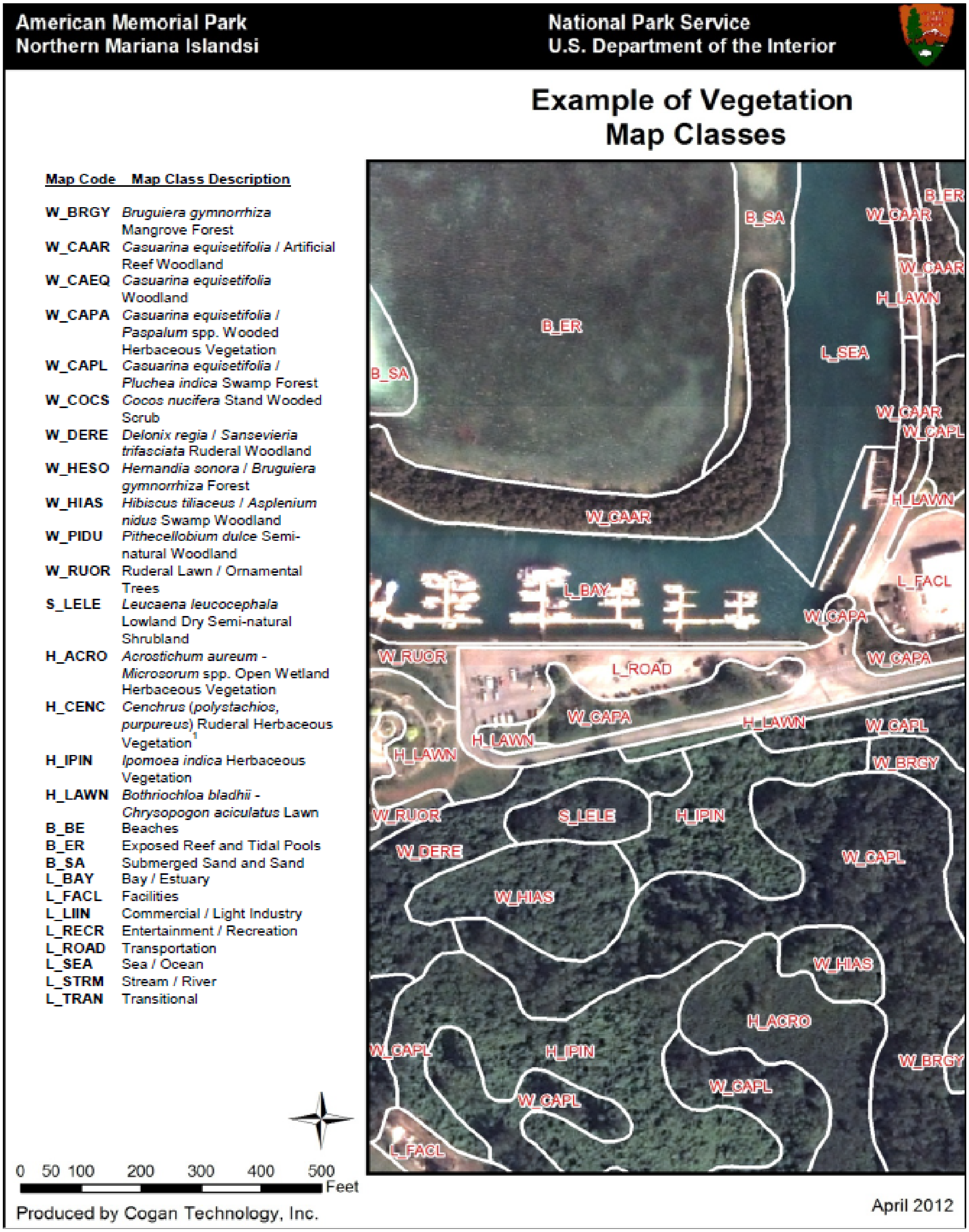
Two land cover maps were utilized to assess trends in vegetation cover; Raulerson and Rinehart (1989) and Cogan et al. (2013). These maps have been extracted from their original publications and are included below.



Vegetation map of American Memorial Park, as published by Raulerson and Rinehart in 1989.



Vegetation map and classes of American Memorial Park, as published by Cogan et al., 2013.



Vegetation classification key, as published by Cogan et al., 2013.

