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Natural Resource Condition Assessment

War in the Pacific National Historical Park

Asan Beach and Asan Inland Units of War in the Pacific National Historical Park.

Natural resource condition assessment: War in the Pacific National Historical Park

Science Report NPS/SR—2024/150

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Abstract

The report summarizes known biodiversity and ecological conditions of terrestrial, aquatic and marine ecosystems found in War in the Pacific National Historical Park (War in the Pacific NHP), Guam. Natural Resource Condition Assessments provide a snapshot-in-time evaluation of park resource conditions. For this report, most or all of the data discovery and analyses occurred during the period of 2013 to 2020. Thus, park conditions reported in this document pertain to that time period. This study focused on three natural resource components: terrestrial plant communities, aquatic communities, and coral reef communities. Due to revised publishing requirements and/or scientific delays, this report was not published until 2024.

Executive Summary

Natural Resource Condition Assessments (NRCAs) provide a snapshot-in-time evaluation of park resource conditions. This report summarizes conditions of natural resources found in the War in the Pacific National Historical Park (War in the Pacific NHP), Guam. For this report, most or all of the data discovery and analysis occurred during the period of 2013 to 2020. Thus, park conditions reported in this document pertain to that time period. The purpose of this report 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 pertaining to War in the Pacific NHP natural resources. Thus, this report provides a means for identifying priority issues related to the monitoring, maintenance, and conservation of War in the Pacific NHP's resources. The report summarizes known biodiversity and ecological conditions of terrestrial, aquatic and marine ecosystems found in War in the Pacific NHP. Due to revised publishing requirements and/or scientific delays, this report was not published until 2024

The report also summarizes historical, current and emerging threats and stressors that cause or may cause negative impacts upon resources contained in these habitats. This report also identifies information gaps and makes recommendations for addressing those gaps so as to increase knowledge of biodiversity, ecological processes and resilience, or lack of it, to perturbations.

The University of Guam Marine Laboratory (UOGML) was contracted initially to perform this NRCA. Pacific Coastal and Regional Planning (PCRP) joined the project as a subcontractor to provide certain editorial and formatting services. The project consisted of collecting and synthesizing existing research and literature and providing supplemental analyses of specific resources from available data sets. Local expertise was consulted in areas for subject matter where data gaps existed, or where otherwise necessary.

This study focused on three natural resource components: terrestrial plant communities, aquatic communities, and coral reef communities. For each focal resource Chapter 4 provides an introduction explaining the importance of the resource to War in the Pacific NHP, methods used for assessing the resources, and a description and graphic icon of the condition, status and trend determined for each resource.

Chapter 5 provides a discussion that summarizes the resource condition assessments and provides a list of threats and stressors as well as identification of data gaps and research needs that can be used to develop effective management strategies for stewardship of the park.

Much of the park borders significant areas of human development that promote degradation of the park's land and seascapes, as well as its cultural resources. Poor land and sea use practices, coupled with the effects of climate change set the stage for further changes in the conditions of the park's natural resources. The park's terrestrial plant communities provide ecological services by creating numerous habitats and trophic resources utilized by many kinds of organisms. They also contribute to soil stability and decrease erosion. Nevertheless, wildfires (often set by humans) destroy vegetation, alter plant community structure, and destabilize soil, thus promoting erosion that contributes to

sedimentation of the park's coral reefs. Invasive plant species further degrade native plant communities through competition for space, water, nutrients and other resources.

Communities of aquatic invertebrates and fishes are important for maintaining biodiversity within streams, springs and other bodies of water. They provide food resources for other organisms, including humans, as well. Streams and other water bodies are important for sustaining riparian plant communities, providing mating and rearing sites for native species, and even providing recreational opportunities to park visitors. Their degradation by fire, erosion and pollution reduces their usefulness but also impacts ecosystems downstream, including coral reefs, seagrass beds, and mangroves, and the communities of organisms found in these habitats. The available data indicate that fish and invertebrate species diversity is being maintained within the park, although invasive species may be found in some water bodies as they are elsewhere on Guam. The impact of these invasives upon native species could be through predation or competition for food or spatial resources.

Damage to marine habitats from terrestrial stressors, coupled with anthropogenic (sea temperature increases from human induced climate change, pollution, physical destruction of habitats, overfishing, etc.) and natural events (typhoons, tropical storms, exceptionally low tides, mass outbreaks of coral predators such as crown-of-thorns starfish, etc.), present great challenges for conservation and management of the park's marine resources. The most imposing challenge comes from surface sea temperature increases that promote coral bleaching, a reduction in coral cover, and the potential loss of threatened or endangered marine species. Coral bleaching and subsequent loss of coral cover (coupled with losses from sedimentation) are increasing, especially for species of *Acropora* corals, within the Asan Beach and Agat units. Less vulnerable corals, such as those of the genus *Porites*, are more resilient in the face of bleaching effects, especially on reefs found within the Agat Unit.

The interactive and cumulative effects of these threats and stressors are not entirely known, and so data gaps exist that must be identified and considered, especially if a more robust assessment of resource condition can be made. The assessments made here utilized the best information available, but inadequacies doubtless exist that should be addressed by future monitoring and research efforts.

Acknowledgments

We are grateful to Michael Gawel, Justin Mills, Jenny Coffman, David Lotz, Sheila McKenna, and Allison Miller of the War in the Pacific National Historical Park, National Park Service (NPS), Guam as well as Tonnie Cummings (NPS) for their kind assistance. We also thank E. Bradley Wells (UOGML) for assistance in data acquisition, and Angela Duenas and MarceAnne Calvo (both UOGML) for assistance with the administration of this project. Considerable unpublished data, graphics, and maps, as well as technical reports or other products used in the writing of this report were provided by the NPS, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), and the University of Guam Water and Environment Research Institute of the Western Pacific (WERI). Unless noted otherwise, all photographs are by T.J. Donaldson and all maps are by M. Kottermair.

Funding and support for this project was provided by the NPS Natural Resource Condition Assessment Program.

Acronyms

CL: Condition Levels

CVI: Coastal vulnerability index

EPA: U.S. Environmental Protection Agency

GEPA: Guam Environmental Protection Agency

GIS: Geographic information systems

GRA: Graduate research assistant

IP: Immature phase

MHW: Mean high-water mark

MPA: Marine Protected Area

NGO: Non-governmental organization

NHP: National Historical Park

NOAA: National Oceanic and Atmospheric Administration

NPS: National Park Service

NRCA: Natural Resource Condition Assessment

ORV: Off-road vehicle

PI: Principal investigator

SL: Significance Levels

TP: Terminal phase

TRI: Toxics Release Inventory

UOG: University of Guam

UOG-IREI: University of Guam and Island Research and Education Initiative UOGML University of Guam Marine Lab

UXO: Unexploded ordnance

WCS: Weighted Condition Score

WERI: Water and Environment Research Institute

Prologue

Publisher's Note, February 2024:

Changes in publishing requirements, and in some cases scientific delays, resulted in several NRCA reports not being published in a timely manner. Since Natural Resource Condition Assessments provide a snapshot-in-time evaluation of park resource conditions, it is important to note that data discovery and analyses for this study was conducted during the period of 2013-2020. Thus, park conditions reported in this document pertain to that time period.

In 2023, the Natural Resource Condition Assessment Program evaluated the content of the information in this report and deemed the information valuable, even though dated. We did not attempt to update the information to align with the publication date. Thus, we alert the reader that this natural resource condition assessment report is pertinent only to the report timeframe of 2013-2020.

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, and
- 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 GIS (map) products;[4]
- Summarize key findings by park areas; and[5]
- Follow national NRCA guidelines and standards for study design and reporting products.

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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.

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 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), and
- 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.

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[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. 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

The War in the Pacific National Historical Park (Park or War in the Pacific NHP) was established by an act of Congress (Section 6, Public Law 95-348) in August 1978 to honor those that served in the Pacific Theater during the Second World War. The purpose of the park is "…to commemorate the bravery and sacrifice of those participating in the Pacific Theater of World War II and to conserve and interpret outstanding natural, scenic and historical values and objects of Guam for the benefit and enjoyment of present and future generations". Details of the provisions of the law relevant to the National Park system and War in the Pacific NHP are summarized in War in the Pacific NHP (NPS 1997).

War in the Pacific NHP contains a number of historic battle sites, gun emplacements, trenches, limestone caves, and historic structures. The Park serves also as an important protected area for biological and geological resources. The natural resources exist in various terrestrial, aquatic and marine environments. Aside from their intrinsic value, the Park's natural resources provide field laboratories for research, education, and demonstration of management actions. Further, the Park provides a venue for various recreational activities including hiking, exercising, picnicking, beach-going, kite-surfing, paddling and kayaking, sports fishing, snorkeling, scuba diving and boating. Some artisanal fishing and traditional harvesting also occur.

2.1.2 Geographic Setting

War in the Pacific NHP is located on the island of Guam, the southern-most and largest island in the Mariana Archipelago in the western Pacific Ocean (Figure 1). Guam is an unincorporated territory of the United States of America and consists of the main island; Cocos Island, located at the southern tip of the main island; Cabras Island, located at Apra Harbor just south of the center of the island along the west coast; and 12 small islets, located along the western and southeastern coastlines (Tracey et al. 1959). Guam is approximately 49 km (30 miles) long and ranges in width from 19 km (12 miles) at its widest point (southern Guam) to just 7 km (4 miles) in central Guam. The total area, including Cocos Island and the coastal islets, is approximately 550 square km (212 square miles) (Thornberry-Ehrlich 2012).

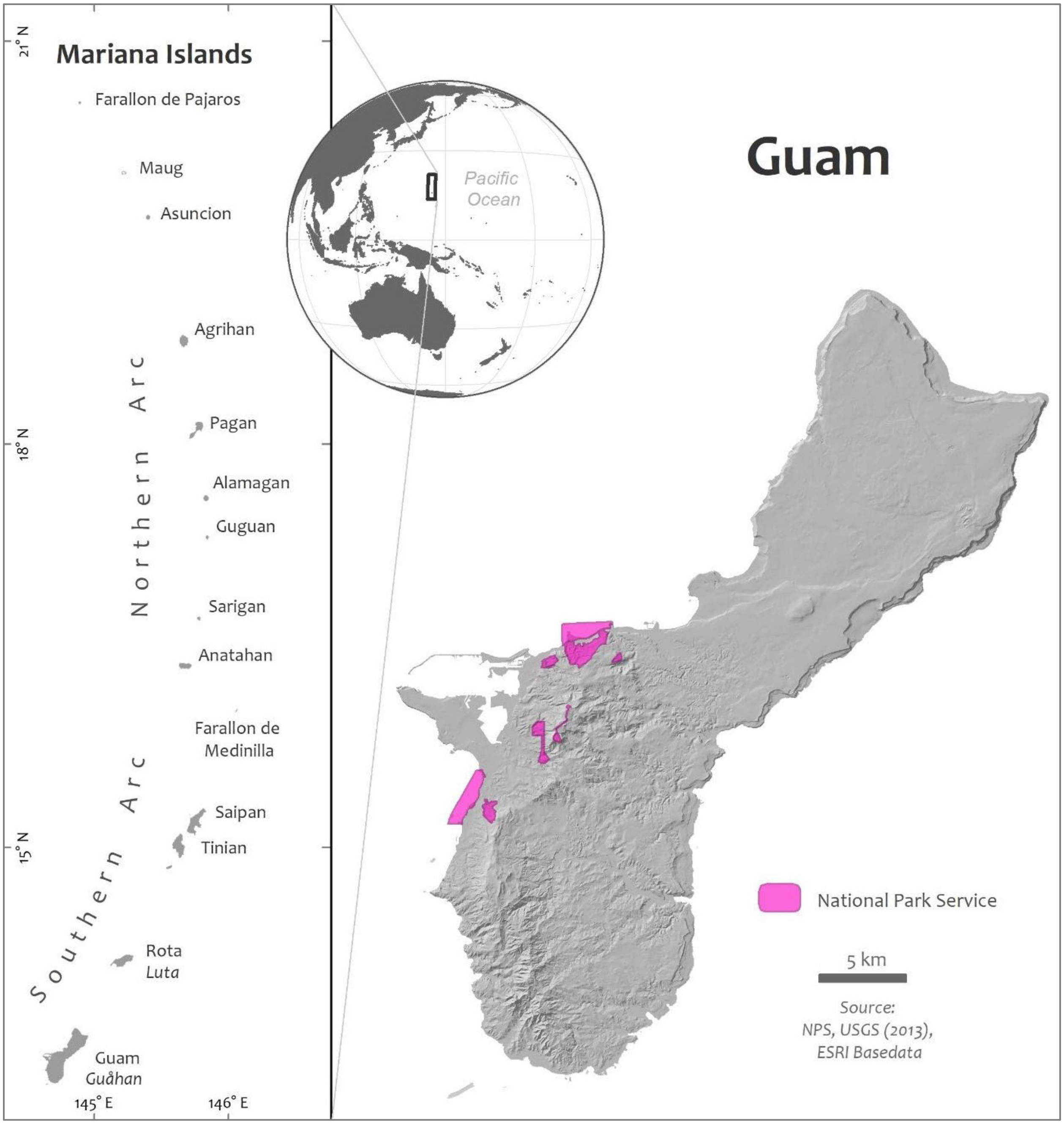


Figure 1. A physiographic relief of the island of Guam, with the location of park units for War in the Pacific NHP delineated in pink. Source: NPS, USGS (2013), ESRI Basedata.

Tectonic Setting

Guam and the Marianas are also part of the Indo-West Pacific Region and are located adjacent to the tectonic boundary where the Pacific and Mariana Plates collide (see Springer 1982; Thornberry-Ehrlich 2012). The Mariana Microplate is situated between the Pacific Plate to the east and the Philippine Plate to the west.

Here, the Pacific Plate subducts westward beneath the Mariana Plate, where it melts at depth and subsequently feeds magma towards the surface creating the Mariana volcanic island arc atop the Mariana Microplate. The deep-sea Mariana Trench occurs on the ocean floor where the Pacific Plate begins to subduct. The trench forms a roughly parallel submarine crescentric arc an average of 120 miles to the east of the volcanic island arc (the Mariana Archipelago) and has the deepest known point in any of the world's oceans Challenger Deep, ca. 10,994 m or 36,069 ft. As Guam is the southern-most island in the Mariana Archipelago, the Mariana Trench is more to the south and southeast, than due east of the island. About 160 km (100 mi) to the west of Guam lies a north-south trending string of submerged back-arc volcanos, known as the West Mariana Ridge. Overall, the Mariana Microplate ranks high among the most geologically active areas in the world.

Guam rests on the edge of an ancient super volcano that is approximately 45 million years old. The island consists mainly of coral reef and foraminiferal limestones overlying basement volcanic rocks in the north and central portions of the island, and basalt capped sporadically with clay-rich limestone in the south. These exposed limestones are ancient reefs that reflect either periods of historically higher sea levels), or uplift of the Mariana Microplate, and hence seafloor by buoyant pressure from the subducting Pacific Plate, or more likely a combination of both processes (Barner 1995; Siegrist and Reagan 2008; see also Figure 5 and discussion in Thornberry-Ehrlich 2012).

The Marianas are arranged in two tectonically offset arcs (Figure 2) that are inherently volcanic (see Figure 3 in Thornberry-Ehrlich 2012). Islands of the southern arc (Guam, Rota, Aguigan, Tinian, Saipan and Farallon de Mendanilla) have more abundant overlying coralline limestone than islands of the northern arc (Anatahan, Sarigan, Guguan, Alamagan, Pagan, Agrigan, Ascension, Maug, and Farallon dos Parajos or Uracas). The islands in the northern arc range in age from 1–1.5 million years, a submerged caldera, has shallow hydrothermal vents more typically and include eight active volcanos. Maug, consisting of three emergent islands from the broken rim of found in the West Mariana Ridge. The older age (up to 30 million years) and less volcanically active to extinct islands of the southern arc provide for their greater occurrence of carbonate reefs, both emerged (fossil reefs) and submerged (living reefs). There are a total of 42 submerged volcanos in the Mariana Archipelago (www.volcanolive.com, accessed on 28 August 2016).

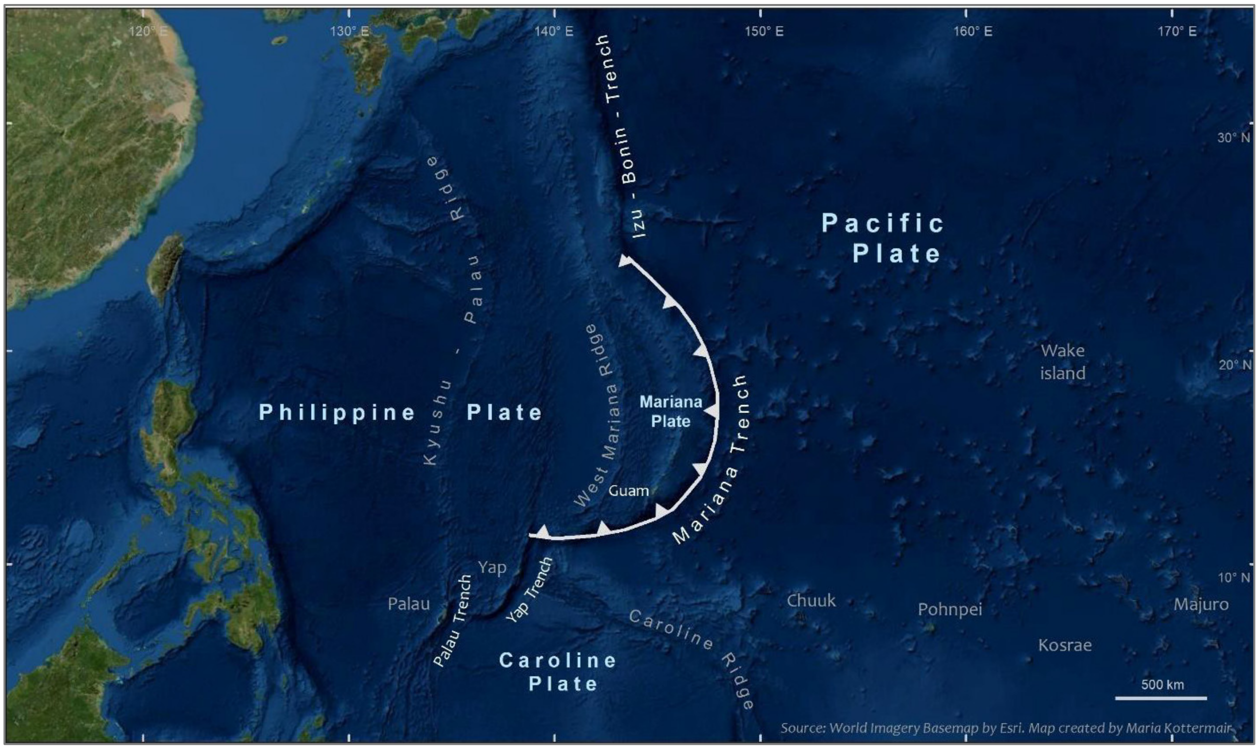


Figure 2. Position of the island of Guam on the Mariana Plate adjacent to the Marianas Trench. Source: World Imagery Basemap by ESRI; map created by Maria Kottermair.

<u>Oceanic Setting</u>

Guam is surrounded by relatively deep water (Figure 3). Depths four kilometers (2.49 miles) or more offshore are in excess of 1,300 meters (4,265 ft). The island is surrounded largely by fringing coral reefs. The exceptions are Cocos Lagoon and Apra Harbor, the former delineated by a barrier reef and the latter by both a barrier reef (now "topped" by the Glass Breakwater) and a fringing reef at Orote Point that effectively delineate the harbor.

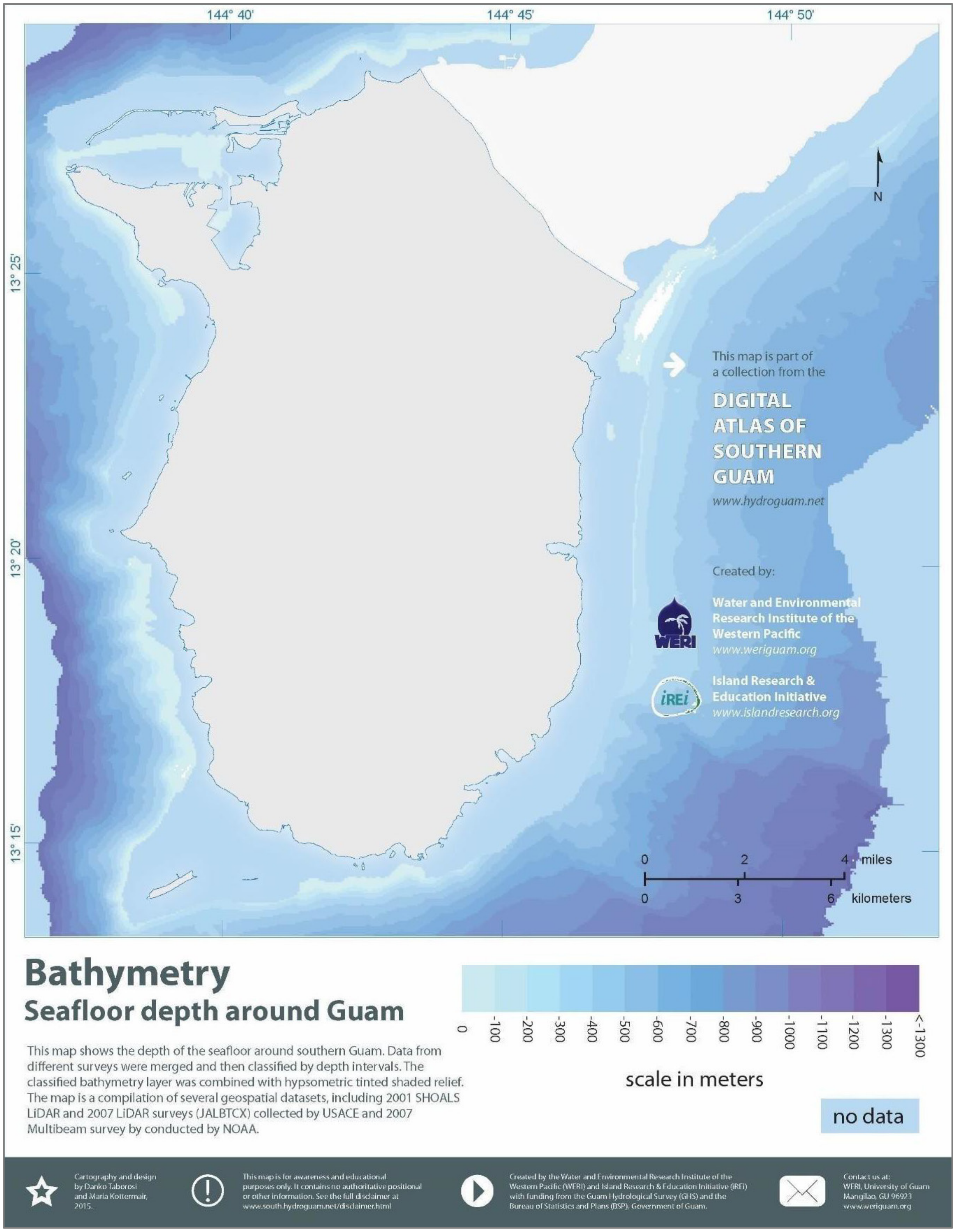


Figure 3. Map of southern Guam showing coastal depth profile to > 6,000 m (19,685 feet) offshore. Source: Digital Atlas of Southern Guam (Water and Environment Research Institute (WERI) / University of Guam and Island Research and Education Initiative-IREI).

The coastal marine and aquatic flora and fauna of Guam consists of both wide-ranging species common to the region and species with narrower ranges or biogeographical affinities unique to the Pacific and Philippine plates (Springer 1982, Donaldson et al. 1994, Myers 1999, Myers and Donaldson 2003). Guam has the most marine and aquatic habitat complexity of all the Mariana Islands, and as such has greater species diversity for a number of taxonomic groups (for fishes, see Donaldson 1995; for other organisms, see reviews in Paulay 2003a). Marine and aquatic habitats at War in the Pacific NHP include fringing coral reefs, seagrass beds, five small estuaries, and as many as 13 creeks (referred to on Guam as "rivers"), two of which are largely ephemeral.

Park Administrative Setting

War in the Pacific NHP is divided into seven formal units, plus parcels owned by the NPS but lying outside of its authorized boundaries, that collectively form the Park (Figure 4). These include two coastal units, three upland units, and two mountain units. The coastal units are Asan Beach and Agat, the latter consisting of Apaca Beach and Ga'an Point. The three upland units consist of Asan Inland, Piti Guns, and Fonte Plateau. The two mountain units consist of Mt. Alifan, and Mt. Chachao-Mt. Tenjo. In addition, the NPS-owned or managed parcels are distributed in the uplands with the largest being the Guatali Parcel. The upland and mountain units are found on volcanic rock formations while the coastal units occur upon coralline limestone in a lowland setting (Thornberry-Ehrlich 2012).

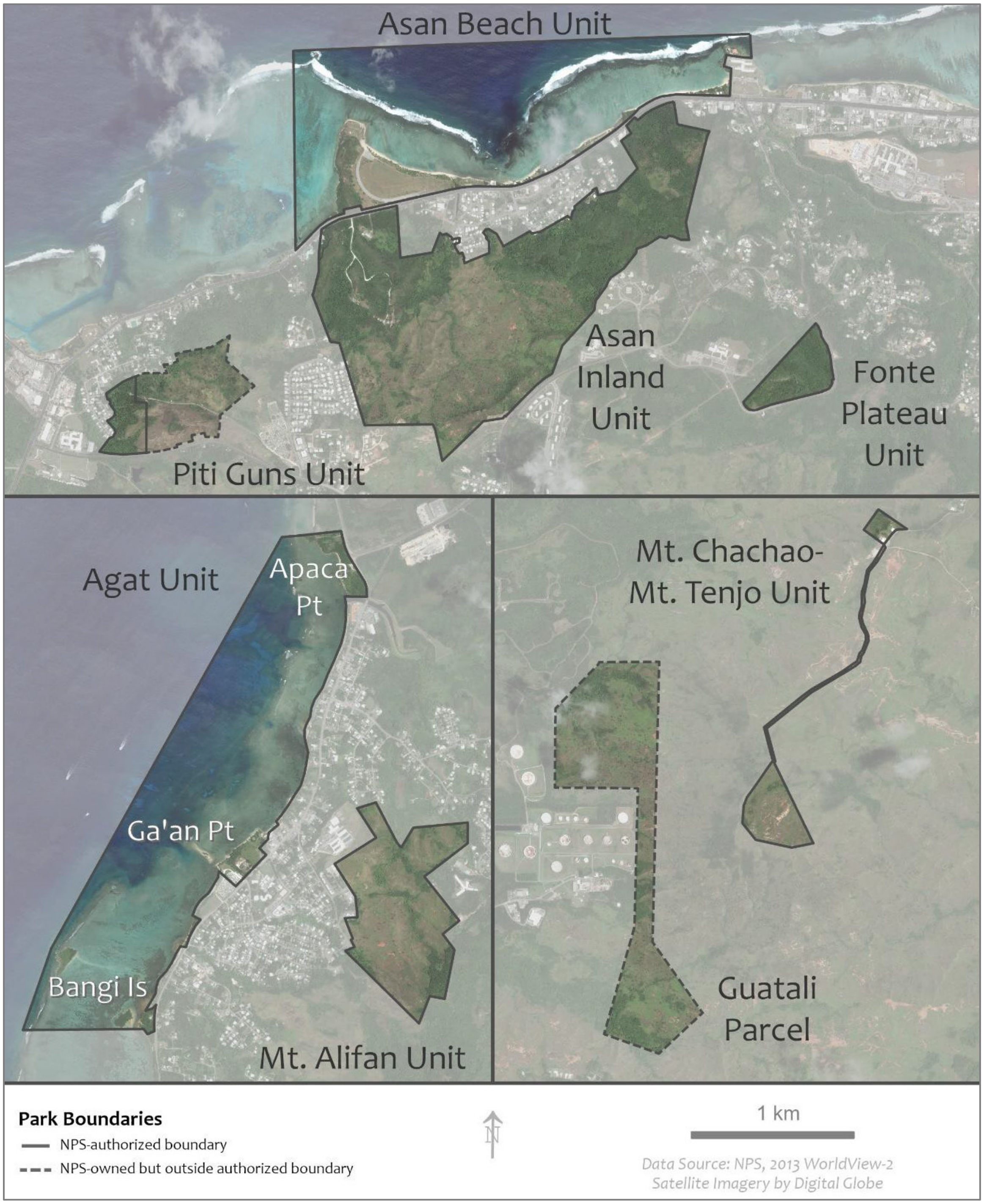


Figure 4. Distribution of units and boundaries of the War in the Pacific NHP. Data Source: NPS, 2013 WorldView-2 Satellite Imagery by Digital Globe.

Climatic Setting

Because of Guam's relatively limited land area and small elevational range, War in the Pacific NHP's climatic conditions are essentially the same for all seven units except for small microclimatic differences in air temperature and humidity between coastal and upland or mountain portions of the park. Mean air temperature ranges between 24 to 30 degrees C (76 to 86 degrees F). There are two seasons, dry and wet. The dry season occurs between the months of December and June while the wet (or rainy) season occurs between July and November. The coolest months of the year, January and February, have temperatures that are influenced by high latitude weather systems that extend their influence southward during the northern hemisphere winter. The lower humidity and patterns of rainfall in the dry season is conducive to the promotion of wildfires that affect both woodlands and grasslands. The wet season tends to coincide with warmer temperatures and higher humidity and rainfall, which is also when most tropical storms occur. The mean annual rainfall is 2,180 mm (96 inches) (NOAA-NWS, Tiyan, Guam data online, accessed 28 August 2021).

2.1.3 Visitation Statistics

War in the Pacific NHP is visited by both local and foreign visitors. Viewing World War II artifacts and battle sites account for some visitor activity, especially amongst foreigners, but most visitors engage in recreational activities. At the Asan Beach Unit, visitors walk, run and cycle on the bike and walking path. Visitors fly kites, play sports, and picnic on the large grassy area there. The beach is used for sunbathing, picnicking, or viewing, and visitors swim or snorkel, fish, paddle, kayak, and kite surf on the reef flat. Scuba divers, brought mainly by boat, tour the reef terrace and slope. Visitors to the Asan Inland and Piti Guns units view war artifacts, battle sites and memorials. Visitors to the Agat Unit also view invasion and battle sites, but also engage in picnics and in swimming, snorkeling, scuba diving, fishing, boating, and other water activities. Hiking is done in the remaining units which tend to be hilly or mountainous, and more remote.

War in the Pacific NHP keeps statistics (STATS - Welcome to Visitor Use Statistics (nps.gov)) on visitors to the Visitor Center (Table 1). Visitation at the center has increased dramatically from its opening in 1985 when there were just 8,623 visitors. The following year the number of visitors increased to 51,567, and there were 488,988 visitors recorded in 2016. Visitation dropped dramatically in 2003, down to just 1,698 visitors before rising to 11,832 visitors the following year. This decline was an outcome of severe damage suffered by the center and park during a series of powerful typhoons that struck Guam between July and December 2002. Storm waves of Typhoon Pongsona washed through the NPS Visitor Center and offices destroying exhibits and files and forcing closure of the center in December of 2002. More recent data for 2017–2019 indicate a very sharp drop in the numbers of visitors to the Visitor Center (Table 1) but likely not all visitors are accounted for. Because of COVID-19 restrictions, the number of visitors between 2019-present has likely dropped even further. Demographics respective of park utilization, and visitor numbers to different units or features, as well as their origin, are not available. NPS visitor statistics (STATS - Welcome to Visitor Use Statistics (nps.gov)), however, indicate that they include Guamanians (Chamorros and other residents) and Stateside Americans, as well as visitors mainly from Australia, China, the European Union, Hong Kong, Japan, Philippines, Russia, South Korea, and Taiwan.

Much of the park, especially the Asan Beach and Agat Units is at or near sea level, and is readily accessible by motor vehicles, foot, or boat, Access to the remaining units is by motor vehicle and foot. Owing to the steeper terrain, much of Mt. Alifan and Mt. Chachao-Mt. Tenjo are the least accessible.

Table 1. Annual visitation to War in the Pacific NHP's Visitor Center between 1985–2016 (NPS Data)

Year	Number of Visitors
1985	8,623
1986	51,567
1987	55,914
1988	48,427
1989	57,404
1990	61,166
1991	59,950
1992	58,287
1993	69,835
1994	112,367
1995	125,806
1996	133,220
1997	124,455
1998	134,067
1999	138,575
2000	155,789
2001	149,865
2002	152,881
2003	1,698
2004	11,832
2005	30,332
2006	40,005
2007	209,661
2008	187,005
2009	271,608
2010	219,349
2011	482,391
2012	255,923
2013	266,267
2014	266,191
2015	322,463
2016	488,988
2017	50,354
2018	37,242
2019	13,939 [A]
Total	**4,844,823**

[A] denotes data from January–May 2019. Data for 2020–2021 not available.

2.2 Natural Resources

2.2.1 Ecological Zones

Three ecological zones within the War in the Pacific NHP were identified for the NRCA: terrestrial, aquatic, and marine:

Terrestrial: Terrestrial ecosystems have topographical features that include mountains, hills, caves, cliffs, plateaus and coastal flatlands that are distributed variously within the Park's units. Vegetation is a mix of coastal strand and scrub (Asan Beach and Agat units, only), grasslands, and forests that include both native and non-native species (NPS 1997).

Aquatic: Aquatic habitats within the park consist of perennial and intermittent streams, and wetlands (NPS 1997; B. Tibbatts, Guam Division of Aquatic and Wildlife Resources, unpublished data). They are found in all units except the Mt. Chachao-Mt. Tenjo Unit. Most streams are relative short in length and small in width, with only the Namo and Asan rivers being of any significance. The wetlands are largely palustrine and adjacent to streams.

Marine: Marine habitats and organisms are found only in the Asan Beach and Agat Units (Figure 5). The marine zone consists of shore and nearshore habitats. The shore habitat is defined as the area between the edge of the strand vegetation and coastal scrub down to the mean high-water mark (MHW). This habitat consists primarily of sand, coral rubble, and in some cases the remains of concrete structures built on the shore or the inner reef flat. The near-shore habitat is defined as being from the shoreline to 100 meters seaward. This habitat consists of the reef flat, reef terrace, reef slope and deep sand flats at the bottom of the reef slope (ca. > 25–30 meters) that extend outward past the 100-meter depth (Figure 6). Within these habitats the benthic structure consists of a mixture of sand, coral rubble, boulders, benthic algae, seagrass, and corals depending upon location (Burdick 2005).

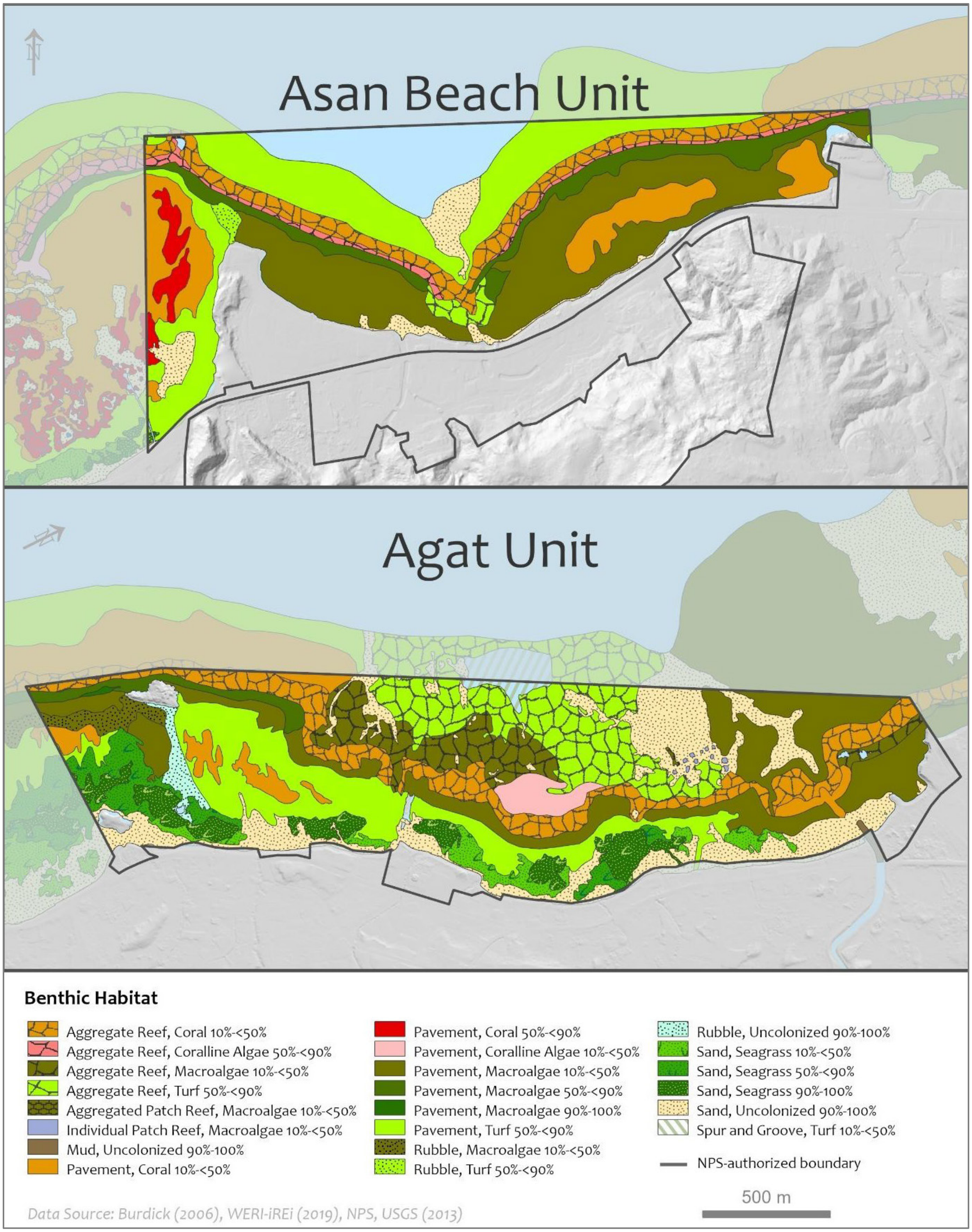


Figure 5. Marine benthic habitats of the Asan Beach and Agat Units. Data Source: Burdick (2006), WERI-iREi (2019), NPS, USGS (2013).

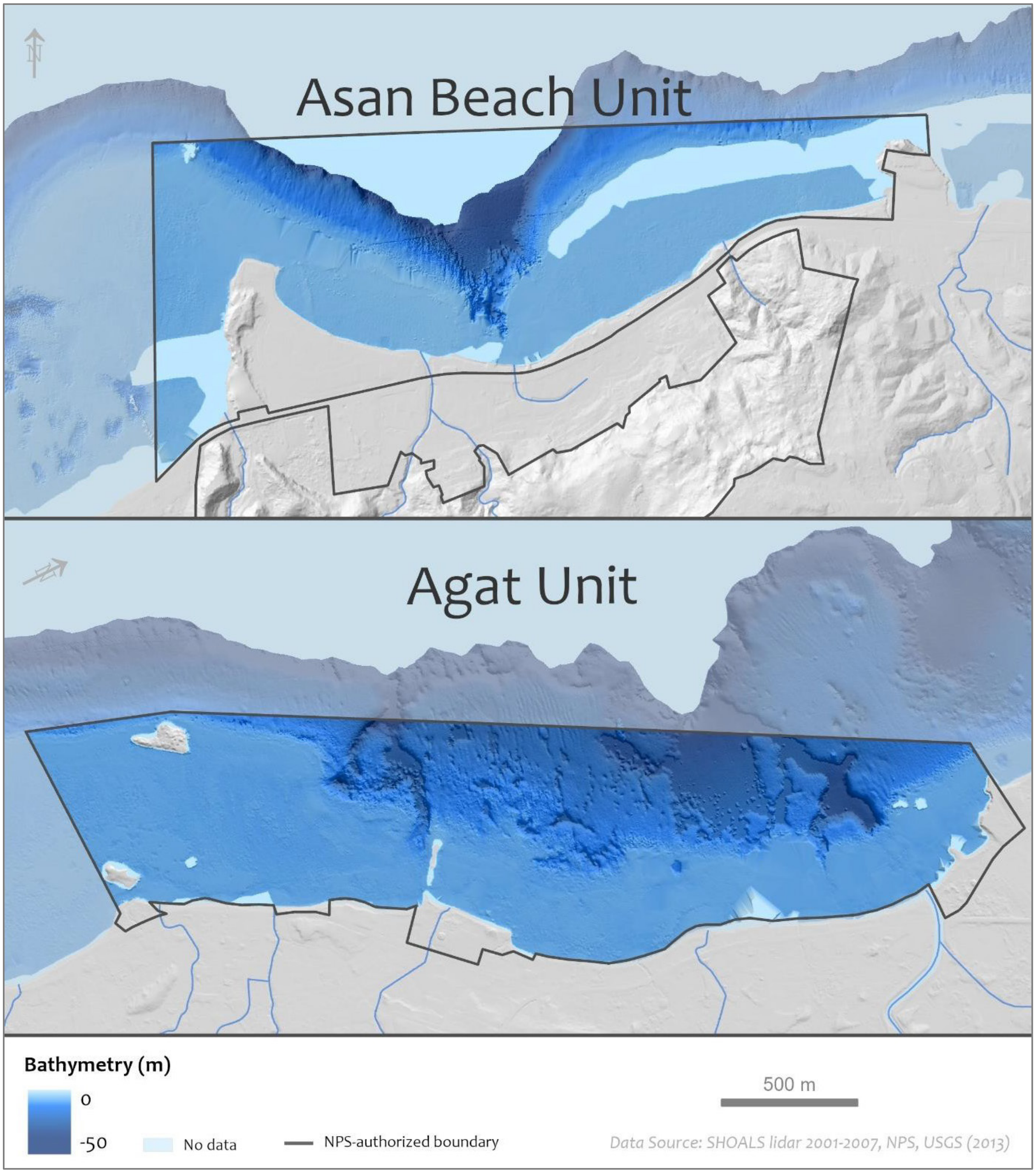


Figure 6. Inshore bathymetry of the Asan Beach and Agat Units. Data Source: SHOALS lidar 2001-2007, NPS, USGS (2013)

Special Historical Areas

Apple (1980) and Thornberry-Ehrlich (2012) provided historical overviews of Guam that are relevant to the establishment of the War in the Pacific NHP. The Park's historical areas include beachheads established during the U.S, invasion to retake the island from occupying Japanese forces on July 21,

1944. These beachheads are located in the Asan Beach Unit and the Agat Unit. The boundaries of these beachheads extend inland as far as Guam Route 1 in Asan and Guam Route 2 in Agat. In both units, the beachheads extend at least 100m from the shore to the reef.

In addition to the two beachheads, the park's Asan Beach and Asan Inland Unit also have battlegrounds of significance (see Apple 1980; Thornberry-Ehrlich 2012) that include Chorrito Cliff, Bundschu Ridge and Nimitz Hill. These areas were fortified heavily by the Japanese. Defensive structures that have survived and are now maintained in this unit include two concrete pillboxes and an unfinished 100 mm (4-inch) artillery battery. Other units within the Park have former command posts, military works, or battlegrounds of significance. For example, a second artillery battery is located within the Piti Guns Unit, the Fonte Plateau unit preserves another battleground and is the site of a war memorial, and mountain units also have battlegrounds that are less well-defined.

Safety Issues in the Special Historical Areas

Of considerable interest from both historical and safety points of view are data describing unexploded and spent ordnance within the park's boundaries (Figure 7), especially the U.S. military landing sites in the Asan Beach and Agat units. Minton et al. (2006) conducted a survey of the Asan Beach Unit and recorded the type, distribution, and abundance of unexploded and spent ordnance observed in Asan Bay. Both forms of ordnance were found on the reef flat, reef terrace, and reef slope, particularly near Camel Rock (Figure 8). In 2009 the Naval Facilities Engineering Command, Pacific conducted a shallow reef survey at Asan Beach Unit for unexploded ordnance (Figure 9). In 2014, NPS contracted GSI Pacific to do a Focused Site Investigation to assess the risks to the environment and to human health of the over sixty tons of unexploded ordnance (UXO) dumped by the Navy near Camel Rock. The study documented that there are no risks to human health or the environment from chemicals released from the UXO.

Unexploded ordinance poses a threat to Park users because of the unstable nature of the explosives contained within. Scuba divers, snorkelers and hikers in battleground areas may encounter UXO more easily than users in areas of the park that are utilized more heavily or are tended by park staff more frequently because it is more likely that UXO would have been discovered and removed previously. Naturally, visitors, researchers, and park employees should exercise extreme caution should they encounter unexploded ordnance, and the location of this ordnance should be reported to the Park's authorities immediately.

The effects of combat and post-combat activities upon physical and biological resources within the Park has been summarized (i.e., Thornberry-Ehrlich 2012) but has not been documented formally. Minton (no date) produced a visual presentation describing the effects of World War II on Guam's environment but no quantitative study has been conducted.