Appendix B. NPSpecies Checklist for American Memorial Park

Table B-1. NPSpecies Checklist for American Memorial Park.

Category	Scientific Name	Common Names	Occurrence
Mammal	*Canis familiaris*	domestic dog, feral dog	Present
Mammal	*Felis catus*	Domestic Cat	Present
Mammal	*Mus musculus*	house mouse	Present
Mammal	*Rattus exulans*	Polynesian rat	Present
Mammal	*Rattus norvegicus*	Norway rat	Present
Mammal	*Rattus rattus*	black rat, roof rat	Present
Mammal	*Suncus murinus*	Asian house shrew, house shrew	Present
Bird	*Aerodramus vanikorensis*	chachaguak, gray swiftlet, island swiftlet, vanikoro swiftlet, yayaguak	Present
Bird	*Pluvialis dominica*	lesser golden plover	Present
Bird	*Gygis alba*	chunge', white tern	Present
Bird	*Actitis hypoleucos*	common sandpiper, dulili	Present
Bird	*Arenaria interpres*	dulili, ruddy turnstone	Present
Bird	*Heteroscelus incanus*	wandering tattler	Present
Bird	*Numenius phaeopus*	kalalang, whimbrel	Present
Bird	*Gallicolumba xanthonura*	paluman apaka (male), paluman fachi (female), paluman kotbata, white-throated ground-dove	Present
Bird	*Ptilinopus roseicapilla*	Marianas fruit-dove, tottot	Present
Bird	*Streptopelia bitorquata*	javanese turtle-dove, paluman apu, paluman lasa, paluman senesa, Phillipine turtle-dove	Present
Bird	*Todiramphus chloris*	White-Collared Kingfisher, sihek	Present
Bird	*Gallinula chloropus guami*	mariana common gallinule, mariana common moorhen, Mariana moorhen, pulattat	Present
Bird	*Acrocephalus luscinia*	ga'ga' karisu, nightingale reed-warbler, padudo	Present
Bird	*Lonchura malacca*	chestnut mannikin	Present
Bird	*Myzomela cardinalis*	cardinal honeyeater	Present
Bird	*Myzomela rubratra*	egigi, Micronesian honeyeater, paluman agaga	Present
Bird	*Passer montanus*	eurasian sparrow, eurasian tree sparrow, gaga pale	Present
Bird	*Rhipidura rufifrons*	na'abak, rufous-fronted fantail	Present
Bird	*Aplonis opaca*	Micronesian starling, Sali	Present

Table B-1 (continued). NPSpecies Checklist for American Memorial Park.

Category	Scientific Name	Common Names	Occurrence
Bird	*Cleptornis marchei*	canario, golden honeyeater, golden white-eye	Present
Bird	*Zosterops conspicillatus*	bridled white-eye, nosa, not'sa	Present
Bird	*Egretta sacra*	chuchuko atilong, Pacific reef-heron	Present
Bird	*Ixobrychus sinensis*	chinese bittern, kakkak, yellow bittern	Present
Bird	*Sula leucogaster*	brown booby, lu'ao	Present
Reptile	*Boiga irregularis*	brown treesnake, kolepbla	Present
Reptile	*Perochirus ateles*	guali'ek, Micronesian gecko	Present
Reptile	*Lamprolepis smaragdina*	green tree skink, guali'ek, halom tano	Probably Present
Reptile	*Varanus indicus*	Indian monitor lizard	Present
Reptile	*Chelonia mydas*	green sea turtle	Present
Amphibian	*Bufo marinus*	giant toad, kairo, marine toad	Present
Fish	*Gambusia affinis*	mosquitofish, western mosquitofish	Present
Fish	*Sarotherodon mossambicus*	tilapia	Present
Fish	*Clarias batrachus*	clarias catfish, walking catfish	Probably Present
Vascular Plant	*Planchonella obovata*	Lalajut	Present
Vascular Plant	*Alocasia macrorrhizos*	giant taro	Present
Vascular Plant	*Polyscias fruticosa*	Ming aralia	Present
Vascular Plant	*Polyscias guilfoylei*	geranium aralia	Present
Vascular Plant	*Cocos nucifera*	Niyok	Present
Vascular Plant	*Phoenix canariensis*	Canary Island date palm	Present
Vascular Plant	*Phoenix roebelenii*	pygmy date palm	Present
Vascular Plant	*Ptychosperma macarthuri*	Macarthur feather palm	Present
Vascular Plant	*Roystonea regia*	Royal palm	Present
Vascular Plant	*Veitchia merrillii*	Manila palm	Present
Vascular Plant	*Hymenocallis littoralis*	Lirio	Present
Vascular Plant	*Sansevieria trifasciata*	Bowstring hemp, Mother-in-Laws tongue, Tigre	Present
Vascular Plant	*Spathoglottis plicata*	Philippine ground orchid	Present
Vascular Plant	*Taeniophyllum marianense*	Worm orchid	Present
Vascular Plant	*Zeuxine fritzii*	–	Present
Vascular Plant	*Bidens alba*	–	Present
Vascular Plant	*Chromolaena odorata*	Masigsig	Present
Vascular Plant	*Conyza canadensis var. canadensis*	Canadian horseweed	Present
Vascular Plant	*Cyanthillium cinereum*	little ironweed	Present