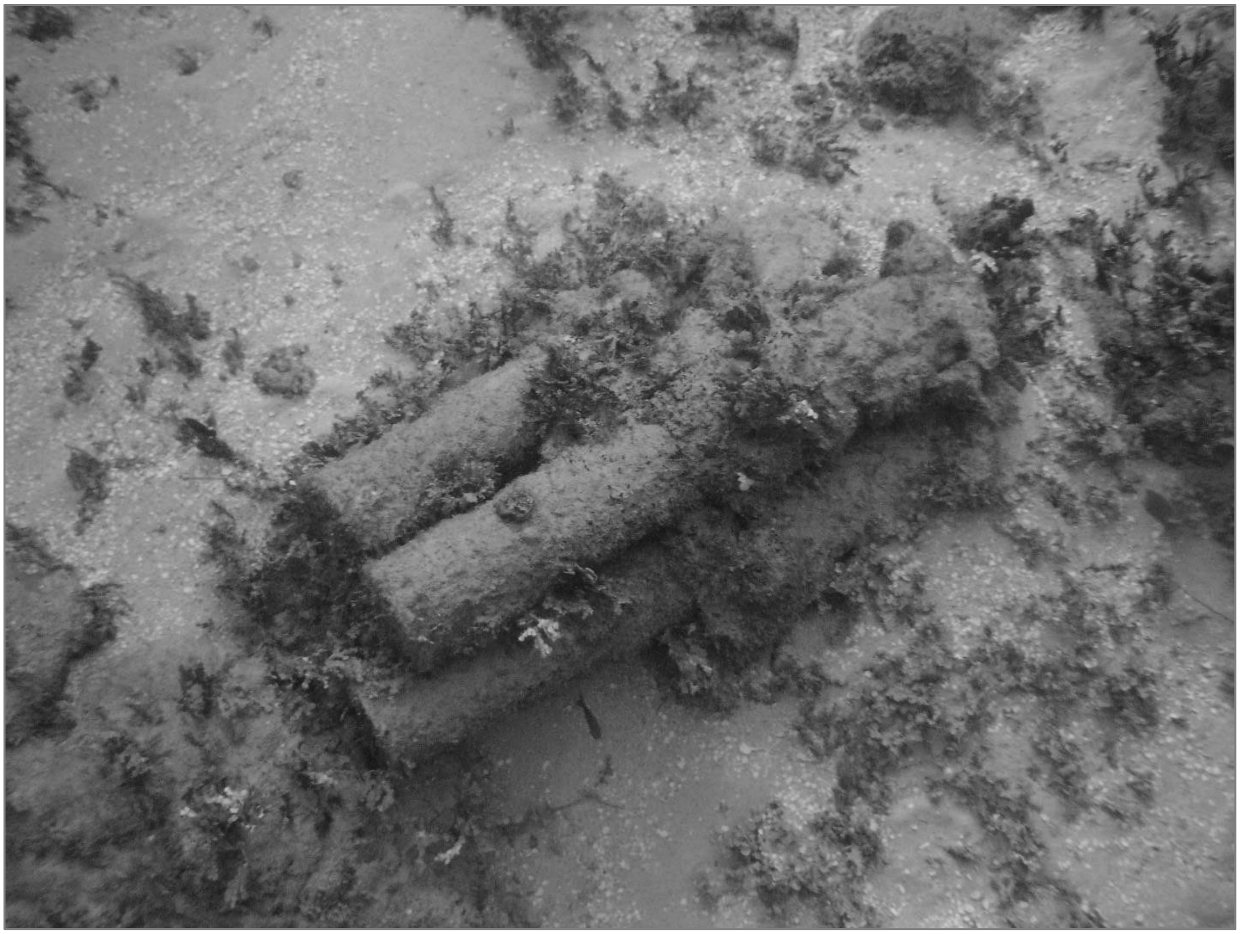


Figure 7. Example of World War Two ordinance found in waters of the Asan Beach Unit. Photograph from Minton et al. (2006).

Figure 8. Distribution of unexploded ordnance (UXO) on the reef flat and upper reef terrace of the Asan Beach Unit (after Minton et al. 2006).

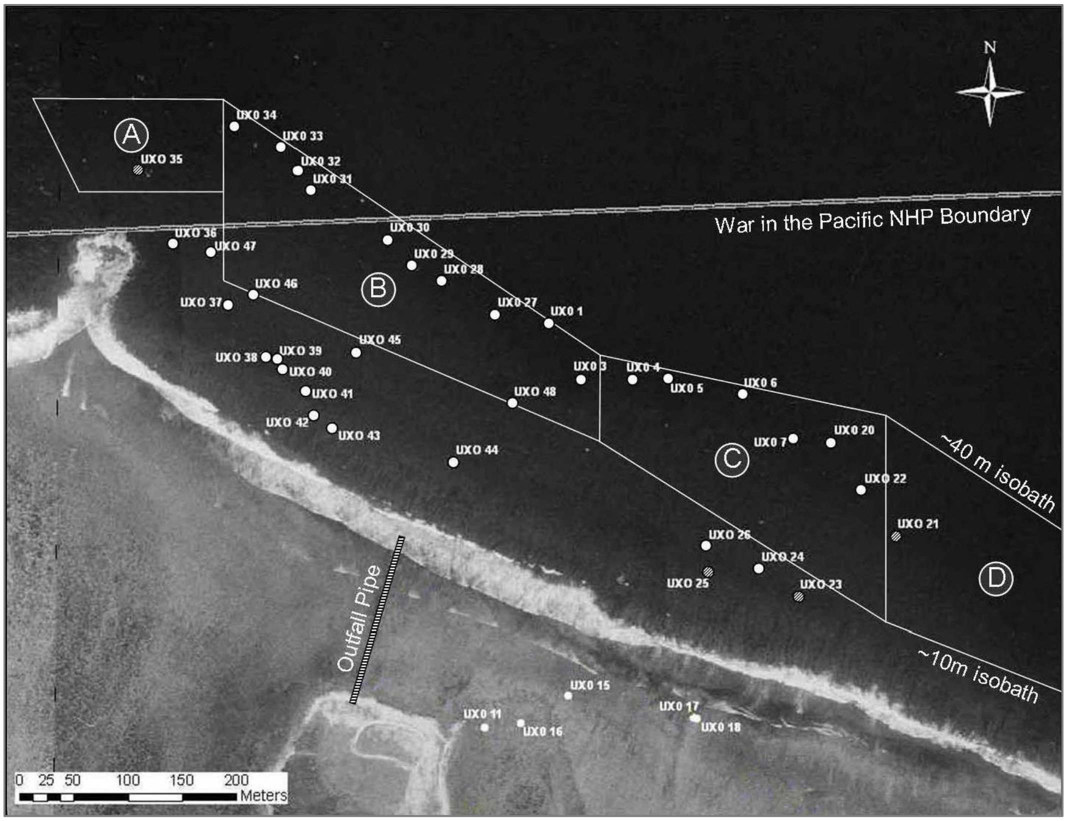


Figure 9. Distribution of UXO on the outer reef flat, and inner and outer reef terrace at the Asan Beach Unit. Hatched points at UXO 21, 23, 25 and 35 indicate where a U.S. Department of the Navy survey found UXO in 1979, but no longer had UXO present in 2006 (after Minton et al. 2006).

<u>Visitor Center</u>

The War in the Pacific NHP is serviced by a visitor center and by administrative offices. The T. Stell Newman Visitor Center, named in honor of T. Stell Newman, the first superintendent of the War in the Pacific NHP, is located on Guam Route 1 just outside the gates of Navy Base Guam in Santa Rita on Department of Defense property (Figure 10). The Visitor Center includes numerous multilingual educational displays, war relics (including a Japanese midget submarine located outside the front of the Visitor Center), a museum and artifact depository, an auditorium, and a bookstore. The auditorium is used for lectures and special events. Thus, the Visitor Center provides significant outreach for informing the public about the Park's natural, cultural and historical resources.

Figure 10. The T. Stell Newman Visitor Center, War in the Pacific National Historical Park, Guam. (Photo by T.J. Donaldson)

2.2.2 Ecosystems and Resource Descriptions

Previously, Thompson (1985), the War in the Pacific NHP (1997, 2003) and Daniel (2006) provided assessments of important geological and biological natural resources found within the War in the Pacific NHP. This new assessment provides a useful background for further expanding our knowledge of the natural resources found in this unique park. Descriptions of valued resources found in terrestrial, aquatic, and marine ecosystems are given below.

<u>Terrestrial Ecosystems</u>

Habitats present within the park are variable and include exposed reef and tidal pools, forests and scrub/shrub, grasslands, bare lands, wetlands, and developed lands. Their distribution among the park's units also varies depending upon location, geology, elevation, watershed complexity and other factors. NPS recognizes six different ecological zones within the park. These include shore and nearshore areas (comprised of reefs, tidal pools, and open sea), wetland, bare land, grassland, scrub-shrub-forest, and developed land. The distribution is given in Figure 11. Wetland and shore and nearshore zones dominate both Asan Beach and Agat units. The Fonte Plateau Unit is dominated by the scrub-shrub-forest zone. This zone and the grassland zone together dominate the Asan Inland, Piti Guns, and Mt. Alifan units. Grassland is dominant in the Mt. Chachao-Mt. Tenjo Unit.

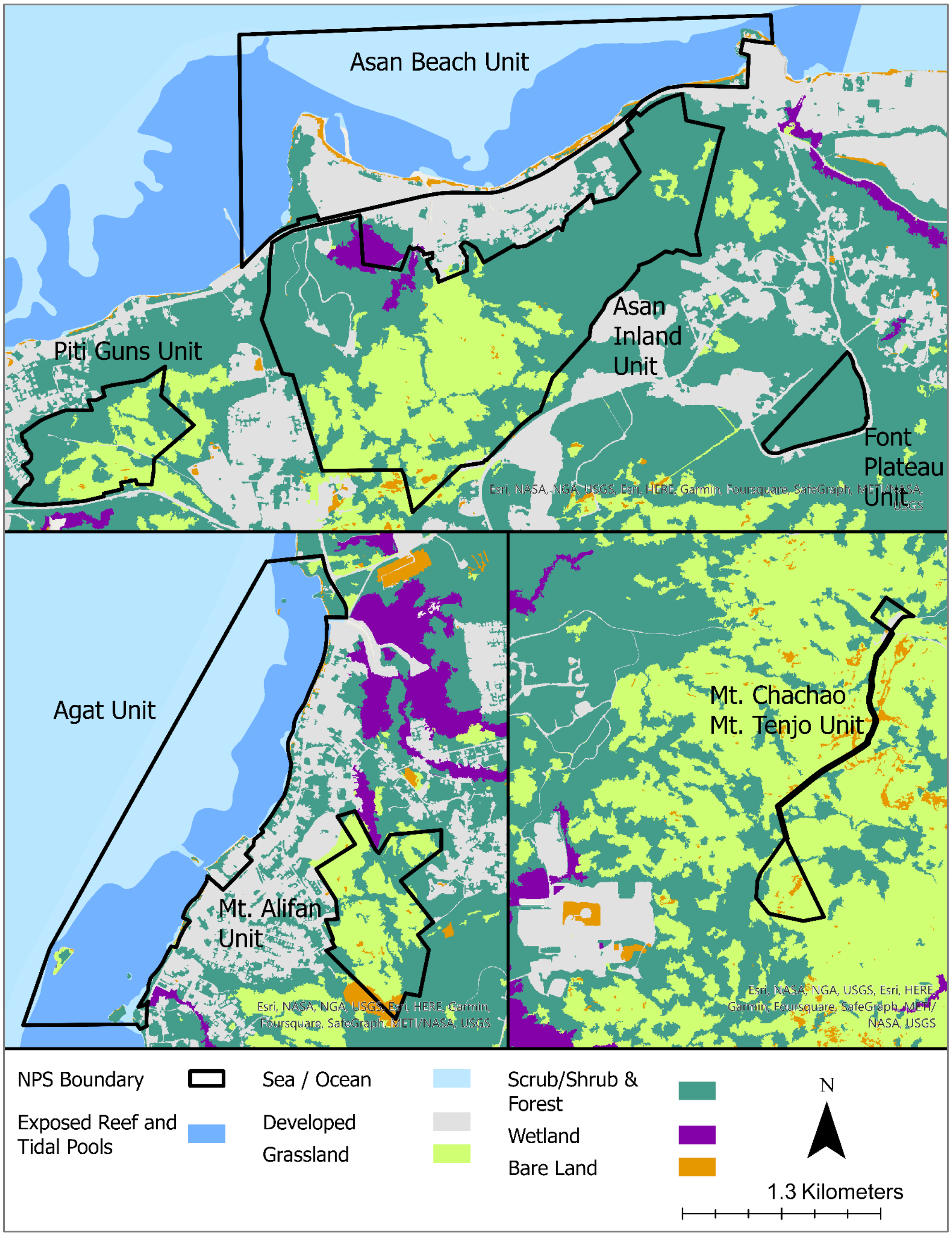


Figure 11. Ecological zonation of the War in the Pacific NHP (note that the Guatali parcel is not shown). Data sources include Cogan et al. (2014) and USGS NLCD (2016). Figure Credit: NPS.

Land cover within the park is subdivided into different habitat types. These range from forests, different forms of wetlands to shore (reef & pools) and water (Figure 12). The Asan Beach Unit consists mainly of water, shore and forest. The Asan Inland Unit is dominated by forest and grasslands, but also has patches of palustrine scrub-shrub and palustrine emergent wetlands. The

Fonte Plateau Unit is largely forest. Grassland dominates the Mt. Chachao-Mt. Tenjo, and Mt. Alifan, units. Grassland is slightly more dominant than forest in the Piti Guns Unit.

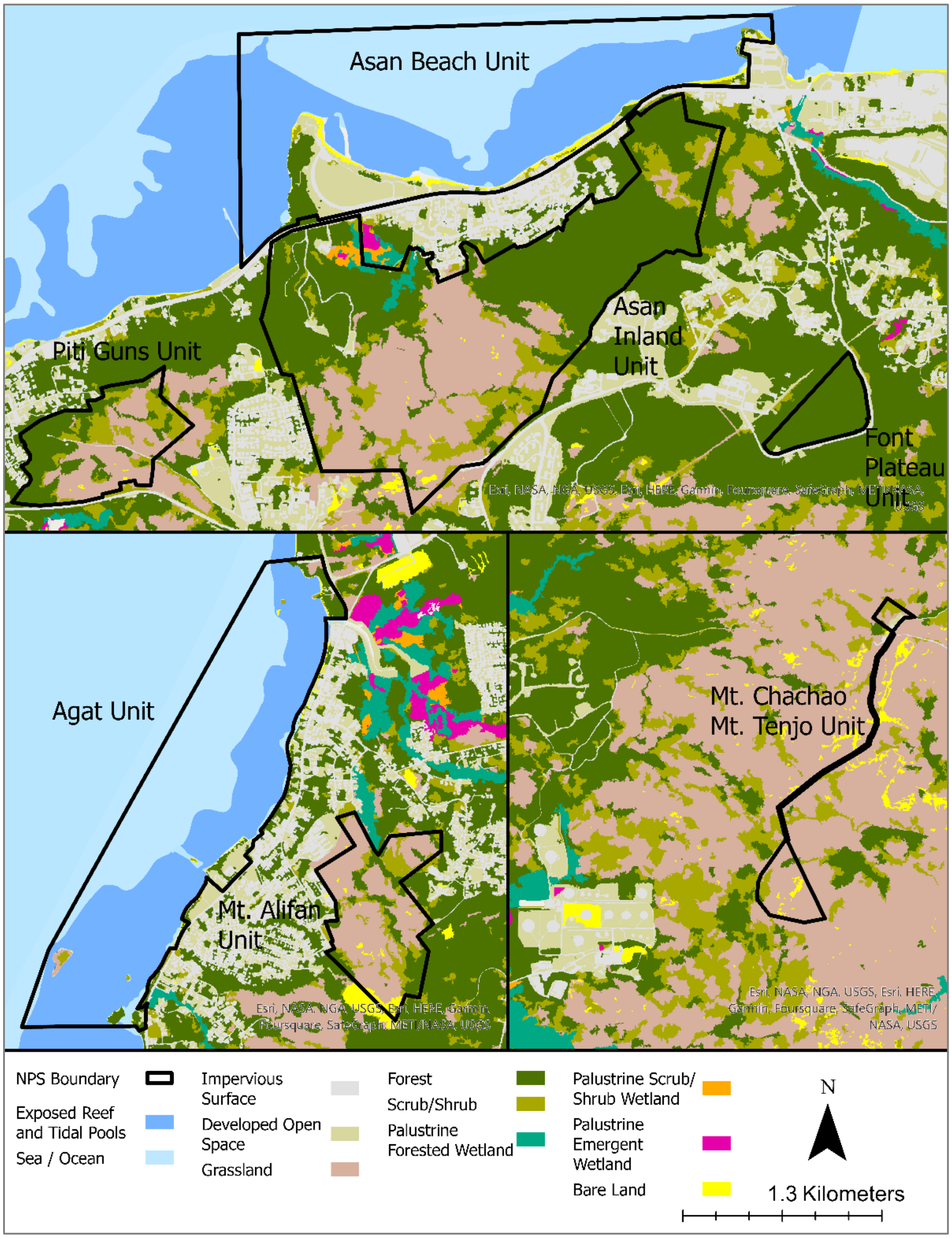


Figure 12. Distribution of different land cover types within the War in the Pacific NHP. (note that the Guatali parcel is not shown). Data sources include Cogan et al. (2014) and USGS NLCD (2016). Figure Credit: NPS.

Among scrub and forested lands (Figure 13), forests are most dominant in the Fonte Plateau and Asan Inland units, and slightly more so in the Piti Guns and Mt. Alifan units. Both habitat types are nearly equivalent in distribution in the Guatali Parcel, while scrub is more dominant in the Mt. Chachao-Mt. Tenjo Unit.

Grasslands are most significant in units such as Mt. Chachao-Mt. Tenjo and Mt. Alifan units, as well as the Guatali Parcel, less so but still important in the Asan Inland and Piti Guns units, and are absent from the Fonte Plateau and Asan Beach units (Figure 14). Bare lands, which include exposed bedrock, "badlands", and frequently burned areas, are found primarily in the Mt. Alifan and Mt. Chachao-Mt. Tenjo units, with small patches occurring in the Asan Inland Unit and narrow patches (mainly bedrock) along beaches in the Asan Beach and Agat units (Figure 15). Wetlands (Figure 16) are sparsely distributed throughout the park, with patches of palustrine forested and palustrine scrub-shrub wetlands present in the Asan Inland Unit (although a patch of palustrine emergent wetland sits on the other side of the park border across from these other types of wetlands). The southern border area of the Guatali Parcel where the Paulana River converges with two intermittent streams is dominated by palustrine forested wetland. All three kinds of wetlands are present along the Namo River upstream of the Agat Unit boundary. Developed lands sit largely in the Asan Beach and Agat units in areas utilized by visitors to the beaches found there. A small patch of developed land is found in the Mt. Chachao portion of the Mt. Chachao-Mt. Tenjo unit. Very significant patches of developed land are found adjacent to park boundaries of the Agat, Asan Inland, Piti Guns, and Mt. Alifan units, as well as the middle section of the Guatali Parcel. Developed land is a very minor part of the Fonte Plateau Unit, and developed areas adjacent to the unit's borders are relatively insignificant (Figure 17).

Changes in land cover between 2005 and 2016 (Figure 18) show modest increases in forest and grassland in all units except for the Fonte Plateau, gains in wetland cover in the Asan Inland Unit, and increases in bare lands in the Mt. Alifan Unit. No changes were recorded in the Fonte Plateau Unit, which remained largely forested, and most land cover in the other units remained unchanged as well.

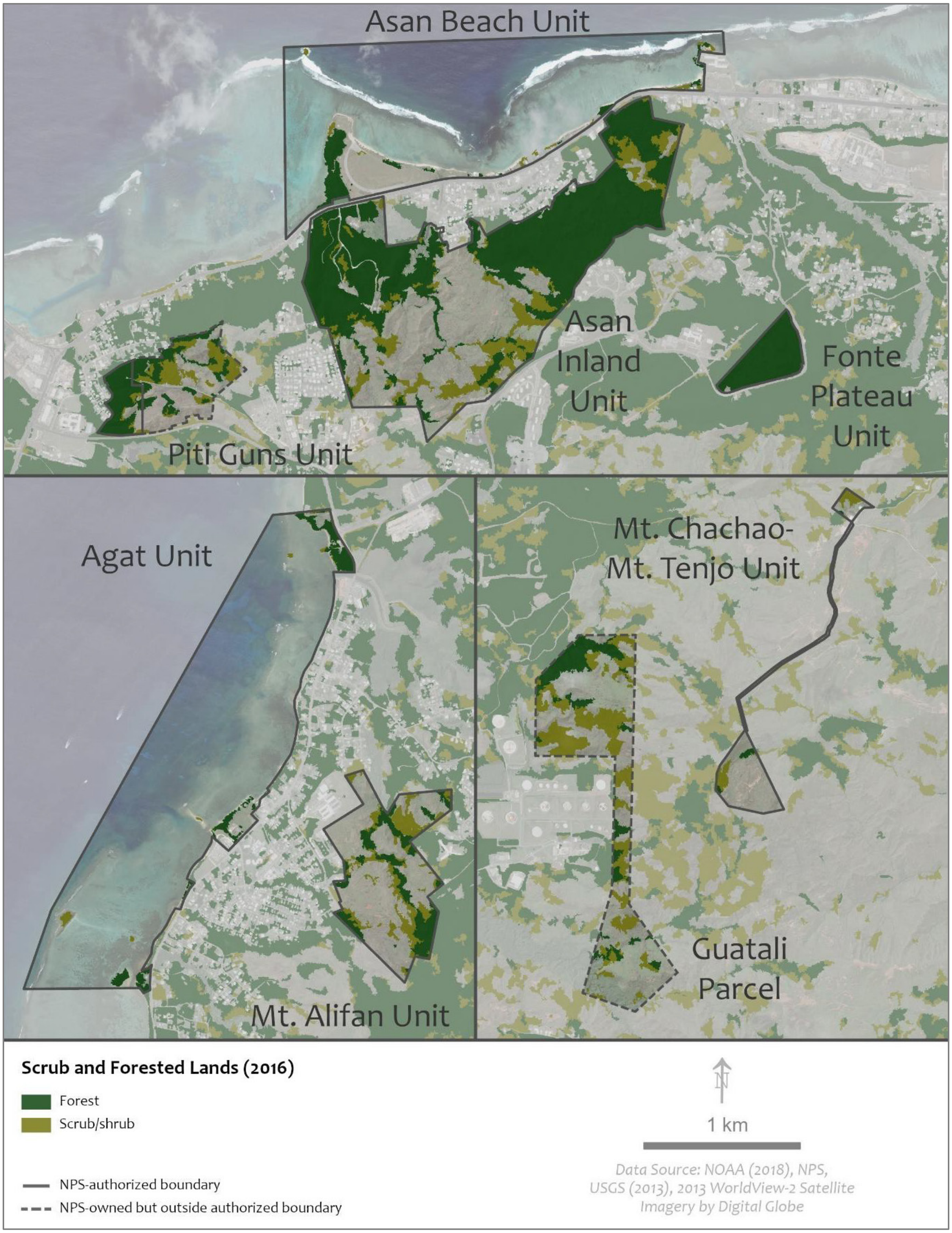


Figure 13. Distribution of forest and scrub land cover in the War in the Pacific NHP. Data Source: NOAA (2018), NPS, USGS (2013), 2013 WorldView-2 Satellite Imagery by Digital Globe.

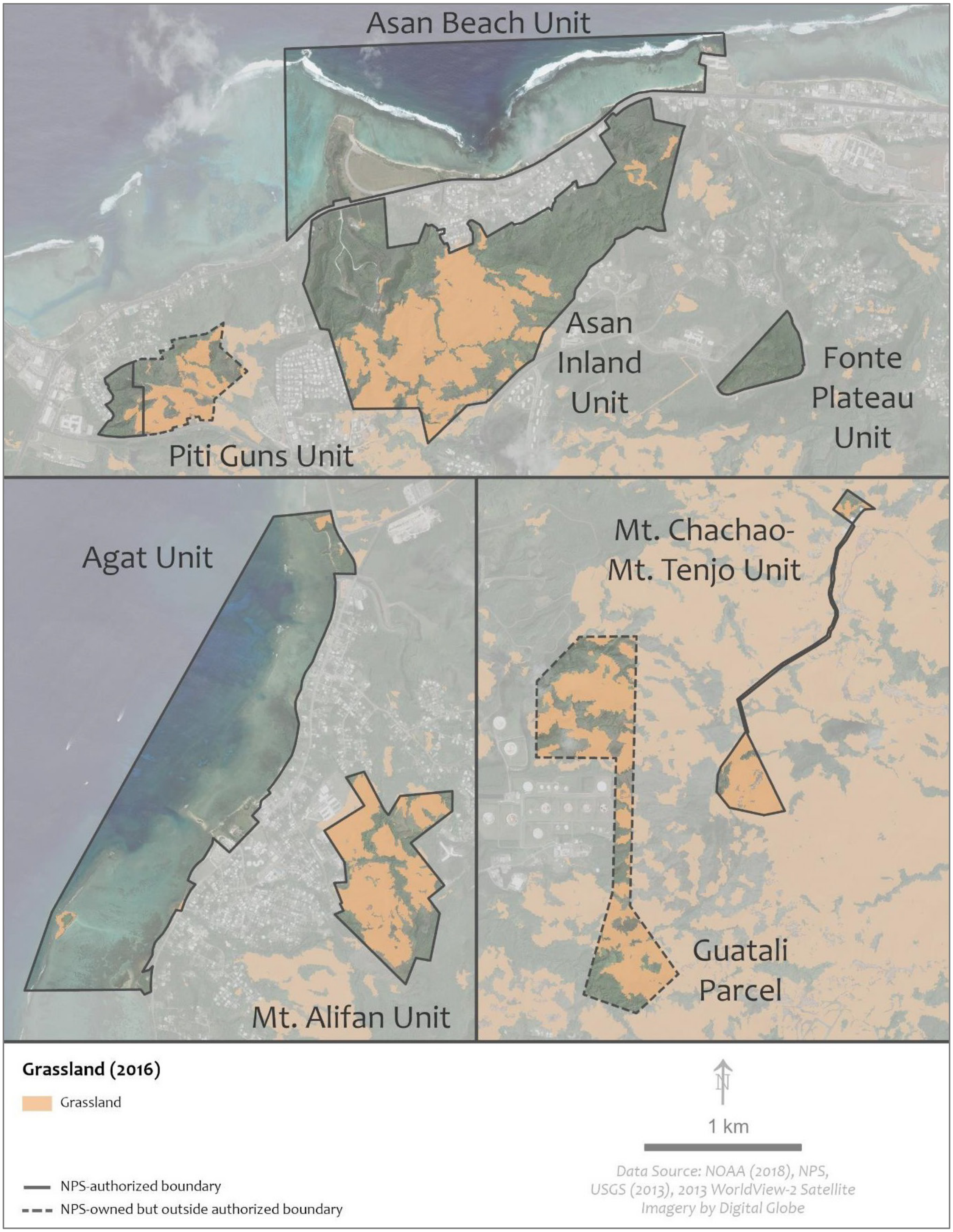


Figure 14. Distribution of grassland coverage in the War in the Pacific NHP. Data Source: NOAA (2018), NPS, USGS (2013), 2013 WorldView-2 Satellite Imagery by Digital Globe.

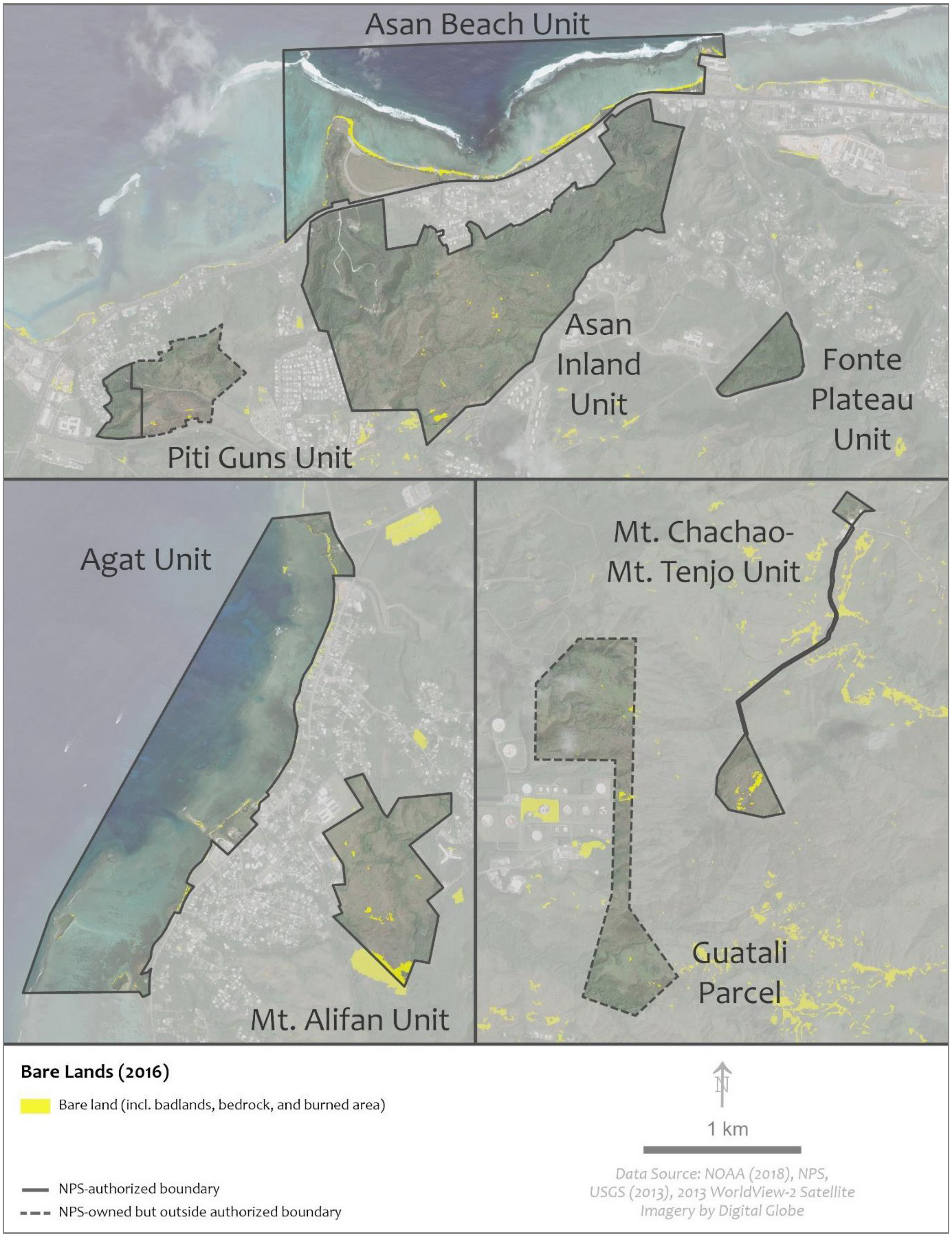


Figure 15. Distribution of bare land cover in the War in the Pacific NHP. Data Source: NOAA (2018), NPS, USGS (2013) 2013 WorldView-2 Satellite Imagery by Digital Globe.

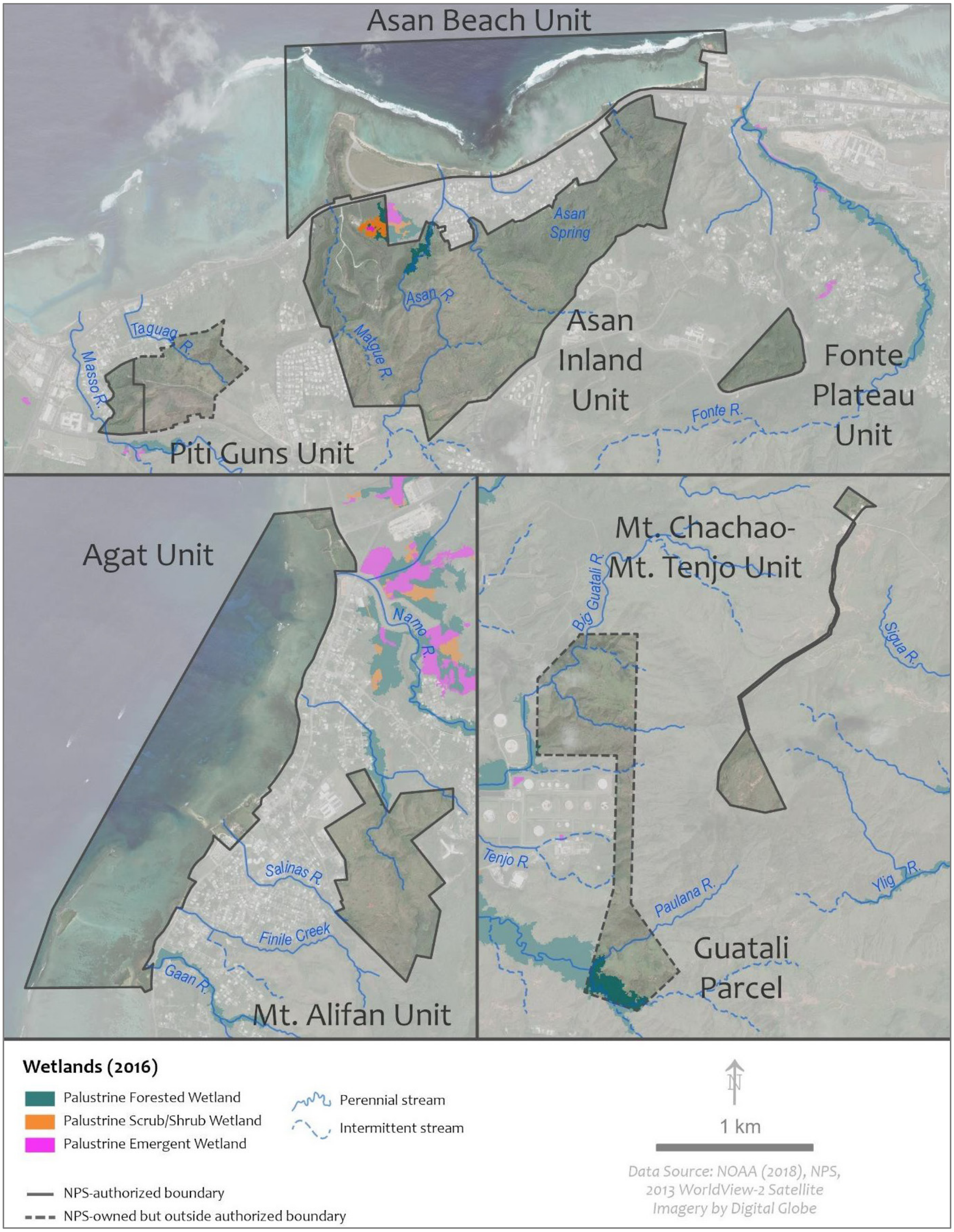


Figure 16. Distribution of wetlands in the War in the Pacific NHP. Data Source: NOAA (2018), NPS, 2013 WorldView-2 Satellite Imagery by Digital Globe.

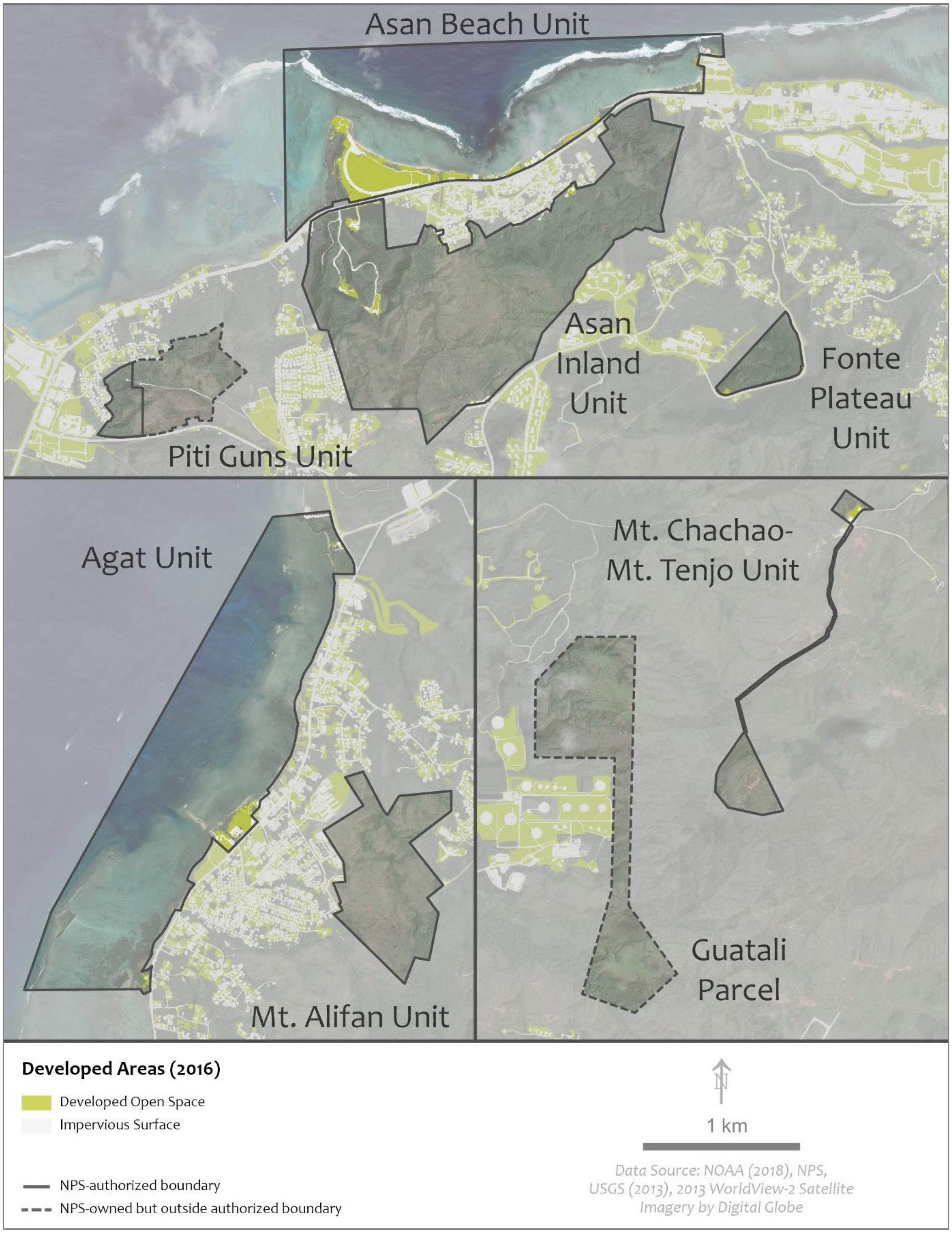


Figure 17. Distribution of developed land in the War in the Pacific NHP. Data Source: NOAA (2018), NPS, USGS (2013), 2013 WorldView-2 Satellite Imagery by Digital Globe.

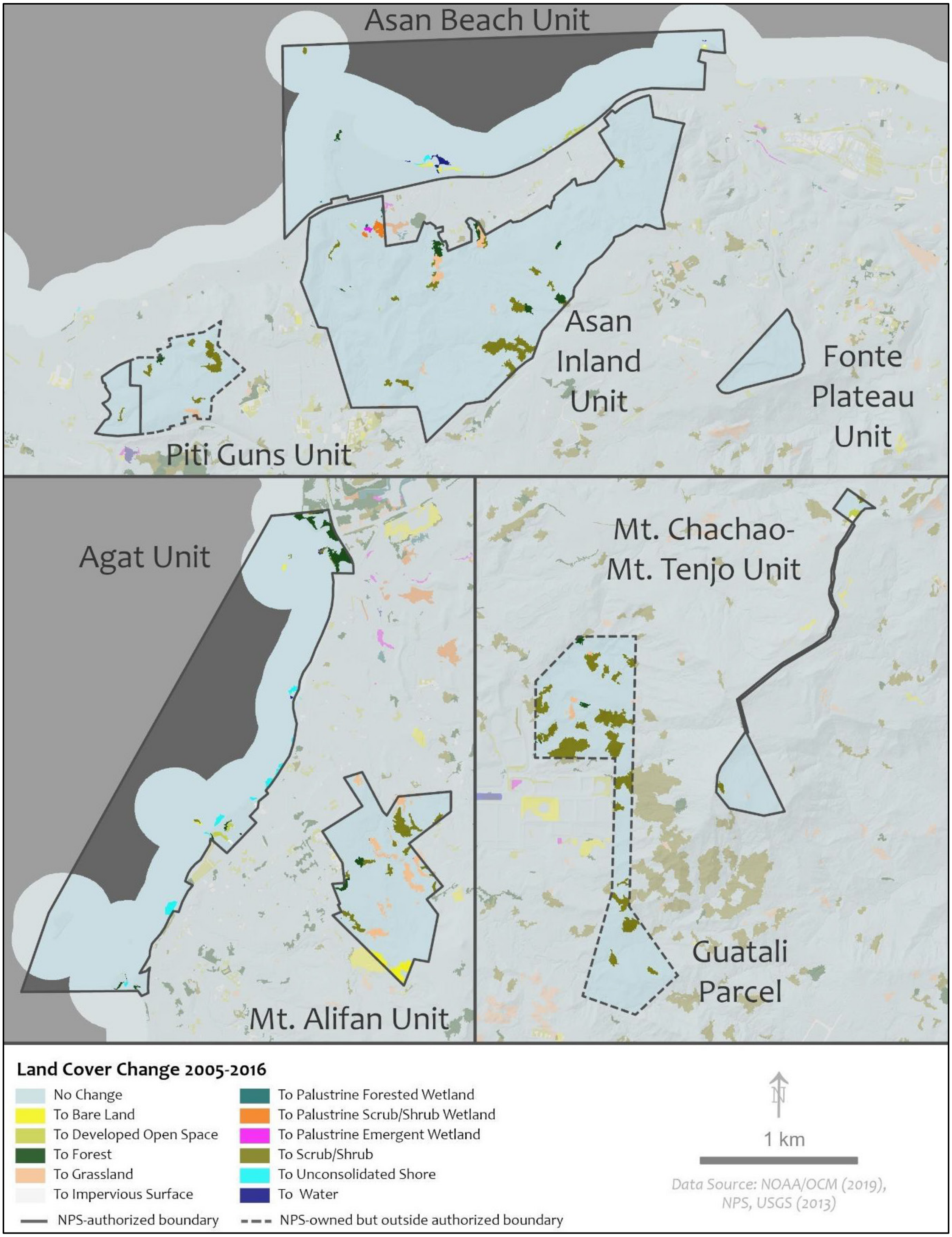


Figure 18. Change in land coverage in the War in the Pacific NHP between 2005–2016. Data Source: NOAA/OCM (2019), NPS, USGS (2013).

Physical Resources

Geology

The island of Guam has been characterized by Tracey et al. (1959, 1964) has having three principal provinces, termed northern, central, and southern. Each was characterized by different geologic units, structures, and processes. Within these three provinces, the land surface is divided into four main categories: limestone plateau, dissected volcanic uplands, interior basin, and coastal lowland and valley floors (Thornberry-Ehrlich 2012). Principal rock types found include volcanic rock and limestone. Volcanic rocks dominate the southern end of Guam and are, for the most part, older. The distribution of limestone rocks indicate deposition in a marine environment defined by fluctuations in sea levels over time. Tracey et al. (1964b) mapped the distribution of both kinds of rocks. Siegrist and Reagan (2008) also contributed to the identification and distribution of rock types. The terminology used in this map was updated by Siegrist et al. (2007), who also provided updated stratigraphic interpretations of the geologic sections identified.

Thornberry-Ehrlich (2012) also provided a glossary of geological terms. The most recent map (Figure 19) includes data from Taborosi et al. (2004), Siegrist and Reagan (2008), NPS and the U.S. Geological Survey (2013), and WERI-IREI (2019).