Table B-1 (continued). NPSpecies Checklist for American Memorial Park.

Category	Scientific Name	Common Names	Occurrence
Vascular Plant	*Mikania scandens*	climbing hempvine, climbing hempweed	Present
Vascular Plant	*Pluchea carolinensis*	cure for all	Present
Vascular Plant	*Pluchea indica*	Indian camphorweed, Indian fleabane, Indian pluchea	Present
Vascular Plant	*Pluchea X fosbergii*	–	Present
Vascular Plant	*Sphagneticola trilobata*	Bay Biscayne creeping-oxeye	Present
Vascular Plant	*Synedrella nodiflora*	nodeweed	Present
Vascular Plant	*Tridax procumbens*	cadillo chisaca, coat buttons, coatbuttons, tridax	Present
Vascular Plant	*Scaevola taccada*	nanaso	Present
Vascular Plant	*Heliotropium procumbens var. depressum*	fourspike heliotrope	Present
Vascular Plant	*Tournefortia argentea*	hunig	Present
Vascular Plant	*Carica papaya*	papaya, pawpaw	Present
Vascular Plant	*Achyranthes aspera*	devil's horsewhip	Present
Vascular Plant	*Deeringia amaranthoides*	–	Present
Vascular Plant	*Bougainvillea glabra*	Bougainvilla	Present
Vascular Plant	*Plumbago auriculata*	Cape leadwort	Present
Vascular Plant	*Plumbago indica*	whorled plantain	Present
Vascular Plant	*Cocoloba uvifera*	Sea grape	Present
Vascular Plant	*Portulaca oleracea*	akulikuli-kula, common purslane, duckweed, garden purslane, little hogweed, little-hogweed, purslane, pursley, wild portulaca	Present
Vascular Plant	*Tradescantia spathacea*	boatlily, oyster plant	Present
Vascular Plant	*Coccinia grandis*	ivy gourd, scarlet-fruited gourd	Present
Vascular Plant	*Momordica charantia*	Atmagosa, Bittermelon	Present
Vascular Plant	*Cycas circinalis*	Cycad, Fadang,, Federico	Present
Vascular Plant	*Cycas revoluta*	False sago palm	Present
Vascular Plant	*Navarretia intertexta*	needleleaf navarretia, needle-leaf pincushion-plant	Present
Vascular Plant	*Pouteria obovata*	–	Present
Vascular Plant	*Abrus precatorius*	Coralbean, Kolales halomtano, Prayerbed	Present
Vascular Plant	*Acacia confusa*	pilampwoia sosigi	Present
Vascular Plant	*Albizia lebbeck*	Clackety-clack, Mames, Tronkon Mames	Present
Vascular Plant	*Alysicarpus vaginalis*	white moneywort	Present
Vascular Plant	*Cassia javanica*	apple blossom	Present

Table B-1 (continued). NPSpecies Checklist for American Memorial Park.

Category	Scientific Name	Common Names	Occurrence
Vascular Plant	*Crotalaria pallida*	salts rattlebox, smooth crotalaria, smooth rattlebox, striped crotalaria	Present
Vascular Plant	*Cynometra ramiflora*	Gulos	Present
Vascular Plant	*Delonix regia*	flametree	Present
Vascular Plant	*Desmanthus virgatus*	wild tantan	Present
Vascular Plant	*Hippocrepis comosa*	horseshoe vetch	Present
Vascular Plant	*Indigofera suffruticosa*	anil de pasto, indigobush	Present
Vascular Plant	*Indigofera tinctoria*	true indigo	Present
Vascular Plant	*Intsia bijuga*	Ifil, Ifit, Ipil	Present
Vascular Plant	*Leucaena leucocephala*	tangantangan	Present
Vascular Plant	*Mimosa pudica*	Sleeping grass	Present
Vascular Plant	*Mucuna gigantea*	Bayogo dikiki, Bayogo-dailaili, Gayatan, small seabean	Present
Vascular Plant	*Pithecellobium dulce*	kamachile	Present
Vascular Plant	*Samanea saman*	Monkeypod	Present
Vascular Plant	*Senna surattensis*	glossy shower	Present
Vascular Plant	*Sesbania cannabina*	–	Present
Vascular Plant	*Polygala paniculata*	orosne	Present
Vascular Plant	*Casuarina equisetifolia*	Gago	Present
Vascular Plant	*Allamanda schottii*	bush allamanda	Present
Vascular Plant	*Nerium oleander*	oleander	Present
Vascular Plant	*Plumeria obtusa*	White plumeria	Present
Vascular Plant	*Plumeria rubra*	frangipani, templetree	Present
Vascular Plant	*Aidia cochinchinensis*	Sumag, Sumak	Present
Vascular Plant	*Aidia racemosa*	Sumag, Sumak	Present
Vascular Plant	*Dentella repens*	Borduegas	Present
Vascular Plant	*Hedyotis strigulosa*	–	Present
Vascular Plant	*Ixora casei*	Ixora	Present
Vascular Plant	*Ixora coccinea*	Ixora	Present
Vascular Plant	*Ixora finlaysonia*	Ixora	Present
Vascular Plant	*Morinda citrifolia*	Lada, Noni	Present
Vascular Plant	*Oldenlandia corymbosa*	flattop mille graines, flat-top mille graines	Present
Vascular Plant	*Psychotria mariana*	Aplokhating	Present
Vascular Plant	*Psychotria mariniana*	forest wild coffee	Present
Vascular Plant	*Spermacoce assurgens*	woodland false buttonweed	Present
Vascular Plant	*Pseuderanthemum carruthersii var. carruthersii*	–	Present
Vascular Plant	*Tabebuia heterophylla*	white cedar	Present

Table B-1 (continued). NPSpecies Checklist for American Memorial Park.

Category	Scientific Name	Common Names	Occurrence
Vascular Plant	*Premna serratifolia*	ahgao	Present
Vascular Plant	*Jasminum marianum*	Banago	Present
Vascular Plant	*Bacopa monnieri*	coastal waterhysso	Present
Vascular Plant	*Bacopa procumbens*	waterhyssop	Present
Vascular Plant	*Russelia equisetiformis*	fountainbush	Present
Vascular Plant	*Phyla nodiflora*	frog fruit, sawtooth fogfruit, turkey tangle, turkey tangle fogfruit, turkey tangle frogfruit	Present
Vascular Plant	*Stachytarpheta cayennensis*	blue snakeweed, bluetop, Cayenne porterweed, Cayenne snakeweed, rattail, rough-leaf false vervain, snakeweed	Present
Vascular Plant	*Stachytarpheta jamaicensis*	light-blue snakeweed	Present
Vascular Plant	*Hernandia sonora*	Nonag	Present
Vascular Plant	*Cassytha filiformis*	Agasi, Mayagas	Present
Vascular Plant	*Calophyllum inophyllum*	Da'ok	Present
Vascular Plant	*Clusia rosea*	Florida clusia, Scotch attorney	Present
Vascular Plant	*Acalypha amentacea ssp. wilkesiana*	Joseph's Coat	Present
Vascular Plant	*Acalypha indica*	Indian copperleaf	Present
Vascular Plant	*Codiaeum variegatum*	garden croton	Present
Vascular Plant	*Euphorbia cyathophora*	fire on the mountain, fire-on-the-mountain, painted leaf	Present
Vascular Plant	*Euphorbia hirta*	golondrina	Present
Vascular Plant	*Euphorbia hypericifolia*	graceful spurge	Present
Vascular Plant	*Euphorbia prostrata*	prostrate spurge	Present
Vascular Plant	*Jatropha integerrima*	peregrina	Present
Vascular Plant	*Melanolepis multiglandulosa*	Alom	Present
Vascular Plant	*Pedilanthus tithymaloides*	redbird flower	Present
Vascular Plant	*Passiflora foetida var. hispida*	Love-in-a-mist	Present
Vascular Plant	*Passiflora suberosa*	corky passionflower, corkystem passionflower, devil's pumpkin, huehue haole, indigo berry, maypop, wild passionfruit	Present
Vascular Plant	*Phyllanthus amarus*	Maigo-lalo	Present
Vascular Plant	*Phyllanthus marianus*	Gaogao-uchan	Present
Vascular Plant	*Bruguiera gymnorrhiza*	Mangle Lahi, Mangle machu, Manglen lahi	Present
Vascular Plant	*Hibiscus rosa-sinensis*	Chinese hibiscus, shoeblackplant	Present
Vascular Plant	*Hibiscus tiliaceus*	Hau), Pago	Present