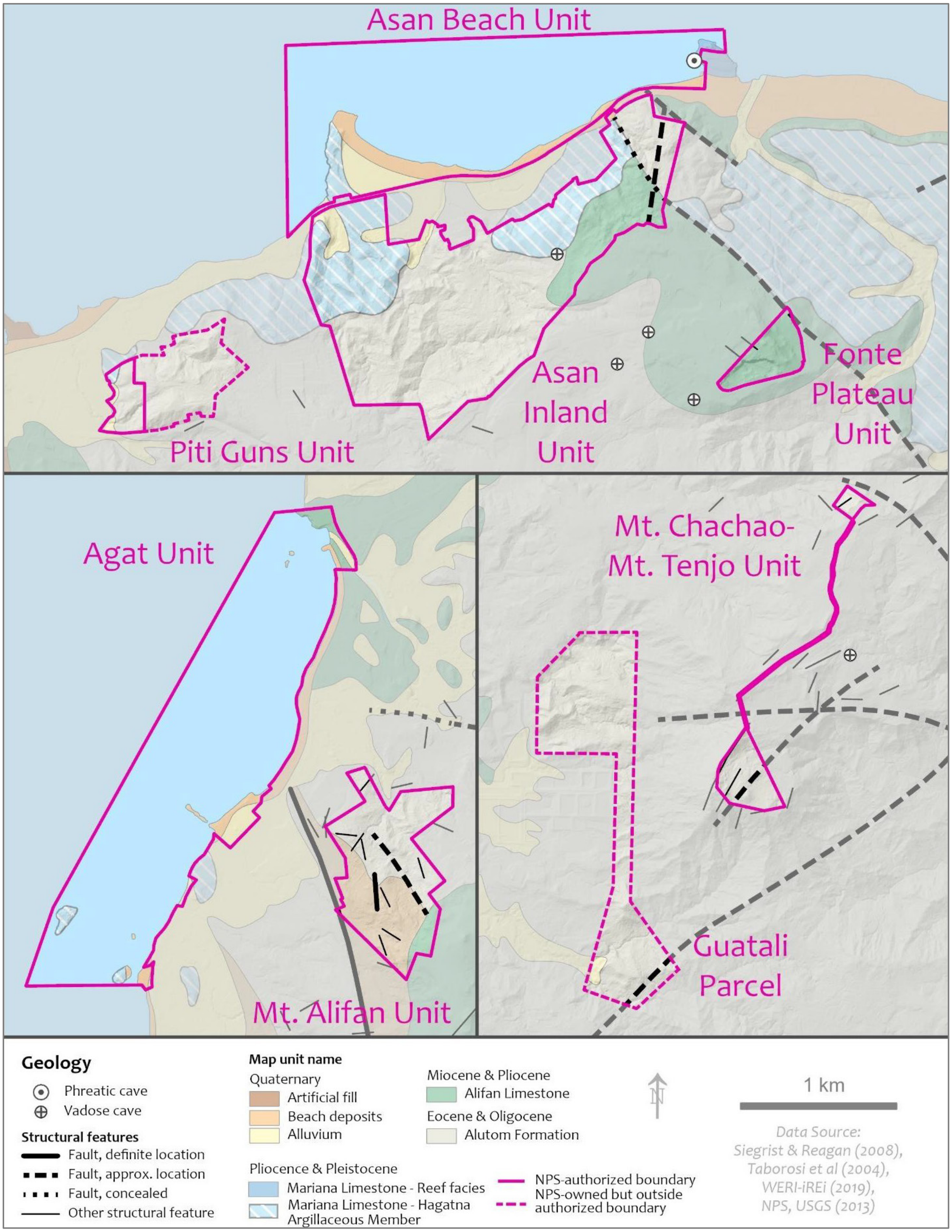


Figure 19. Geological map of the War in the Pacific NHP. Data Source: Siegrist and Reagan (2008), Taborosi et al. (2004), WERI-iREi (2019), NPS, USGS (2013).

Geological Features

Thornberry-Ehrlich (2012) provided a detailed description of principal geological features found in the War in the Pacific NHP. These are summarized here.

Karst

Karst is found in both coastal and inland units of the park where limestones are present. Karst is produced by geomorphic processes, mainly the chemical erosion and weathering of carbonate rocks such as limestone (Palmer 1984). The various limestones found on Guam have a variety of karstal features that result from the various ways in which carbonate rock may be dissolved by lower pH water (see Table 1 in Thornberry-Ehrlich 2012). Taberosi (1999) and Taberosi et al. (2004) describe such features as karren, runnels, epikarst, enclosed-contour depressions, subsurface caves, and coastal discharges. Karren is the creation of channels or furrows by the dissolution of massive, bare limestone surfaces by contact with rainwater. Runnels are channels eroded in the limestone by a small stream. Epikarst is formed when dissolution of limestone extends downward toward bedrock but is usually only to a shallow depth (Taborosi 1999). Features found in epikarst include localized cavernous weathering, shafts, soil pipes, pits and tunnels (Taborosi et al. 2004).

Along coastlines, epikarst results from the dissolution of limestone by a spray of marine waters (from wave action) that mixes with rainwater to create irregular, jagged surfaces (Taborosi et al. 2004). Closed-contour depressions occur where freshwater discharges diffusely through porous limestone over a limited area and remove underlying material (rock and/or soil), thus undermining the foundation for surficial rock or soil (Mylroie et al. 2001). The resulting "collapse" creates a depression. Examples include large cockpit karst sinkholes (deep closed depressions separated by narrow limestone ridges), point recharge sinkholes, collapse sinkholes, and blind valleys (Thornberry-Ehrlich 2012). Although not well studied within the park subsurface, caves are present and arise when acidic water dissolves significant amounts of subsurface limestone. Flank margin caves (created by wave action on coasts), stream caves (containing flowing water running through subterranean tunnels), and pit caves (vertical shafts) all form from this action (Taborosi 1999). Coastal discharge karst also occurs as water flows through limestone and is discharged directly into the sea as runoff or springs (Thornberry-Ehrlich 2012).

Other forms of karst are also present within the park. "Macabre" is a particularly noticeable karst feature found in the northern third of the Asan Inland unit under carpets of moss (Thornberry-Ehrlich 2012). Island karst results from freshwater-saltwater mixing, but is also influenced by changes in sea-level, freshwater recharge inputs, and the burial depth of the limestone undergoing karstic processes. Coastal karst may also arise from biogenic effects upon limestones. For example, notches in karst may be formed from erosion caused by mollusks, such as limpets and chitons, and by crustaceans, such as boring barnacles (Thornberry-Ehrlich 2012). Decaying plant material, plant roots, and cyanobacteria films also produce carbon dioxide that, when mixed with standing water, creates an acidic solution that dissolves limestone and creates karst.

Tectonic Features

Guam and the other Mariana Islands are located within the Pacific Ocean's "Ring of Fire" in which tectonic forces acting upon oceanic plates drive volcanic and seismic activity within these islands.

The islands form an arc consisting of a curved line of volcanoes that originate on the ocean floor and are powered by molten material created during subduction. Facpi volcanics, the oldest volcanic rocks on Guam, erupted approximately 44 million years ago and that are responsible for some of the early phases of island-building volcanism within this group of islands. Facpi volcanics, which are pillow basalts with columnar joints, have been mapped in the Mt. Alifan unit. Explosive pyroclastic eruptions within the Alutom Formation deposited volcanic breccias in exposed portions of the Mt. Chachao-Mt. Tenjo, Agat, Piti Guns, and Asan Inland units (Thornberry-Ehrlich 2012). Exposed limestone of marine origin found at elevation within the park resulted from uplift driven, at least in part by earthquake activity (Thornberry-Ehrlich 2012). Hill and mountain slopes are often rugged and steep, especially those found in the Mt. Alifan, and Mt. Chachao-Mt. Tenjo units and the Guatali Parcel (Figure 20). Some are prone to habitat disturbance, and hence erosion, landslides, and other events (see Threats and Stressors, below).

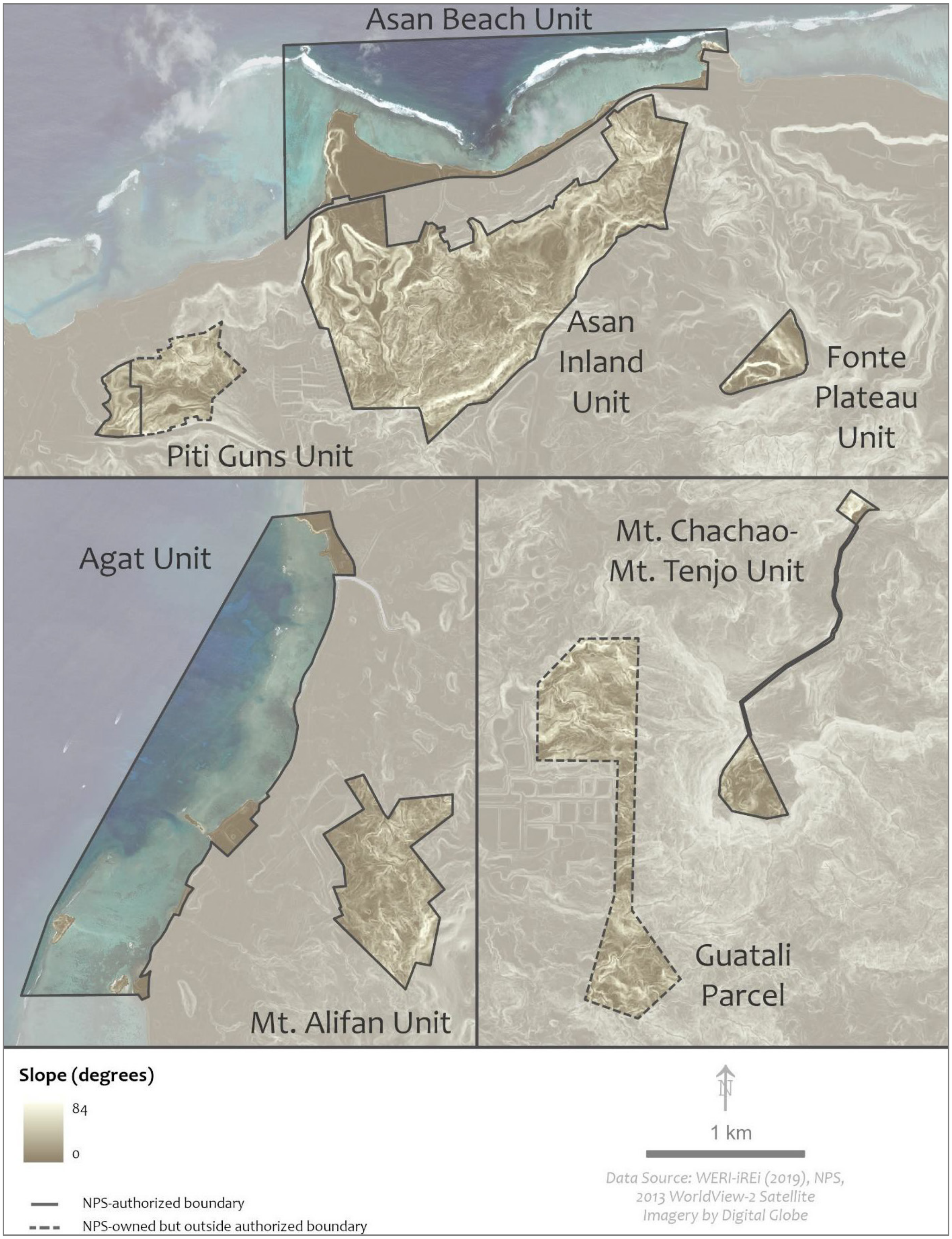


Figure 20. Sloping (degrees) of mountains and hills within the War in the Pacific NHP. Data Source: WERI-iREi (2019), NPS 2013 WorldView-2 Satellite Imagery by Digital Globe.

Limestone Forests

The War in the Pacific NHP has the only remnants of limestone forest found anywhere within the National Park System (Ainsworth 2010). Limestone forests support flora and fauna unique to Guam and the Mariana Islands and occur in different community subtypes (Daniel 2006, Hess and Pratt 2006). Limestone forests are relatively widespread within the park but are particularly important in the Asan Beach and Fonte Plateau units (Daniel 2006; Thornberry-Ehrlich 2012). The Asan Inland Unit has a limestone forest on a rocky slope along the unit's northern boundary, and another on a ridge along the southern boundary (Hess and Pratt 2006). Exposed Alifan Limestone in the Mt. Alifan Unit also supports limestone forest (Tracey et al. 1964, Yoshioka 2005, Hess and Pratt 2006). In the Agat Unit, native strand and limestone vegetation can be found along the beach at Ga'an Point (Thornberry-Ehrlich 2012).

Wetlands

Wetlands are defined as land with substrates that are seasonally or permanently saturated with water. These may be completely or partially covered by shallow, still pools of fresh, brackish, or saline water. Swamps, marshes, and bogs are all wetlands (Thornberry-Ehrlich 2012). The underlying geology of a given area with poor drainage may lead to the formation of wetland and these differ in structure and origin. Thus, wetlands may be palustrine (small, pond-like), lacustrine (larger, flooded, lake-like), riverine (channelized, river-like), estuarine (low-wave-energy, brackish-water tidal areas), or marine (tidal areas exposed to waves) (U.S. Fish and Wildlife Service criteria cited in Thornberry-Ehrlich 2012). Wetlands within the War in the Pacific NHP are discussed in greater detail, below.

Coastal Features

Coastlines are found in the Asan Beach and Agat units. Beaches comprised of coral sand are present in much of the park's coastline, but rocky or deltaic (near river outlets) areas also occur. The park's coral reefs are mainly fringing, although submerged patch reefs also occur in the Agat Unit with lagoonal flats occurring landward of the reef (Thornberry-Ehrlich 2012). The reefs extend an average of about 100 m (330 ft) offshore and then drop sharply in depth, usually with four submarine terraces found at mean depths of 17, 32, 59, and 96 m (55, 105, 195, and 315 ft) (Emery1964). Reef slopes are covered with coral. Cuts in the reef, especially in former stream channels now submerged, occur in both units. Ephemeral and perennial streams, as well as other discharge features such as springs, incise the reef flats (Emery 1964, Daniel 2006). Coastal features will be discussed in more detail, below.

Paleontological Features

While no formal paleontological survey has been conducted within the park (Thornberry-Ehrlich 2012), Hunt et al. (2007) provided a summary based upon existing literature that discussed known fossil deposits or their potential. Various limestone outcroppings within the park, as well as lava tubes and caves, have or could have fossils. Most known fossils are of marine invertebrate species. Vertebrate (reptiles, birds or mammals) fossils might be found in caves. Foraminifera, single-celled organisms that deposit calcium carbonate shells, might be the most common types of fossil present. At least 14 species of planktonic foraminifera have been recorded from outcrops of Alutom Formation limestone in the Asan Inland, Fonte Plateau, Mt. Chachao, Mt. Tenjo, and Piti Guns units of the park. Fossil forminifera has also been found in Mariana and Alifan limestone formations in the Asan Inland, Mt. Alifan, Asan Beach, and Agat units.

Mariana Limestone formations have a wide diversity of fossils, including reef organisms such as sea urchins, mollusks, foraminifera, and corals. The Alifan Limestone also contains foraminifera. Beaches within the Asan Beach and Agat Units yield fossil corals, mollusks, barnacles, crabs, shrimp, and ray teeth (Hunt et al. 2007). Calcareous algae fossils for 82 species have been described (Johnson 1964).

Soils

Soils of the War in the Pacific NHP were surveyed by the NPS and a map published in 1997. Since then, additional data from NPS (2013), NRCS (2009), and the University of Guam's Water and Environment Research Institute (WERI-iREi 2019) have led to greater understanding of the soil types present and their distribution (Figure 21). The principal soil types present in each unit are summarized as follows:

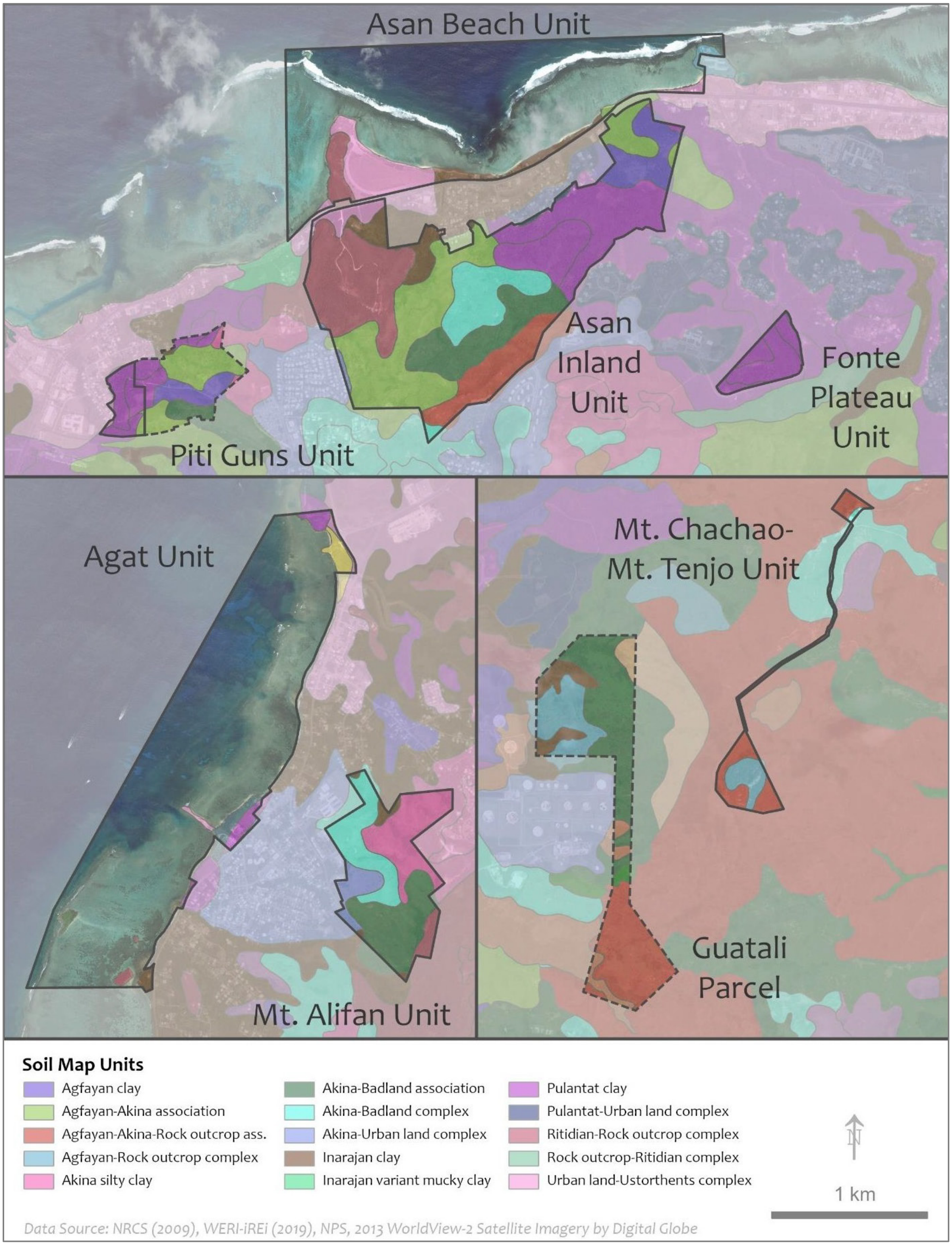


Figure 21. Distribution of soil types within the War in the Pacific NHP. Data Source: NRCS (2009), WERI-iREi (2019), NPS 2013 WorldView-2 Satellite Imagery by Digital Globe.

Asan Beach Soils

Two soil types dominate the Asan Beach Unit and are, in order of importance, Akina clay and Ritidian-Rock outcrop complex. Coral sand is found on the beach.

Asan Inland Soils

Nine soil types are found in the Asan Inland Unit. The most abundant soil is Agfayan-Akina association, followed by Ritidian-Rock outcrop complex, and Pulantat clay. The least abundant soil type is Pulantat-Urban land complex.

Piti Guns Soils

Eight soil types have been identified from the Piti Guns Unit. The most abundant soil is Agfayan-Akina association, followed by Agfayan clay and Akina-Badland association. The least abundant soil type is Inarajan clay.

Fonte Plateau Soils

One soil type in two formations occurs in the Fonte Plateau Unit. The soil type is Pulantat clay and is found primarily on slopes occurring there.

Mt. Chachao-Mt. Tenjo

Four soil types identified from the Mt. Chachao-Mt. Tenjo Unit. The most abundant soil is Agfayan-Akina-Rock outcrop association, followed by Agfayan-Rock outcrop complex and Akina-Badland complex. The least abundant soil type is Akina-Badland association.

Guatali Soils

In the Guatali Parcel, six soil types have been found, with the most abundant being Akina-Badland association, followed by Agfayan-Akina-Rock outcrop association and Agfayan-Rock outcrop complex. The least abundant soil type is Ritidian-Rock outcrop complex.

Mt. Alifan Soils

Six soil types identified from the Mt. Alifan Unit. The most abundant soil type is Akina-Badland association, followed by Akina silty clay and Akina-Badland complex. The least abundant soil type is Inarajan clay.

Agat Soils

Four soil types have been identified from the Agat Unit. The most abundant soil type is Pulantat clay, followed by Inarajan variant mucky clay and Inarajan clay. The least abundant soil type is Inarajan clay.

Generally, soils are well drained throughout much of the War in the Pacific NHP (Figure 22). This is true in elevated units with steep slopes, i.e., Fonte Plateau, Mt. Tenjo-Mt. Chachao, Mt. Alifan and the Guatali Parcel, but some portions of the latter two units bordering streams are poorly drained. Most of the Piti Guns, Asan Inland and Agat units also were well drained but poorly drained soils occur along the western borders of the first two and the eastern border of the third. The Agat Unit also has soils in areas bordering the beach that are somewhat excessively drained.

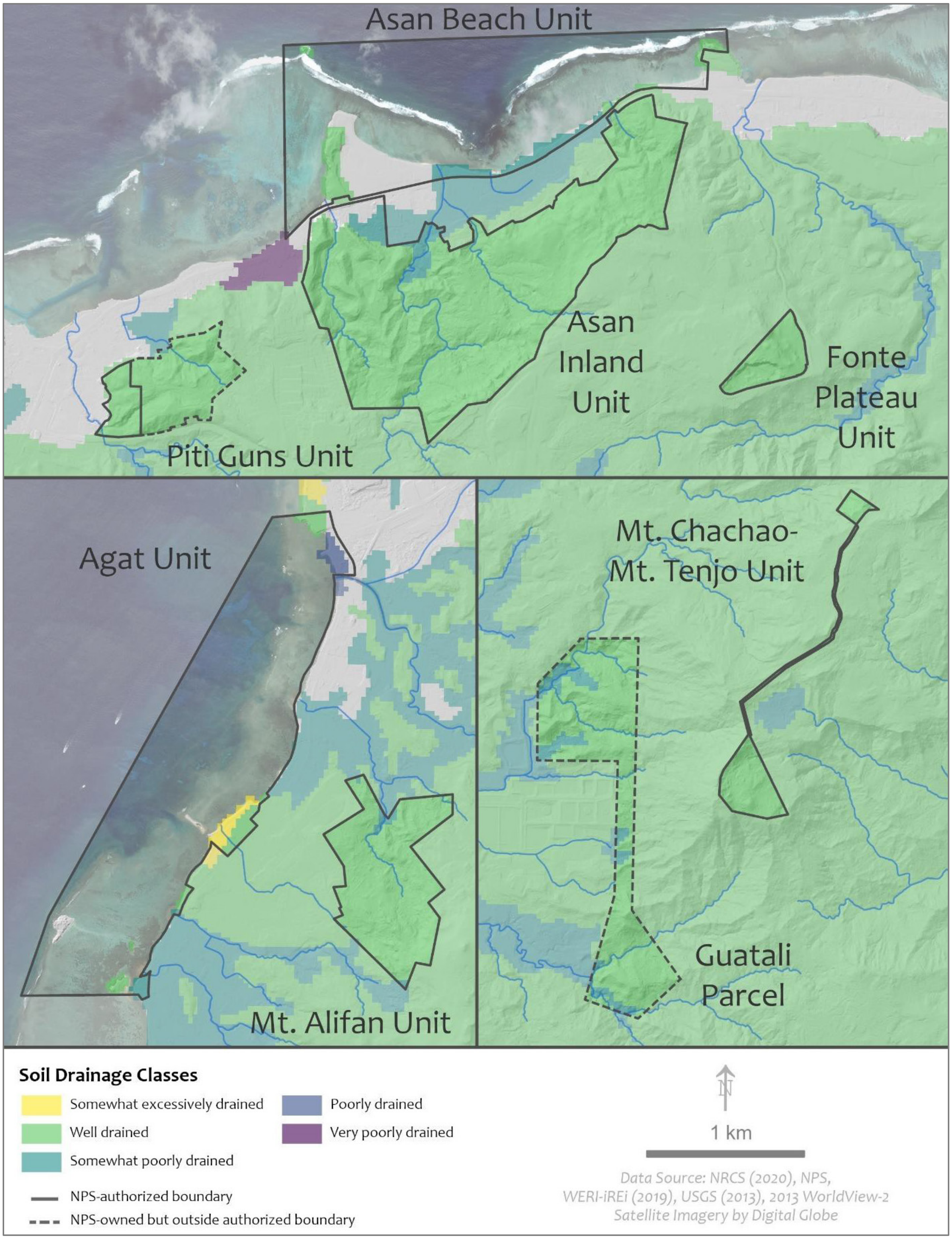


Figure 22. Soil drainage classes distributed in the War in the Pacific NHP. Data Source: NRCS (2020), NPS, WERI-iREi (2019), USGS (2013), 2013 WorldView-2 Satellite Imagery by Digital Globe.

In contrast, about half of Asan Beach soils are poorly drained along the beach, especially where streams enter the ocean, but those on rocky outcrops are well drained, although the southeast corner of the unit borders and area that is very poorly drained.

Aquatic Resources

Watersheds

War in the Pacific NHP is contained within six watersheds and units of the park are either contained solely in a single watershed or straddle two or more watersheds (Figure 23). The Piti Guns Unit is contained within the Piti-Asan Watershed while the Fonte Plateau Unit is contained within the Fonte Watershed. The Guatali Parcel is contained within the Apra Watershed, while the Agat and Mt. Alifan units are contained solely in the Agat Watershed. The Asan Beach and Asan Inland units straddle both the Piti-Asan Watershed and the Fonte Watershed but are largely contained within the former. The Mt. Chachao-Mt. Tenjo Unit straddles three watersheds, the Apra, the Pago, and the Ylig.

Figure 23. Distribution of units of the War in the Pacific NHP in the watersheds of Guam. Data source: NPS, USGS, and WERI/iREi.

Rainfall

Guam has essentially two seasons, the dry season (December to June) and the rainy or wet season (July to November). Seasonality in rainfall has a considerable impact upon palustrine, lacustrine, and riverine habitats. During the dry season, wetlands may dry out, water levels may fall in ponds or reservoirs, and some streams become intermittent or fragmented because of a lack of water. During the wet season, wetlands may flood, ponds and reservoirs may fill to excess, and streams may flood sufficiently to overflow onto terrestrial habitat well above the banks of the stream. An example of rainfall patterns on Guam as measured from a rain gauge station on Mt. Chachao, located within the Mt. Chachao-Mt. Tenjo Unit, shows cumulative rainfall measured between January 2014-November 2019 ranging between ca. 80–140 inches per year (calculated from annual data available at USGS Current Conditions for USGS 132617144423366 Mount Chachao Rain Gage near Piti, Guam). Sharp increases in rainfall indicated by a steeper curve in the figures, corresponds to the annual rainy season. A map illustrating precipitation patterns within the park is given in Figure 24.

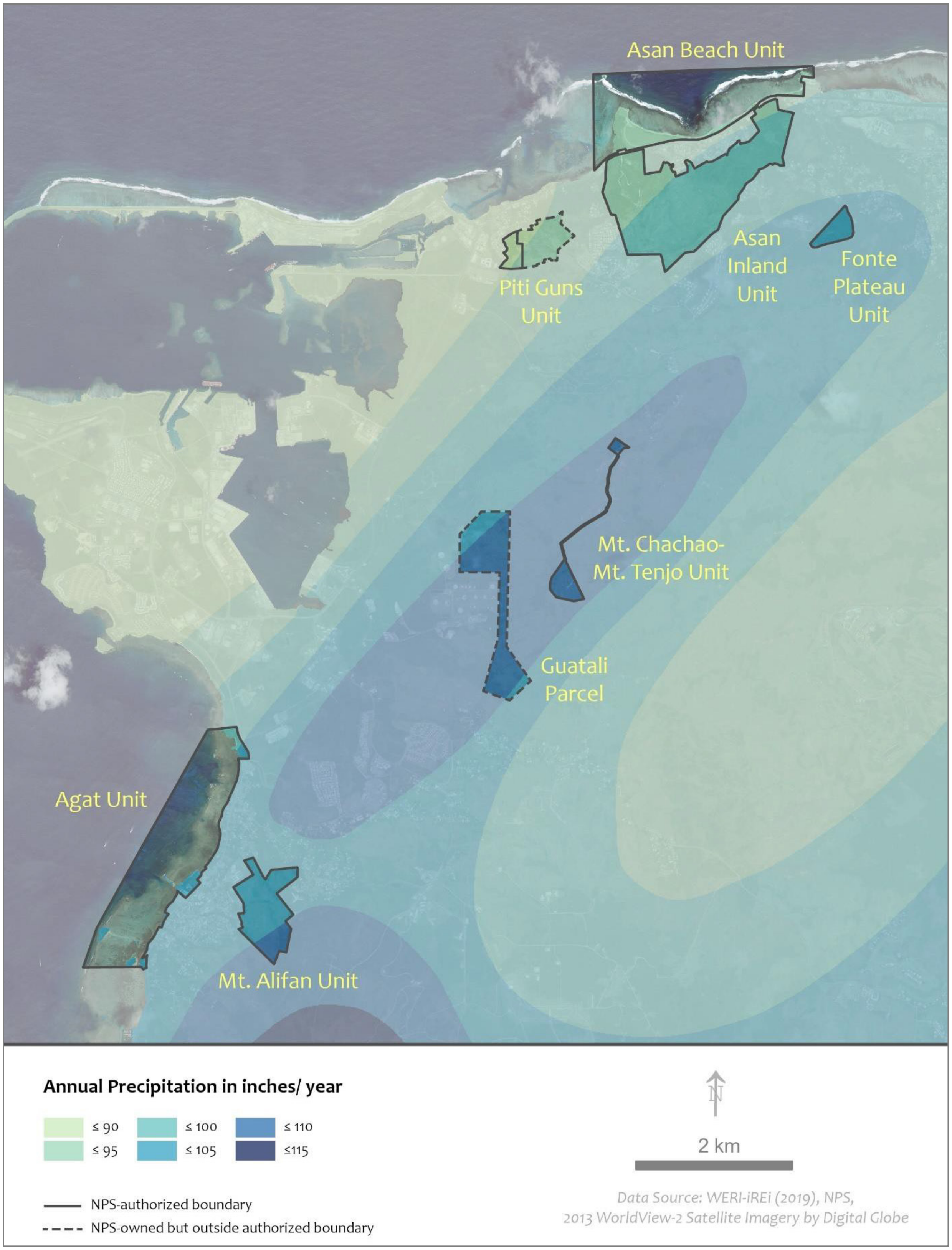


Figure 24. Precipitation map of the War in the Pacific NHP. Data Source: WERI-iREi (2019), NPS, 2013 WorldView-2 Satellite Imagery by Digital Globe.

Water Bodies

Surface freshwater is present within all units of the park except for the Mt. Chachao-Mt. Tenjo and Fonte Plateau units (the Fonte River does not flow within the latter unit). Water bodies include springs and streams (Figure 25). All streams are relatively small in size except for the Namo River which widens considerably before entering the ocean in the Agat Unit. Most streams that flow within the park are perennial, although the upper reaches of some may be intermittent. Some streams are spring fed (i.e., Finile Creek, which flows through the Agat Unit), but its springs are located outside of park boundaries. Principal streams of each unit are summarized in Appendix A.

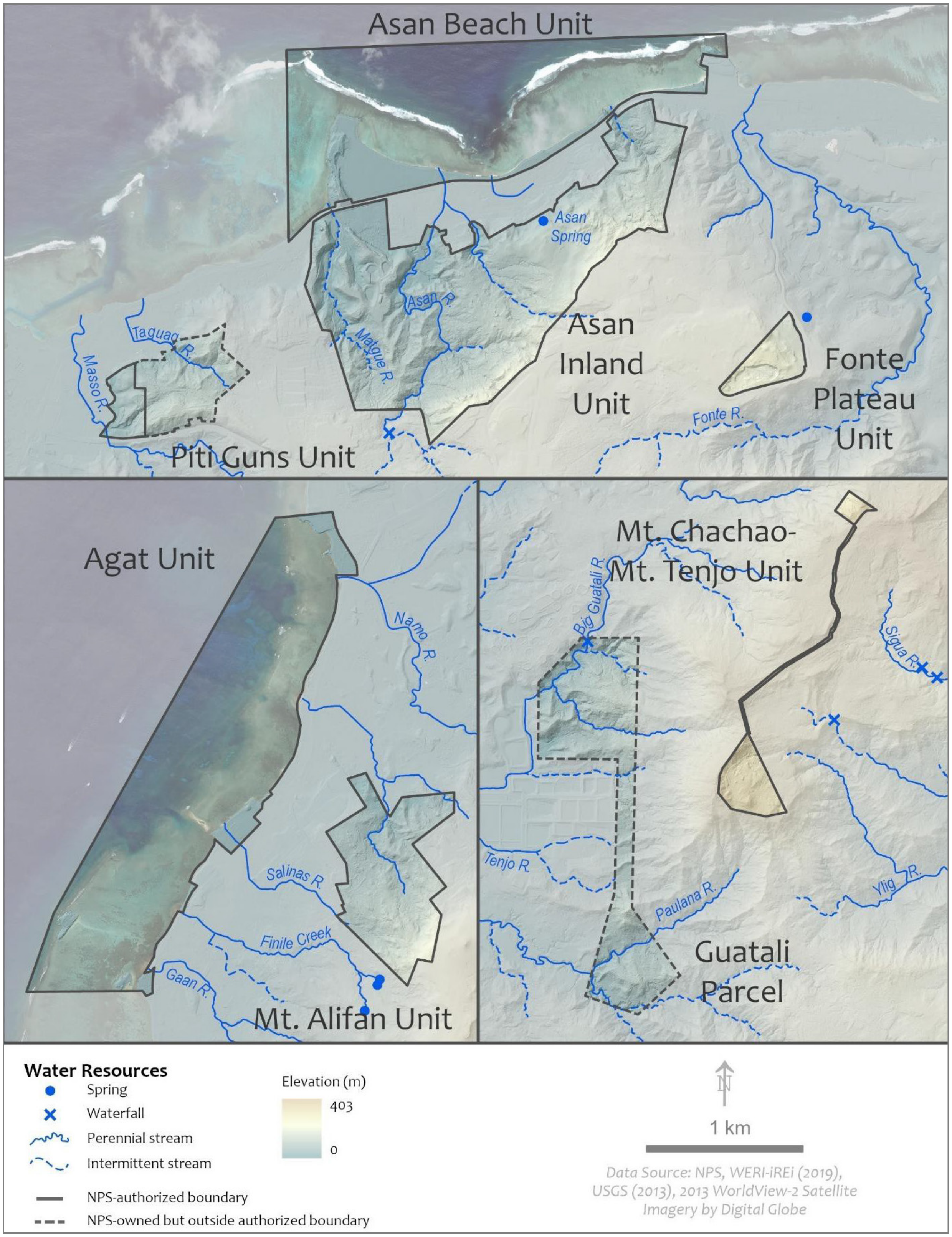


Figure 25. Distribution of springs, streams and waterfalls within and adjacent to the War in the Pacific NHP. Data Source: NPS, WERI-iREi (2019), USGS (2013), 2013 WorldView-2 Satellite Imagery by Digital Globe.

Stream Gradients

Stream gradients within the park ranged from less than 4% to over 15% (Figure 26). The Fonte River near the Fonte Plateau Unit had the steepest gradient (>15%) while streams near sea level in the Asan Beach and Agat units had the shallowest gradients (< 4%).

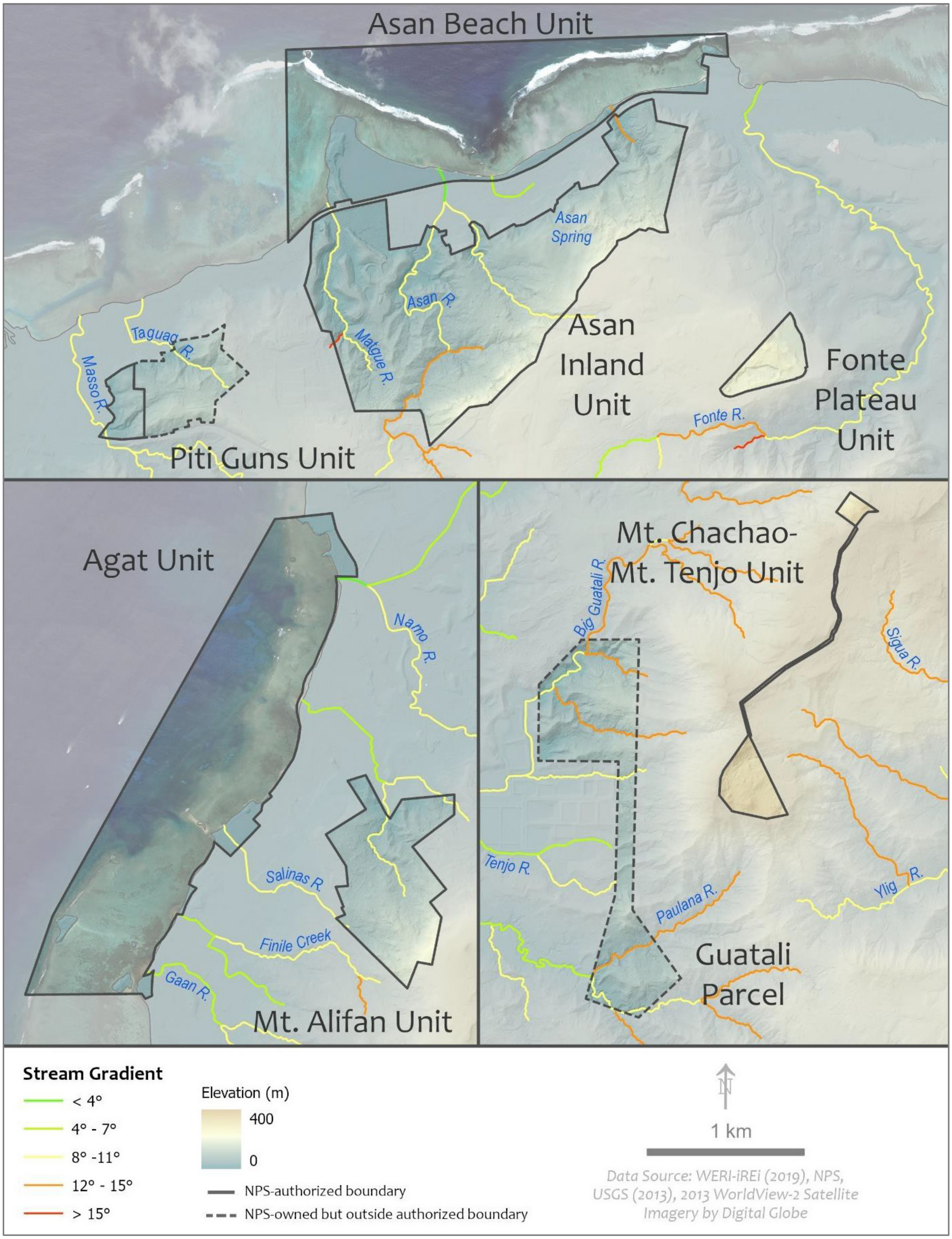


Figure 26. Stream gradients (degrees) in relation to elevation within the War in the Pacific NHP. Data Source: WERI-iREi (2019), NPS, USGS (2013), 2013 WorldView-2 Satellite Imagery by Digital Globe.

Stream Flows

Streamflow gauge data have been generated from two streams, the Asan River and the Namo River. The Asan River flows through both the Asan Inland and Asan Beach units. When water flows are low, during the dry season, sandbars form at the mouth of the rivers and water does not reach the ocean. With rainfall river flows increase and sandbars are breached allowing the interchange of fresh and saline waters. Data taken from a USGS river gauge on the Asan River (Figure 27) between 1998–2015 range from nearly 4,000 cfs in 2002 (likely coinciding with severe typhoon activity experienced in July and again in December of that year) to nearly 300 cfs in late 2013 (data taken in 1998, indicating 0 cfs, is likely a gauge error). Data from this gauge are sparse, however, and it was not until 2006 that sufficient data were collected to establish any pattern under normal circumstances. Between 2006 and 2015, most readings ranged between 500 to ca. 1,400 cfs, with an outlier in 2012 that is likely a result of tropical storm activity.

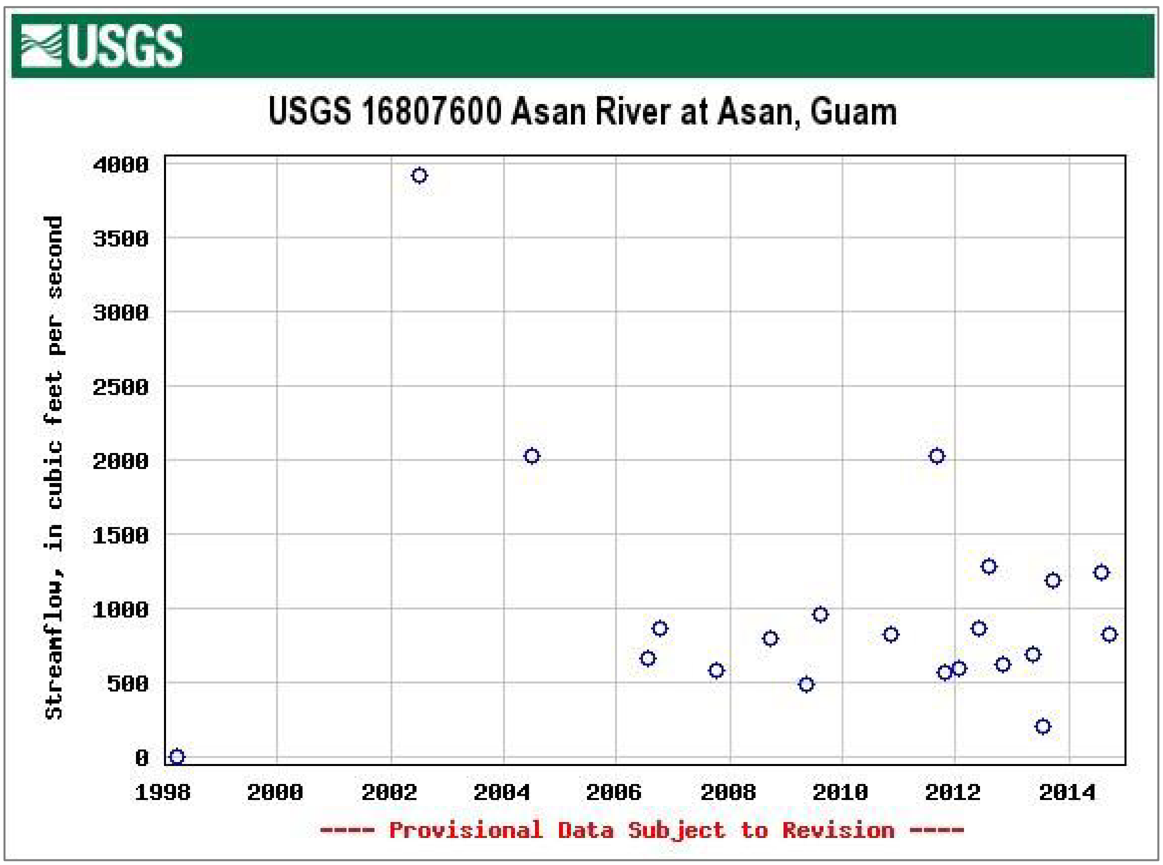


Figure 27. Streamflow (cubic feet per second, cfs) of the Asan River (Asan Beach and Asan Inland units) between 1998 and 2014. High flows in 2002 correspond to an intensive typhoon season with two typhoons (Chataan and Halong) in the month of July and Typhoon Pongsona December. Data and graph are from of the U.S. Geological Survey.

The Namo River flows through the northern part of the Agat Unit. This river discharges into Agat Bay, just south of Apaca Point, where a small estuary is located. This estuary is the only portion of the river within this unit and flows without obstruction into the sea because no sandbar forms at the mouth during the dry season. Data from the USGS Namo River gauge (Figure 28) are sparse, presumably because of instrument failure or a lack of data collection (this gauge no longer appears to be active) but do indicate significant pulses in stream flow in 2002, consistent with the typhoon effects mentioned above. The data also reveal highly variable flows in 2014 that ranged from less than 100 cfs to over 3,000 cfs.