Table B-1 (continued). NPSpecies Checklist for American Memorial Park.

Category	Scientific Name	Common Names	Occurrence
Vascular Plant	*Malvastrum coromandelianum*	threelobe false mallow	Present
Vascular Plant	*Sida rhombifolia*	Escobilla adumelon, Escobilla apaca, Escobilla dalili	Present
Vascular Plant	*Thespesia populnea*	Banalo	Present
Vascular Plant	*Muntingia calabura*	strawberrytree	Present
Vascular Plant	*Terminalia catappa*	Pacific almond, Talisai	Present
Vascular Plant	*Pemphis acidula*	Nigas	Present
Vascular Plant	*Eugenia palumbis*	Agatelong	Present
Vascular Plant	*Ludwigia octovalvis*	Mexican primrosewillow, Mexican primrose-willow	Present
Vascular Plant	*Ophioglossum nudicaule*	least adderstongue, least adder's-tongue	Present
Vascular Plant	*Oxalis corniculata*	creeping oxalis, creeping woodsorrel, 'ihi, yellow oxalis, yellow wood sorrel	Present
Vascular Plant	*Pandanus dubius*	Pahong	Present
Vascular Plant	*Pandanus tectorius*	Kafu	Present
Vascular Plant	*Cyperus compressus*	poorland flatsedge	Present
Vascular Plant	*Cyperus difformis*	smallflower umbrella sedge, variable flatsedge	Present
Vascular Plant	*Cyperus javanicus*	Javanese flatsedge	Present
Vascular Plant	*Cyperus polystachyos*	manyspike flatsedge	Present
Vascular Plant	*Fimbristylis cymosa*	tropical fimbry	Present
Vascular Plant	*Kyllinga brevifolia*	shortleaf spikesedge	Present
Vascular Plant	*Kyllinga nemoralis*	whitehead spikesedge	Present
Vascular Plant	*Scirpus littoralis* var. *capensis*	–	Present
Vascular Plant	*Flagellaria indica*	–	Present
Vascular Plant	*Cenchrus echinatus*	Sandspur, Sticky birds	Present
Vascular Plant	*Cenchrus purpureus*	napier grass	Present
Vascular Plant	*Chloris barbata*	swollen fingergrass	Present
Vascular Plant	*Chrysopogon aciculatus*	golden beardgrass, golden false beardgrass, inifuk, Mackie's pest, matapekepeke, pilipiliula, seed grass	Present
Vascular Plant	*Cynodon dactylon*	Bermudagrass, chiendent pied-de-poule, common bermudagrass, devilgrass, grama-seda, manienie, motie molulu	Present
Vascular Plant	*Dactyloctenium aegyptium*	crowfoot grass, Durban crowsfoot grass, Egyptian grass	Present
Vascular Plant	*Dichanthium bladhii*	–	Present

Table B-1 (continued). NPSpecies Checklist for American Memorial Park.