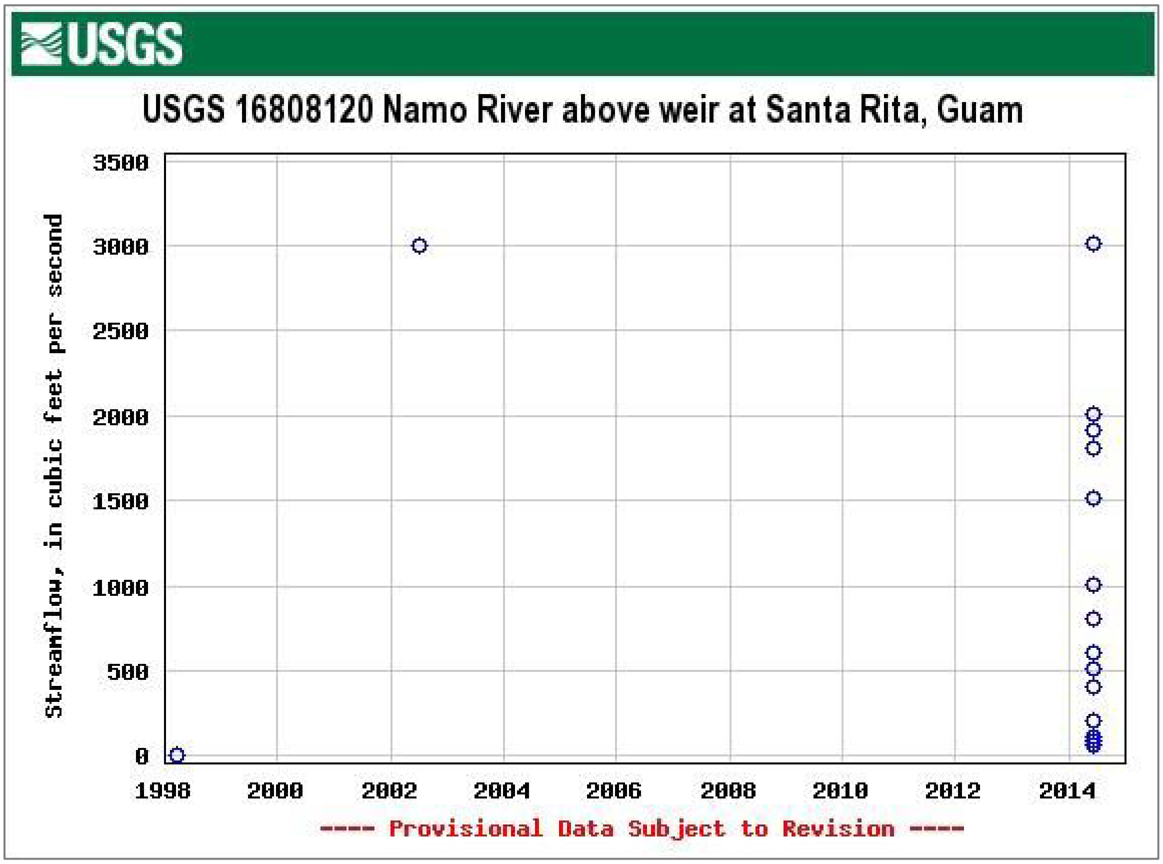


Figure 28. Streamflow (cfs) of the Namo River (Agat Unit) between 1998 and 2014. High flows in 2002 correspond to an intensive typhoon season with two typhoons (Chataan and Halong) in the month of July and Typhoon Pongsona in December. High flows in 2014 reflect more intense tropical storm activity compared to the previous 12 years; data are incomplete and do not report for the years 2000 and 2004–2013. The data and graph are from the U.S. Geological Survey.

Streams within WAPA are relatively unimpacted by anthropogenic effects, except for wildfires that promote erosion (see Minton 2006) or flood control projects, such as those seen on Asan and Namo rivers adjacent to the park (Figure 29 and Figure 30, respectively). The lower reaches of both these streams were modified by channelization during the 1980s. Modifications to the flow of the Asan River directly upstream of Marine Corps Drive include straightening the stream bed and the banks were stabilized.

Figure 29. Channelization and streambank modification on the Asan River just upstream of Marine Corps Drive and the Asan Beach Unit. (Photo by T. J. Donaldson)

Figure 30. Channelization and streambank enhancement on the Namo River. This reach is adjacent to the Agat Unit, just upstream of the Guam Highway 2 bridge. A spillway that drains a wetland is in the upper left corner of the photograph. (Photo by T.J. Donaldson)

Watershed Habitats

The War in the Pacific NHP has two habitats associated with watersheds: aquatic and riparian. Aquatic habitats consist of rivers and streams. Riparian habitats include palustrine wetlands, terrestrial woodlands and savannas. Rivers and streams in the park are relatively small in length and width and may flow permanently or intermittently depending upon seasonal and other rainfall patterns. They can provide important habitat for amphidromous, catadromous, or euryhaline fishes, shore and sea birds, invertebrates and plants. These rivers and streams may be influenced by tidal cycles, at least as far as the first cataract or significant slope upstream of the estuary or shore. Palustrine wetland habitats are located adjacent to a river or stream, but not exclusively so since some can form in depressions of land where moisture (rainfall or groundwater) can collect. The U.S. Fish and Wildlife Service considers palustrine wetlands to be non-tidal marshy or swampy habitats that may be temporarily flooded, seasonally flooded, intermittently flooded, semi-permanently flooded, permanently flooded, or saturated/seepage; all are characterized by having emergent vegetation (see https://www.fws.gov/wetlands/Documents/classwet/palustri.htm).

Within the park, the bottom structures are designated as rock bottom, unconsolidated bottom, aquatic bed, emergent wetland, scrub-shrub wetland, and forested wetland. Palustrine rock bottom wetlands have substrates consisting of stones, boulders, or bedrock that comprise 75% or greater of the habitat with vegetative cover of less than 30%. They may be permanently flooded, semi-permanently flooded, or intermittently exposed. Palustrine unconsolidated bottom wetlands have at least 25% cover of particles smaller than stones, with a vegetative cover of less than 30%. They are also permanently flooded, semi-permanently flooded, or intermittently exposed. Palustrine aquatic bed wetlands are characterized by having plants that grow mainly below or on the surface of the water and may be regularly flooded, permanently flooded, semi-permanently flooded, intermittently exposed, or seasonally flooded. Palustrine emergent wetlands have vegetation (i.e., grasses) growing just above the surface of the water and may be temporarily or seasonally flooded. Palustrine scrub-shrub wetlands have short scrub or shrub plants growing well above the water surface and are seasonally or semi-permanently flooded but may also be in saturated or seepage areas well above standing water. Palustrine woodland wetlands have stands of trees growing in water and are temporarily or seasonally flooded. Streams and wetlands of each unit are described below. Riparian woodlands and savannas consisting of terrestrial plant species that border streams and wetlands provide cover, shade, food (especially insects), sediment traps, and other potential benefits to aquatic and wetland organisms but are not considered here.

Rivers, Streams and Palustrine Habitats by Unit

Asan Beach Unit

Two principal streams flow through the Asan Beach Unit: the Asan River and the Matgue River. The Asan River flows from the Asan Inland Unit into the Asan Beach Unit where it is just slightly above or at sea level (see Figure 25). The length flowing through the Asan Beach Unit alone is relatively short. The total length of this stream in both units is 1,981 m (6,499 ft) but most flows outside of this unit (Appendix A). The river passes under Guam Route 1 (Marine Corps Drive) and forms a small estuary at the beach. This estuary is often blocked by a sandbar that forms from wave action that shifts beach sand across the mouth of the stream but also allows for the deposit of sediments brought downstream. The sandbar is especially evident during the dry season. Higher flows brought on by rainfall, especially in the rainy season, will breach the sandbar and open the estuary (Figure 31). The river is quite shallow, often less than a meter deep depending upon seasonal stream flow, and the bottom is essentially sand with some mud, rubble and aquatic algae.

Some tidal influence that could send a small bore of seawater upstream may be exerted during periods of high water when the sandbar at the mouth of the estuary has been breached. Only a short reach of the Matgue River is present before it reaches the coast (Appendix A). The stream flow, though intermittent, may reach the ocean during periods of high rainfall. Palustrine habitat is absent from this unit.

Figure 31. Estuary of the Asan River at the Asan Beach Unit. The sandbar at the mouth of the river is often breached during the rainy season when stream flows are higher. During the dry season, when flows are lower, the sandbar blocks the river preventing surface flow from reaching the ocean. Tidal activity affects shallow subsurface hydraulic connectivity between the stream and the ocean, however. (Photo by T.J. Donaldson)

Asan Inland Unit

The Asan and Matgue Rivers, and some unnamed tributaries are found in the Asan Inland Unit (Figure 25, Appendix A). The Asan River has also been channelized in its lower reaches (Figure 29). Some tidal influence may be exerted upriver from the Asan Beach Unit during periods of high water when the sandbar downstream in the estuary has been breached. The Matgue River's flow is also intermittent in this unit.

Palustrine wetlands found within the Asan Inland Unit occupy a relatively small area compared to what may be found in most other units. These wetlands are palustrine emergent, palustrine forested, and palustrine scrub/shrub (Figure 32).

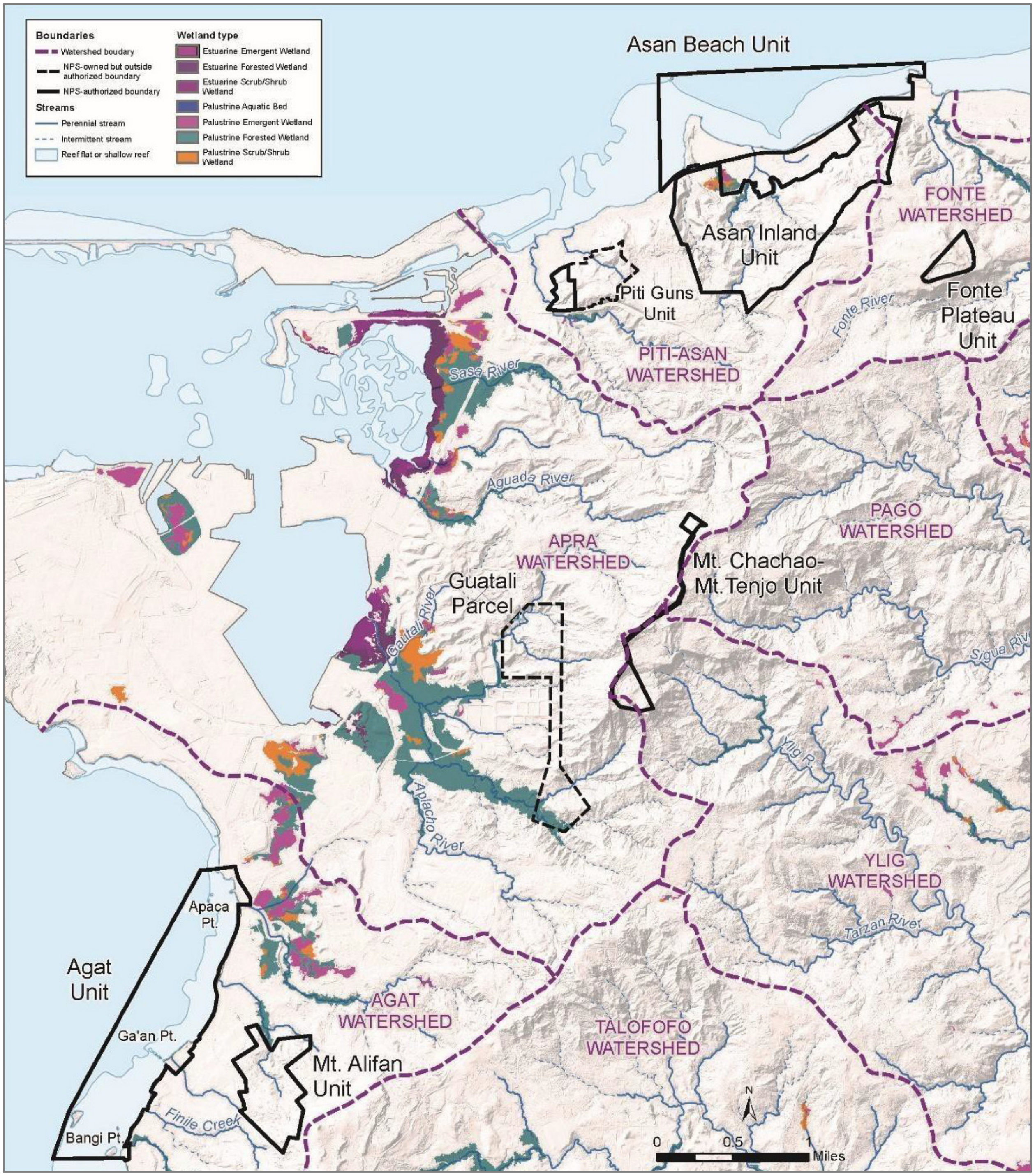


Figure 32. Palustrine (wetland) habitats within and adjacent to the War in the Pacific NHP. There are seven types of palustrine habitat present. Data source: Coastal Change Analysis Program (NOAA), NPS-USGS and WERI/iREi.

Piti Guns Unit

The Masso River is the only named stream present in this unit (Appendix A) and just 62m of the river flows within the authorized park boundary before it exits and flows into the adjacent Masso

Reservoir that is outside of the boundary. This body of water is managed as a sport fishery by the Guam Division of Aquatic and Wildlife Resources (DAWR). The reservoir was stocked with *Kuhlia rupestris* (Kuhliidae), a freshwater sportfish, by DAWR and mosquitofish and guppies have been stocked in this body of water historically. A 465 m (1,525 ft) reach of the Taguag River flows through NPS land outside of the unit's authorized boundaries (Figure 25). Some palustrine forested wetland habitat is present along this reach (Figure 32).

Mt. Chachao/Mt.Tenjo Unit

Streams are absent from this unit.

Mt. Alifan Unit

A small, unnamed stream rises in this unit and flows down slope into the Agat Unit (Figure 25). There is some palustrine forested wetland habitat present (Figure 32).

Guatali Parcel

There are 2,957 m (9,701 ft) of riverine habitat in the Guatali Paracel that is divided between four named and unnamed streams (Appendix A). Three of the named streams, the Atantano, Big Guatali, and Paulana rivers, and some of the unnamed streams are perennial, while the Tenjo River and some unnamed streams are intermittent. Palustrine forested wetland exists along the southern and southwestern portions of the Guatali Parcel adjacent to the Paulana and Atantano rivers and tributaries (Figure 25).

Agat Unit

Palustrine emergent wetland, palustrine forested wetland, and palustrine scrub/shrub wetland habitats are all found upstream along the Namo River, and on nearby Apaca Point (Figure 32). The Apaca Point area of the Agat Unit was designated by the Guam Coastal Management Program as a part of the Namo River floodplain wetland; this is recognized as significant by the United Nations Protected Area Program (Daniel 2006).

Palustrine emergent wetland is the most abundant of the three types of wetlands present in this area. This wetland drains into the Namo River upstream of the War in the Pacific NHP boundary. Four named streams flow within the Agat Unit (Figure 25). Stretches within park boundaries of three are remarkably small, the Salinas (208 m or 62 ft), the Ga'an (4.2 m or 13 ft), and Finile Creek (15.1 m or 45 ft). The fourth consists of small reach (106m or 347 ft) of the Namo River and is essentially the estuary of this stream (Appendix A). An unnamed stream arising in the Mt. Alifan Unit flows into the sea south of the Namo River, but the amount of riverine habitat present is negligible. Palustrine forested wetland exists along a portion of the eastern border of the unit where an unnamed stream is found (Figure 32). A drainage channel that was constructed to drain new Agat areas, built post-war, lies along the east border of the Ga'an part of Agat Unit. It supports palustrine forested wetland, traditional tree crops and an estuary and has threatened to erode the NPS bathroom foundation.

Marine Habitats

Asan Beach Unit

Physical zones within this unit (Figure 33) consist of intertidal and marine components and comprise an area of ca. 175 hectares (432 acres). The Asan River and its small estuary creates a deep cut into the reef and has strong outgoing tidal flows that are extremely dangerous to fishers and swimmers. The southern boundary is delineated by the eastern edge of the reef flat to the southwest of Asan Point. The beach, which extends 2,875 m (9,432 ft) between the two boundaries and has an area of approximately 14,375 sq m (142,891 sq ft) (inclusion of upper rocky reaches gives a total area of hectares). The south-southwest portion of the unit is contained within the Government of Guam's Piti Bomb Holes Marine Protected Area. Burdick (2005) mapped the benthic composition of the coast.

The intertidal zone is dominated by coralline and forminiferan sands, rubble and rock (Figure 34). Large rocks are evident inshore from Camel Rock (Gapang Rock). The beach is subject to high and low tides, but these are relatively minimal with a mean range of 0.71m (2 ft 4 in) and maximum daily ranges of 0.16–1.10m (6.3 in – 3 ft 7 in) (Storlazzi et al. 2009). The reef flat is subject to considerable exposure during excessive spring low tides. Heavy surf occurs usually only during tropical storms or westerly wind winter swells come ashore. Storlazzi et al. (2009, 2014) deployed a wide array of oceanographic instruments within the Asan Beach and Agat Unit's waters to examine current patterns, tidal periodicity, wave height and dominant wave period, conductivity, temperature, turbidity, luminance, dissolved oxygen, salinity, chlorophyll, sediment deposition, pressure as a measure of river discharge via the Asan River estuary, and other variables. Six months of data collection in 2007–2008 produced the following conclusions: 1) current flow within Asan Bay is to the west and off-shore because of reef morphology and trade winds; 2) turbidity tends to be relatively low within the bay, although long term measurements to examine variability could not be made because of biofouling of instruments; 3) sedimentation results from a combination of wave erosion of reef bottom, and from suspended sediments carried by the Asan River especially during heavy rainfall; 4) sedimentation tends to build a sandbar across the mouth of the Asan River that is breached only during periods of high rainfall or by large wave events; 5) significant volumes of terrigenous sediment can deposit on the reef and have negative impacts unless dispersed by wave action; 6) internal tidal bores deliver deeper oceanic water to the reef system affecting both temperature and salinity; positive effects include the delivery of nutrients to corals and lowering water temperatures sufficiently to provide relief from heat stress, while negative effects include the delivery of organics generated by sewage outfalls.

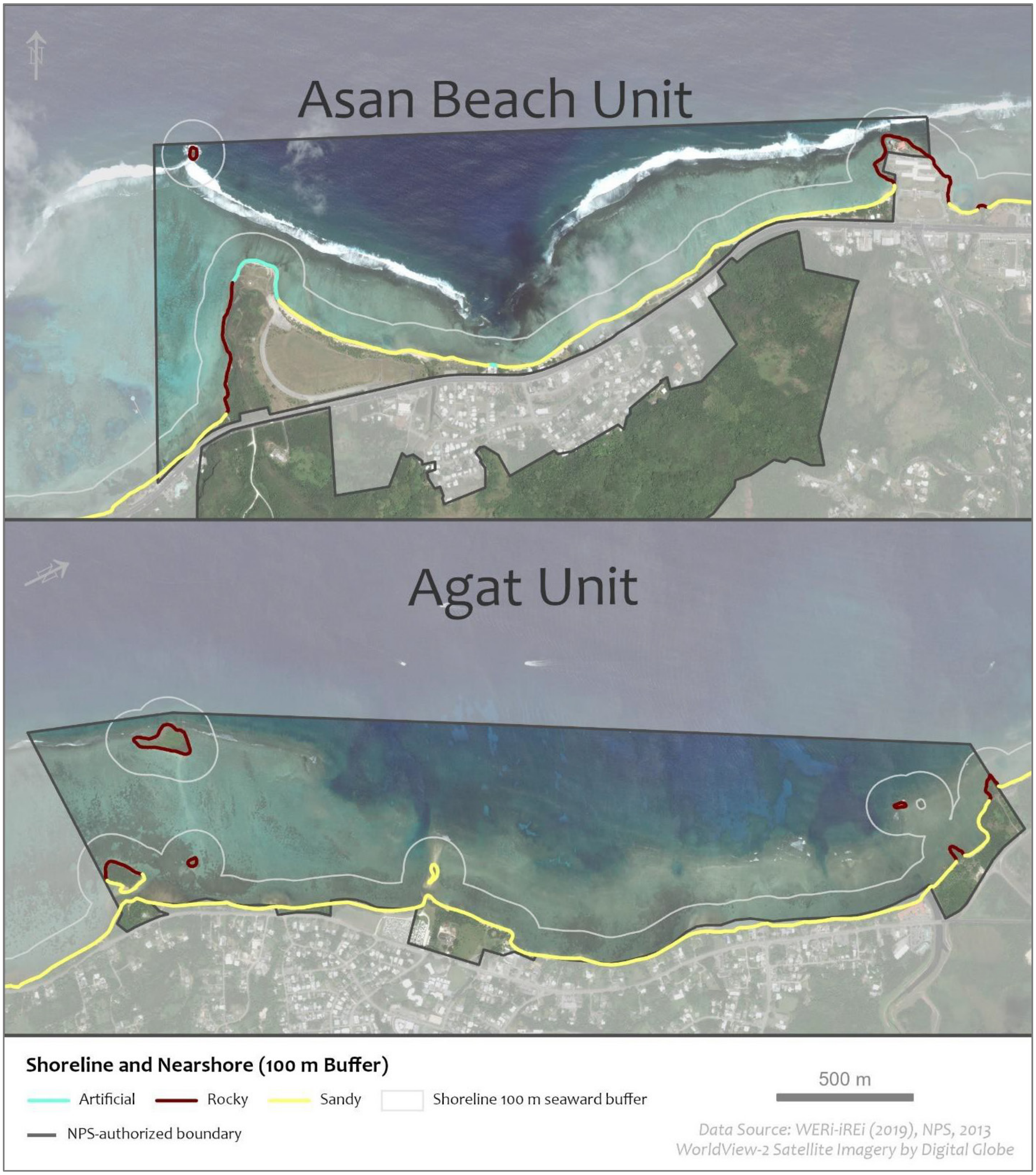


Figure 33. The shoreline and nearshore area of Asan Beach Unit and Agat Unit in the War in the Pacific NHP. Data Source: WERI-iREi (2019), NPS, 2013 WorldView-2 Satellite Imagery by Digital Globe.

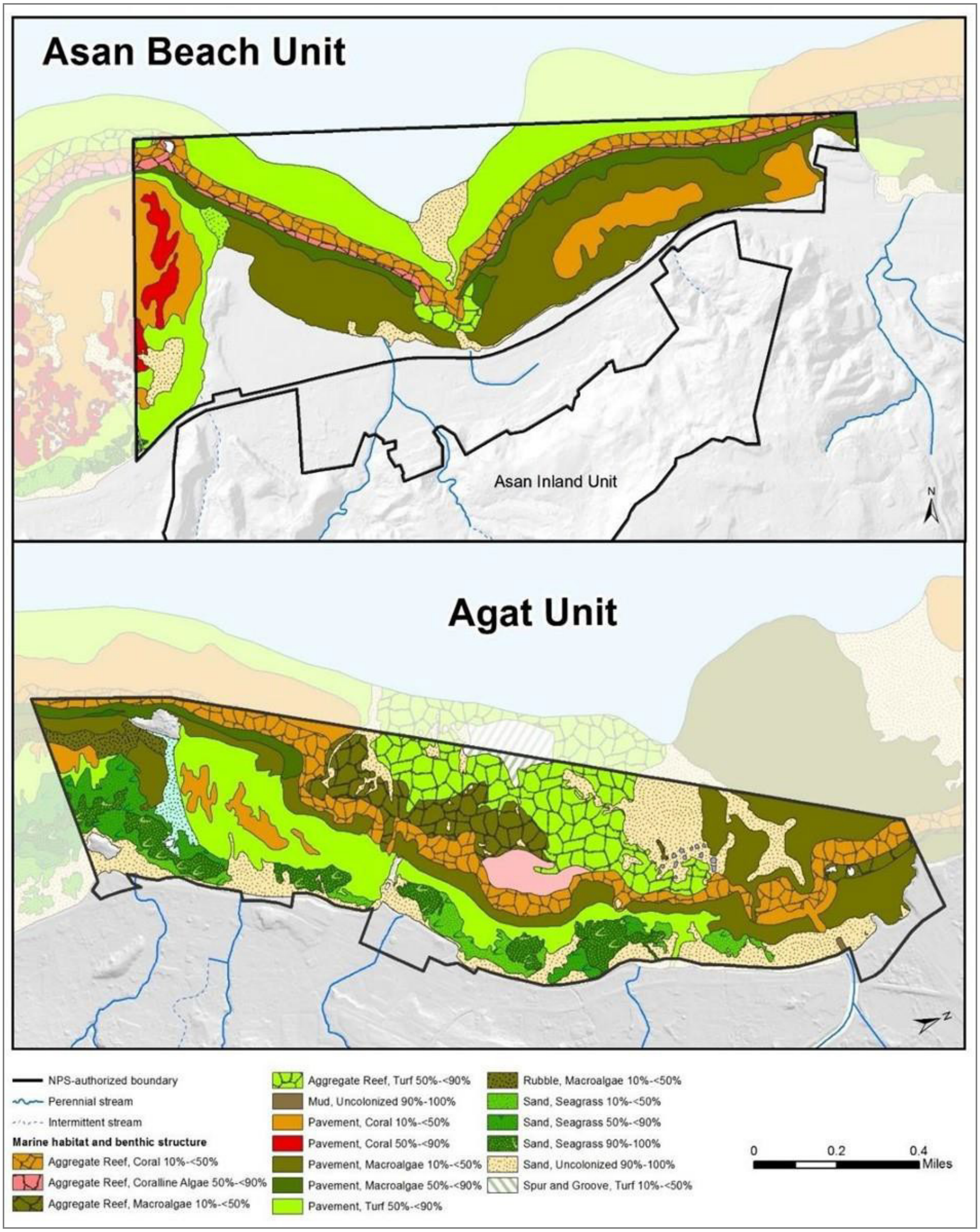


Figure 34. Detail of marine habitats and benthic structure of the Asan Beach and Agat Units. Data source: Burdick (2005), NPS, USGS, and WERI/iREi.

Air Quality

The health of park ecosystems, the integrity of cultural resources, and visitor enjoyment depend upon clean air. Amendments to the 1977 Clean Air Act designated 48 national parks as Class I areas that were afforded special air quality protections. Other NPS areas, including the War in the Pacific NHP, were designated as Class II air quality areas. The NPS Organic Act, the Wilderness Act, and NPS 2006 Management Policies provide the basis for protection of air quality and air quality related values in all areas managed by the NPS. Air quality related values are resources sensitive to air quality, including visibility, oceans, lakes, streams, vegetation, soils, and wildlife.

On Guam, burning of fuel oil at power plants is the primary source of sulfur emissions. Nitrogen compounds, mainly nitrogen oxides and ammonia, result from fuel combustion and agricultural activities. Ozone is formed when nitrogen oxides and volatile organic compounds emitted from vehicles, industry, and vegetation react in the atmosphere in the presence of sunlight. Ozone can contribute to atmospheric warming but, paradoxically, can also insulate the planet from harmful ultraviolet radiation. This insulation has been compromised because of the action of other pollutants that effectively reduces the amount of ozone in the upper atmosphere. Persistent bioaccumulative toxics include heavy metals like mercury (emitted from mining processes, coal combustion and incinerators, of which the latter has operated on a small scale on Guam) and organic compounds such as pesticides and industrial by-products.

The NPS Air Resources Division’s approach for evaluating air quality conditions and trends in NPS units in the continental U.S. is based on estimates of ozone, wet sulfur and nitrogen deposition, and visibility (NPS 2017). For condition assessments, the Air Resources Division uses all available data collected over a five-year period by NPS, U.S. Environmental Protection Agency (U.S. EPA), state, tribal, and local monitors to generate interpolations for each air quality indicator. Unfortunately, these estimates are not available for War in the Pacific NHP.

Based on monitoring data and model results from the 1970s, two areas near the Piti Power Plant and the Tanguisson Power Plant (the latter is no longer in operation) were classified as nonattainment for the U.S. EPA sulfur dioxide National Ambient Air Quality Standard (U.S. Department of the Navy, 2013). Additional emission controls were installed at these power plants in the early 1990s. Monitoring was terminated in 1991, and Guam is now designated as unclassifiable/attainment for the National Ambient Air Quality Standards for all pollutants (Fletcher Clover, U.S. EPA, personal communication with Tonnie Cummings, NPS, 2015). The older larger Cabras power units installed in 1975 at the Piti power plants will be phased out when a new Okudu power plant is completed after 2026.

2015 data from the U.S. EPA Toxics Release Inventory (TRI) Program indicate 10 facilities on Guam reported releases of toxic chemicals to air, water, or land (Figure 35). Out of the reported 687 million pounds of toxic chemicals released to the air in 2015 in the U.S., 236,200 were released in Guam. Guam ranked 23 out of 56 states/territories nationwide based on total releases per square mile (Rank 1 = highest releases).

Figure 35. Map of facilities in Guam reporting to the U.S. Environmental Protection Agency's Toxics Release Inventory (TRI) Program in 2015 (from U.S. EPA 2017).

Sulfuric acid accounted for 93 percent of the atmospheric releases in Guam (Figure 36). Nevertheless, given the relatively small number of pollution sources, dispersed population centers, and the seasonal trade winds that may blow daily, the region is considered to have good air quality (U.S. Department of the Navy, 2013).

In 2020, the U.S. Environmental Protection Agency settled with the Guam Power Authority and the Marianas Energy Company, L.L.C. for violations of the Clean Air Act. It's expected that hazardous emissions will be reduced, including a 99% reduction in sulfur dioxide emissions in the Cabras – Piti area (U. S. EPA 2020).

Sullivan et al. (2011a) calculated the relative threat from nitrogen and sulfur deposition at all 270 NPS Inventory and Monitoring parks. They concluded there was a moderate risk of acidification from sulfur and nitrogen deposition (Sullivan et al. 2011a) and a very low risk of nutrient enrichment from nitrogen deposition (Sullivan et al. 2011b). Cummings (2015) reported on air quality within the War in the Pacific NHP. Because of a lack of data, however, it is not possible to determine air pollution concentrations or resource effects there. The park is affected by smoke or emissions from various sources. These include smoke generated by dry season wildfires, occasional emissions from volcanic eruptions in the islands north of Saipan, or dust and smoke pollution from the Asian mainland. Portions of the park are also exposed infrequently to Piti Power Plant emissions when winds blow from the west-southwest.

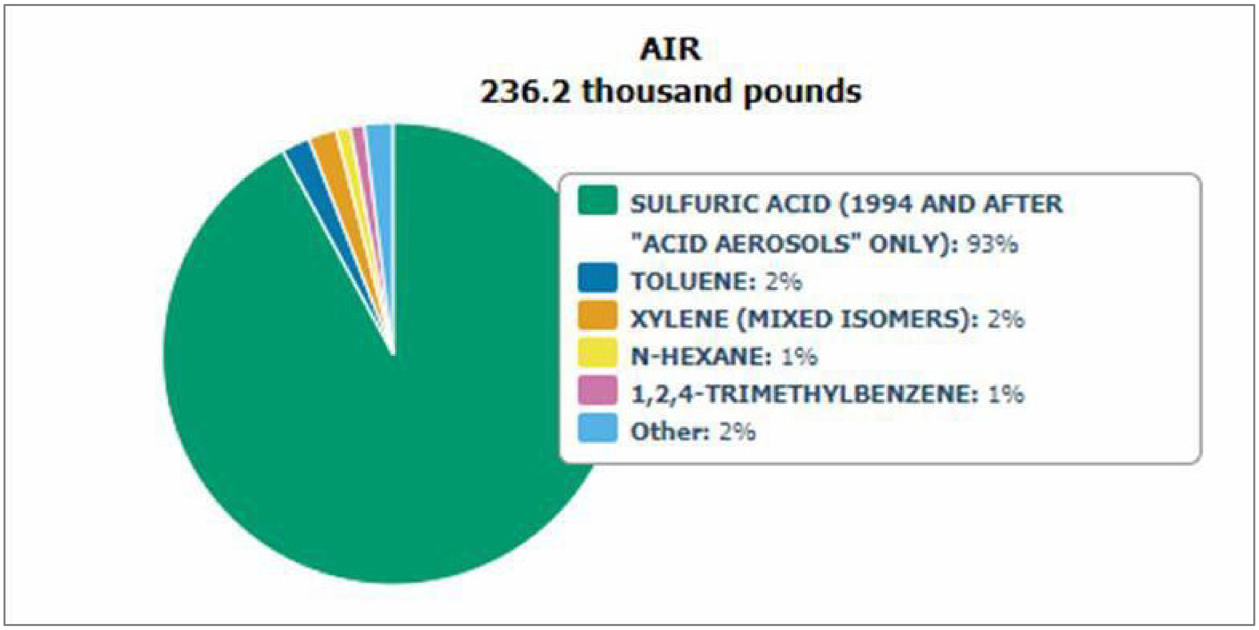


Figure 36. Top five chemicals released to air in Guam in 2015 (from U.S. EPA 2017).

Biological Resources

Terrestrial Vegetation

The terrestrial vegetation resources of the Park were assessed by the U.S. National Park Service (Cogan et al. 2014). This reassessment included vascular plant checklists, patterns of distribution, and comparisons of native versus non-native species. What follows is a preliminary assessment based upon previously available reports and checklists provided by the Park Service. From these, a total of 403 species was reported, with 175 native species (43.4 %), 222 non-native species (55.1 %), and six species of unknown origin (1.5%). All plant species recorded previously from War in the Pacific NHP are given in Appendix A. Distributions of plant communities are given in Figure 37 using data found in Appendix B.

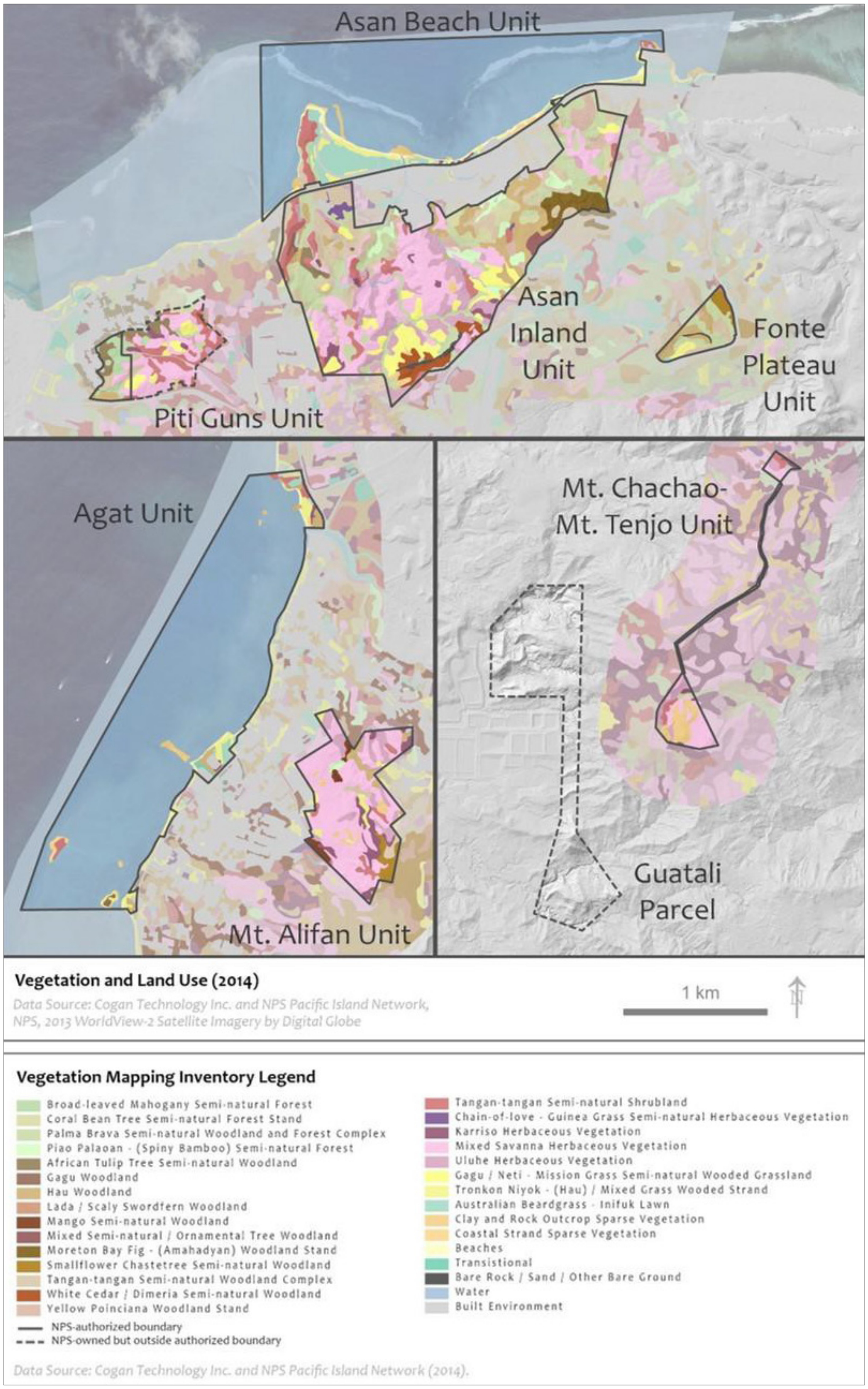


Figure 37. Distributions of plant communities in War in the Pacific NHP. The map legend is shown as cited in Cogan et al. (2014) vegetation mapping report. However, some of the terms listed are Hawaiian instead of CHamoru plant names such as hau, rather than the CHamoru pago and uluhe rather than the CHamoru mana. Data Source: Cogan Technology Inc., NPS Pacific Island Network (2014).

Brief Descriptions by Units

Asan Beach and Asan Inland Units: The distribution of plant communities within the Asan Beach Unit (Figure 38) is relatively simple and consists of developed land, mainly lawn with coconut palms maintained as a recreational area, mixed savanna herbaceous vegetation, and tangantangan (Leucaena leucocephala) semi-natural shrubland coastal strand. However, Asan Ridge vegetation contains established limestone forest species and is being managed to restore a limestone forest habitat on the karst substrate. Plant communities within the Asan Inland Unit (Figure 38) are more complex than those found in the Asan Beach Unit. The principal communities are mixed savanna-herbaceous woodland, mission grass, palma brava (*Heterospathe elata*) semi-natural woodland and forest complex, and tangantangan semi-natural scrubland. Invasive *Tabebuia* (Pink Tacoma) trees are rapidly replacing the historic savanna landscape. There is also some developed land present.

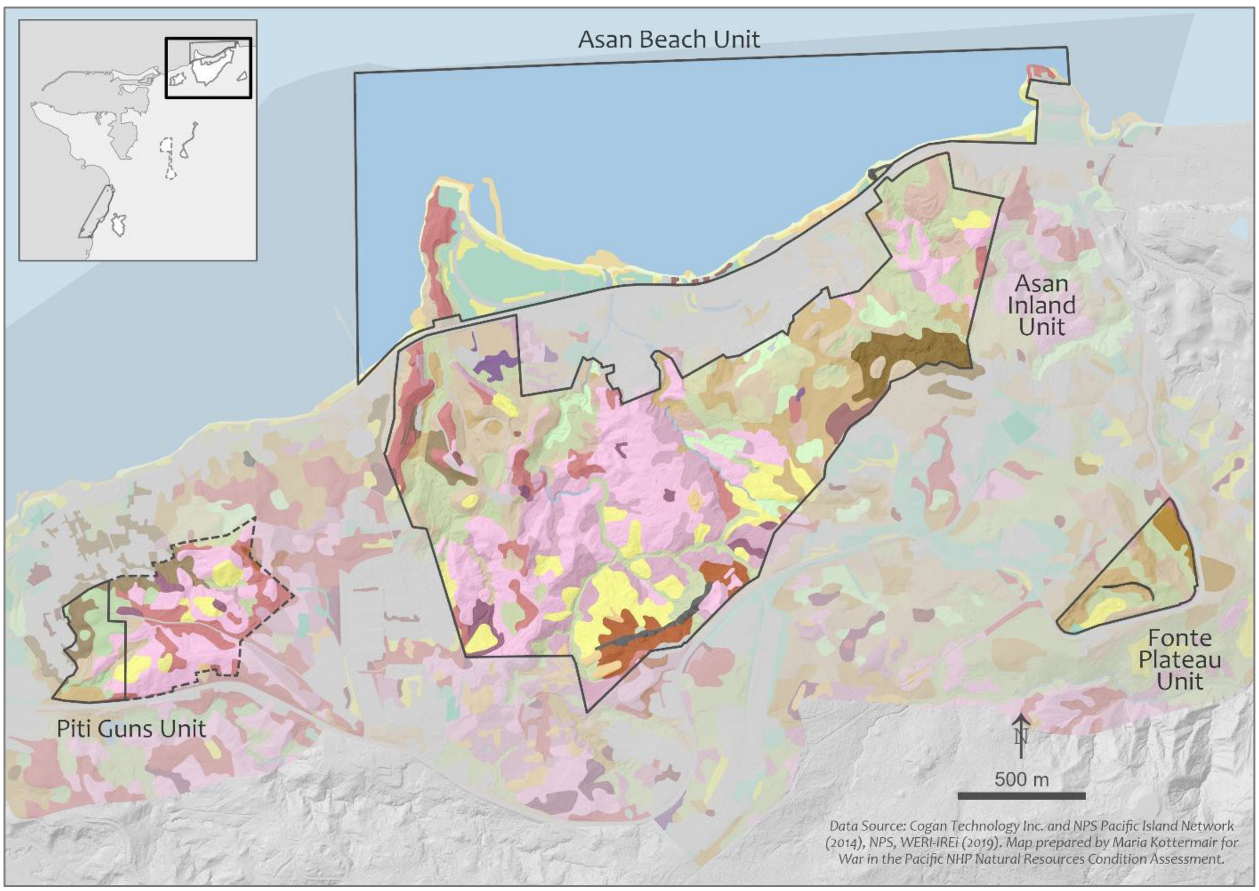


Figure 38. NPS Vegetation Mapping Inventory - Piti-Asan-Fonte Area (for legend refer to Figure 37). Data Source: Cogan Technology Inc, NPS Pacific Island Network (2014), NPS, WERI-iREi (2019). Map prepared by Maria Kottermair.

Piti Guns Unit and Fonte Plateau Unit: Plant communities within the Piti Guns Unit (Figure 38) are divided into two sections. The first is dominated by mixed savanna herbaceous tangantangan semi-natural shrubland, and mission grass. The second is dominated by broadleaved mahogany semi-natural forest, part of an experimental plantation (Daniel 2006), African tulip, and tangantangan semi-natural woodland complex. Palma brava semi-natural woodland and forest complex dominates the Fonte Plateau Unit (Figure 38), followed by pago (hibiscus) woodland and tangantangan semi-natural woodland complex. The single type of soil present there likely explains the dominance of scrub forest.

Mt. Chachao-Mt. Tenjo Unit, Gutali Parcel, and Mt. Alifan Unit: The Mt. Chachao-Mt. Tenjo Unit's plant communities (Figure 39) are primarily mixed savanna herbaceous vegetation, clay and rock outcrop sparse vegetation, and mana (savanna fern) herbaceous vegetation. The Mt. Alifan Unit is dominated by mixed savanna herbaceous vegetation, mana (savanna fern) herbaceous vegetation and karriso (wetland reed) herbaceous vegetation. The vegetation communities in the Guatali Parcel are not characterized in Figure 39.

Agat Unit: Plant communities in the Agat Unit (Figure 40) include pago (hibiscus) mixed grass and woodland, coastal strand vegetation, and Australian beardgrass/Inifuk lawn. Remnants of an estuarine Nypa Palm population remain at Apaca wetlands following the channelization of the Namo River. This species is traditionally important and protected on Guam.

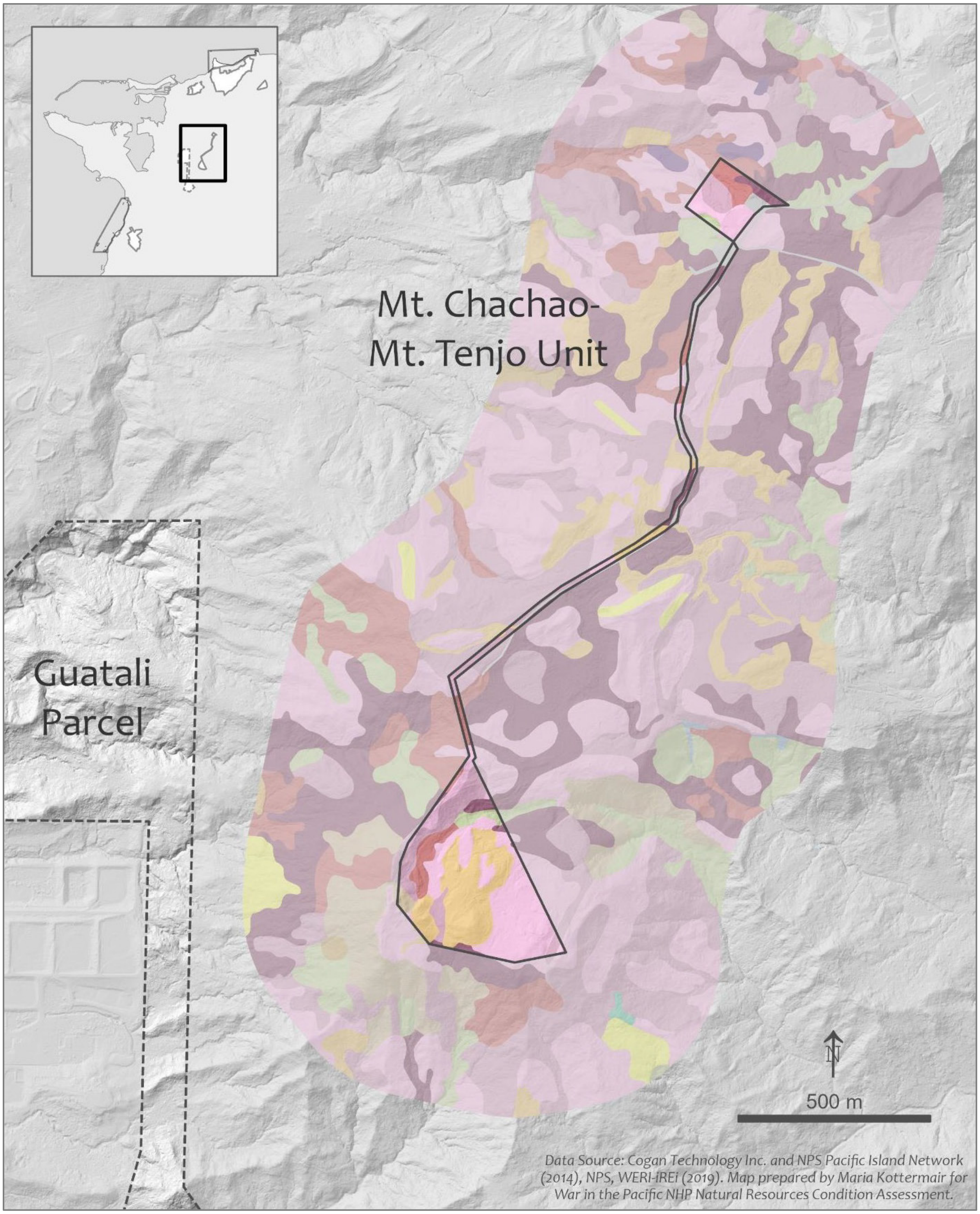


Figure 39. NPS vegetation mapping inventory – Mt. Chachao-Mt. Tenjo Area (for legend refer to Figure 37). Data Source: Cogan Technology Inc., NPS Pacific Island Network (2014), NPS, WERI-iREi (2019). Map prepared by Maria Kottermair.

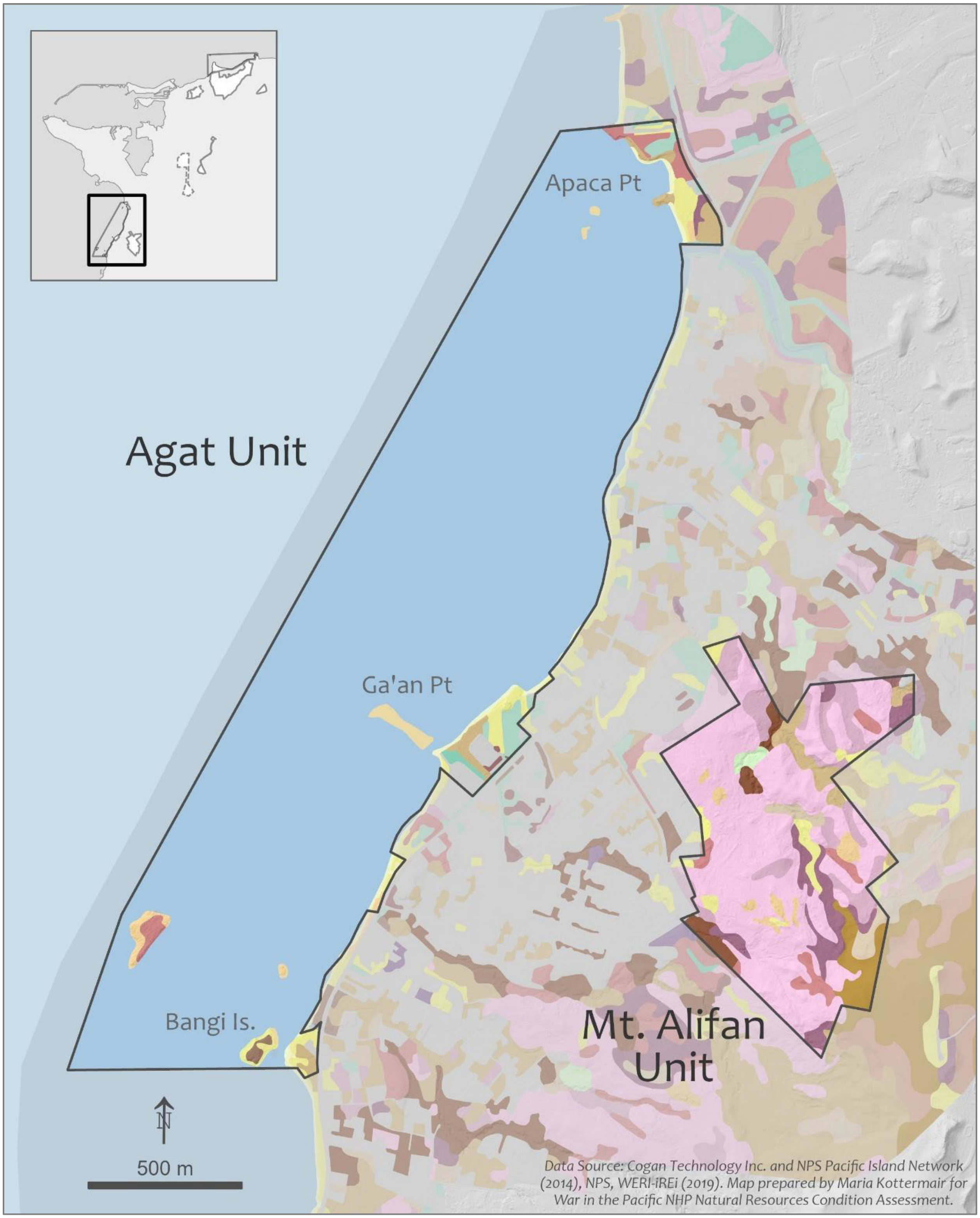


Figure 40. NPS vegetation mapping inventory - Agat Area (for legend refer to Figure 37). Data Source: Cogan Technology Inc, NPS Pacific Island Network (2014), NPS, WERI-iREi (2019). Map prepared by Maria Kottermair.

Terrestrial Animals

Terrestrial invertebrates

The terrestrial invertebrate community is not described here because data sets are incomplete. Among terrestrial gastropods, three endangered of partulid snails found on Guam include *Partula gibba, P. radiolata*, and *Samoana fragilis*; a fourth species, *Partula salifana*, is extinct (B.D. Smith, personal communication, 30 November 2019). Populations of surviving species have been found in the Asan Inland Unit and Piti Guns Unit. Gressitt (1954) provided an early comprehensive study of Guam's insects and estimated that approximately 2,000 species occurred on the island with an endemism rate of 45%. More recent efforts have addressed different species groups and the large number of invasive species entering Guam, but no study has been specific to War in the Pacific NHP. The invasive little fire ant (*Wasmannia auropunctata*) has been reported (NPS 2014) in the park. The coconut rhinoceros beetle (*Oryctes rhinoceros*) is also a serious invasive species that is causing severe damage to coconut palms variously throughout War in the Pacific NHP and elsewhere on Guam (University of Guam College of Natural and Applied Sciences, https://cnas-re.uog.edu/crb).

Amphibians

Amphibians established as invasive species within War in the Pacific NHP include the cane or marine toad (*Rhinella marina*) and eastern dwarf tree frog (*Litoria fallax*) (Appendix D).

Reptiles

Twenty-two species of reptiles have been reported from Guam as having established populations (Rodda and Dean-Bradley 2001; Christy et al. 2007, Kerr 2013), and many of them are invasive or introduced species. Of these, eleven species have been recorded from War in the Pacific NHP (Appendix D). Two are marine species, the green sea turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricate brissa*) that may come ashore, although nesting in War in the Pacific NHP has not been reported for either species.

At least three extant species of geckos, one skink (*Emoia caeruleocauda*), and since 2020, one monitor lizard (*Varanus tsukamotoi*) are considered to be native. It had long been believed that the Indian monitor lizard (*Varanus indicus*) had been introduced but was proven to be the endemic, *V. tsukamotoi,* (Weijola et al. 2020), based on recent phylogenetic studies. The Brahminy blind snake (*Ramphotyphlops braminus*) is a prehistorical invasive while the green anole (*Anolis carolinus*), the island skink (*Carlia ailanpalai*, formerly *C. fusca*), and the infamous brown tree snake (*Boiga irregularis*) are recent arrivals. The latter species is largely responsible for the extinction or extirpation of most of Guam's native avifauna, and remains a serious threat to Guam's remaining birds, geckos and skinks. The Micronesian gecko (*Perochirus atelese*) and the rock or pelagic gecko (*Nactus pelagicus*) are examples; the former species was last collected in 1978, and the last has not been seen for some considerable time. Both were likely resident within the boundaries of the park and are presumed extinct on Guam (Kerr 2013).

Birds

Virtually all native bird species likely present four decades ago within the park are locally extinct or extinct in the wild because of brown tree snakes that feed upon eggs, chicks, and smaller-sized adults (Savidge 1987, Engbring and Fritts 1988) Twenty-nine species of birds have been recorded from the park (Appendix E; see also Wiles 2003 for a complete checklist of Guam's birds). Of these, one, the Mariana grey swiftlet (*Aerodramus vanikorensis*), is a native terrestrial species, two are migratory raptors that visit occasionally, seven are invasive terrestrial species, three are native freshwater or wetland species, 12 are shore birds, and seven are seabirds. An additional four native terrestrial species have been extirpated from the park (i.e., the Guam rail, *Rallus owstoni*; Micronesian kingfisher, *Halycon cinnamomina*; Micronesian starling, *Aplonis opaca*; and the Marianas crow, *Corvus kubaryi*) and only the Micronesian starling may still be found in the wild on Guam. Another ten species of native terrestrial, aquatic and sea birds may have resided within the park historically but have been extirpated from Guam or are extinct in the wild. An additional 48 species have been reported as visitors to Guam (Pratt et al. 1987) but have not been recorded for War in the Pacific NHP. Invasive red junglefowl (*Gallus gallus*) may also stray into the park.

Terrestrial Mammals

Nine species of mammals have been recorded from War in the Pacific NHP and all but one species are invasive or otherwise introduced to Guam. These include deer (*Cervus mariannus*), wild boar (*Sus scrofa*), wild cats (*Felis silvestris*), dogs (*Canis familiaris*), three species of rats (*Rattus exulans*, *R. norvegicus*, and *R. tanezumi*), house mice (*Mus musculus*), and house shrews (*Suncus murinus*). Historically, the native Marianas fruit bat (*Pteropus mariannus mariannus*) was found in habitats within the park's boundaries but has since been extirpated with only a small, migratory and protected population resident on federal lands in northern Guam. A checklist of mammal species found in the park is given in Appendix F.

Summaries of Terrestrial Vertebrates for Each of the Park Units

Asan Beach Unit: Within the Asan Beach Unit, amphibians, mainly the cane toad (*Rhinella marina*) and the eastern dwarf tree frog (*Littoria falax*), are present near the Asan River and in the tangantangan thicket. The cane toad wanders onto the lawn. Reptiles likely present include geckos (*Gehyra mutilate, Hemidactylus frenatus,* and *Lepidodactylus lugubris*), skinks (*Emoia caeruleocauda* and *Carlia fusca*), the green anole (*Anolis carolinus*), the native monitor lizard (*Varanus tsukamotoi*), the Brahminy blind snake (*Ramphotyphlops braminus*), and the brown tree snake (*Boiga irregularis*). Birds present include various resident and migratory or visiting seabirds and shorebirds, as well as the invasive Eurasian house sparrow (*Passer montanus*), red junglefowl (*Gallus gallus*), drongo (*Dicrurus macrocercus*), Philippine turtle dove (*Streptopelia bitorquata*), and rock dove (*Columba livia*). The Pacific reef heron (*Egretta sacra*) occurs along the banks of the Asan River. Mammals likely present include invasive rats, a mouse, and a shrew, as well as feral dogs and cats.

Asan Inland Unit: Within the Asan Inland Unit, amphibians, mainly the cane toad and the eastern dwarf tree frog, are present near the Asan River and in the Palustrine Forested Wetland. Reptiles include geckos, skinks, the green anole, the native monitor lizard, the Brahminy blind snake, and the brown tree snake. Birds present include the invasive Eurasian house sparrow, red junglefowl, drongo, Philippine turtle dove, and rock dove. Along the river and in the Palustrine Forested Wetland, the Mariana common moorhen (*Gallinula chloropus guami*) and the Pacific reef heron may be found. The white tern (*Gygis alba*) may nest in casuarina trees, and the yellow bittern (*Ixobrychus sinensis*) may nest in other species of trees, as well. Mammals include invasive rats, a mouse, a shrew, and feral dogs and cats, feral pig (*Sus scrofa*), and the Philippine brown deer (*Cervus mariannus*).

Piti Guns Unit: In the Piti Guns Unit, the cane toad and the Eastern dwarf tree frog are likely found in the Palustrine Forest Wetlands and straying into other plant communities. Reptiles likely include geckos, skinks, the green anole, the native monitor lizard, the Brahminy blind snake, and the brown tree snake. Birds present include the invasive Eurasian house sparrow (*Passer montanus*), drongo (*Dicrurus macrocercus*), Philippine turtle dove (*Streptopelia bitorquata*), and rock dove (*Columba livia*). The yellow bittern and various shorebirds may be found in the Palustrine Forested Wetlands. Mammals include invasive rats, a mouse, a shrew, feral dogs and cats, feral pig, and the Philippine brown deer.

Fonte Plateau Unit: Vertebrates likely present in the Fonte Plateau include the cane toad and the eastern dwarf tree frog in the Palustrine Forest Wetland and straying into the Scrub Forest. Reptiles likely include geckos, skinks, the green anole, the native monitor lizard, the Brahminy blind snake, and the brown tree snake. Birds present include the invasive Eurasian house sparrow, drongo, Philippine turtle dove, and rock dove. Yellow bittern and possible the white tern may utilize some trees as nest sites. Two introduced gamebirds, black francolin (*Francolinus francolinus*) and blue-breasted quail (*Coturnix chinensis*), may also be found. Mammals include invasive rats, a mouse, a shrew, feral dogs and cats, feral pig, and the Philippine brown deer.

Mt. Chachao - Mt. Tenjo Unit and the Guatali Parcel: In the Mt. Chachao-Mt. Tenjo Unit and the Guatali Parcel include the cane toad and the eastern dwarf tree frog in the Palustrine Forest Wetland and straying into other plant communities. Reptiles likely include geckos, skinks, the green anole, the native monitor lizard, the Brahminy blind snake, and the brown tree snake. Birds present include the invasive Eurasian house sparrow, drongo, Philippine turtle dove, and rock dove. The native Marianas swiftlet (*Aerodramus vanikorensis bartschi*) may occur here incidentally. Yellow bittern and possibly the white tern may utilize some trees as nest sites. The black francolin and blue-breasted quail may also be found in the Grassland/Herbaceous plant community. Mammals may include invasive rats, a mouse, and a shrew, but more likely feral dogs and cats, the feral pig, and the Philippine brown deer are found.

Agat Unit: As with the other units described previously, vertebrates likely present in the Agat Unit include the cane toad and the eastern dwarf tree frog in the Palustrine Emergent Wetland and straying into other plant communities. Reptiles likely include geckos, skinks, the green anole, the native monitor lizard, the Brahminy blind snake beneath planted vegetation, and the brown tree snake. Birds present include the invasive Eurasian house sparrow, red junglefowl, drongo, Philippine turtle dove, and various resident and migratory or visiting seabirds and shorebirds. The Marianas gallinule (Moorhen) and the Pacific reef heron may be found along the Namo River, the latter species also on rocky outcrops along the beach or emergent rocks on the adjacent reef flat. Yellow bittern and possibly the white tern may utilize some trees as nest sites. Mammals likely include invasive rats, a mouse, a shrew, feral dogs and cats, and possibly the feral pig.

Mt. Alifan Unit: Within the Mt. Alifan Unit, the terrestrial invertebrate community is not characterized here, except to say that threatened land snails (Partulidae) may be present in limestone forest remnants (Hopper and Smith 1992, Daniel 2006). As with the other units described previously, vertebrates likely present in the Mt. Alifan Unit include the cane toad and the eastern dwarf tree frog in the Palustrine Forest Wetland and straying into other plant communities. Reptiles likely include geckos, skinks, the green anole, the native monitor lizard, the Brahminy blind snake, and the brown tree snake. Birds observed in this unit include the invasive Eurasian house sparrow, drongo, Philippine turtle dove, and rock dove. The Marianas swiftlet may occur here incidentally given that it nests in a cave in the adjacent Naval Magazine. Migratory black kite (*Milvus migrans*) and gray-faced buzzard (*Butastur indicus*) might occur here as rare wanderers to Guam. Yellow bittern and the white tern may utilize some trees as nest sites. The black francolin and blue-breasted quail may also be found, especially in the Grassland/Herbaceous plant community. Mammals likely include invasive rats, a mouse, and a shrew, but more likely feral dogs and cats, the feral pig, and the Philippine brown deer.

Aquatic Plants

Raulerson (1979) and Tibbatts (unpublished data, Guam Division of Aquatic and Wildlife Resources) provided inventories of aquatic organisms, and four native and two invasive species of aquatic vascular plants have been recorded. A checklist of species is given in Appendix G.

Aquatic Invertebrates

Checklists for aquatic invertebrate species are largely incomplete and available data are limited only to a few streams in a few units. Based on six days of field work for NPS on Guam Chris Rogers (2011) reported 77 freshwater and terrestrial decapod taxa estimated from Guam. A few of these are undescribed new species.

Previously nine species of native crustaceans and a single species of aquatic insect had been recorded. Eleven species of native and three species of invasive mollusks have been recorded as well. An invasive species of leech has also been recorded from at least two streams. Perhaps the most important invertebrate species is a native crustacean, the freshwater prawn *Macrobrachium lar*, that is collected by Guam fishers for food. A checklist of species is given in Appendix G.

Aquatic Vertebrates

Freshwater Fish

Guam's native freshwater fishes have different life history strategies. Catadromous fishes reproduce and die at sea but as juveniles migrate to freshwater where they live until the return to the sea to spawn (Helfman et al. 2009). Examples include two species of freshwater eel (Anguillidae), *Anguilla bicolor* and the more common, on Guam, *Anguilla marmorata*, both of which are accomplished climbers and are able to bypass all but the most difficult stream barriers. Amphidromous fishes begin life in freshwater but as larvae are carried downstream into the ocean (Helfman et al. 2009); from there they migrate upstream as post-larvae or juveniles where they reside, grow into adults, and reproduce. Gobies (Gobiidae) such as *Sicyopterus lagocephalus* have modified pelvic fins in the form of suckers that allow them to ascend streams, even steep vertical barriers, such as those found in waterfalls, in order to secure habitat that is protected by predatory fishes lacking these capabilities and are thus restricted to stream reaches at or near sea level. A third life strategy, in which fishes are tolerant to a wide range of salinities, is also found. These species are euryhaline in that they are normally found in marine or brackish waters but can enter freshwater, as well (Myers 1999, Myers and Donaldson 2003). Their distribution in streams, however, is limited by barriers found upstream.

Within the park, both species of catadromous freshwater eels are likely found. Five goby species (all amphidromous), one sleeper (Eleotridae), also amphidromous, and one flagtail (Kuhliidae) are native species. Twelve species of native euryhaline species occur. These include a tarpon (Megalopidae), three mullets (Mugilidae), a needlefish (Belonidae), a glass perchlet (Chandidae), a trevally (Carangidae), a snapper (Lutjanidae), a mono (Monodactylidae), and three gobies. Invasive species found in War in the Pacific NHP include a walking catfish (Clariidae), two poecilids (Poecilidae), guppy and mosquitofish, and a cichlid (Cichlidae). tilapia, A checklist of species is given in Appendix H and their distribution in streams of each park unit is given in Appendix I.

Marine and Shore Birds Found in Aquatic Habitats

Aquatic or shorebirds may be found in streams of the park, although the shorebirds are likely limited to stream reaches found at or near sea level (see Appendix E, also Wiles 2003). However, the yellow bittern may be expected to occur along streams at relatively higher elevations.

Descriptions of Aquatic Plant and Animal Assemblages by Unit

Asan Beach Unit

Within the Asan Beach Unit, the aquatic plant, molluscan, crustacean and fish assemblages of the Asan and Matgue rivers have been characterized in part. Aquatic plants in the Asan River appear to be limited to two species, one native and another invasive, while aquatic plants have not been documented from the Matgue River (Appendix G). Native freshwater mollusks in the Asan River have relatively high diversity with six species, but only a single invasive species has been found in the Matgue River (Appendix G). Five species of native crustaceans occur in the Asan River and two in the Matgue River (Appendix G). The fish fauna of the Asan River is depauperate with only four native species and one invasive species reported, while that of the Matgue River has six native, three euryhaline (marine) and one invasive species (Appendix I). A short reach of the Tenjo River has a single native species, *Kuhlia rupestris* (Kuhliidae), and two euryhaline marine species (Appendix I).

Asan Inland Unit

Known wetland plant species may be found in Appendix C. Documentation of invertebrate communities by wetland type is incomplete. Both the cane toad and the eastern dwarf tree frog may be expected to occur, as would the native monitor lizard and the brown tree snake. Aquatic birds, such as the yellow bittern, and various shorebird species may be present. Among mammals, feral cats, dogs and increasing populations of pigs may be seen. The aquatic plant, molluscan, crustacean and fish assemblages of the Asan and Matgue rivers have been characterized in part.

Piti Guns Unit

The aquatic plant, molluscan, crustacean and fish assemblages of the Masso and Taguag rivers within the Piti Guns Unit have been characterized on a limited basis. Aquatic plants in the Masso River have not been recorded (Appendix G). There are seven species of native and two species of invasive freshwater mollusks, and three species of native crustaceans (Appendix G). Fish diversity is relatively low in all the streams of this unit. The fish fauna of the Masso River consists of seven native and three invasive freshwater species, and a single euryhaline species (Appendix I). The Taguag River has no recorded aquatic plant species, one species of native mollusk and one species of native crustacean (Appendix G). Seven native freshwater fish species are present (Appendix I).

Fonte Plateau Unit

Aquatic organisms appear to be absent from the Fonte Plateau Unit and the Mt. Chachao-Mt. Tenjo Unit. Known wetland plant species may be found in Appendix C. Documentation of invertebrate communities by wetland type is incomplete. The cane toad and the eastern dwarf tree frog may be expected to occur. Among reptiles, the native monitor lizard and the brown tree snake are likely present. Aquatic birds, including the yellow bittern, and various shorebird species may be present. Among mammals, feral cats, dogs and possibly pigs may be seen, as would the Philippine brown deer.

Agat Unit

In the Agat Unit, the aquatic plant, molluscan, crustacean and fish assemblages of the Finile, Ga'an, Namo and Salinas rivers have been characterized also on a limited basis. Aquatic plants have not been recorded from any of these streams. The Finile has three native species of freshwater mollusks, and three species of native crustaceans (Appendix G). The fish fauna of the Finile River consists of three native and one invasive freshwater species (Appendix I). No aquatic plants or mollusks have been reported from the Ga'an River but there are two native species of crustaceans (Appendix G). The fish fauna is very limited and consists of one native and one invasive freshwater species each (Appendix I). No aquatic plants have been recorded from the Namo River, but three native mollusks and three native crustacean species occur there (Appendix G). There are five native and two invasive freshwater fish species, and a single euryhaline species present in the river (Appendix I). No aquatic plants or invertebrates, and just two species of freshwater fishes, one native and one invasive, have been recorded from the Salinas River (Appendix I).

Mt. Alifan Unit

No aquatic plants or invertebrates have been recorded and just one native and one invasive freshwater fish species are found in this stream (Appendix I). The extent of their distribution within this unit is unknown. The Tenjo River has one native crustacean species (Appendix G) and one native freshwater and two euryhaline fish species (Appendix I). A quantitative survey of native and invasive species found in rivers of this unit should be undertaken and include measures of abundance, species diversity, and habitat association.

Mt. Chachao-Mt. Tenjo Unit

The aquatic plant, molluscan, crustacean and fish assemblages of the Atantano, Big Guatali, Paulana and Tenjo rivers have been characterized on a limited basis. Aquatic plants have been recorded only from the Atantano River, and these include four native and one invasive species (Appendix G). The Atantano has two native species of freshwater mollusks, and three species of native crustaceans (Appendix G). The fish fauna of the Atantano River consists of six native and three invasive freshwater species, and eight euryhaline species (Appendix I). The Big Guatali River has not been surveyed for aquatic plant and animal species. Two native mollusks and three native crustacean species have been reported for the Paulana River, but no aquatic plant species or fish species have been recorded.

Descriptions of Marine Habitats and Organisms by Unit: Asan Beach and Agat

Asan Beach Unit

Physical and Biological Setting: The beach at the Asan Beach Unit is dominated by sand, coastal strand, boulders, and remnants of man-made structures dating from World War II (Figure 41, Figure 42). Reef structures within the Asan Beach Unit are dominated by reef pavement, reef aggregate, sand, rubble, and unknown (Figure 34), the latter likely because the reef slope is not well surveyed. Macroalgae (10 to less than 50% coverage, also this is likely higher now; A.K. Miller, NPS, personal communication, 13 December 2016) and turf algae (50 to less than 90% coverage) account for most marine plant coverage, although coralline algae (50 to less than 90% coverage) and small but dense stands (90 to 100% coverage) of seagrass (mainly *Enhalus acoroides*) may also be found (Table 2).

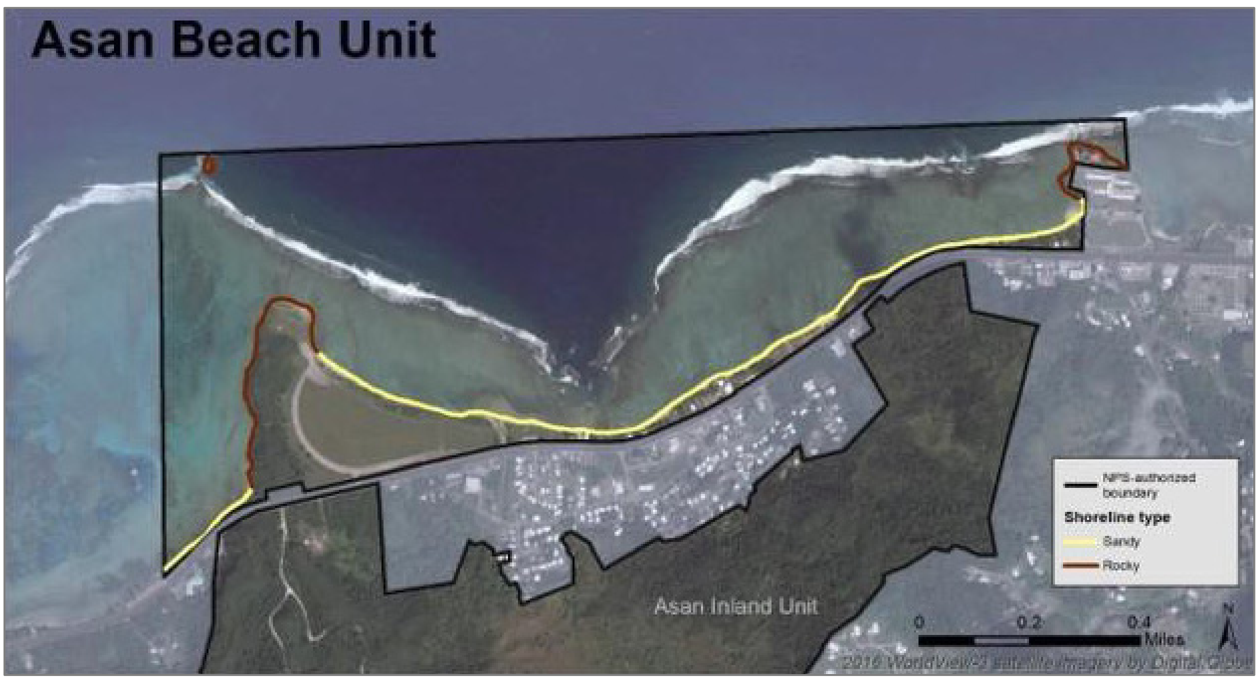


Figure 41. Satellite view of the inshore portion of the Asan Beach Unit showing the distribution of sandy beach habitat in yellow and rocky beach or rock wall habitat in brown. Data source: 2016 WorldView-3 satellite imagery by DigitalGlobe, USDA-NRCS, NPS.

Figure 42. Beach and reef flat at the Asan Beach Unit. (Photo by T.J. Donaldson)

Table 2. Park profile by park units. Some data sets are incomplete. Source: Unless otherwise noted, numbers derived from various geospatial layers provided by NPS or the Digital Atlas of Guam (www.hydroguam.net) using spatial analysis. Definitions: ac = acres, ft = feet, km = kilometers, m = meters, mi = miles, spp = species.

Profile Category	Metric	Asan Beach	Asan Inland	Fonte	Piti Guns	Mt. Chachao-Mt Tenjo	Agat	Alifan	Piti Guns (not within the park)	Guatali (not within the park)	Summary
Park Area	Land area within park in ha (ac)	208 (513)	220 (543)	14 (35)	9 (23)	18 (45)	240 (594)	62 (154)	30 (73)	81 (200)	882 (2180)
	Marine area within park in ha (ac)	175 (432)	–	–	–	–	222 (548)	–	–	–	397 (981)
	Total lands under NPS fee ownership in ha (ac)	85 (209)	191 (471)	14 (35)	9 (23)	0 (0)	24 (58)	62 (154)	30 (73)	81 (200)	495 (1223)
	Percent of park unit area	41	87	100	100	0	10	100	100	100	56
	Elevation range in m (ft)	24 (77)	175 (573)	88 (290)	67 (219)	97 (318)	11 (37)	185 (608)	100 (330)	101 (332)	302 (991)
Population of Guam and Park Visitation	Total population size	–	–	–	–	–	–	–	–	–	170,023
	Average total park visitors/year	–	–	–	–	–	–	–	–	–	266,191
Roads and Trails	Total length of road network in km (mi)	1 (0.6)	1.8 (1.1)	–	–	–	0.24 (0.15)	–	0.5 (0.3)	–	3.6 (2.2)
Marine Habitats	Marine in ha (ac)	175 (432.5)	–	–	–	–	221.9 (548.4)	–	–	–	397 (980.9)
	Intertidal in ha (ac) [A]	1.7 (4.2)	–	–	–	–	2.1 (5.2)	–	–	–	3.8 (9.3)
Aquatic Habitats	Streams – perennial	2	2	–	1	–	3	2	1	4	11
	Streams – intermittent	2	2	–	–	–	–	–	–	3	7
Watersheds	Number of watersheds	2	2	1	1	3	1	1	1	3	6

[A] Length of shoreline x 4 meters (estimated average width).

[B] NPS Vascular Plant Database.

[C] Includes amphibians, reptiles, birds, and mammals, plus fire ant and coconut rhinoceros beetle—efforts are being made by various agencies to control both insects and the brown tree snake

Table 2 (continued). Park profile by park units. Some data sets are incomplete. Source: Unless otherwise noted, numbers derived from various geospatial layers provided by NPS or the Digital Atlas of Guam (www.hydroguam.net) using spatial analysis. Definitions: ac = acres, ft = feet, km = kilometers, m = meters, mi = miles, spp = species.

Profile Category	Metric	Asan Beach	Asan Inland	Fonte	Piti Guns	Mt. Chachao-Mt Tenjo	Agat	Alifan	Piti Guns (not within the park)	Guatali (not within the park)	Summary
Shoreline	Length of shoreline within and along park boundary in km (mi)	4.2 (2.6)	–	–	–	–	5.2 (3.2)	–	–	–	9.4 (5.9)
	Length of shoreline only within park boundary in km (mi)	4.2 (2.6)	–	–	–	–	2.9 (1.8)	–	–	–	7.2 (4.4)
	Length of beach within park boundary incl. islets in km (mi)	2.8 (1.8)	–	–	–	–	1.2 (0.7)	–	–	–	4.0 (2.5)
Native Species	Numbers of plant spp [B]	53	91	48	50	65	46	83	–	–	163
	Numbers of amphibian, reptile and bird spp	–	–	–	–	–	–	–	–	–	27
	Numbers of strictly freshwater fish spp	–	–	–	–	–	–	–	–	–	9
	Numbers of marine fish, reptile, and mammal spp	–	–	–	–	–	–	–	–	–	322
Non-native Species	Numbers of plant spp [B]	81	93	81	94	50	144	73	–	–	210
	Plant spp targeted for treatment [B]	–	–	–	–	–	–	–	–	–	1
	Numbers of animal spp	–	–	–	–	–	–	–	–	–	25C
	Animal spp targeted for treatment or removal	–	–	–	–	–	–	–	–	–	3C

[A] Length of shoreline x 4 meters (estimated average width).

[B] NPS Vascular Plant Database.

[C] Includes amphibians, reptiles, birds, and mammals, plus fire ant and coconut rhinoceros beetle—efforts are being made by various agencies to control both insects and the brown tree snake.

Coral cover of 10 to less than 50% coverage is most common but over 40,000 sq m has coverage of 50 to less than 90% (Table 2). Over 80,000 sq m of the reef is uncolonized (50 to 90% coverage) and this is reef pavement, sand and rubble.

Randall and Holloman (1974) and Randall and Eldredge (1976) described coastline features of the Asan Beach Unit; the latter work included an atlas of reefs and beaches that included this unit. More recently, Burdick (2005) utilized GIS methods to characterize the shoreline and reef flat. Amesbury et al. (1999) conducted a survey of marine plants, corals, macroinvertebrates, and fishes of the Asan Beach Unit. This study provided comparisons of species richness and benthic cover for both inner and outer reef flats, reef terraces, and the reef slope.

Marine Organisms in the Asan Beach Unit

Marine Plants: In their survey of marine plants, Amesbury et al. (1999) found eight species of green algae (Chlorophyta), five species of brown algae (Phaeophyta) and seven species of red algae (Rhodophyta). Green algae were most diverse on the inner reef flat, brown algae were most diverse on the outer reef flat, and red algae were most diverse on the outer reef slope. (Currently, brown algae, specifically the Sargassaceae, appear to provide more benthic cover. M. Gawel and A.K. Miller, NPS, personal communication, 13 December 2016.) Seagrasses were not reported from this site (Amesbury et al. 1999).

Corals and Reef Structure: In their survey of corals, Amesbury et al. (1999) reported 36 species of corals with an additional 21 species within the area. Randall (2003) reported 403 species of hard corals in 21 families and 108 genera from the Mariana Islands, and most species occur in Guam's waters. M. Gawel (1977) listed over thirty soft coral species in shallow Guam waters and at least ten of these occur in the Asan Beach Unit (M. Gawel, personal communication, 2023). Diversity of species at Asan was greater on the reef slope (including the reef terrace) compared to the reef flat. Coral cover at Asan was greater than at the Agat Unit, likely because the latter locality suffers from higher turbidity and sedimentation owing to relatively greater inputs from streams (Amesbury et al. 1999). High cover of soft coral species occurs in the Marine Preserve portion of the Asan Beach Unit including *Asterospicularia randalli* which was first discovered and described from Guam in 1977 (Gawel 1977). Park staff, interns and volunteers monitor coral and conduct training for snorkelers on shallow transects within the preserve area (M. Gawel, personal communication, 2023).

Minton and Lundgren (2006) and Minton et al. (2007) conducted a 2-year coral larvae settlement study and found that corals in this unit had poor levels of recruitment at depths of 10 to 20 meters. Corals of the family Pocilloporidae were the most common coral species recruiting, however, followed by species of the families Portitidae and Acroporidae. Minton et al. (2007) suggested that settlement patterns were influenced by light levels, rather than sediment or predation, but that other local or regional factors that regulate larval distribution, such as current patterns, may be important. Storlazzi et al. (2009) found that sedimentation patterns during periods of high terrigenous input could have negative effects, but that these effects could be lessened by wave action that could effectively disperse these sediments via offshore current flows.

Macroinvertebrates: Macroinvertebrates (generally larger mollusks, larger crustaceans, and echinoderms) occurring in the Mariana Islands are described in Paulay (2003b), Paulay et al. (2003a, b), Smith (2003), Carlson and Hoff (2003), Ahyong and Erdmann (2003), Kirkendale and Messing (2003), and Starmer (2003). Other taxa are described variously by authors in Paulay (2003a). In their surveys of macroinvertebrates at the Asan Beach and Asan units, Amesbury et al. (1999) recorded 191 species of macroinvertebrates (mollusks, crustaceans and echinoderms). Vermetid mollusks, associated with corals, had particularly high densities at this locality. Various echinoderm species were especially evident compared with more cryptic mollusks and crustaceans (Amesbury et al. 1999). Echinoderms were conspicuous, as well, with the sea cucumber *Holothuria atra* being the most commonly recorded species on the reef flat and the sea urchin *Echinostrephus* sp. being more common on the reef slope, followed by another sea urchin, *Echinometra* sp. that was found on the reef terrace. *Holothuria atra* may not be as common here now (A.K. Miller, NPS, personal communication, 13 December 2016).

Reef Fishes: In their study, Amesbury et al. (1999) recorded 193 species between both Asan Beach and Agat units with species richness being slightly greater at Asan. Reef slope habitat had greater fish abundance compared to reef flat habitat, but abundance on the reef flat at Asan was greater than at Agat. Tupper and Donaldson (2005) provided data from a fishery survey conducted in the Asan Beach Unit to examine fishing activity by method, catch statistics, principal target species, biomass harvested, and the contribution that each fishing method had towards marine debris. These data were compared with certain metrics from the neighboring Piti Bomb Holes Marine Protected Area (MPA) in an attempt to validate the effects of this MPA. The data indicated that the MPA had a positive effect upon the quality of the fish populations contained within its boundaries compared with those in Asan Bay outside of the MPA. Donaldson (2008a) examined fish assemblage structure between Camel Rock (Gapang Rock) and Asan Point, and the Asan River. The areas surveyed, from the lower spur and groove zone to the edge of the reef slope, had a fish assemblage typical of an exposed reef front (versus a protected reef) with moderate levels of both species richness and diversity. During this survey, a reef fish spawning aggregation site was detected (Donaldson et al. 2009). This resident spawning aggregation site (Domeier and Colin 1997) was utilized by two species of parrotfishes, *Chlorurus sordidus* (now *C. spilurus*) and *Scarus schlegeli* (Labridae: Scarinae). Chop (2008) studied the reproductive behavior of *C. sordidus* there and determined that terminal phase (TP) males arrive from neighboring parts of the reef and form temporary courtship territories that are defended against rival TP males as well as immature phase (IP) males. TP males also use these territories as courtship sites and passing females are courted there. These territories form early in the morning, just after sunrise, on a daily basis and their defense lasts until around 1300H, although courtship of females may cease prior to this time if the tide has turned. IP males also court females without using territories and spawn either in groups or as sneakers that mimic females while joining a TP male and a female in a spawning rush towards the surface (Chop 2008). More recently, Brown and Capone (2014) published the results of a biodiversity and ecological assessment of the marine fish assemblages found in the park. Descriptions of species diversity and body size were discussed above. In addition, the park's fish assemblages are denoted by having relatively low biomass with few apex predators. The authors recommended that fisheries management guidelines be implemented to provide for a continued presence of fishes on reefs. A checklist of marine species assembled from various sources is given in Appendix J. Photographs of representative species are given in Appendix K.

Sea Turtles: Eldredge (2003) listed three species of sea turtles reported from Guam, the green (*Chelonia mydas*, Cheloniidae), the hawksbill (*Eretmochelys imbricata bissa*, Cheloniidae), and the leatherback (*Dermochelys coriacea*, Dermochelyidae). Green and hawksbill sea turtles have been observed off the Asan Beach Unit. An aerial survey conducted in 2000 found green sea turtles off the Asan Beach Unit in the vicinity of the Asan River Cut during the months of May, June and August. The abundance of turtles, however, was quite low with only one turtle observed during each of these months (DAWR, unpublished data). Low abundances were reported for the Asan area by Martin et al. (2016), as well.

Marine Birds: Wiles (2003) has provided a checklist of birds from marine habitats of Guam. Six species of marine birds and 11 species of aquatic and shorebirds have been reported from, or are probably present, within the park (Appendix E). Among marine birds, the white tern (*Gygis alba*) has been confirmed. Among aquatic and shorebirds, the Pacific golden plover (*Pluvialis dominica fulva*) has been confirmed.

Marine Mammals: Surveys of marine mammals in the waters of Guam and the lower Northern Mariana Islands (Hill et al. 2016) were undertaken using visual, acoustic, satellite tracking, and genetic profiling methods. These surveys documented the species diversity and movement patterns of baleen and toothed whales, many of which are likely found in waters off the Asan Unit. Only the spinner dolphin (*Stenella longirostris*, Delphinidae) has been observed off the Asan Beach Unit, however. Densities of small delphinids with the Asan area (beyond the unit's boundaries) have been relatively low for the past 50 years (see Martin et al. 2016). A checklist of species reported from or likely present in the Park's marine waters (but not documented formally) is given in Appendix L.

Ongoing Surveys: Two ongoing research efforts have been established for the park that include surveys and the establishment of permanent transects on the reef in the Asan Beach Unit. Dr. Sheila McKenna (NPS Pacific Islands I&M) and her colleagues since 2008 have been conducting annual monitoring surveys of fishes and benthic cover on 15 Asan transects at depths of 10 to 20m. These surveys are part of a larger NPS Pacific Island Network Inventory and Monitoring Program. Results from this study so far that are comparable to those from similar efforts in other national parks within the Network are presented in Brown et al. (2016). The second effort involves the establishment of a series of permanent transects with data logger stations (sea surface temperature, irradiance, and water levels) along the reef flats between Adelup and Piti and at Agat (see Hoot and Burdick 2017). Permanent transects to monitor coral bleaching (part of the Guam Coral Reef Response Team efforts) have also been established and are monitored (Hoot and Burdick 2017).

Agat Unit

Physical and Biological Setting: The marine and intertidal zones contained within the Agat Unit (Figure 43) have an area of 221.9 hectares (548 acres). The Namo River and its small estuary form part of the northern boundary, which during the rainy season discharges considerable sediment out through the former river channel and onto adjacent deeper reef flats. The southern boundary is delineated by the eastern edge of the reef flat to the southwest of the Ga'an River. The beach has an area of approximately 5.85 hectares (14 acres) southwest of the Ga'an River and south of Bangi Island.

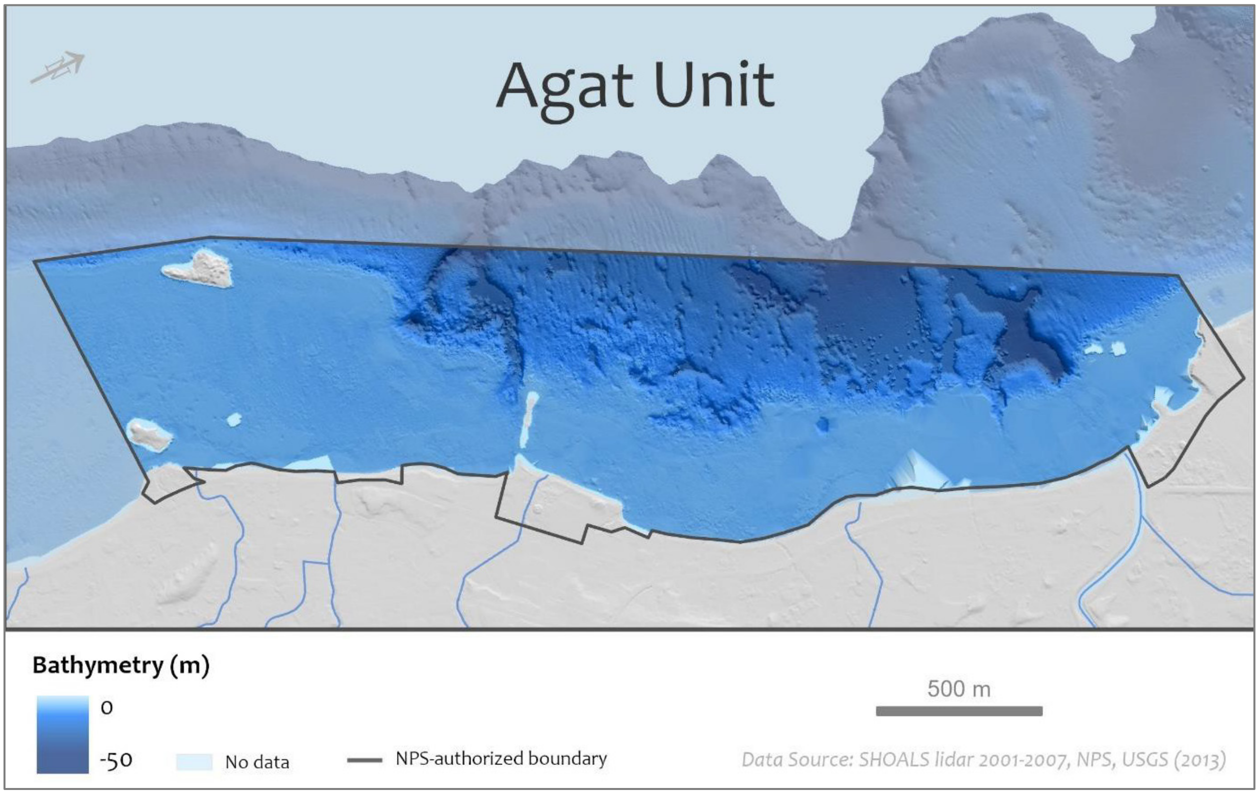


Figure 43. Marine and intertidal bathymetry within Agat Unit. Data Source: SHOALS lidar 2001-2007, NPS, USGS (2013).