Category	Scientific Name	Common Names	Occurrence
Vascular Plant	*Digitaria insularis*	sourgrass	Present
Vascular Plant	*Echinochloa colona*	Chaguan tasi	Present
Vascular Plant	*Eleusine indica*	Umog	Present
Vascular Plant	*Eragrostis amabilis*	lovegrass	Present
Vascular Plant	*Eragrostis ciliaris*	gophertail lovegrass	Present
Vascular Plant	*Eragrostis cumingii*	Cuming's lovegrass	Present
Vascular Plant	*Eustachys petraea*	pinewoods fingergrass	Present
Vascular Plant	*Imperata conferta*	–	Present
Vascular Plant	*Ischaemum polystachyum*	–	Present
Vascular Plant	*Lepturus repens*	Pacific Island thintail	Present
Vascular Plant	*Oplismenus compositus*	running mountaingrass	Present
Vascular Plant	*Oplismenus hirtellus* ssp. *hirtellus*	basketgrass	Present
Vascular Plant	*Paspalum conjugatum*	herbe creole, Hilo grass, hilograss, muhsrasre, rehn wei, sour grass, ti grass	Present
Vascular Plant	*Paspalum distichum*	knotgrass, knotroot paspalum	Present
Vascular Plant	*Sporobolus indicus* var. *major*	–	Present
Vascular Plant	*Sporobolus virginicus*	seashore dropseed	Present
Vascular Plant	*Thuarea involuta*	Kuroiwa grass	Present
Vascular Plant	*Urochloa maxima*	guinea grass	Present
Vascular Plant	*Urochloa mutica*	buffalo grass, California grass, Mauritius grass, para grass, puakatau	Present
Vascular Plant	*Zoysia matrella* var. *pacifica*	Manila grass	Present
Vascular Plant	*Davallia solida*	Rabbit foot fern	Present
Vascular Plant	*Dryopteris tenebrosa*	Na Pali-Kona woodfern	Present
Vascular Plant	*Nephrolepis biserrata*	Swordfern	Present
Vascular Plant	*Nephrolepis hirsutula*	scaly swordfern	Present
Vascular Plant	*Microsorum punctatum*	bird's nest fern	Present
Vascular Plant	*Phymatosorus grossus*	monarch fern	Present
Vascular Plant	*Polypodium punctatum*	Birds nest fern	Present
Vascular Plant	*Pyrrosia lanceolata*	–	Present
Vascular Plant	*Acrostichum aureum*	Langayao	Present
Vascular Plant	*Antrophyum plantagineum*	–	Present
Vascular Plant	*Pteris vittata*	Chinese brake, ladder brake	Present
Vascular Plant	*Vittaria incurvata*	shoestring fern	Present
Vascular Plant	*Thelypteris opulenta*	jeweled maiden fern	Present
Vascular Plant	*Psilotum nudum*	whisk fern	Present
Vascular Plant	*Ficus prolixa*	Nunu, Strangler fig	Present

Table B-1 (continued). NPSpecies Checklist for American Memorial Park.

Category	Scientific Name	Common Names	Occurrence
Vascular Plant	*Ficus thonningii*	Chinese banyan	Present
Vascular Plant	*Ficus tinctoria*	Dyer's fig, Hodda, Hotda	Present
Vascular Plant	*Ficus tinctoria* var. *neo-ebudarum*	–	Present
Vascular Plant	*Colubrina asiatica*	Gasoso	Present
Vascular Plant	*Pilea microphylla*	rockweed	Present
Vascular Plant	*Swietenia macrophylla*	Honduras mahogany	Present
Vascular Plant	*Citrus macroptera*	Bitter orange, Soap orange	Present
Vascular Plant	*Allophylus timorensis*	Nger	Present
Vascular Plant	*Dodonaea viscosa*	Florida hopbush, hopbush, hopseed bush	Present
Vascular Plant	*Ipomoea indica*	Blue morning glory, Fofgu	Present
Vascular Plant	*Ipomoea pes-caprae* ssp. *brasiliensis*	Beach morning-glory	Present
Vascular Plant	*Ipomoea triloba*	littlebell	Present
Vascular Plant	*Ipomoea violacea*	Moonflower	Present
Vascular Plant	*Operculina turpethum* var. *ventricosa*	Woodrose	Present
Vascular Plant	*Stictocardia tiliifolia*	spottedheart	Present
Vascular Plant	*Solanum americanum*	Black Nightshade	Present
Vascular Plant	*Solanum lycopersicum* var. *cerasiforme*	garden tomato	Present

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National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525