Intertidal Zone: The intertidal zone is dominated by coralline sand, rubble and rock (Figure 34). The beach is subject to high and low tides, but these are relatively minimal with a typical range of less than 1m except during spring tides. The reef flat is often deeper than that in the Asan Beach Unit and is less subject to considerable exposure inshore during excessive spring low tides. Heavy surf occurs usually only during tropical storms or during periods of heavy westerly winds, but overall, the reef here is more protected than that at the Asan Beach Unit. A quantitative assessment of oceanographic conditions, especially current patterns, on par with the work at Asan of Storlazzi et al. (2009) that was done on Agat reefs as well (Storlazzi et al. 2014).

Marine Plants, Corals and Reef Structure: Randall and Holloman (1974) and Randall and Eldredge (1976) described coastline features of the Agat Unit; the latter work included an atlas of reefs and beaches that included this unit. More recently, Burdick (2005) utilized GIS methods to characterize the shoreline and reef flat and produced maps of these habitats.

Eldredge et al. (1977) conducted a biological survey of the inshore waters of the Agat Unit. Tsuda (1977) observed one species of seagrass and 59 species of algae. Randall (in Eldredge et al. 1977) found 164 species of corals. Amesbury et al. (1999), using different methods, found only 57 species of corals but was able to provide better estimates of coral cover for at least 36 of these species. The reef flats and terraces at Agat are impacted by considerable freshwater flows and these may limit the diversity, recruitment and abundance of corals there (personal observation). Reef structures in this unit (Table 2) are dominated by reef pavement, reef aggregate, sand, and rubble, but also reef spur and groove (at and below the reef margin), patch reefs, and mud. Macroalgae (10 to less than 50% coverage), turf algae (50 to less than 90% coverage), and seagrass (90 to 100% coverage) account for most marine plant coverage, although denser stands of macroalgae and coralline algae (50 to less than 90% coverage), and less dense patches of turf algae (10 to 50% coverage) may also be found. Coral cover of 10 to less than 50% coverage is most common. About 395,663 sq m of the reef is uncolonized (50 to 90% coverage) and this is reef pavement, sand, rubble and mud.

Macroinvertebrates: Eldredge et al. (1977) found 93 gastropod species, 17 bivalves, 52 opistobranchs, 42 crustaceans and 46 echinoderm species in its survey of this unit. Macroinvertebrate diversity measured by Amesbury et al. (1999) was comparable to that measured by them at the Asan Beach Unit. As with Asan, echinoderms in the Agat Unit were the most conspicuous, with the sea cucumber *Holothuria atra* being the most commonly recorded species on the reef flat and the sea urchin *Echinostrephus* sp. being more common on the reef slope, followed by another sea urchin, *Echinometra* sp. that was found on the reef terrace. Currently, *Actinopyga echinites* may be more common at this site (A.K. Miller, NPS, personal communication, 13 December 2016).

Fishes: Gawel (1977) listed 202 species of fishes from this unit while Amesbury et al. (1999) recorded 193 species of marine fishes from both the Agat and Asan Beach park units. Species richness was slightly lower at Agat. As with Asan, reef slope habitat had greater fish abundance compared to reef flat habitat, but abundance on the reef flat at Agat was less than at Asan. Subsequent surveys of inshore waters of adjacent naval submerged lands, but also off Apaca Point, measured both the diversity and abundance of reef fishes (Smith et al. 2010). Donaldson (unpublished data; University of Guam) found a suspected spawning aggregation site for a large triggerfish, *Pseudobalistes flavimarginatus* (Balistidae), on rubble and sandflats of the reef terrace just off Apaca Point. The spawning aggregation site, denoted by the presence of an aggregation of large nests, appeared to no longer be used given that the time of the survey was just prior to the new and full moons and triggerfishes should have been present at the site at this time. Brown and Capone (2014) more recently provided an assessment of biodiversity and ecological structure of marine fish assemblages in the Agat Unit.

Sea Turtles: Reports of sea turtle observations off the Agat Unit are anecdotal. In an attempt to quantify sea turtle sightings, Guam's DAWR has performed monthly aerial surveys of inshore coastal habitats irregularly. For example, a survey conducted in 2000 DAWR found a single green sea turtle (*Chelonia mydas*, Cheloniidae) off terraces of the Agat Unit in the vicinity of Apaca Point during the months of December. No turtles were observed in other months during this year, however (DAWR, unpublished data). A new study of aerial survey data over a 50-year period (Martin et al. 2016) found sea turtle densities to be relatively low, although mean densities for sea turtles were higher (0.17 per km2) than at the Asan Beach Unit.

Marine Birds: Marine, aquatic and shorebirds found on Guam were listed in Wiles (2003) and are likely to occur in the Agat Unit. These include six species of marine birds and 11 species of aquatic and shorebirds (Appendix E). As with the Asan Unit, the white tern (*Gygis alba*) and the Pacific golden plover (*Pluvialis dominica fulva*) have been sighted regularly.

Marine Mammals: Eldredge (2003) listed 14 species of marine mammals, virtually all cetaceans, from Guam. These include three species of baleen whales (Mysticeti, Balaenopteridae), 10 species of toothed whales (Odontoceti: Delphinidae, Physteridae, and Ziphiidae)), and a dugong (*Dugong dugon*, Sirenia, Dugongidae), a straggler species that likely came from the western Caroline Islands (Palau or Yap) and was seen in Cocos Lagoon, southern Guam in 1974 (Randall et al. 1975) and variously again in 1985 (D. Grosenbough, cited in Eldredge 2003). Species of marine mammals that have been reported from waters of the park or may be present offshore are listed in Appendix L. See Martin et al. (2016) for data on small and large delphinid densities in areas of the Asan Beach and Agat Units.

Surveys of marine mammals in the waters of Guam and the lower Northern Mariana Islands (Hill et al. 2013; 2016) were undertaken using visual, acoustic, satellite tracking, and genetic profiling methods. These surveys documented the species diversity and movement patterns of baleen and toothed whales, many of which are likely found in waters off the Agat Unit. Inshore, spinner dolphins appear to be regular visitors to the northern portion of the unit and their presence is predictable enough to warrant regular daily attention from the "dolphin watching" component of Guam's tourist industry (Figure 44). Martin et al. (2016) found the mean density of small delphinids to be low, however, but comparable to other localities on Guam where they have been observed. Larger delphinids had a very low mean density (Martin et al. 2016).

Recent Surveys: Recent annual monitoring surveys by S. McKenna (NPS) and colleagues since 2008 have examined fish assemblages and benthic cover on 15 transects at depths of 10 to 20m (see Brown et al. 2016). They identified aggregated coral reef areas with high coral cover and hard substrates, seagrass beds (*Enhalus acoroides*), the presence of endangered sea turtles, and marine mammals. They stated that 1,000 species of fishes and 400 species of corals were found but these numbers refer to what has been reported from or inferred for the Mariana Islands previously (i.e., Randall 2003; Myers and Donaldson 2003) and not just for War in the Pacific NHP. In addition, they identified threats including intense fishing, sedimentation and runoff, sewage, increased coral disease and bleaching, litter, World War II military debris, and crown-of-thorns starfish (*Acanthaster planci*).

Figure 44. Spinner dolphin-watching tourist boats anchored off Apaca Point, Agat Unit near the border with Navy Base Guam. These boats slowly follow a pod of dolphins along the reef. When not dolphin-watching, the boats anchor, and guests snorkel or swim over the reef. (Photo by T.J. Donaldson)

Threatened and Endangered Species

Terrestrial Plants

Seven species of plants are newly listed as endangered and seven as threatened on Guam (Federal Register, 2015). Endangered and threatened species, as well as species of concern, found within the War in the Pacific NHP are listed in Table 3.

Table 3. Endangered (E), threatened (T) and species of concern (SC) plants of Guam listed in the U.S. Federal Register (2015). Y denotes that this species is present within the boundaries of the War in the Pacific NHP.

Family	Species	Status	Park
Malvaceae	*Heritiera longipetiolata*	E	–
Menispermaceae	*Tinospora homosepala*	E	Y
Myrtaceae	*Eugenia bryanii*	E	–
Phyllanthaceae	*Phyllanthus saffordii*	E	–
Rubiaceae	*Hedyotis megalantha*	E	Y
Rubiaceae	*Psychotria malaspinae*	E	Y
Solanaceae	*Solanum guamense*	E	–
Cycadaceae	*Cycas micronesica* (formerly *C. circinalis*)	T	Y

Table 3 (continued). Endangered (E), threatened (T) and species of concern (SC) plants of Guam listed in the U.S. Federal Register (2015). Y denotes that this species is present within the boundaries of the War in the Pacific NHP.

Family	Species	Status	Park
Apocynaceae	*Tabernaemontana rotensis*	T	–
Orchidaceae	*Bulbophyllum guamense*	T	–
Orchidaceae	*Dendrobium guamense*	T	–
Orchidaceae	*Maesa walkeri*	T	–
Orchidaceae	*Nervilia jacksoniae*	T	–
Orchidaceae	*Tuberolabium guamense*	T	Y
Lamiaceae	*Hyptis pectinate*	SC	Y
Tiliaceae	*Corchorus aestuans*	SC	Y

Terrestrial Animals

Four species of native terrestrial snails are listed as endangered on Guam (Federal Register 2015). These include *Partula gibba*, *P. langfordi*, *P. radiolata*, and *Samoana fragilis* (all Partulidae). *Partula radiolata* has been found in Piti Guns, Asan Beach and Asan Inland Units. A colony found near the mouth of the Matgue River had to be relocated because of the presence of invasive little fire ants; the ants had to be treated with a pesticide that would have threatened the snails. Dr. Curt Fiedler (University of Guam Biology Program) and students tagged the snails and relocated them to the Asan side of Asan Ridge where they are currently being monitored (M. Gawel, NPS, personal communication, 13 December 2016). Two butterflies, *Hypolimnas octocula mariannensis* and *Vagrans egestina* (both Nymphalidae), are listed as endangered on Guam (Federal Register 2015); the latter may possibly be extinct. A cooperative program with US FWS began in 2017 to establish rare native host plants (*Procris pedunculata* and *Elatostema calcareum*) within War in the Pacific NHP to support recovery of the former butterfly species. Another insect, *Neptis guamensis*, is also listed as endangered. Its presence in the park is not known (Daniel 2006), but it is believed to be extinct.

Slevin's Skink (*Emoai slevini*, Scincidae) is listed as endangered (Federal Register 2015). Populations of this species likely no longer exist within the park or even on Guam but may be found only on Cocos Island off the southern tip of Guam. All of Guam's native terrestrial birds are listed endangered, extinct in the wild, or extinct. Historically, all may have been found in habitats distributed within the park's boundaries. Only the Micronesian swiftlet (*Aerodromus bartschi*, Apodidae) has been observed recently but does not appear to be resident in the park. The Marianas crow (*Corvus kurbaryi*, Corvidae), which is now rare and confined to the island of Rota, has not been reported from the park. The Guam gallinule or moorhen (*Gallinula chloropus guami*, Rallidae) and the Guam subspecies of the Micronesian kingfisher (*Todiramphus cinnamominus cinnamominus*), both endangered, are associated with freshwater habitats. The Guam gallinule has been reported from the park. The kingfisher is extinct in the wild but exists in a captive breeding program.

Among terrestrial mammals, the Mariana fruit bat (*Pteropus mariannensis*, Pteropodidae) is nearly extinct on Guam because of hunting, habitat loss, and other threats. This species is found elsewhere in the Mariana Archipelago and at Ulithi Atoll in Yap State of the Federated States of Micronesia. It is not known if this species forages in the park. The Pacific sheath-tailed bat (*Emballonura semicaudata rotensis*) is listed as endangered (Federal Register 2015) with populations on Guam known only from historical records (greater than 20 years before the time of listing). It likely occurred in parts of the park.

Freshwater Plants and Animals

No aquatic plants, invertebrates, fishes, amphibians, reptiles or mammals found in freshwater habitats are known to be threatened or endangered in the park. Two species of fishes are of concern, however, because of climate change and overfishing effects. These are the freshwater eels *Anguilla bicolor* and *A. marmorata* (Anguillidae). Unfortunately, no population data have been collected for either species.

Marine Plants

No endangered marine plant species have been reported from the park.

Marine Animals

Among corals, *Tubastraea floreana* (Dendrophylliidae) has been listed as endangered by the Federal Government. *Pavona diffluens* (Agariciidae), *Acropora globiceps* (Acroporidae) and *Seriatopora aculeata* (Pocilloporidae) are listed as threatened and occur in Guam (Table 4).

Table 4. List of threatened, endangered and proposed threatened coral species in U.S. jurisdictions. Source: National Oceanic and Atmospheric Administration 50 CFR Part 223 Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal To List 66 Reef-Building Coral Species and To Reclassify Elkhorn and Staghorn Corals; Final Rule September 10, 2014.

<table>
<tr><th>U.S. Jurisdiction</th><th>Species</th></tr>
<tr><td rowspan="14">Indo-Pacific</td><td>Acropora globiceps</td></tr>
<tr><td>Acropora jacquelineae</td></tr>
<tr><td>Acropora lokani</td></tr>
<tr><td>Acropora pharaonic</td></tr>
<tr><td>Acropora retusa</td></tr>
<tr><td>Acropora rudis</td></tr>
<tr><td>Acropora speciosa</td></tr>
<tr><td>Acropora tenella</td></tr>
<tr><td>Anacropora spinosa</td></tr>
<tr><td>Euphyllia paradivisa</td></tr>
<tr><td>Isopora crateriformis</td></tr>
<tr><td>Montipora australiensis</td></tr>
<tr><td>Pavona diffluens</td></tr>
<tr><td>Porites napopora</td></tr>
</table>

[A] species currently listed as Endangered.

Table 4 (continued). List of threatened, endangered and proposed threatened coral species in U.S. jurisdictions. Source: National Oceanic and Atmospheric Administration 50 CFR Part 223 Endangered and Threatened Wildlife and Plants: Final Listing Determinations on Proposal To List 66 Reef-Building Coral Species and To Reclassify Elkhorn and Staghorn Corals; Final Rule September 10, 2014.

U.S. Jurisdiction	Species
Indo Pacific (continued)	*Seriatopora aculeata*
Caribbean-Western Atlantic	*Acropora cervicornis* [A]
	Acropora palmata [A]
	Dendrogya cylindrus
	Mycetophyllia ferox
	Orbicella annularis
	Orbicella faveolata
	Orbicella franksi

[A] species currently listed as Endangered.

Acropora globiceps has been observed on NPS reefs (M. Gawel, NPS, personal communication). Earlier surveys of neighboring habitats (Smith et al., 2010) have not listed these species. A more recent listing has seven Indo-Pacific species that are threatened or endangered and 31 species that are proposed as threatened.

Surveys to determine their presence, where relevant, in the park are being conducted.

Members of the genera *Tridacna* and *Hippopus* (Cardiidae), otherwise known as giant clams, are listed on the IUCN's Red List of Endangered and Threatened Species (Neo and Todd 2013). Species present on Guam and within the waters of War in the Pacific NHP are at risk from harvest but no data on enforcement to protect these species appears to be available. *Tridacna maxima* is common in park reefs of Asan and Agat. *Tridacna squamosa* is also found in Guam but less common. A project to identify *Tridacnids* on Asan shallow reefs and monitor their growth and health using youth volunteers was conducted for a couple of years before 2020. Research on DNA samples of park specimens proved the species to be *T. maxima* versus a look-alike species (Mike Gawel personal communication, 2023).

The bumphead parrotfish (*Bolbometopon muricatum*, Labridae: Scarinae) has largely disappeared from Guam's reefs and is listed as "Vulnerable" by the IUCN and is considered by the U.S. government to be a "Species of Concern" (Federal Register 2012). The Guam population has been decimated by overfishing, particularly scuba spearfishing at night. Populations of this species at other localities in the Indo-West Pacific are also threatened (Donaldson and Dulvy 2004). The scalloped hammerhead shark (*Sphyrna lewini*, Sphyrnidae) is a U.S listed threatened species known to give birth in Apra Harbor waters located between the NPS Asan and Agat Unit reefs and believed present in War in the Pacific NHP managed waters.

The green sea turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*) have been observed swimming and feeding in waters of the Asan Beach and Agat units. Both species (including the Central and Western Pacific Population Segment of *C. mydas*) are listed as endangered by the Federal Government. The former species nests on Guam, with nesting sites recorded on Anderson Air Force Base, on Navy lands, and at Cocos Island in southern Guam.

Most species of whales, porpoises and dolphins, the only marine mammals likely to be observed within waters of the Asan Beach and Agat Units, are afforded protection under the Marine Mammal Protection Act. Spinner dolphins, which provide the basis for dolphin-watching tourism in waters of Guam (Figure 44), including those of War in the Pacific NHP, might be exposed to harassment from boats (tourist or otherwise) that venture too close to these animals and from frequent military exercises. They are afforded this protection, but negative interactions and subsequent enforcement are not well documented.

2.2.3 Resource Issues Overview

War in the Pacific NHP is impacted by various factors or processes that threaten the integrity of the park and its resources. These include invasive species, water pollution, runoff and erosion, wildfires, poor land use practices, recreational uses, military training uses, unexploded ordnance, habitat and microhabitat destruction, and illegal dumping of refuse. Both Thompson (1985) and the War in the Pacific National Historical Park (1997, 2003) provide detailed descriptions of a number of these resources, and data from these reports are augmented by more recent reports or observations reported here. Here, they are discussed briefly with additional details appearing in Chapters 4 and 5.

<u>Invasive Species</u>

Invasive Plant Species

Invasive plant species could pose a threat to native plant species, particularly those deemed threatened by or vulnerable to extinction (NPS Pacific Islands Network2012). Competition for space and other resources occurs. Non-native terrestrial plants are prevalent on Guam, and so little monitoring or control of plant species identified as being invasive has been undertaken. Although NPS has a monitoring protocol for invasive plant species in place (NPS Pacific Islands Network 2012), little monitoring or control within the park has been conducted because nonnative species are prevalent on the island, but an NPS Inventory & Monitoring survey for non-native species did occur in 2019.

Invasive Animal Species

Similarly, invasive animal species pose threats to native plants and animals, and terrestrial and aquatic habitats. Prominent species include wild pigs, deer, dogs, house cats, cattle, and the brown tree snake. More recent invasive species, especially insects such as the rhinoceros coconut beetle and the fire ant, have been reported from within the park's boundaries. These two species are being monitored island-wide by federal and local government agencies working with researchers from the University of Guam, and efforts are underway to control them.

Invasive Aquatic and Marine Species

A few invasive aquatic plants, invertebrates and vertebrates have been reported occurring in freshwater systems within Guam, and some of these are present in the park. No monitoring of these species is being done, however.

Damage to Marine Habitats by Human Activities

Coral reefs and associated habitats within the park have been damaged by human activities that include careless wading or swimming, anchor deployment, abandoned fishing nets and line, fuel spills from boats, and litter. Public outreach and education activities conducted locally may be effective in reducing these impacts but may be less so, in the case of litter, which can originate locally or be transported hundreds if not thousands of miles before being deposited on beaches in the Asan Beach or Agat units.

Water Pollution

Pollution of streams and inshore areas, particularly from adjacent agricultural activities, highway runoff, litter, sewage leaks and poorly treated sewage discharges carried by currents are present on Guam and directly or indirectly within the park (Thornberry-Ehrlich 2012). Discharges of animal wastes and nutrients from farmlands adjacent to park units are sources of contamination. The proximity of some units (Asan Beach, Asan Inland, Agat) to heavily traveled highways expose them to petroleum products and other motor vehicle exhaust pollutants deposited on road surfaces and then carried into waters by rainfall. Litter deposited along highways and side streets adjacent to and within the park ultimately be deposited into streams, wetlands, and inshore ocean waters. Maintenance activities conducted by park personnel in units can remove litter from areas utilized by the public but may have less impact elsewhere. Locally organized beach cleanups can provide information on the types of litter found in the Asan Beach and Agat units, but these are often not regular events for which sufficient data can be collected over time.

Wildfires

Wildfires are an important force within that can have wide-ranging effect upon the integrity of the park's resource. Fires may burn park and adjacent lands, destroy vegetation, and promote erosion and sedimentation (Minton 2005; Minton and Lundgren 2006). They can occur in various ways. For instance, farmers and landowners may use fire to control vegetation or to burn green waste or rubbish and may lose control of the fire, which then spreads onto park lands. Fires may result from lightning strikes, as well.

More commonly, however, is that poachers set fires in order to clear land and promote opportunities for hunting invasive deer and pigs. Outreach and educational activities conducted by park managers, perhaps in collaboration with local natural resource managers, can be somewhat effective in discouraging this practice, as can enforcement activities conducted by local and federal authorities.

Recreational Activities

Erosion in upland areas caused by the use of off-road vehicle (ORV) and mountain bicycles contributes sediment to streams and inshore marine waters within the park. The erosion caused also promotes the formation of "badlands" that resist natural and artificial revegetation efforts and further promotes erosion. Upland areas affected include the Mt. Tenjo-Mt. Chachao Unit (Hess and Pratt 2006). Although falling within the legislated boundaries of the park, the land is not owned by the NPS and so it is not managed for visitor use or conservation. Park managers can use public outreach and education activities that may lead to controlling vehicle use within these sensitive areas (Thornberry-Ehrlich 2012).

Adjacent Development and Disturbed Areas

Guam has suffered historically from the effects of war and natural disasters, but more recently from poor land use planning, outdated zoning regulations, and weak enforcement. As such, residential, commercial and even industrial developments bordering or even entering park lands pose a threat to the park's integrity (Daniel 2006, Thornberry-Ehrlich 2012). Development in upland areas promote erosion and sedimentation while those along the coast, including sea walls, runoff from parking lots, etc., threaten water quality and marine resources (Daniel 2006).

Military Training

The Navy performs training and testing activities within the Mariana Islands Training and Testing Study Area. Various types of warfare activities, such as in-water detonations and the use of sonar and other transducers, are performed for military readiness. The National Oceanic and Atmospheric Administration conducted a study in 2020 that examined stranding events of Cuvier's beaked whales (*Ziphius cavirostris*) in the Mariana Archipelago since 2007 and the association of sonar impacts from military readiness activities (Simonis et al. 2020).

Geological and Oceanographic Issues

Thornberry-Erlich (2012) provided a description of different geological (including oceanographic) issues identified during meetings held by the NPS at the War in the Pacific NHP on March 20–21, 2003, and a follow-up conference call on March 2, 2011. These included terrestrial erosion and coastal sedimentation, relative sea-level rise and coastal vulnerability, adjacent development and disturbed areas, groundwater withdrawal and contamination, seismicity and tsunamis, mass wasting, storm damage, and radon potential.

Terrestrial Erosion snd Coastal Sedimentation

Terrestrial erosion contributes to coastal sedimentation on Guam. Slopes, such as those found in the Asan Inland, Mt. Alifan, Mt. Tenjo-Mt. Chaco, and Fonte Plateau units, promote erosion during heavy precipitation events if stabilizing vegetation is disturbed by fire, grazing, and ORV use (Thornberry-Erlich 2012), or if streams flood and strip soil from the adjacent ground that is carried back into the stream (T.J. Donaldson, personal observations). Areas directly adjacent to the park that undergo coastal development and have poor land-management practices also create significant erosion problems. Erosion ultimately leads to high sedimentation on the coral park's reefs (Storlazzi et al. 2009). Fires deliberately set in savannas within the park experience severe erosion at rates six times higher than that of undisturbed savannas with sedimentation collection rates among the highest on record (Minton 2006). Excessive turbidity and sedimentation blocks light or otherwise smothers corals and causes coral mortality. With the loss of live corals, algal growth is promoted, and overall biodiversity is reduced (National Park Service 2002).

Precipitation events that promote erosion produce plumes of terrestrial sediment that collect on the reef and forereef. These sediments may contain bacteria, pesticides, and other substances that are harmful, as well. (Storlazzi et al. 2009). Sediments may be transported off the reef or may accumulate in eddies that may deposit them on the reef, especially under low-energy conditions (i.e., reduced runoff or onshore wave activity). An example of where this occurs is in the Asan Beach Unit, where sediments carried down from the Asan Inland Unit enter the ocean and accumulate on the reef (Minton et al. 2007, Storlazzi et al. 2009). A large quantity of terrestrial sediment accumulates on the forereef, but sedimentation is not burying the elevated reef (Minton et al. 2007, Storlazzi et al. 2009).

Relative Sea-Level Rise and Coastal Vulnerability

Climate change resulting in global warming is contributing to sea level rise that will have profound effects on coastal areas. Sea level rise can increase shoreline erosion, inundate estuarine areas and coastal wetlands, damage groundwater aquifers through saltwater intrusion, and threaten the Park's cultural resources and infrastructure (Pendleton et al. 2005). The Park's 11 km (7 miles) of coastline was mapped in a simulation to predict vulnerability of the Park and its resources to sea level rise (Pendleton et al. 2005). The map was created using a coastal vulnerability index (CVI) that ranked the contribution of geologic and physical process factors towards change because of sea level rise. These factors included geomorphology, regional coastal slope, rate of relative sea-level rise, historical shoreline change rates, mean tidal range, and mean significant wave height. The authors found that geomorphology, regional coastal slope and wave energy were the most important CVI variables. The Agat Unit was predicted to have the highest vulnerability within the park because it possesses low slope and high wave energy values. This was especially evident for Apaca and Ga'an points, where sandy beaches or rubble flats occur (Pendleton et al. 2005). In the Asan Beach Unit, however, erosion has been evident only in sandy beach areas but not in rocky portions of the coastline.

In general, risks to coastal integrity require monitoring to detect change. Useful variables to monitor include:

1) shoreline change
2) coastal dune geomorphology
3) coastal vegetation cover
4) topography/elevation
5) composition of beach material
6) wetland position/acreage
7) coastal wetland accretion (Bush and Young 2009).

Groundwater Withdrawal and Contamination

Being a relatively small island, Guam has limited groundwater resources. Guam's aquifers hold groundwater that is pumped to the surface in order to supply its population's water needs. Groundwater discharges from these aquifers also occur naturally, and water moves through porous limestone rock before being discharged. Thus, water flowing through limestone rock goes downhill until it reaches the sea. There, water may be discharged from springs, seeps, fractures, and caves along the coast or may even emerge from submarine vents in the sand or rock on the reef flat (Barner 1995; Taborosi et al. 2009). Within the Park, the Asan Inland Unit serves as the source area for Asan Spring, and this spring may be connected to a pond within the park that has historical significance (Thornberry-Ehrlich 2012).

Seismicity and Tsunamis

Guam commonly experiences earthquakes, with many minor tremors occurring on a daily basis with more pronounced events of varying strength occurring less frequently. These quakes result from subsurface liquefaction and lateral spreading. Limestone bluffs may experience local slumps and rockfalls, ground may subside, sand may spew from fissures or sand boils, and lagoonal deposits in bays may subside. Man-made structures, such as buildings and water storage reservoirs, may be damaged. These outcomes were typical of the large quake experienced in 1993 (Comartin 1995). Guam has several faults capable of generating large quakes, including the Pago-Adelup Fault, that runs from Pago Bay in the east through the Fonte Plateau, Asan Inland and Asan Beach units (Comartin 1995). Because of the presence of artificial fill within the park, particularly within the Agat Beach Unit, potentially serious risks exist because filled areas are quite vulnerable to liquefaction and lateral spreading that promote ground subsidence, differential settlement, and sand boils (Vahdani et al. 1994).

Low-lying areas within the park, such as the Asan Beach, Asan Inland, and Agat Units, are vulnerable to tsunamis. These consist of often massive waves that arise when the water column is displaced by submarine earthquakes or landslides. Tsunamis may be generated locally or from distant sources anywhere within the Pacific and can travel very rapidly before coming ashore on Guam. Gently sloping reefs with significant shallow areas allow for the formation of large waves prior to landfall. Fortunately, Guam has reef slopes that, for the most part, drop-off relatively quickly thus preventing the buildup of large waves (see Thornberry-Ehrlich 2012). This outcome is not always guaranteed, however, since a few tsunamis have caused significant damage (Daniel 2006). For example, a tsunami generated from a large earthquake near Guam in 1993 caused damage along the eastern coast of Guam (Harada and Ishibashi 2008).

Mass Wasting

Mass wasting events, such as landslides, blockfalls, debris flows, and slumps, occur on Guam. These are caused by the island's active tectonic environment, steep topography, geologic framework, tropical climate, and human activities (Thornberry-Ehrlich 2012). Guam has two types of bedrock, volcanic and limestone. Both are present within the park and have overlying materials (regolith or residuum) that are unconsolidated and weathered. They also behave differently in their structural integrity and vulnerability to mass wasting (Santi 1998). Volcanic rocks are predominately basalts and andesites and have low permeability. Thus, rainfall infiltration is low and during high precipitation events high runoff and heavy flooding in stream basins usually occur (Gingerich 2003). Within the Asan Inland Unit, much of the bedrock present consists of volcanic tuff. This rock is relatively weak and vesicular and is prone to weather deeply enough to form a clayey regolith that has joints and fractures which create zones of weakness. The interface between the weak, unconsolidated rock and the stronger bedrock beneath it can create slip surfaces that promote mass wasting (Callender 1975). This phenomenon occurs to a greater extent in the Mt. Alifan unit and is common in the southern part of the Park (Thornberry-Ehrlich 2012). Elsewhere within the Park, however, the underlying rock is limestone which is soluble and may contain small pockets, cavities, and widened fractures seen in karst landscapes. These rocks produce thin clay or gravel residuum soils when weathered (Santi 1998). Knobs and cliffs made of limestone in the upland units are produce rockfall events while dissolved cavities in the limestone may lead to localized collapse or sinkhole subsidence. Typhoons, tropical storms, and heavy thunderstorms that appear seasonally, produce significant amounts of rain that can saturate unconsolidated regotith formations found on the bedrock of slopes. In turn, landslides and slumps may occur. These formations can fracture or be further weakened by earthquakes that can result in landslides on slopes. This occurred along the western face of the Asan Ridge during the 1993 earthquake on Guam (Rutherford and Kaye 2006). Poor land-use practices, such as burning, clearing, and ORV use lead to the creation of "badlands" that have so little soil present that vegetation growth is limited or non-existent (Rutherford and Kaye 2006).

Storm Damage

Tropical storms, including typhoons, as well as heavy thunderstorms that produce high winds, heavy precipitation, and flooding, occur seasonally (July through December) on Guam, but may occur in other months, as well. The wind, waves and landslides generated in such storms pose a threat to the park's natural and cultural resources and facilities (Greco 2003, Winzler & Kelly Consulting Engineers 2003).

Radon Potential

Radon infiltration into the park's facilities poses a threat to visitors and staff alike. This radioactive gaseous element is colorless and toxic, and results from the decay of radium, an element that results from the decay of uranium. Uranium occurs at low levels naturally in many minerals, and thus is present in rock, soil, and water. If decaying in the regolith surrounding a building's foundation it will move upward and contaminate the air held within a room within that building where it may be trapped if the room is sealed (e.g., air conditioned). A geologic radon potential map produced by the Park indicates that Park units have variable levels potential exposure. Low levels occur the Mt. Alifan, Mt. Chachao-Mt. Tenjo, and Piti Guns units.

Moderate or variable levels occur in the Agat, Asan Beach, and Asan Inland units. Earthquakes and construction activities that disturb the ground may release radon from highly permeable weathered bedrock (Otton 1993, Thornberry-Ehrlich 2012).

2.3 Resource Stewardship

2.3.1 Land Ownership

Lands contained within War in the Pacific NHP's legal boundaries include NPS holdings, Government of Guam lands, private inholdings, and submerged lands (Figure 45). Undeveloped Government of Guam land within War in the Pacific NHP is managed under the administrative authority of the NPS. This authority stems from a Memorandum of Agreement between NPS and the Government of Guam that went into effect in 2000. Developed Government of Guam land within the park's legal boundaries is managed in the same manner as private inholdings. The NPS has only a vaguely defined authority over private inholdings and this authority has not been exercised to date. NPS does not have a formal relationship with private inholding owners within park as is normally established in most NPS units. The Mt. Tenjo Unit was included in Public Law 95-348 as one of the original park units and is included with other Park units in the park's Boundary Map (War in the Pacific NHP, P-24-80,000B, March 1978). The property, however, was never acquired and is not under U.S. federal ownership. The larger part of Piti Guns Unit is much larger than the area defined by Public Law 95-348 because the Government of Guam gave additional property to the NPS in order to expand the boundaries of this unit within the Park. Submerged lands within the park, whether owned by NPS as being part of a former military reservation, or owned by the Government of Guam, fall under NPS jurisdiction. Outside the authorized boundary of War in the Pacific NHP, the Guatali Parcel, which was part of a quit-claim deed but has not been incorporated officially within the park, is a fee-simple landholding transferred to the NPS in the 1970's and separate from Public Law 95-348.

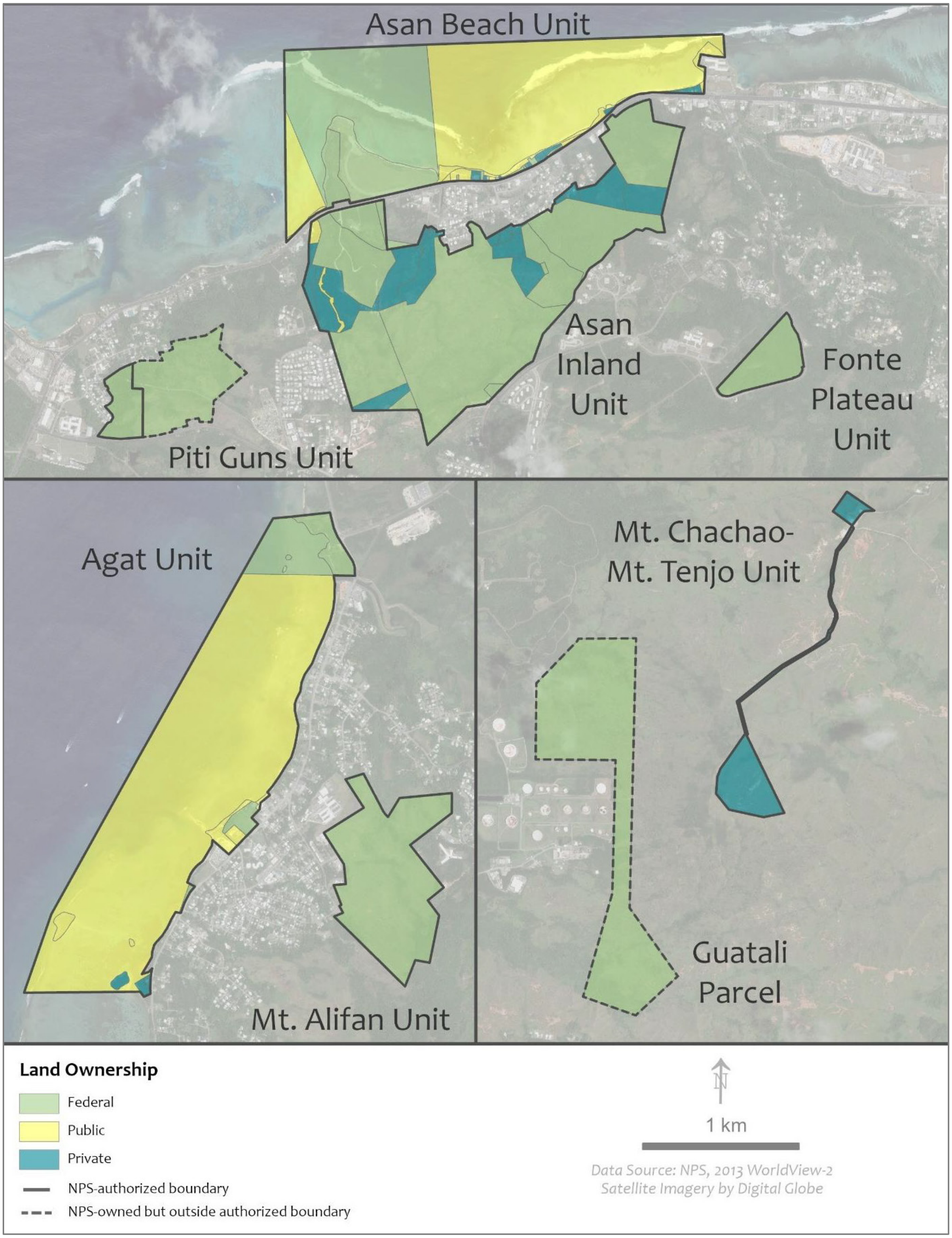


Figure 45. Land ownership within War in the Pacific NHP. Data source: NPS, 2013 WorldView-2 Satellite Imagery by Digital Globe.

2.3.2 Management Directive and Planning Guidance

A statement for the management of the War in the Pacific NHP was published in 1988 that provided the impetus for development of the park as established under Public Law 95-348. The purpose of the park was to "commemorate the bravery and sacrifice of those participating in the Pacific Theater of World War II and to conserve and interpret outstanding natural, scenic, and historic values and objects on the island of Guam for the benefit and enjoyment of present and future generations" (NPS 1997). A management plan was produced in 1997. The plan defined each of the units within the park, provided summaries of the geology, soils, climate, flood and tsunami zones, storm zones, alien species invasions, and land ownership.

Management objectives for cultural and historical resources included 1) provision of interpretative activities that would be conducted in the English, "Chomorro" (*sic*), and Japanese languages; and 2) address needs for the preservation of cultural resources related to the American re-invasion of Guam and to develop interpretive programs related to the Pacific encounters of World War II Management objectives for natural resources included 1) "management of native terrestrial ecosystems generally in accord with those conditions just prior to the American re-invasion of Guam"; 2) "preserve and manage important geographical and historical features within the park in order to provide a setting with sufficient historical integrity to adequately interpret the battle for Guam as an example of the island-by-island fighting in the Pacific war battles"; and 3) "preserve and interpret important natural features such as native plant communities and stream and marine bed environments for public use and enjoyment" (NPS 1997). The plan also provided status reports of cultural and natural resources, as well as data on the status of project funding for assessment of the park's resources.

2.3.3 Status of Supporting Science

<u>Background</u>

The management plan (NPS 1997) identified four major issues as drivers for project assessments and monitoring: 1) defining and managing "National Historic Landscapes"; 2) the invasive brown tree snake (*Boiga irregularis*) and its effects upon wildlife within the park; 3) reef and ocean management under mixed ownership; and 4) munitions dumped on the reef at Asan Point within the Asan Beach Unit.

<u>National Historic Landscapes</u>

Projects (proposed or implemented) intended to define and manage National Historic Landscapes, and their status, are given in Table 5.

Table 5. Projects proposed in the War in the Pacific NHP Resource Management Plan (NPS 1997) to define and manage "National Historic Landscapes" including natural resources.

Proposed project	Proposed or actual study(ies)	Outcome(s)
Park Mapping	NPS with private contractor	Contribution to GIS capability
Establishment of GIS Capability	NPS cartographer; RMAP analysis	GIS capability established
Aerial Photography	Contract survey/remote sensing	Contribution to base map/GIS capability

Table 5 (continued). Projects proposed in the War in the Pacific NHP Resource Management Plan (NPS 1997) to define and manage "National Historic Landscapes" including natural resources.

Proposed project	Proposed or actual study(ies)	Outcome(s)
Boundary Survey of All Units	NPS staff	–
"Historic Scene" Restoration	NPS scientists/historians/managers	Ongoing multidisciplinary approach
Botanical Resources Survey and Mapping	UOG/Government of Guam team	Preliminary without maps
Tangantangan Plant Control	Maintenance staff/biologist	Project not executed
Mission Grass Ecological Study	Proposed surveys by UOG or U Hawaii	–
Alien Pig Status Study	Survey forests for population and damage assessments	–
Endangered Tree Fern Study	NPS, UOG, private contractor surveys	–
Wildfire Study	NPS staff	Minton (2005); erosion effects on reefs
Faunal Surveys	Data poor; new studies required UOG/UOGML terrestrial, aquatic and marine teams, plus NPS biologist; park and Guam-wide	Deferred because of invasive species effects on native terrestrial fauna; subsequent studies by USFWS marine surveys by Eldredge et al. (1977), Amesbury et al. (1999), Donaldson (2008), Smith et al. (2010) Brown, D.P. and M. Capone. 2014. Fishes of War in the Pacific National Historical Park. Micronesica 2014-01: 1–28. Rogers, D.C. 2011. Field and laboratory guide to the freshwater and terrestrial decapoda of Guam. Draft for NPS. Rodda, G. H., and K. Dean-Bradley. 2001. Inventory of the reptiles of the War in the Pacific National Historical Park, Guam. 58pp. US Geological Survey, Fort Collins, Colorado
Biological Study of Small Islands	UOG team to study Guam small islands as refugia from brown tree snake	Not implemented; later studies by USFWS; Perry et al. 1998
Endangered Bird Study	UOG team to conduct surveys	Subsequent studies on Guam by Guam DAWR, USFWS; Savidge (1987), Wiles (2003)
Endangered Bat Study	DAWR, UOG, contractors, Harvard U. and US Navy proposed ecological study of three species of bats	DAWR and federal government leads; NPS abandoned surveys because of losses from snake predation

Table 5 (continued). Projects proposed in the War in the Pacific NHP Resource Management Plan (NPS 1997) to define and manage "National Historic Landscapes" including natural resources.

Proposed project	Proposed or actual study(ies)	Outcome(s)
Off-Road Vehicle Control	Impact study; barriers and fencing installed; patrols	PCR Environmental (2009)
Development of Water Resource Management Plan	Collaborate with EPA, GEPA, U.S. Navy	–
Natural History Interpretative Trails	NPS, UOG program development	Asan Ridge Limestone Forest Interpretive Trail created with signage.
Monitor and Manage Archeological Resources	NPS, assess wildfire impacts; mapping	–
Underwater Cultural Resources Survey	NPS surveys; mapping	Quantitative surveys needed NPS Submerged Resources Team reports of 2023

In 1997, the park lacked a proper boundary survey for each unit. Knowledge of accurate boundaries promote effective park management, so the NPS proposed a set of surveys to include the installation of permanent markers. "Historical scene" restoration was recognized as a means of returning park lands to pre-World War II, non-agricultural landscapes based upon native vegetation patterns. Aside from removal of exotic plant species, disused structures, rubbish, etc., it was necessary also to conduct an historic survey of vegetation patterns to gain knowledge of how the landscape was prior to the war (NPS 1997). The NPS proposed a program of multidisciplinary study and management utilizing scientists, historians, and landscape managers to achieve these goals. The physical control of an introduced plant species, tangantangan (*Leucaena leucocephala*), that is invasive and destructive to plant communities, was proposed by NPS in order to protect native species and habitats. Similarly, the Mission grass (*Pennisetum polystachion*) is an introduced species that dominates the savanna ecosystem and inhibits the re-establishment of and replaces native sword grass. The NPS was not aware of the extent of this species within the park but did recognize it as a threat to native grasses and especially the endangered tree fern (NPS 1997).

The endangered tree fern has been threatened by commercial collecting and the population within the park was at risk from this activity, as well as that of wildfires and invasive Mission grass. The NPS required surveys to determine the precise locations of tree ferns within the park, the extent or threat of illegal collecting, or the ecological effects of fire and/or mission grass on tree ferns (NPS 1997). Wild (referred to as "alien" in the Resource Management Plan) pigs disturb plant communities when foraging, cause erosion, and expose various organisms to direct predation by other species. The NPS proposed to survey pigs in forested areas, obtain estimates of population densities in park units, and valuate their impact upon vegetation. Surveys by the Guam Division of Aquatic and Wildlife Resources (DAWR) across Guam have shown the presence of wild pigs within the park but the extent of damage caused remains to be examined. NPS studies of the effects of wildfires within the park (Lundgren and Minton 2005, Minton 2005; Minton et al. 2006) provided data on the negative effects of these events (habitat loss, and sedimentation of streams and corals).

Faunal surveys of the park's terrestrial habitats were proposed but were often not conducted because of observations of the effects of brown tree snake predation on native species that rendered many species-specific surveys moot (NPA, 1997). Surveys of small islands (islets) offshore of Guam, viewed as potential refugia for native reptile species threatened by the brown tree snake, were found that the islets could serve as refugia only in the short term. Surveys of threatened and endangered native birds and bats have been conducted by Guam's DAWR, the U.S. Geological Survey (USGS), and other researchers have led to the conclusion by NPS that these organisms have been decimated by brown snake predation and are no longer present within the park, and that birds are limited to migratory shore and marine species, and invasive species (Savidge 1987; Wiles 2003; see also Pratt et al. 1987, for a checklist of species and their status). Inventories related to fish (Brown and Capone 2014) and reptiles (Rodda and Dean-Bradley 2001) have been completed as well as a guide to decapoda (Roger 2011). A study of the effects of off-road vehicles on terrestrial habitats revealed the potential and actual negative impacts from off-roading, mainly the destruction of vegetation, exposure of soil, runoff during rain and tropical storms, and sedimentation of streams and reefs (PCR Environmental 2009). Development of a joint water management plan to address water quality concerns was undertaken by NPS in collaboration with the Guam Environmental Protection Agency (GEPA), the U.S. Environmental Protection Agency (EPA) and the U.S. Navy. Surveys of terrestrial archaeological and underwater cultural resources were proposed, and activities were linked to restoration of National Historic Landscapes (NPS 1997) and underwater unexploded ordinance (Minton et al. 2006).

Brown Tree Snake

Projects to assess and monitor the brown tree snake, and to assess its impacts upon wildlife within Guam, including the War in the Pacific NHP, have been conducted island-wide by Guam's DAWR, the and the U.S. Department of Agriculture. Relevant findings based upon early but significant research efforts that document major impacts upon native bird and lizard fauna are given in Savidge (1987), Perry et al. (1998) and Rodda and Dean-Bradley (2001).

Reef and Ocean Management

To determine potential or actual patterns of reef disturbance, a study of local subsistence activities to determine extent of collecting done on park reefs, types of biota exploited, and the population dynamics of exploited species, was proposed. The basis and patterns of traditional reef collection and potential impacts of restrictions on traditional users would also be documented, as would the extent, rate and distribution of habitat damage resulting from destructive fishing techniques. Projects to provide for reef and ocean management, including assessments, and their status are given in Table 6. Since then, additional surveys have been undertaken by NPS (inventory surveys), the University of Guam Marine Laboratory (biological surveys of corals, reef fishes and other organisms), the Guam Division of Aquatic and Wildlife Resources (fisheries effort). Surveys of Guam's reefs by the NOAA's Coral Reef Ecosystem Division have been conducted periodically and have included waters of the War in the Pacific NHP (see http://www.fisheries.noaa.gov/pacific-islands/ecosystems/coral-reefs-pacific).

Table 6. Projects proposed in the War in the Pacific NHP Resource Management Plan (NPS 1997) to address ocean and reef management.

Proposed project	Study	Outcome
Impact Study of Reef Construction Removal	Proposed UOGML study	UOGML technical report
Reef Disturbance Study	–	–
Monitor and Manage Ocean Habitats Studies	NPS staff; mapping; contract surveys; UOGML thesis research; subsistence fishing	NPS and UOGML studies; Eldredge et al. 1977 studies; Eldredge et al. 1977; Amesbury et al. 1999; Burdick 2005; Lundgren and Minton 2005; Minton 2005; Tupper and Donaldson 2005; Minton and Lundgren 2006; Donaldson 2008a; Chop 2008; Brown and Capone 2014; McKenna et al. unpublished; etc.
Removal of Sewage Discharge, Ga'an Point	Proposed UOGML study	UOGML technical report
NPS UXO Surveyof Asan Point Reef	Minton et al., 2006 plus U.S. Navy surveys	Various munitions and locations detected and Identified

Munitions Dumping

As a consequence of battles between the defending Japanese and invading American forces landing on invasion beaches, and actions taken by U.S. forces afterwards, unexploded munitions became a problem for management after the establishment of the park immediately afterwards. The Resource Management Plan called for NPS to survey for munitions or ordinance within the park. Surveys conducted previously by the U.S. Navy and later by the NPS discovered UXO in shallow waters of the Asan Beach Unit. Since the release of the 1997 Resource Management Plan, many of the original projects listed were not but others began to address park needs or new requirements. The War in the Pacific NHP has relied upon data from Guam-wide surveys of brown tree snake population biology, distributions, and ecology conducted variously by Guam Division of Aquatic and Wildlife Resources, the U.S. Fish and Wildlife Service, and the U.S. Department of Agriculture. The results of these explained the decimation of native birds and reptiles within the park. Work conducted for Ocean and Reef Management was mainly by various researchers, mainly from NPS, the University of Guam Marine Laboratory, and NOAA (Table 6). Burdick (2005) provided a coastal and reef atlas. Lundgren and Minton (2005), Minton (2005) and Minton and Lundgren (2006) described sedimentation and effects upon corals. Tupper and Donaldson (2005) described subsistence fishing in the Asan Beach Unit and its potential effect.; Chop (2008) described a parrotfish residential spawning aggregation site and its dynamics. Donaldson (2008a) and Brown and Capone (2014) described reef fish diversity. More recently, a NPS team (McKenna et al. unpublished data) collected quantitative data as part of a long-term survey of benthic organisms. Surveys of munitions (live rounds fired during combat or those dumped into the sea by U.S. forces) by Minton et al. (2006) described the distribution and status of UXO (Minton, n.d; Minton et al. 2006). The Asan Bay study on UXO impacts (above) found no impacts of concern on health of consumers or the ecology.

While efforts to assess and monitor the War in the Pacific NHP's natural resources, including the collection of data relevant to terrestrial, aquatic and marine systems within the park, have been ongoing (i.e., Paulay 2003), the work undertaken has been inconsistent. Funding to undertake resource inventories and research projects proposed in the Resource Management Plan (NPS 1997) was often lacking to support work by NPS personnel or contractors. Projects that were funded were often either short-term projects, or part of larger projects that involved data collection from either Guam or the Mariana Archipelago (Table 6; information below). Such projects were funded variously by other federal agencies, the territorial government, or other sources of external funding. Datasets from research and monitoring of many biological resources or monitoring of environmental indicators are absent or historically insufficient to provide comparative or time-series analyses. This is often because research projects are not funded to provide for monitoring in addition to basic assessments. Nevertheless, there are some well-documented assessments of natural resources. These pertain mainly to marine organisms and are limited to species checklists across a wide range of taxa, from algae to marine mammals (Paulay 2003). Recent assessment and monitoring efforts within the park and throughout Guam, including assessment of habitats (i.e., Burdick 2005; Daniel 2006; Smith et al. 2010; Brown et al. 2016; Hill et al. 2016; Burdick et al. unpublished; McKenna et al. unpublished), as well as some baseline studies by Lundgren and Minton (2005), Minton (2005), Minton and Lundgren (2006) and Minton et al. (2007), will now allow for some comparative and time-series analyses, however.

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, geologic conditions are not expected to change significantly over time (although assessment techniques, classifications, and accuracy may), but plant and animal populations and assemblages are dynamic, especially in the marine environment. For instance, rapid changes in coral abundance and community structure from bleaching will result in corresponding changes in the community structure of the coral reef system at local and regional scales. Therefore, temporal considerations should be weighed heavily towards prioritizing future scientific efforts.

As of 2019, the following scientific studies, inventories, plans and data development efforts are underway or recently completed. Though several of these efforts are not necessarily specific to the War in the Pacific NHP, they provide important information for managers and/or future research and monitoring efforts. See Table 6 for a list based upon the Resource Management Plan (NPS 1997), and the descriptions below.

National Park Service Inventory and Monitoring Program (I&M)

- Terrestrial
  - Vegetation surveys every five years. This work was not funded for several years; however, a survey was conducted during the past five years and a report is in preparation.
- Aquatic
  - Annual physical and chemical stream condition monitoring of the Asan River (= stream) at 8 fixed and 4 – 8 random sites conducted by NPS biologists (active).

- Annual biomonitoring at Asan River sites – surveys of fishes, crustaceans, gastropods and gastropod eggs (proposed but not active).
- Quarterly water quality monitoring of the Asan River (proposed but not active).

- Marine
  - Annual marine benthic cover photo-transects at 15 fixed and 15 random sites conducted by NPS biologists to assess and monitor changes in benthic cover over time. A report of the results of these activities is in preparation by NPS.
  - Quarterly water quality monitoring at marine survey sites. Monitoring of all parks within the Pacific islands is reported (including metadata and data files) by the NPS Pacific Island Network (PACN) at: https://irma.nps.gov/DataStore/Reference/Profile/2260084. The water quality monitoring protocol and annual reports for PACN are available at: https://irma.nps.gov/DataStore/Reference/Profile/2166407

Other research and monitoring projects within the park or with relevance to it:

- Terrestrial
  - Monitoring and control of Little Fire Ant (LFA; *Wasmannia auropunctata*)—NPS reported the presence of LFA within the Asan Beach Unit, Asan Inland Unit, and Ga'an Point of Agat Unit. Monitoring and control efforts have been proposed, but projects are not active.
  - Assessing Coconut Rhinoceros Beetle (CRB; *Oryctes rhinoceros*) damage and coconut palm health—Recent surveys have shown little efficacy in current control techniques of CRB and no decline in palm mortality. A USFS Forest Health report was drafted in 2019. Breeding site sanitation, CRB damage, and palm vigor assessments are ongoing.
  - Eradicating invasive Pink Tecoma (*Tabebuia heterophylla*) trees in Asan Inland savanna—A study was proposed but the project is not active.
  - Monitoring savanna post-fire resurgence in Asan Inland—Project is active.
  - Assessing the vigor of Piti Guns Mahogany forest—Surveys were completed in 2019 and findings were published in Bevacqua and Cruz (2020).
  - Translocation and monitoring of endangered tree snails—Park managers are in possession of 2016 translocation and 2017 monitoring data. Continuation of inventory and monitoring efforts for endangered tree snails are proposed, but not active.
  - Transplanting and monitoring of *Procris pedunculata* and *Elatostema calcareum* host plants for the endangered Mariana's Eight-Spot Butterfly (MESB; *Hypolimnas octocula marianensis*)– Project was completed in 2018. Continuation of monitoring has been proposed, but not active.
  - Eradicating Brown Tree Snake (BTS; *Boiga irregularis*) from Asan Ridge—USGS, FWS, UOG, and NPS have proposed a collaborative effort in eradicating BTS populations in Asan Beach Unit, but the project is not active.
- Marine

- Recreational diver impact control research in Guam's waters including those of the park (UOGML: Ashton Williams thesis). The results from this thesis research are being prepared for publication.
- Assessing coral cover and diversity on the reef flat over time at fixed sites across the park using CoralNet semi-automated image annotation (NPS)
- Reef flat coral restoration using nursery-grown fragments of *Acropora aspera* and *A. pulchra* at Asan unit, tracking growth and survival over time (NPS, UOGML, and BSP)
- Coral restoration in the park's Agat unit using coral nurseries for novel species production (NPS—we're starting this soon)
- Reef flat inventory of fishes, invertebrates, corals, and algae (NPS)
- Coral inventory project (contractor)
- Assessing giant clam (*Tridacna* spp.) cryptic species diversity through DNA analysis—UOGML and Guam – Park staff completed DNA analysis showing *Tridacna* in the park are not *T. noae* but *T. maxima*.
- Assessing giant clam (*Tridacna* spp.) population status, bleaching and health, and growth on War in the Pacific NHP reef flats (Park staff and volunteers carried out these studies as Asan in 2016-2017).
- Temperature and light monitoring on reef flats – UOGML and Guam Bureau of Statistics and Plans/Coastal Zone Management have been conducting studies on Guam that are informative to NPS management of the park's reefs. Work is in progress.
- Coral bleaching and health monitoring on reef flats using Coral Watch methods – NPS, UOGML, Guam Bureau of Statistics and Plans/Coastal Zone Management and NOAA have been conducting studies on Guam, including the park's reefs, that are informative to NPS management of the park's reefs. Work is in progress.
- Staghorn coral (Several *Acropora* species) restoration—UOGML. A research team is conducting a long-term restoration project funded by NOAA. Information is available at www.uog.edu.
- Triennial marine resource cruise surveys around Guam—NOAA. The National Marine Fisheries Service and local researchers (Government of Guam agencies; UOGML) participate in reef surveys of benthic algae, corals, invertebrates and fisheries using standard protocols. Oceanographic data and benthic mapping may also be undertaken. Reports are available from: https://www.fisheries.noaa.gov/pacific-islands/ecosystems/coral-reefs-pacific.
- Guam Coral Reef Response Team (GCRRT) monitors coral reef health and bleaching events. Data are reported to the Government of Guam, relevant federal agencies, and researchers after bleaching and other incidents.
- Long-term Coral Reef Monitoring Program assesses reef conditions over time – UOGML and Guam Bureau of Statistics and Plans—Coastal Zone Management Program/NOAA. The UOGML monitors coral, benthic cover, fishes and reef conditions at selected sites

and produces annual reports for NOAA. Reports are available at: https://data.nodc.noaa.gov/.../grants/NA11NOS4820007/Guam_Reef_Monitoring. Metadata are available at https://www.coris.noaa.gov/metadata/records/faq/Metadata_GuamLTCRMP_v3_fish.html.

- University of Guam-U.S. Geological Survey Pacific Islands Climate Science Center, GIS@CIS Laboratory, "Guam Historical Shoreline Change". A project mapping shoreline change in Piti and Tumon bays. Piti Bay is relevant to War in the Pacific NHP. This project, funded by the USGS, is in progress.
- Guam EPA Water Quality Monitoring Program. An EPA-funded water quality monitoring program allowing for trend analysis of water quality parameters at sample points within and adjacent to the park. Results of monitoring of water quality at beaches are available at (epa.guam.gov/beach-report).
- Guam DAWR Fisheries Monitoring Program. A NOAA-funded fisheries monitoring program conducted nearly island-wide by Guam DAWR on a monthly basis. Shoreline fishing activity occurring in the Asan Beach and Agat units are monitored from selected points.
- Boat-based fishing activity data are collected at the Agat Marina and may reflect fishing off the Agat Unit. Similarly, boat-based fishing activity data collected at the Hagatna Boat Basin may reflect fishing activity off the Asan Beach Unit. Data are available from Guam DAWR.

Chapter 3. Study Scoping and Design

3.1 Study Process

Initial meetings were held between team members from the primary contractor, the University of Guam (UOG), and representatives of the National Park Service at the War in the Pacific NHP. These meetings were to establish goals and objectives and describe and assign project roles and responsibilities among team members. UOG's team consisted of the principal investigator (PI), a geographic information systems (GIS) specialist, and two graduate research assistants (GRAs). The PI administered project logistics, organized data outputs, contributed to writing of the NRCA, and provided oversight on project deliverables. The GIS specialist produced maps and tables based upon existing data sets. The GRAs conducted literature searches and organized data under direction from the PI. Later, a Saipan-based group was contracted, first by UOG as a subcontract, then by the NPS to provide formatting and editorial services.

Four major sources of input were used in this study: (1) The compilation and review of relevant literature based upon assessments and research results, (2) processing, and analyzing or assessing relevant environmental datasets that are publicly-available, (3) utilization of unpublished scientific datasets made available by local or NPS researchers, (4) consultation with local or regional experts from academia, resource management agencies, and private environmental firms or non-governmental organizations (NGOs).

After consultation with War in the Pacific NHP staff, goals for the NRCA were determined and are as follow:

- List and assess existing literature related to park resources or, if park-specific information is not available, relevant island resources
- Identify unique and significant natural resources present in the park as a whole (ecological zones) and by unit
- Determine the presence or absence of historical baseline and subsequent assessments of park resources
- Determine the existence and extent of monitoring protocols for all relevant resources
- Identify threats and stressors to park resources

Three principal ecosystems were identified during discussions with War in the Pacific NHP staff members. These were terrestrial, aquatic and marine. The distribution of these ecological zones is unequal amongst the eight park management units/parcels identified by the NPS. Key natural resources were identified within each of these ecological zones based upon the most complete data sets available. These include terrestrial (native forest, scrublands and grasslands), aquatic (streams and wetlands), and marine (coral reefs and associated habitats). New or currently ongoing research projects were outside the scope of the War in the Pacific NHP NRCA. Rather, assessments utilized existing data sets and research results with additional input from analyses of spatial data within the GIS framework that provided additional information.

GIS and geospatial data, and data collected in biodiversity assessment surveys contributed significantly to the design of the NRCA. The most recent releases of publicly available geospatial data were utilized to describe the configuration of natural systems and current resource conditions within the park. Geospatial data provided by the University of Guam Water and Environmental Research Institute of the Western Pacific (WERI) and the NPS comprised the bulk of the datasets utilized. Data from biodiversity surveys conducted in and adjacent to the park, however, were collected sporadically, in most cases, over the last 50+ years. These surveys were often not comprehensive or detailed enough and had to be evaluated using more recent local knowledge and unpublished data offered by researchers and managers working at the UOG, NPS, NPS-War in the Pacific NHP, and local Guam agencies.

Data from the literature and other reports were examined to create a set of threats and stressors to the natural resources found in these zones. Then, data gaps were identified and compiled for simple analysis.

3.2 Study Design

3.2.1 Indicator Framework, Focal Study Resources and Indicators

The natural resource indicator framework of park resources addressed in this report is given in Table 7. This framework was chosen because the best data sets were available that describe resources in terrestrial, aquatic and marine (coral reef) ecosystems found within the park and its units. This matrix provides an overview of terrestrial, aquatic and marine resources that have been identified, and issues associated with each. The matrix also describes threats to the systems in which these resources are found that should be considered for management of the park's ecological integrity.

The three categories listed in Table 7 define the integrity of the ecosystem-based management units delineated for the NRCA. For each category, a focal point is defined, and the level of assessment is stated. Indicators and measures are defined to describe the health or stability of the resource or system. Unless noted otherwise, shifting climate conditions and potential proliferation of invasive species are assumed to be inherent stressors for all components.

Table 7. Indicator framework, showing framework category, focal study resources, assessment level (reporting area for each focal resource), and indicators and measures analyzed for each focal resource.

Framework Category	Focal Resource	Assessment Level	Indicators and Measures
Terrestrial Ecosystem Integrity	Terrestrial plant communities (native forests and grasslands)	Park units	• Species richness (diversity) of native plants • Species richness (diversity) of non-native (invasive) plants • Percentage of non-native plants versus the percentage of native plants • Percentage of endangered and threatened plant species versus all plants • Percent coverage of plant communities ○ Percentage of developed versus undeveloped plant coverage within units
Aquatic Ecosystem Integrity	Aquatic habitats	Park units	• Species richness of aquatic crustaceans • Species richness of aquatic mollusks • Species richness of aquatic fishes

Marine Ecosystem Integrity	Coral reefs and marine species status	Two park units: Asan Beach Agat	• Coral species diversity
			• Species richness
			• Coral health
			  ○ Bleaching index
			  ○ Coral disease
			• Benthic composition
			  ○ Percent cover
			• Fish species diversity
			• Species richness
			• Water quality
			• Turbidity
			• Sedimentation rate

3.2.2 Standard Resource Component Methods

Existing literature, reports, datasets, and resource assessments were collected, collated and, coupled with relevant geospatial data and examined to assess both the effort devoted to the study of the park and the current condition of its resources. Not all data were park-specific but rather were from island or Mariana Archipelago-wide surveys. The latter have utility in framing what is known about War in the Pacific NHP's resources within a broader geographical context.

Data Mining

Reports and datasets relevant to the park's natural and historical resources, as well as non-park specific sources were collected and collated into categories based upon subject matter prior to review. Subject-specific spreadsheets were created providing the title of a study or dataset, reference details, a brief summary of the study and its outputs, and its relevance to the park. These spreadsheets were used subsequently to assess resources, provide basis for analysis, produce maps and tables, and focus writing effort. New sources, including recent reports, newly collected data sets, or materials sourced from the internet, were incorporated where possible. Local resource managers and biologists, especially from War in the Pacific NHP, were consulted. All geospatial data were provided by NPS/War in the Pacific NHP, WERI, UOG, or other local, regional or national sources. All data were assessed for relevancy in content and time. Scope, thoroughness, and resolution of reports were assessed qualitatively.

Data Development and Analysis

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

Scoring Methods and Assigning Condition

The scoring method for assigning resource condition that was developed by St. Mary's University of Minnesota GeoSpatial Services for NPS Natural Resource Condition Assessments was adopted for this study. Although not universally used for all NPS NRCAs, this method was constructive in quantifying a range of values for otherwise relative terms of expression for resource condition. This study followed the application as demonstrated in the NRCA for Kenai Fjords National Park in Alaska (Stark et al. 2015), as explained below.

Significance Level

A set of measures are useful in describing the condition of a particular resource, but all measures may not be equally important. A "Significance Level" represents a numeric categorization (integer scale from 1–3) of the importance of each measure in assessing the resource's condition; each Significance Level is defined in Table 8. This categorization allows measures that are more important for determining condition of a resource (higher Significance Level) to be more heavily weighted in calculating an overall condition. Significance Levels were determined for each resource measure in this assessment through discussions with park staff and/or outside resource experts.

Table 8. 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 completed (including any possible data analysis), SMUMN GSS analysts assign a Condition Level for each measure on a 0–3 integer scale (Table 9). This is based on all the available literature and data reviewed for the resource, as well as communications with park and outside experts.

Table 9. Scale for Condition Level of individual measures.

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 of the resource.
2	Of **MODERATE** concern. Pronounced signs of widespread and uncontrolled degradation.
3	Of **HIGH** concern. Nearing catastrophic, complete, and irreparable degradation of the resource.

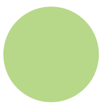
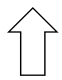
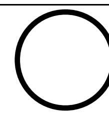
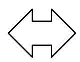
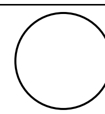
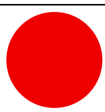
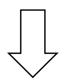
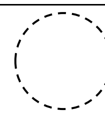
Weighted Condition Score

After the Significance Levels (SL) and Condition Levels (CL) are assigned, a Weighted Condition Score (WCS) is calculated using the following equation:

$$WCS = \frac{\sum_{i=1}^{\#\,of\,measures} SL_i * CL_i}{3 * \sum_{i=1}^{\#\,of\,measures} SL_i}$$

The resulting WCS value is placed into one of three possible categories: good condition (WCS = 0.0–0.33); condition of moderate concern (WCS = 0.34 – 0.66); and condition of significant concern (WCS = 0.67 to 1.00). Table 10 displays all of the potential graphics used to represent a resources' condition in this assessment. The colored circles represent the categorized WCS; red circles signify a significant concern, yellow circles a moderate concern and green circles a good condition. Gray circles are used to represent situations in which SMUMN GSS analysts and park staff felt there were currently insufficient data to make a statement about the condition of a resource. For example, condition is not assessed when no recent data or information are available, as the purpose of an NRCA is to provide a “snapshot-in-time” of current resource conditions.

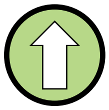
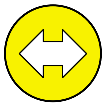
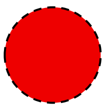
Table 10. Indicator symbols used to indicate condition, trend, and confidence in the assessment.

Condition Status		Trend in Condition		Confidence in Assessment	
Condition Icon	**Condition Icon Definition**	**Trend Icon**	**Trend Icon Definition**	**Confidence Icon**	**Confidence Icon Definition**
	Resource is in Good Condition		Condition is Improving		High
	Resource warrants Moderate Concern		Condition is Unchanging		Medium
	Resource warrants Significant Concern		Condition is Deteriorating		Low

The arrows inside the circles (Table 11) indicate the trend of the condition of a resource, based on comparing current conditions of resources with baseline or reference conditions, as well as expert opinion. An upward pointing arrow indicates the condition of the resource has been improving in recent times. A two-sided arrow indicates condition is unchanging, and an arrow pointing down indicates a decline in the condition of a resource in recent times. These are only used when it is appropriate to comment on the trend of condition of a resource. If the trend of a resources’ condition is currently unknown or indeterminant, such as when baseline references were not available, then no arrow is given.

The confidence rating was based upon the availability and quality of information for a given resource. A thick, thin or dashed circle respectively represent high, medium and low levels of confidence in the resource condition determination based on the amount and quality of data available for the assessment. Similarly, the pattern of line thickness around the arrows indicates level of confidence in the determination of trend in resource condition.

Table 11. Example indicator symbols with verbal descriptions of how to interpret them in WCS tables.

Symbol Example	Verbal Description
	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.

Development and Review of Focal Resource Assessments

After reviews of draft reports by War in the Pacific NHP specialists, feedback was incorporated into the final draft of the NRCA. This provided a means for establishing confidence in the assessments made.

Chapter 4. Natural Resource Conditions

4.1 Terrestrial Plant Communities

Assessment of terrestrial ecological conditions within units of the War in the Pacific NHP might best be assessed by using data for plants. Terrestrial plant communities within the park are varied with respect to area of coverage and species composition. Comparisons of the diversity of species, proportions of native versus non-native species, and proportions of rare, threatened and endangered species over time can be made. Similarly, available data offer comparisons between coverage of different major plant communities over time as well.

4.1.1 Measures

- Species richness (diversity) of native and non-native (invasive) plants
- Percentage of non-native plants versus the percentage of native plants
- Percentage of endangered and threatened plant species versus all plants
- Percent coverage of plant communities
    - Percentage of developed versus undeveloped plant coverage within units

4.1.2 Reference Conditions/Values

A baseline reference date of 1997 was selected to coincide with the publication of the park's Resource Management Plan (NPS 1997). This plan included a preliminary checklist of terrestrial plant species found on Guam and within the park's boundaries, differentiated between native and non-native (invasive) species, and provided estimates of rarity and threatened or endangered status. These values can be used to estimate conditions within the park as a whole by comparing the species richness of native versus non-native species and by calculating percentages of non-native and native species between 1997 and the checklist produced in 2015 (Appendix C). Similarly, the percentage of endangered/threatened plant species based upon data reported in 1997 versus data in Appendix C can be calculated. The Resource Management Plan (NPS 1997) did not provide estimates of percent coverage of plant communities. So, estimates of percent coverage of developed versus undeveloped areas by unit were used to estimate reference conditions in each unit.

4.1.3 Data and Methods

Data on terrestrial plant species diversity, the diversity of native versus non-native species, and the diversity of rare, threatened and endangered species, assembled in two checklists (NPS 1997; NPS unpublished data for 2015) are given in Table 12.

A comparison of the time series data of the percent coverage of different plant communities within units of the park between 1997 and 2015 was not possible because data are lacking for 1997. To indicate the reference condition, a comparison between the amount of developed versus undeveloped land, as a proxy for the relative integrity of a plant community or group of communities within each unit, was made (Table 13).

Table 12. Comparison of species richness of native, invasive, unknown origin, rare and endangered or threatened plant species in the War in the Pacific NHP reported between 1997–2015 (based upon NPS unpublished data).

Metric	Species richness	Total species	Native species	Invasive species	Unknown origin	Rare [A]	Threatened/ Endangered
Plant Species	1997 survey	153	133	20	24	9	4
	2015 survey	403	175	222	6	10	14
Percentage of Total	1997 survey	153	86.9	13.1	n/a	6.8	3
	2015 survey	403	44.9	55.1	n/a	5.7	8

[A] Denotes percentage values calculated from the total number of native species recorded, only.

Table 13. Comparison of developed versus undeveloped lands as an indicator of the status of plant community integrity within units of the War in the Pacific NHP. Data are based upon area calculations (NPS unpublished data). Values are percentages of total area for each unit.

Status	Asan Beach	Asan Inland	Fonte Plateau	Piti Guns	Mt. Tenjo/ Mt. Chachao	Guatali Parcel	Mt. Alifan	Agat
Developed	70.1	2.2	100	0.13	1.2	0.08	0.1	45.5
Undeveloped	29.9	97.8	0	99.87	98.8	99.92	99.9	54.5

4.1.4 Current Condition and Trend

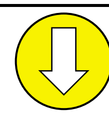
In 1997, the total number of species was 153, of which 86.9% were native and 13.1% were non-native or invasive. In 2015, however, of the 405 species reported native species declined to 44.9 % while invasive species increased to 55.1% and thus outnumbered native species within the park (see Appendix C). Rare species declined to 5.7% of total species reported in 2015 from 6.8% reported in 1997. Threatened and endangered species increased from 3% to 8% between 1997 and 2015. The values reported for rare, threatened and endangered species might be artifacts of survey methods or intensities between the two sampling periods but the differences in native versus non-native periods are not. Rather, they are indicative of invasive species posing a significant threat to the park's native terrestrial plant fauna.

Predictably, there was more undeveloped land in more remote units (i.e., Mt. Chachao /Mt. Tenjo, Guatali Parcel and Mt. Alifan) or else in small units (Asan Inland, Fonte Plateau and Piti Guns). With little disturbance, the integrity of plant communities present is likely greater if it were not for the effects of invasive species present on native plants. In contrast, Asan Beach and Agat units, both adjacent to the ocean, had considerable developed areas that are utilized by visitors for recreation and sightseeing. As such, native plant communities in more-developed areas are at threat from habitat destruction or alteration (i.e., groundskeeping, parking lots, etc.), and will have reduced biodiversity.

Overall Condition

Measures for the terrestrial component are listed here, accompanied by respective scores for importance (1–3) and condition (0–3), are given in Table 14. A significance score of 3 is assigned to the measure of native versus invasive species given that invasives are increasingly dominant within the park to the point that control measures are largely ineffective. A condition level score of 3 is given because native plants, especially rate species, are threatened by competition with invasives for resources, especially space in critical habitats. An overall score of 6 is assigned. Rare species are important components of biodiversity with the park's plant communities. A significance score of 3 is assigned. Rare plant species have also declined recently, and so a condition level of 3 is assigned. The overall score is also 6. The presence of threatened and endangered plant species within the park is extremely important because they serve as indicators of the resource integrity. A significance score of 3 is assigned. Threatened and endangered species found in surveys within the park have reportedly increased but this may be an artifact of how data were collected over time. A condition score of 2 is assigned. Developed lands within the park have increased somewhat but not significantly so although increased development would negatively impact plant communities present. A significance score of 1 is assigned. Development in lands adjacent to the park, however, has increased significantly and with it come threats to native plants because of the introduction of invasive species. A condition score of 2 is assigned, although data on colonization rates of invasives from adjacent developed lands is not known but could pose significant problems in time. The weighted condition score of 5 indicates that although there is moderate concern for the condition of plant communities it is not catastrophic. The dominance of invasive over native species is very worrisome and monitoring is necessary to predict a tipping point where invasives become the dominant plants within the park.

Table 14. Weighted condition score for terrestrial plant communities.

Measures	Significance Level	Condition Level	Weighted Condition
NativeVersus Invasive Species	3	3	–
Percentage of Rare Species	3	3	–
Percentage of Threatened and Endangered Species	3	2	–
Undeveloped Versus Developed Lands Supporting Plant Communities	1	2	–
Overall	**–**	**–**	

4.2 Aquatic Communities

Most streams within the War in the Pacific NHP have not had extensive biodiversity surveys conducted on them. The three most sampled biological taxa are crustaceans, mollusks, and fishes (Myers 1999; Myers and Donaldson 2003; and B. Tibbatts, Guam DAWR, unpublished data). Native crustaceans include the prawn *Macrobrachium lar* and the shrimps *Atyoida pilipes* and *Caridina* sp. Native mollusks include various *Neretina* sp. Native fishes include the freshwater eel (*Anguillia marmorata* and *A. bicolor*), glass perchlet (*Ambassis buruensis*), jungle perch (*Kuhlia rupestris*), and various gobioid species (families Eleotridae and Gobiidae). Native euryhaline species, including Indo-Pacific tarpon (*Megalops cyprinoides*) and mullets (Mugilidae), may enter the lower reaches of streams in the Asan Beach and Agat units. Invasive species include mosquitofishes (*Gambusia affinis*), guppies (*Poecilia reticulata*), and tilapia (*Oreochromis mossambicus*) (Appendix H).

4.2.1 Measures

- Species richness of aquatic crustaceans and proportion of invasive species
- Species richness of aquatic mollusks and proportion of invasive species
- Species richness of aquatic fishes and proportion of invasive species

4.2.2 Reference Conditions/Values

Because of data limitations, assessment of ecological conditions within the aquatic component of units of the War in the Pacific NHP is limited to comparisons of species richness for native crustaceans, mollusks, and fishes based upon unpublished checklists between units (Myers 1999; Myers and Donaldson 2003; B. Tibbatts, Guam DAWR, unpublished data).

4.2.3 Data and Methods

Native and invasive crustacean, mollusk and fish species were summarized from data given in Appendices G and H. Comparisons between native and invasive species of crustaceans and mollusks were made by summing the totals for each respective taxonomic group and then calculating their percentages for each stream. For fishes, native species were partitioned to indicate proportions of native freshwater and native euryhaline fishes for each stream. For comparisons of native versus invasive species, native freshwater and euryhaline fishes were summed for each stream and their proportion out of the total number of fish species present was calculated and compared against the corresponding proportion of invasive species.

4.2.4 Current Condition and Trend

The crustacean fauna of streams within the park (Table 15) is relatively depauperate and native species predominate in all streams but the Asan River. Crustaceans have not been reported from three streams (Big Guatali, Salinas and Tenjo rivers).

The mollusk fauna has low diversity also but in most of the streams where they have been reported they tend to be native species (Table 15). The invasive species *Gyraulus chinensis* is the only mollusk reported from the Matgue River while (*Pila conica*) occurs with four native species in the Masso River. Mollusks have not been reported from the Big Gautali and Tenjo rivers.

Native freshwater and euryhaline fish species dominate in most streams of the park but invasive species are more prevalent in the park's streams compared to crustaceans and mollusks (Table 15). Streams with the highest species diversity (the Atantano, Masso, Matgue, and Namo rivers) are dominated by native freshwater species. One stream, the Big Gutali, has just a single species (the tilapia, *Oreochromis mossambicus*) and this is invasive. In contrast, the Paulana River has just a single species (*Stiphodon* sp., a goby) but it is native. The Salinas River has only a single species of each, the jungle perch (*Kuhlia rupestris*), which is native, and the guppy (*Poecilia reticulata*) that is invasive.

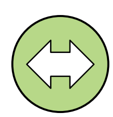
Table 15. Comparison of native and invasive species of crustaceans, mollusks, and fishes for streams in the War in the Pacific NHP. Values are percentages. For fishes, percentages of native freshwater and euryhaline species are given first while comparisons between native (freshwater + euryhaline) and invasive species follow. Streams are identified as follows: 1 = Asan, 2 = Atantano, 3 = Big Guatali, 4 = Finile, 5 = Ga'an, 6 = Masso, 7 = Matgue, 8 = Namo, 9 = Paulana, 10 = Salinas, 11= Taguag, 12 = Tenjo.

Aquatic Animal	Native, Invasive, or Total	Stream											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Crustaceans	Native species	80	100	0	100	100	100	100	100	100	0	100	0
	Invasive species	20	0	0	0	0	0	0	0	0	0	0	0
	Total crustacean species	**5**	**3**	**0**	**3**	**2**	**3**	**2**	**3**	**3**	**0**	**1**	**0**
Mollusks	Native species	100	100	0	100	0	80	0	100	100	0	100	0
	Invasive species	0	0	0	0	0	20	100	0	0	0	0	0
	Total mollusk species	**3**	**1**	**0**	**1**	**0**	**5**	**1**	**2**	**1**	**0**	**1**	**0**
Fishes	Native freshwater species	80	43	0	75	50	88	67	83	100	50	100	33
	Native euryhaline species	0	57	0	0	50	13	33	17	0	0	0	67
	Total native species	**80**	**82**	**2**	**75**	**100**	**67**	**90**	**75**	**100**	**50**	**100**	**100**
	Invasive species	20	18	100	25	0	33	10	25	0	50	0	0
	Total fish species	**5**	**17**	**1**	**4**	**2**	**12**	**10**	**8**	**1**	**2**	**7**	**3**

Overall Condition

Measures for the aquatic component are listed here, accompanied by respective scores for importance (1–3) and condition (0–4), are given in Table 16. While species richness of aquatic crustaceans is relatively low, the species present are important to ecosystem function because of the roles they play in trophic chains and nutrient cycles. A significance score of 3 is given. Competition from invasive species could cause shifts within the ecosystem but given that only low abundances of invasive species have been found, and in just a single stream, the relative impact of invasive species upon native fauna is nearly negligible. A condition score of 0 is given, although further surveys and monitoring are warranted. Native species of mollusks within streams are important components of biodiversity and also provide a source of food for other species including fish, crustaceans, and shorebirds. Their importance to trophic cycles warrants a significance score of 3. Invasive species of aquatic mollusks are, however, largely absent in the park except for two streams, but in one stream, the Matgue River, the only species of mollusk present is invasive. A condition score of 0 is given also, although further surveys and monitoring are warranted. Native species of fishes are especially important because of the ecological roles they play in streams, mainly as predators or prey (with some important to subsistence fisheries), and because of their inherent biodiversity value. A significance score of 3 is assigned. Given that the proportion of invasive fish species in streams within the park ranges from 0 to 100 percent, that a single invasive species is the sole fish present in one stream (the Big Guatali River), and that invasives constitute 20–50 percent of all fishes in six other streams, native species may be threatened.

Table 16. Weighted condition score for aquatic communities.

Measures	**Significance Level**	**Condition Level**	**Weighted Condition**
Species Richness of Aquatic Crustaceans and Proportion of Invasive Species	3	0	–
Species Richness of Aquatic Mollusks And Proportion of Invasive Species	3	0	–
Species Richness of Aquatic Fishes and Proportion of Invasive Species	3	1	–
Overall	**–**	**–**	

Types of threats could include competition, predation risk, or shifts in the forage base within a given stream. Therefore, a condition score of 2 is assigned. The weighted condition score of 1.6 indicates that while invasive species, particularly fishes, are of concern they do not appear to be dominating native species in most streams, and so are of minimum concern for now except in those where invasives are present in significant numbers and a downward trend is indicated. Native fish faunas of streams near areas of human occupation and urbanization (i.e., the Asan and Namo rivers) may see colonization by additional invasive species via introductions, however.

4.3 Coral Reef Communities

Assessment of ecological conditions within the marine component of units of the War in the Pacific NHP has been more extensive compared to terrestrial and aquatic components. Much of the effort has been focused upon the diversity and health of coral reefs. Guam has a diversity of coral reef types, including fringing reefs, barrier reefs, and patch reefs. Fringing reefs are the most common, however, and these are dominant in both the Asan Beach and Agat units of the War in the Pacific NHP (see Burdick 2005). Amesbury et al. (1999) conducted a marine biological survey of both Asan Beach and Agat units. This study provided a checklist of marine algae, seagrasses, corals (164 species), macroinvertebrates and fishes found at both localities.

Mangroves were not recorded, however, because of the absence of significant estuarine habitats within the park necessary to sustain them. Randall (2003) provided a comprehensive checklist of corals found in the Mariana Islands. This was augmented by Paulay et al. (2003) who listed non-scleractinian anthozoans from the archipelago. Most species of both taxonomic groups are estimated to occur within the park. Various authors writing in Paulay (2003a) provided comprehensive checklists and some new species descriptions of various marine invertebrate taxa found in the Mariana Islands. At least some of these taxa occur or may be expected to occur in the Asan Beach and Agat units of the park.

Marine communities within the Asan Beach and Agat units of the park are vulnerable to various environmental and anthropogenic stressors (see Chapter 5) that can negatively affect their ecological integrity. The most significant environmental are climate change effects (sea temperature increases, ocean acidification and sea level rise), and sedimentation. The most significant anthropogenic threats are sewage pollution and overfishing. Invasive species may recruit to the park's marine waters, particularly as a consequence of climate change.

Guam largely escaped significant effects from the massive coral bleaching events within the region that occurred in 1998. Since then, however, both the frequency and severity of mass coral bleaching events has increased significantly since 2013 with severe events occurring then and subsequently in 2014, 2016 and 2017 (Raymundo et al. 2017, 2019; Burdick et al. 2019). These events have or may cause rapid declines in coral cover, changes in local species diversity, and declines in the overall conditions of the reefs affected (Raymundo et al. 2019). Coral cover on shallow reef flat sites surveyed along the western coast of Guam (where the Asan Beach and Agat units are found) declined by 37% with staghorn corals (Acropora spp.) declining by as much as 36%. The greatest declines, however, were along the shallow slope communities along the eastern (windward) coast of Guam where, between 2013–2017, an estimated 60% of coral cover was lost. These losses are attributed to increases in sea surface temperatures (SSTs) coupled with a major ENSO event that triggered extreme low tides and excessive coral mortality from subaerial exposure in 2014–2015 (Burdick et al. 2019, Raymundo et al. 2019).

4.3.1 Measures

- Coral coverage
- Coral bleaching
- Sedimentation

4.3.2 Reference Conditions/Values

Data on coral diversity or coverage within the Asan Beach and Agat units have been collected previously (Eldredge et al. 1977; Amesbury et al. 1999) but the diversity data are incomplete. Data from more recent and comprehensive surveys have been collected recently by NPS biologists but regrettably these data have not been published yet.

Data on coral bleaching within the Asan Beach and Agat units collected recently by NPS biologists have also not been reported yet. Surveys conducted by the UOGML's Long Term Coral Monitoring Project do not include either unit but those of Raymundo et al. (2017) cover portions of each. Surveys conducted on the west coast of Guam as part of this project, however, indicate that coral bleaching is not significant in either unit compared to the 30% coral mortality rate island-wide and the 60% coral mortality rate found by these surveys on the east coast of Guam, but *Acropora* spp. corals have undergone significant bleaching island-wide and including in both units (Burdick et al. 2019; personal communication, 19 January 2020; Raymundo et al. 2017, 2019).

4.3.3 Data and Methods

Data from a qualitative (Eldredge et al. 1977) or mixed qualitative-quantitative survey (Amesbury et al. 1999) surveys of coral coverage within the Agat Unit were compared against data obtained by the UOGML Long-term Coral Reef Monitoring Project (Burdick et al. 2019) for an adjacent site at Fouha Bay. An estimate of coral coverage at Asan Beach is based upon Amesbury et al. (1999) with a comparison provided by Burdick et al.'s (2019) recent estimate of total species coral cover from an adjacent site at Piti.

Coral bleaching estimates for reefs in the park, reflected in the loss of coral cover, are from Raymundo et al. (2019, Figure 4) for *Acropora* spp. and Burdick et al.'s (2019) survey of an adjacent site at Piti Bomb Holes Marine Protected Area.

4.3.4 Current Condition and Trend

Coral coverage estimates for Asan Beach are based on those made from the reef flat by Amesbury et al. (1999) and compared against recent data for an adjacent reef at Piti Bomb Holes (Burdick et al. 2019). Average coral cover on the Asan Beach reef flat ranged from 0.01% to 80% with *Leptastrea purperum* and *Porites* spp. predominating (Amesbury et al. 1999). Average coral cover in shallow waters within the Piti Bomb Holes Marine Protected Area is approximately 16%, with *Porites* spp. corals (63% of species) dominating the assemblage there. Large areas of the Piti Bomb Holes MPA within the Park are covered by a few species of massive soft corals.

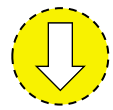
Coral coverage at the Agat Unit Coral coverage estimates made recently from Fouha Bay, directly south of the Agat Unit, varies between 0 to about 18% depending upon location within the bay (Burdick et al. 2019).

Overall, coral coverage tends to be low, and this may be attributed to the input of terrestrial sediments carried by stream runoff (Amesbury et al. 1999; Burdick et al. 2019).

Severe bleaching events have not been recorded from either unit of the park but have been elsewhere along the western coast of Guam (Burdick et al. 2019; Raymundo et al. 2017, 2019), although bleaching of *Acropora* spp. corals is of concern (Raymundo et al. 2017). *Porites* spp. corals found within the park, especially within the Agat Unit, are apparently more resistant to bleaching compared to many other species (D. Burdick, UOGML, personal communication, 21 January 2020). *Acropora* spp. corals are vulnerable to bleaching, however, and show worrisome declines in coverage within the Asan Beach (Asan/Adelup) and Agat (Agat Cemetery) units (Raymundo et al. 2017).

<u>Overall Condition</u>
Measures for the marine component are listed here, accompanied by respective scores for significance or importance (1–3) and condition (0–3), are given in Table 17. The weighted condition score of 5. Loss of corals from increased rates of bleaching, particularly of *Acropora* spp. corals, are evident in both units, and results in lower coral coverage and declining biodiversity. Increased rates of sedimentation of corals threatens both existing corals and recruits, particularly in the Agat Unit (Amesbury et al. 1999; Burdick et al. 2019) but also in the Asan Beach Unit (Lundgren and Minton 2006; Minton 2005; Minton and Lundgren 2006; Minton et al. 2007). Both coral bleaching and sedimentation critically affect coral coverage because both increase mortality and reduce abundance resulting in a reduction of coverage. A significance score of 3 is given to coral coverage as a proxy for coral reef health. A condition score of 2 indicates that although there has been a decrease in coral cover from bleaching and sedimentation, the extent of degradation is still moderate. An overall score of 5 is assigned. A significance score of 3 is given to coral bleaching rate because frequent increases of bleaching associated with increases in surface sea temperatures on coral reefs occur both globally and locally. A condition score of 2 is assigned because rates of bleaching within the park are not leading to mass mortalities of corals. Thus, an overall score of 5 is assigned. A significance score of 3 is given also to sedimentation rates that increase with increased erosion events and lead to coral mortality. A condition score of 2 is assigned because efforts to control erosion have prevented high levels of sedimentation and total coral mortality. The overall score of 5 is assigned. The weighted condition score is 5 and indicates an assessment of moderate concern. Of particular importance, however, is that measurements of rates of sedimentation have not been made consistently over time and so the condition score for this measure may be underestimated. While observations of reef quality made during recent surveys of much of the Asan Beach reef terrace (3–20m depth) did not detect sedimentation (T.J. Donaldson, personal observations 2015–2020), the same may not be said for the reef in the Agat Unit. There, the Namo River often has turbid, sediment laden flows during the rainy season that can deposit sediments in the submerged river channel that cuts through the reef and on the adjacent reef flats fronting Rizal Beach and portions of reef terraces and patch reefs as deep as 30m (T.J. Donaldson, personal observations, 2008–2010). Thus, the reliability of the condition measure may be low, as indicated by the dashed line of the circle.

Table 17. Weighted condition score for marine communities.

Measures	Significance Level	Condition Level	Weighted Condition
Coral Coverage	3	2	–
Coral Bleaching	3	2	–
Sedimentation	3	2	–
Overall	**–**	**–**	

Chapter 5. Discussion

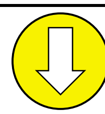
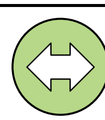
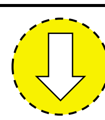
Chapter 5 serves as a concluding section for the NRCA, involving brief summaries of the assessment, and an overview of concerns that resource stewards may need to address in the coming years. Specifically, the chapter is broken down into:

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

5.1 Component Condition Designations and Observations

Primary natural resource components of the War in the Pacific NHP and their assigned condition assessments are given in Table 18. This table translates a synthesis of 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 (Table 18). The availability and quality of data varied per component, which is reflected in the confidence assessment. Trends were assigned when they could be determined with confidence.

Table 18. Component Scores for War in the Pacific NHP Natural Resources.

Component	Weighted Condition Score	Condition
Terrestrial Plant Communities	5	
Aquatic Communities	1.6	
Coral Reef Communities	5	

5.2 Park-wide Threats and Stressors

Threats and stressors currently affecting the War in the Pacific NHP are numerous and diverse. Some mitigation strategies are being implemented currently to address the most pressing concerns. Stressors, as defined by the National Park Service, 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 components, patterns, and processes in natural systems" (NPS 2006).

Primary threats and stressors that currently affect, or have the potential to significantly impact the War in the Pacific NHP include:

- poor land use practices, wildfires, and erosion;
- invasive species
- climate change and variability;
- illegal or excessive harvest, hunt, and take;
- diseases and pathogens;
- contaminants, sewage, and debris;
- visitor use;
- stochastic events.

5.2.1 Land Use Practices, Wildfires, and Erosion

Since the end of the war in 1945, much of the coastal and inland areas within and adjacent to units of War in the Pacific NHP have been developed for agriculture, residential and military uses. Poor land use practices have contributed to erosion (Lundgren and Minton 2005, Minton 2005, Minton and Lundgren 2006, Minton et al. 2007). Off-road vehicle use promotes erosion, as well (PCR Environmental 2009).

Wildfires generated by human activities affect at least 10% of all of Guam's land (Minton 2005). The Impact of wildfires within the park may be considered significant. For example, between 2003 and 2005 approximately 9% of War in the Pacific NHP was burned and, in subsequent wet seasons, erosion from burned savanna was six times that found in non-burned or vegetated savanna (Minton 2005).

Further, after a recovery period of 18 months Minton (2005) found that erosion of soil was still twice that in burned savanna compared with vegetated savanna. Changes in the community structure of vegetation were detectable (Minton 2005) and likely in the structure of invertebrate and even vertebrate assemblages as well. Invasive species colonization rates were promoted by fire; thus, native species of vegetation were replaced. (Minton 2005).

Sediments released by erosion caused by wildfires or other processes are carried downhill. They can enter a wetland and suffocate vegetation there. They can enter a stream, promote increased erosion with heightened water flows, scour benthic habitats, erode banks, uproot vegetation, displace resident organisms, restructure stream communities, and close off estuaries thus preventing both stream water and organisms from moving between aquatic and marine habitats. If entering standing water, they may have similar effects that could lead ultimately to eutrophication. Minton (2005) documented the effects of erosion and sedimentation in aquatic streams as a consequence of wildfires. Streams act as conduits that transfer sediments to marine environments. This transfer is especially significant during the onset of the rainy season after a serious burn cycle but also during and after tropical storms or heavy monsoonal weather when rainfall creates flash flood conditions.

Sediments released by wildfires are transported downstream, especially during the rainy season and during tropical storms, are deposited in coastal marine systems. The effects upon coral reefs are significant. Coral recruitment is negatively affected, and adults can be killed by sediment deposition or stressed by higher levels of turbidity (Minton 2005,; Lundgren and Minton 2005; Minton and Lundgren 2006; Minton et al. 2006, 2007). Other organisms may be affected to varying degrees, as well.

5.2.2 Invasive Species

<u>Terrestrial Plant Species</u>
There are 221 species of invasive terrestrial plants present within the park that account for (55.7%) of all recorded vascular plant species within the park (Appendix C). Perhaps the most widely distributed invasive species is tangantangan (*Leucaena leucocephala*) that was first established on Guam in 1905 but gained a wider distribution after it was supposedly seeded aerially by the Naval Government in 1947, presumably to reduce or prevent erosion in areas damaged heavily from bombardment and subsequent fighting during the battle of Guam.

<u>Animal Species</u>
In June 2014 the little fire ant (*Wasmannia auropunctata*, Formicidae) was discovered in two sites of the Asan Beach Unit (Figure 46). This invasive species was reported in Guam in 2011 and has started spreading throughout parts of the island. NPS closed the areas where the colonies were discovered to public access and an intensive eradication program was successfully implemented in one infestation at Asan Beach Unit.

The coconut rhinoceros beetle (*Oryctes rhinoceros*, Scarabaeidae) has infested coconut palms at various locations throughout Guam including the park. The adult of this species bores into the tops of coconut palms, feeds on the plant tissue and sap contained within, and often kills the tree. This species breeds and lays eggs in stands of leaf litter, so steps to reduce or eliminate piles of “green waste” have been taken in an attempt to prevent the spread of this destructive invasive species; the use of collection traps has been first demonstrated in the Park’s Asan Beach Unit and subsequently has also been implemented island-wide. Biocontrol with a virus that has worked for this species’ control in Palau and Fiji has not been successful with the Guam strains of this beetle.

The invasive cane toad secretes a poison from epidermal sacs as a defensive mechanism; the poison is toxic. Potential predators of this species (i.e., brown tree snake, native monitor lizard, feral pig and feral dog) are susceptible to this toxin. The eastern dwarf tree frog preys upon native insects but no data appear to be available to suggest that negative impacts occur within the park. The ecologically destructive brown tree snake has decimated populations of native bird and lizard species on Guam and is naturally a threat to populations of surviving species in the War in the Pacific NHP. The blind snake, another historically invasive species, appears to not be a threat in the park. The native monitor lizard is likely a threat to some native lizards and birds, but the latter, have been largely extirpated from the park and Guam. Nesting native aquatic birds, such as the yellow bittern that frequent tall shrubs accessible to monitors, might be at risk to predation. Invasive birds account for most terrestrial birds now found on Guam and in the park. Their impacts are likely negligible to most species in, although the drongo is highly territorial and has been known to attack other bird species. Invasive mammals also cause habitat destruction within the park (A.M. Gawel, 2012). The Philippine brown deer and the feral pig are both destructive to stands of vegetation but also to threatened plant species on the island (A.M. Gawel 2012); both species are a threat within the park. Ironically, however, feral pigs play an important role in promoting forest regeneration in the absence of the largely extinct or locally extinct native bird fauna of Guam (A.M. Gawel et al. 2018). Feral cats, feral dogs, and Norway rats may prey upon various species of birds, lizards, and even sea turtle hatchlings on Guam, and are perceived as a threat within War in the Pacific NHP.

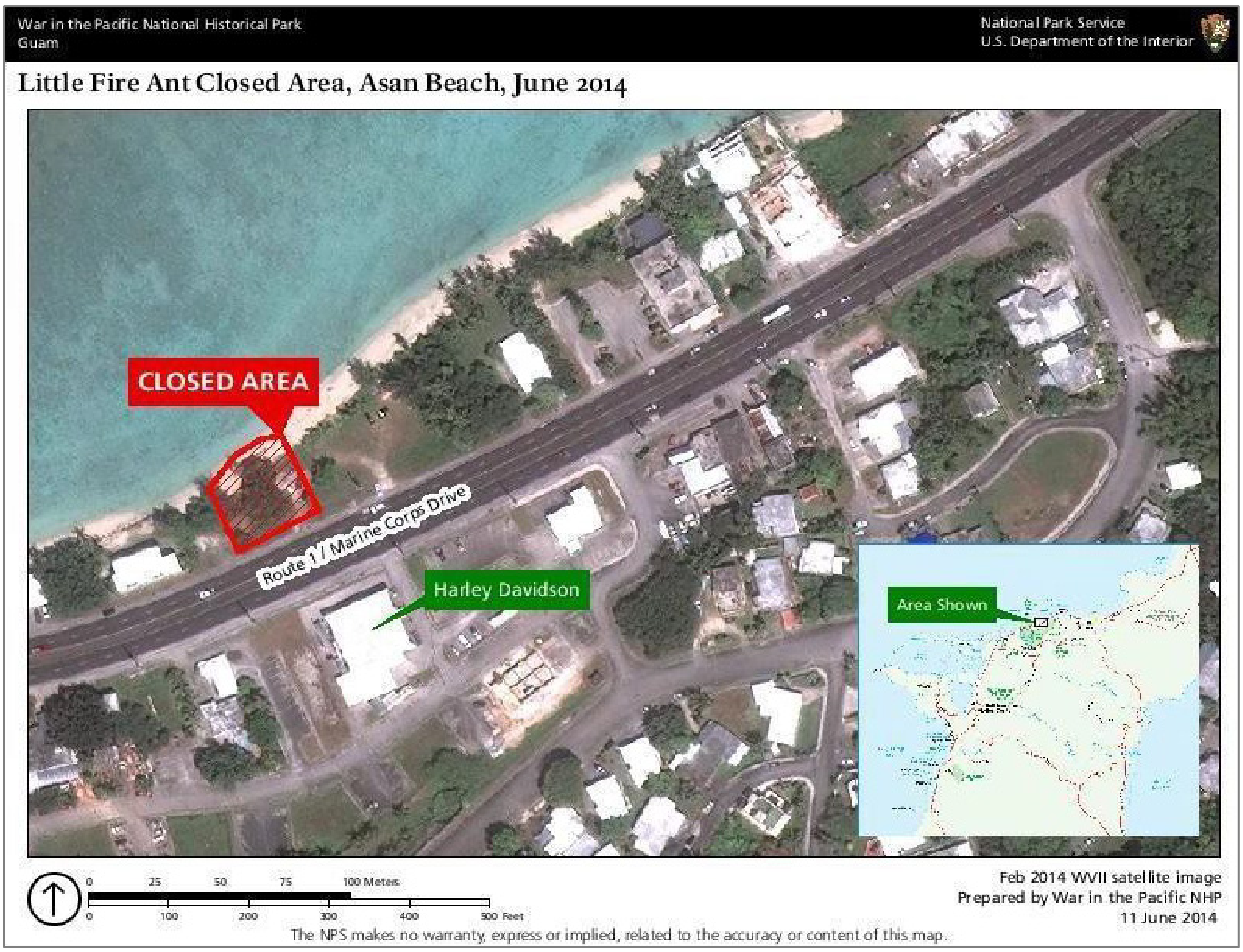


Figure 46. Location of an invasive fire ant colony along the beach in the Asan Beach Unit in June 2014. Source: NPS-War in the Pacific NHP.

<u>Aquatic Plants</u>

Two species of aquatic plants invasive on Guam have been found within the park: *Echinodorus* sp. (Asan River), and *Hydrilla verticillata* (Atantano River) (B. Tibbatts, Guam DAWR, unpublished data). These species have the potential to compete with native species and could exclude them. The extent of their invasion in each of these streams has not been documented inside or outside of the park.

Invertebrates

Two species of aquatic gastropods, *Pila conica* and *Pomacea canaliculata* have been reported from the Masso River, while *Gyraulus chinensis* has been reported from the Matgue River (Appendix G). These mollusks may have the potential to carry parasitic worms that could infect native mollusks, crustaceans, fishes, shorebirds, and humans but data are lacking. The extent of these invasions is not well known, either.

Vertebrates

Four species of invasive fishes have been reported from the park (Appendix H). These include the walking catfish (*Clarias batrachus*, Clariidae) the mosquitofish (*Gambusia affinis*, Poeciliidae), the guppy (*Poecilia reticulata*, Poeciliidae), and the tilapia (*Orechromis mossambicus*, Cichlidae). Their distributions within the park are given in Appendix I. As with other aquatic invasive species, the extent of their invasions is not well documented. A species of snakehead (Channidae) occurs in a single stream system in the vicinity of Achang, southern Guam, and while there is no direct threat to aquatic systems in the park the potential for an anthropomorphic introduction of this species is not impossible.

Similarly, introduced aquatic turtles on Guam (see Leberer 2003) might be relocated to waters in the park from other bodies of water (e.g., Agana Swamp) but no studies have been undertaken to document this, although the red-eared slider, *Trachemys scripta elegans*, has been reported from the Asan Unit (A.K. Miller, NPS, personal communication, 13 December 2016). The impact of introduced turtle species remains to be seen and documented (Leberer 2003).

Marine Plants

Invasive algae and other marine plants are not well documented within the park. The potential for invasion by a species of *Chaetomorpha* sp. algae that is rapidly colonizing Cocos Lagoon in the south and spreading along the east coast of Guam as far north as Pago Bay is under investigation by the University of Guam Marine Laboratory. It has also been seen on the west side of the park, as far north as Agana Bay. This species may have spread to marine habitats in the Agat Unit.

Invertebrates

Marine invertebrate species invasions of the park's marine habitats have not been documented. Given the potential for transport of larvae by seagoing vessels, invasions by sponges, hydrozoans, gastropods, crustaceans and other taxa are likely.

Vertebrates

Invasion of the park's marine habitats by reptiles, birds and mammals has not been documented. Among fish species, two that have entered Guam's marine waters may eventually be found in on the park's reefs. One is the tilapia (*Oreochromis mossambicus*, Cichlidae), an African freshwater species that has been introduced to Guam for aquaculture, has entered the aquatic ecosystem, and is remarkably euryhaline (Trewavas 1983).

An invasive damselfish, *Neopomacentrus violescens* (Pomacentridae) that colonized Apra Harbor in the 1980s, likely in ship's ballast, and later Cocos Lagoon, probably after a series of very powerful typhoons in 2002, has the potential to colonize the park's protected inshore reefs found in the Agat Unit (Donaldson, unpublished data; University of Guam). The impact of these species on Guam's reefs is not known.

5.2.3 Climate Change and Variability

Elevated surface air temperatures as a consequence of climate shifts have the potential to increase risks of wildfires in terrestrial ecosystems; this may be especially true if seasonal rainfall patterns are altered and sustained periods of drought occur. Both plant and animal communities may be affected by these changes, as well. Increased intensity of typhoons can damage ecosystems and native vegetation more than has happened in the past. Invasive species may take advantage of stress acting upon native species and the former may be better adapted to cope with environmental changes at the expense of the latter. A long-term study of representative species or whole plant and animal communities within major habitat types in relation to temperatures and other physical factors within War in the Pacific NHP could measure any shifts in community structure. Increased intensity of typhoons which is predicted for the future would lead to greater storm wave damage to coastal habitats and to structures there. As an example, the park visitor center and main office was devastated by waves from Typhoon Pongsona washing through the building in 2002 (Winzler & Kelly 2003).

Elevated surface air temperatures and subsequent changes in rainfall patterns, especially if they lead to prolonged droughts, will also affect streamflow regimes within aquatic ecosystems. The results may include increased water temperatures, especially in shallow reaches, and interrupted flows along stream reaches even in perennial streams. Patches of streambed lacking water will result in the mortality of numerous benthic organisms, and reduce habitat availability for aquatic plants, invertebrates, and fishes within patches of streams that still have water. This will likely result in crowding and also in competition for limited resources (space, food, shelter, etc.). Reduced flows will mean lower levels of oxygen, decreased productivity, and migration of more mobile organisms into more favorable habitats downstream. These favorable habitats, however, may expose migrants to increased rates of predation as they encounter new predators not present in upstream reaches. Reproductive behavior and ecology, physiological processes, and even life history strategies may be affected by these changes, as well.

Ocean-warming and ocean-acidification are the two primary threats to the marine ecosystem in War in the Pacific NHP. Both are a consequence of carbon dioxide accumulation in the atmosphere that causes global warming. Deposition of carbon dioxide into the ocean causes ocean acidification as the pH of oceanic waters shifts towards being more acidic.

Ocean warming promotes coral bleaching, stress and increases the exposure to disease, loss of habitat and forage, and may also alter patterns of distribution, development, reproduction, foraging and a host of other ecological processes (Munday et al. 2008) to the extent that species, including corals, are threatened with extinction (Donaldson 2008b, NOAA 2014). Since 2014 War in the Pacific NHP (and all Guam) reefs have suffered sudden extensive bleaching and death of corals related to elevated sea temperatures.

5.3 Sea Level Rise as a Result of Ocean Warming Globally Affects Beach Structure, as well.

The effects of ocean acidification on tropical coastal marine systems, and especially coral reefs, are still relatively poorly known. A decrease in pH would have obvious detrimental effects upon organisms that utilize calcium carbonate. For example, structural weakness may occur in calcareous algae, corals, and mollusks. Developmental impediments in the formation of shells (many mollusks) or skeletal structures (i.e., corals and larval fishes) may occur (i.e., Munday et al. 2008, 2011; Bignami et al. 2013a, 2013b). Ocean acidification may also alter behavior in larval, juvenile and even adult organisms such as fishes (Munday et al. 2014). Increased intensity of typhoons can cause more damage to reef ecosystems than experienced in the past especially if reefs are weakened structurally by coral death and acidification.

5.3.1 Illegal or Excessive Harvest, Hunt, and Take

Hunting

Hunting for land crabs, game birds (i.e., the black francolin), wild pigs, and deer, is not allowed in the park but poaching, especially in more remote areas likely occurs. The collection of plants and plant products (i.e., coconuts, breadfruit, and other useful fruits and nuts) also occurs but the impact remains to be documented. The practice of hunters starting wildfires to clear grasslands so that deer are attracted to new growth promotes significant sedimentation (Minton 2005).

Fishing

Fishing in some streams of the park may occur sporadically, mainly for freshwater eels (*Anguilla* spp., Anguillidae) and prawns (*Macrobrachium* spp, Paleomonidae). Overfishing of these species is possible, especially for the two species of freshwater eels that occur here (Appendix H) since both likely are impacted negatively, as are other members of the genus *Anguilla* globally, by climate change effects, habitat destruction and poor land use practices (Knights 2003, Chen et al. 2014, Tzeng, W.N. 2016). While there are no local restrictions for the use of traps, nets, hook and line, or spears, the use of toxins, including "swimming pool bleach", natural toxins (i.e., Derris root, etc.), and electric shockers is restricted. These restricted methods are detrimental to both fishes and invertebrates and, in the case of chlorine-based bleaches, can severely impact the community structure of streams, including assemblages of algae and diatoms, at localized scales (T.J. Donaldson, University of Guam,, personal observations).

Marine fishing within the park is far more common. The Guam Division of Aquatic and Wildlife Resources undertakes creel surveys that include both direct interviews of fishers (mainly from boat trips that land at the Hagatña and Agat marinas) or observations of spatial, temporal, and method patterns of shore and reef flat fishers conducted more or less randomly each month. These surveys include both the Asan Beach and Agat units. The data are analyzed to estimate fishing activity and catch composition island-wide. Island-wide data may be accessed at https://inport.nmfs.noaa.gov/inport. Data specific to both units might be extracted to estimate fishing intensity, catch composition, and frequency of use of methods (hook and line, spearfishing, netting, jigging, etc.). *In situ* surveys of habitats fished should provide data on fishery debris (e.g., abandoned nets, fishing line, and fishing weights) that can contribute negatively to fish community health because of entanglement and lead pollution. Tupper and Donaldson (2005) provided data on fisheries within the Asan Beach Unit of the park that provide insight into targeted species and their catch rates (Table 19). Biomass estimates were less than in the adjacent Piti Bomb Holes Marine Protected Area.

Table 19. Species composition and catch rates for the 15 most-commonly exploited reef organisms within the War in the Pacific NHP, based on 63 creel surveys reported by Tupper and Donaldson (2005).

Species	Number	Mean Length	Effort (hrs)	CPUE
Siganus spinus	66	12.4	19.5	3.33
Octopus cyanea	55	n/a	26.5	2.08
Acanthurus nigricans	42	10.0	48.0	0.88
Caranx melampygus	32	15.4	10.5	3.05
Scarus spp.	31	15.0	36.0	0.86
Acanthurus triostegus	26	7.3	10.0	2.60
Katsuwonus pelamis	26	31.3	8.0	3.25
Naso unicornis	24	13.9	30.0	0.80
Chlorurus sordidus	21	13.5	32.0	0.66
Naso lituratus	19	12.3	17.0	1.12
Naso annulatus	11	19.2	15.0	0.73
Kyphosus spp.	10	16.8	4.0	2.50
Epinephelus merra	8	12.8	8.0	1.00
Gymnosarda unicolor	4	52.5	4.0	1.00
Belonidae spp.	3	15.0	3.0	1.00

Regulation and monitoring of fisheries and fishing-related impacts are limited. The Guam DAWR provides some monitoring of fishing activities in both the Asan Beach and Agat units, and Department of Agriculture conservation officers provide enforcement on the MPA-portion of the Asan Beach Unit. Unfortunately, poaching still occurs (A.K. Miller, NPS, personal communication, 13 December 2016).

5.3.2 Diseases and Pathogens

Pathogens affecting plants in terrestrial ecosystems on Guam were recognized over 100 years ago. In 1917, the Tinangaja virus was detected in coconut plantations on Guam involved in copra production; it appears to be native to Guam. This virus was believed to have spread to coconut trees outside of plantation areas. This virus resulted in the mortality of a number of coconut trees across the island and presumably within the boundaries of the park. Presumably, the effects of bombardment, fighting, and the corresponding loss of coconut trees from these stressors during World War II would have likely masked any effects of this virus after the cessation of hostilities, but may have been a factor later when new growth occurred. This and other plant viruses and pathogens affecting coconut palms and native or introduced fruit plants (i.e., papaya, banana) that may occur in War in the Pacific NHP have been under study by the University of Guam's College of Natural and Applied Sciences (see Wall 2002; see also www.pestnet.org/fact_sheets/coconut_tinangaja_198.htm).

Other introduced pathogens are a significant threat to Guam's wildlife, and an outbreak would likely have severe consequences. Freshwater streams found in the park are breeding grounds for mosquitoes that serve as disease vectors for many pathogens. Those that affect birds (native, migratory and invasive species) and mammals, as well as park visitors, could include dengue, zika, malaria, pox, and West Nile virus. With the high number of international visitors Guam receives annually, its role as an airline hub, and as the location of an active air force base, the introduction of novel pathogens remains a concern.

In aquatic ecosystems, leptospirosis has been reported from various streams, including estuaries, on Guam (B. Tibbatts, Guam Division of Aquatic and Wildlife Resources, personal communication), and poses a risk to humans. Leptospirosis may occur in any stream or standing body of water that is utilized by wild pigs or other wild or domesticated animals, and rats may also carry this bacterium (Maraya 2000). Fecal coliform also may occur in these water bodies, and this poses a risk. A survey of diseases and pathogens of organisms in freshwater bodies in the park is warranted, especially for the Asan and Namo Rivers and their tributaries.

Coral diseases are a potentially significant impact upon marine ecosystems on Guam. Various diseases have been identified from Guam's waters, including the park, and these are being investigated by Dr. Laurie J. Raymundo and her team at the University of Guam Marine Laboratory (Redding 2013, Raymundo et al. unpublished data). Diseases of sea cucumbers (holothurans) have been observed also (A.K. Miller, NPS, personal communication, 13 December 2016). Fecal coliform in inshore areas near estuaries or within proximity of sewage outfalls, i.e., two potential locations in the Asan Beach and Agat Units. Only one STP outfall exists in Agat waters and this is treated sewage from a U.S. Navy plant, while Asan may be impacted by Hagatña STP primary treated discharges and runoff contaminated by livestock into the Asan River. These are potential threats to humans, marine birds and marine mammals. The Guam Environmental Protection Agency monitors *Enterococcus* bacteria (which in Guam occurs naturally in soil, unlike in the U.S. Mainland, where this is a better indicator of sewage) contamination at most accessible beaches on Guam (at least bimonthly reports are issued at epa.guam.gov/beach-report/current-beach-report). A study of potential or actual contamination during wet and dry seasons within War in the Pacific NHP is needed to gauge possible effects of contamination on park users and natural resources. Diseases and pathogens affecting other marine organisms remain to be documented.

5.3.3 Contaminants, Sewage, and Debris

Terrestrial habitats within War in the Pacific NHP, particularly those near roads, may be contaminated by fuel leaks, automobile exhaust captured in rainwater and deposited on land, direct air pollution (automobile and power plant exhaust) that negatively impacts roadside vegetation, sewage leaks, and litter. The extent of damage caused remains to be examined in detail.

Marine Corps Drive (Guam Route 1) partitions the Asan Beach Unit from the Asan Inland Unit. This highway experiences relatively heavy traffic. Most of it is from motor vehicles that range from cycle motor scooters to heavy-duty diesel semi-tractor trucks. All generate pollution from exhaust, tire wear, and leaks of fuel and lubricants. This pollution may be captured during rainstorms, deposited on the roadway, and eventually may wind up in storm sewers or simply in runoff into nearby streams. A similar process occurs in the Agat and Piti Guns units. The various pollutants, including heavy metals, may affect aquatic organisms in different degrees depending upon the pollutant, its concentration, and the organism exposed to it. The impact of this exposure remains to be examined in detail. A broken sewage line in a remote part of the Asan Inland Unit apparently dumped sewage into the Matgue drainage for many months before it was discovered and repaired in 2011 (M. Gawel, NPS, personal communication).

Litter from passing motor vehicles, pedestrians and other sources may also foul aquatic habitats. How significant this is remains to be determined but it doubtless has an effect upon the quality of the habitats exposed to this form of pollutant.

There are no sewage outfalls in streams found in War in the Pacific NHP. Instead, non-point source or pollution from livestock kept adjacent to streams may contribute both chemical and pathogenic pollutants to streams that flow within the park. Non-point sources may include septic fields that increase levels of nitrogen and phosphorus with corresponding detrimental effects. Livestock pens, if kept upstream of park units, will contribute both chemical pollutants and pathogenetic organisms to the stream, again with obvious negative effects (i.e., eutrophication, mortality of resident species, shifts in distribution, threat of disease, etc.).

Wildlife such as wild pigs, deer and carabao, may also contribute to these effects. Quantification of these effects remains to be undertaken.

Sewage can have significant negative impacts upon coral reefs (see Redding et al. 2013). Pollutants and litter carried downstream, especially during periods of heavy rain, may eventually be deposited into coastal waters of the park. Pollutants may be chemically pathological, and can promote mortality among marine plants and animals, enter the food chain at multiple levels, causing shifts in their distribution or promoting disease among marine organisms and humans alike. Litter is unsightly but may also provide unsafe conditions for beach use by humans (i.e., broken glass) or entangle marine organisms and cause mortality. Plastics may drift out to sea and contribute to the increased levels of oceanic plastic and microplastics that threaten marine life on a global scale.

5.3.4 Visitor Use

Much of the park is relatively isolated from roads and must be accessed by foot or illegally by off-road vehicles. Hiking is a popular pastime on Guam and given the scenic and historical value of the park it is expected to occur. Off-road vehicles can penetrate more isolated areas and may be inhibited only by heavy vegetation, steep inclines, and geological or riverine structures that act as barriers. Hikers may cause impacts by trampling sensitive vegetation, accelerating path formation that, when wet, creates mud that overtime and use could lead to erosion. Sediments could be carried downslope and into streams. Off-road vehicles cause the same impacts but only on a greater scale (PCR

Environmental 2009). Damage to the park's terrestrial habitats that results in erosion could, during periods of rainfall, transport sediments into streams and wetlands with deleterious effects. Hikers traversing streams in reaches with unstable banks also cause erosion. Littering by hikers, fisherpersons and other users is another negative impact. On coral reefs, sediment carried downstream and onto reefs as a consequence of erosion caused by visitor use on land is a negative impact because of the effects sedimentation has upon reef organisms. Other negative impacts include littering by beachgoers, picnickers, boaters, and fishers (the main threat is fouling of monofilament nets and fishing line, as well as lead fishing weights that put toxic lead into the ecosystem). Coral damage caused by careless scuba divers, snorkelers, fishers walking on the reef, kite surfers, and boaters, as well as anchor damage, pollution from leaking boat motors, overharvest by fisherpersons, and potential harassment of marine mammals, especially spinner dolphins, are also potential or actual impacts that require greater study to gauge their relative importance.

5.3.5 Stochastic Events

Natural forces can also contribute to this. Guam sits upon the boundary between the Pacific and Mariana tectonic plate and undergoes considerable seismic activity on a daily basis. Some of this activity is in the form of damaging earthquakes that may cause landslides that contribute to habitat destruction and potential damage to plant and animal communities.

Seismic activity, in the form of earthquakes or volcanic eruptions, can generate potentially damaging tsunamis as well. This damage would result from inundation of coastal areas within the park by saltwater that would kill or damage most plant life and also cause mortality, injury or dislocation amongst any animals present. Damage to or loss of historical and cultural resources, and War in the Pacific NHP facilities and infrastructure, could also result.

Tropical storms and typhoons, as well as heavy rainfall caused by seasonal monsoon systems, can cause erosion but also inundation. Damage to terrestrial plant communities from wind forces, saltwater spray, flooding, and landslides occurs.

Landslides, erosion and sedimentation from excessive rainfall and tropical storms, and seismic activity, would have corresponding negative effects upon aquatic streams and wetlands. Streambanks can be undercut banks during heightened stream flows and vegetation can be uprooted and deposited downstream where it may, as in the case of uprooted bamboo, form logjams or even dams. These impacts may cause shifts in stream habitat structure that can cause corresponding shifts in the behavior and ecology of the organisms present, thus altering the community structure of the stream.

Sediments transported downstream can be deposited in estuaries or directly on reef flats. These sediments can be redistributed by wave action and deposited elsewhere on reef flats, on seagrass beds and algae stands, on reef terraces and even on reef slopes. These deposits will smother corals, seagrasses, algae and other benthic organisms. Burrowing organisms may be forced from their preferred habitats, as well. For example, shrimp gobies and their commensal prawns may be forced to relocate if silty and muddy sediments smother their burrows; these finer sediments will likely not be conducive to burrow construction (Donaldson, unpublished data; University of Guam). Increased levels of turbidity in the water column will also impact negatively both benthic and water columndwelling species because of reduced visibility (Lundgren and Minton 2006, Minton and Lundgren 2006, and Minton et al. 2007).

5.3.6 Summary of Threats and Stressors

Threats and stressors that may affect terrestrial, aquatic and marine habitats and resources within War in the Pacific NHP are often interconnected to the extent that if something happens in one part of the park, such as a wildfire, sediment can be expected to be carried downstream in aquatic streams and deposited on reefs or sea grass beds in coastal habitats. Similarly, pollutants or litter that originate on land may be carried by stream water down and into the sea. Tourist or recreational activities, such as scuba diving and snorkeling, may cause damage to corals or sea grass beds often through carelessness rather than by any overt action.

Fisherpersons may leave lost tackle, fishing line or nets on the sea floor to the detriment of the organisms that dwell there. On a grander scale, elevated carbon dioxide levels consequence of burning fossil fuels, both locally and globally, is resulting in elevated sea temperatures and decreased pH levels as the ocean warms and acidifies, respectively, with corresponding negative physical and biological impacts. How these impacts affect the park, both singularly and cumulatively, should be examined.

Identifying the Extent of Problems at War in the Pacific NHP

Daniel (2006) identified the following threats and stressors for War in the Pacific NHP: fishing, sedimentation, savanna wildfires, pollution (including contaminants and ordnance), air quality and climate, seismic activity, invasive and alien species, and soundscape effects upon landscapes. These have been discussed variously above with the exception of soundscape effects. Daniel (2006) identified the loss of bird song as a consequence of predation by the invasive brown tree snake. In marine environments, sound pollution in the form of commercial, military, and recreational shipping or boating activities, is the principal problem.

Cultural and management issues relevant to the park were also discussed by Daniel (2006). These are not addressed in this report and so the reader should consult this publication and is encouraged also to search the literature and relevant online resources for more recent treatments on these subjects.

Describing the Knowledge Base of Threats and Stressors

Much of the data reproduced here in the form of tables and figures is derived from many of the publications cited in this report; much of this has been done by the National Park Service as it seeks to understand what resources are present in War in the Pacific NHP, how terrestrial, aquatic and marine ecosystems within the park function, and what may stress or threaten these ecosystems or species contained within. Data, especially GIS and ecological survey data, are present also in data bases created and maintained by other government agencies, the University of Guam, and other institutions. The creation of a NPS maintained park data base that collects, digitizes, collates, and stores all data relevant to the park, its resources, and the functioning of its ecosystems is warranted. What is equally important is the necessity to conduct new studies and incorporate the data into this data base so that quantitative analyses may be undertaken that seek to answer questions posed by park managers.

Quantifying the Magnitude of Impact on Ecosystems

Threats and stressors on terrestrial, aquatic and marine systems of War in the Pacific NHP have not been addressed well quantitatively with the exception of a series of studies conducted by Minton (2005), Minton et al. (2006, 2007), Lundgren and Minton (2006), and Minton and Lundgren (2006) that managed to connect processes of land use or misuse, erosion, and sedimentation as they moved between terrestrial, aquatic and marine systems. Similar effort remains to be made in understanding the processes and links between other threats and stressors within the park, including overfishing, climate change, pollution, invasive species, dive tourism, and threatened and endangered species.

5.4 Data Needs

Principal data needs for terrestrial, aquatic and marine habitats, and invasive species, threatened and endangered species, human use, and air quality, are listed in Table 20 and summarized below.

Table 20. Data needs for the War in the Pacific NHP. Key: T = terrestrial, A = aquatic, M = marine, IS = invasive species, H = human use, G = general, QS = quantitative survey, C = checklist, MP = monitoring program.

Need	Ecosystem	Asan Beach	Asan Inland	Fonte Plateau	Piti Guns	Mt. Tenjo/ Mt. Chachao	Gutali Parcel	Mt. Alifan	Agat
Threatened and Endangered Plants	T	QS-C MP	QS-C MP	QS-C MP	QS-C MP	QS-C MP	QS-C MP	QS-C MP	QS-C MP
Habitat Integrity	T	MP	MP	MP	MP	MP	MP	MP	MP
Stream Invertebrates	A	QS-C	QS-C	QS-C	QS-C	–	QS-C	QS-C	QS-C
Stream Fishes	A	QS-C	QS-C	QS-C	QS-C	–	QS-C	QS-C	QS-C
Stream Water Quality	A	MP	MP	MP	MP	–	MP	MP	MP
Stream Sediment Transport	A	MP	MP	MP	MP	–	MP	MP	MP
Coastal Oceanography	M	MP	–	–	–	–	–	–	MP
Coral Bleaching and Recovery	M	MP	–	–	–	–	–	–	MP
Sedimentation and Coral Loss	M	MP	–	–	–	–	–	–	MP
Threatened and Endangered Species	M	QS-C MP	–	–	–	–	–	–	QS-C MP
Invasive Terrestrial Plants	IS	QS-M	QS-M	QS-M	QS-M	QS-M	QS-M	QS-M	QS-M
Invasive Insects	IS	QS-C	QS-C	QS-C	QS-C	QS-C	QS-C	QS-C	QS-C
Invasive Stream Plants and Invertebrates	IS	QS-MP	QS-MP	QS-MP	QS-MP	–	QS-MP	QS-MP	QS-MP
Invasive Stream Fishes	IS	MP-C	MP-C	MP-C	MP-C	–	MP-C	MP-C	MP-C
Poaching and Plant Collecting	H	MP	MP	MP	MP	MP	MP	MP	MP
Air Quality	G	MP	MP	MP	MP	MP	MP	MP	MP

5.4.1 Terrestrial

Threatened and Endangered Plants

Previous surveys of terrestrial plants within the park have identified species threatened with extinction (Appendix C). Quantitative surveys are necessary to better identify where these plants are distributed in units of the park, and the size and status of their populations. A revised checklist of species should be created, and a program developed and implemented in order to monitor changes in population sizes and status.

Habitat Integrity

Habitat destruction occurs because of a combination of anthropogenic and natural processes. A program should be developed and implemented to monitor changes in habitats, especially relatively pristine, habitats within units of the park. Measurement of changes over time from erosion, fires, off-road vehicle use, and corresponding changes in dominate vegetation types (forests, grasslands, scrub, etc.) should be undertaken using field surveys coupled with GIS methods to produce maps illustrating changes over time.

5.4.2 Aquatic

Stream Invertebrates

A quantitative survey of invertebrates, principally mollusks, crustaceans, and aquatic insects, should be undertaken for perennial and annual streams found in all units except for Mt. Tenjo/Mt. Chachao, where no streams are present. Estimates of species distribution, population sizes, and habitat use should be made, and checklists of species should be developed for each taxonomic group within each unit.

Stream Fishes

Similarly, a quantitative survey of fishes should be undertaken for perennial and annual streams found in all units except for Mt. Tenjo/Mt. Chachao, where no streams are present. Surveys should include netting, electrofishing, traps, hook and line methods, and snorkeling (where possible). Estimates of species distribution, population sizes, and habitat use should be made. Checklists of species should be developed for each taxonomic group within each unit.

Stream Water Quality

A long-term monitoring program of water quality should be implemented for streams in all units except for Mt. Tenjo/Mt. Chachao (where streams are absent) in order to measure and understand seasonal (rainy vs dry) patterns of variation. Variables should include but not be limited to water temperature, pH, dissolved oxygen, stream morphology, stream flow rates, and chemical composition (nitrates, ammonia, phosphorous, etc.).

Stream Erosion and Sediment Transport

Building upon earlier work by Minton (2005), a monitoring program to measure sources and rates and erosion, and the rates of sedimentation, the quantities and transport distances of sediments, and locations of sediment deposition, should be established in perennial and annual streams within each of the units of the park (except for Mt. Tenjo/Mt. Chachao). This program should consider seasonal differences in the variables measured.

5.4.3 Marine

Coastal Oceanography

Long-term monitoring of coastal oceanographic processes, with data comparable to those in conducted recently by the University of Guam Marine Laboratory off Anderson Air Force Base and Navy Base Guam (Schils et al. unpublished), and at Pago Bay (Comfort et al. 2019), should be undertaken in both Asan Beach and Agat units in order to measure changes in sea surface temperature, irradiance, turbidity, sedimentation, pH, dissolved oxygen, tidal patterns and sea level rise, and current flow patterns. These variables are important for understanding negative impacts upon coral reefs but also resilience. Data collected would complement those taken previously on Agat Reef (Hoot and Burdick 2017).

Coral Bleaching and Recovery

Permanent transects to monitor coral bleaching and recovery on Guam have been established as part of the Guam Coral Reef Response Team efforts. Additional permanent transects should be established and monitored in both Asan Beach and Agat units in order to obtain a wider area and increased depth of coverage over time.

Threatened and Endangered Species

There is no long term and consistent dataset of green (*Chelona mydas*) and hawksbill (*Eretmochelys imbricate bissa*) sea turtle sightings for the Asan Beach and Agat units. Similarly, a survey of periodic spinner dolphin activity in relation to dolphin watching cruises is warranted to examine potential negative effects upon dolphin behavior within waters of the Agat Unit. Data from aerial surveys over a 50-year period have shown that the mean density of small delphinids such as spinner dolphins is low although comparable to other localities on Guam (Martin et al. 2016).

5.4.4 Invasive Species

Terrestrial Plants

Invasive terrestrial plants have made significant impacts plant communities including those found on Guam and in the park. Such impacts can promote the extinction of native species (Veitch and Clout 2002). While many species have been identified (Appendix C), estimates of population sizes and their patterns of distribution based upon quantitative surveys remain to be made within each of the park's units. Field surveys, including the use of unmanned aerial vehicles (drones) equipped with cameras and multispectral sensors, coupled with GIS mapping, should be undertaken. Similarly, surveys should be designed and implemented to allow for monitoring over time in order to measure the rate and area of distribution of colonization.

Terrestrial Insects

Invasive species are an increasing threat to native flora and fauna on Guam and within the park. Rhinoceros coconut beetle, little fire ants, and others have been destructive. A quantitative survey program to identify species, estimate their distributions and abundances, and determine their rates of colonization should be implemented for all units of the park. Similarly, estimates of plant loss or damage from herbivorous species should be made over time to quantify the negative impacts caused by these invasive species.

Aquatic

Surveys of streams within the park should be designed and implemented to identify, quantify, and describe populations of invasive plant, invertebrate and vertebrate species. The design of the surveys should allow for mapping of patterns of distribution and rates of colonization over time.

Marine

Surveys of the adjacent Agat Marina and Nimitz Beach, where murky, lagoon-like habitat exists, may yield sightings of invasive species, however. Transport of invasive algae, invertebrates, and larval fishes by vessels, mainly on hulls and in ballast water, may allow for these organisms to settle on reefs within the park. This likelihood remains to be investigated. Further, a comprehensive survey of invasive marine species and their patterns of distribution remains to be made.

5.4.5 Human Use

Poaching and Plant Collecting

Poaching of invasive deer and pigs, and introduced black francolin, likely occurs in remote portions of the park (i.e., Mt. Chachao-Mt. Tenjo, Mt. Alifan, and Gutali Parcel units) but the extent of this is unknown. While the removal of invasive species by hunters might have positive effects within the park there are safety and legal concerns to consider. A monitoring program should be developed and implemented, perhaps in collaboration with the Guam Division of Aquatic and Wildlife Resources and the Guam Department of Agriculture's Conservation Enforcement section.

The removal of native plants, including threatened and endangered species, by individuals or commercial interests may also occur but again the extent of this activity, if it does occur, is unknown. Negative impacts from collecting could include a reduction of plant biodiversity within the park and the extinction or near extinction of some species. A monitoring program, perhaps one utilizing unmanned aerial vehicles to facilitate monitoring, should be developed and implemented.

5.4.6 Air Quality

If opportunities arise in the future, it would be valuable to collect air quality data in the park to determine current pollutant sources and concentrations, and better clarify the threat to park resources from air pollution (mainly automobile and power plant emissions). Data on air emissions of particulate matter, carbon dioxide, nitrogen oxides, and volatile organic compounds should be collected annually in order to plot trends in air quality.

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Appendix A. Freshwater Streams of War in the Pacific NHP

Table 21. Freshwater streams of War in the Pacific NHP (War in the Pacific NHP, unpublished data). These data indicate the amount of freshwater habitat (less wetlands) available for aquatic plants and animals within the park.

Stream	Type	Unit	Watershed	Length (m) within War in the Pacific NHP
Asan River	Perennial	Asan Inland, Asan Beach	Piti-Asan	1,981
Atantano River	Perennial	Guatali Parcel	Apra	329
Big Guatali River	Perennial	Guatali Parcel	Apra	630
Finile Creek	Perennial	Agat	Agat	5
Gaan River	Perennial	Agat	Agat	15
Masso River	Perennial	Piti Guns	Piti-Asan	62
Matgue River	Intermittent	Asan Inland, Asan Beach	Piti-Asan	1,291
Namo	Perennial	Agat	Agat	106
Paulana River	Perennial	Guatali Parcel	Apra	526
Salinas River	Perennial	Mt. Alifan, Agat	Agat	208
Taguag River	Perennial	Piti Guns (not War in the Pacific NHP)	Piti-Asan	465
Tenjo River	Intermittent	Guatali Parcel,	Apra	4
Unnamed Streams	Intermittent	Guatali Parcel	Apra	1,874
Unnamed Streams	Perennial	Guatali Parcel, Mt. Alifan, Asan Inland, Asan Beach	Apra, Agat, Piti-Asan	2,114
Unnamed Streams	Both	Agat	Agat	Unavailable

Appendix B. Vegetation Cover by Park Unit

Table 22. Vegetation cover by park unit based on C-CAP data from the Vegetation Mapping Inventory Project at War in the Pacific National Historical Park (Cogan 2014). Table updated in April 2017. Values are in square meters. The summary statistics were calculated using geospatial analysis.

Description	Asan Beach	Asan Inland	Fonte Plateau	Piti Guns [A]	Piti Guns	Mt. Tenjo [B]	Guatali Parcel	Agat	Mt. Alifan
African Tulip Tree Semi-natural Woodland	0	14,291	0	21,174	19,007	0	0	0	0
Clay and Rock Outcrop Sparse Vegetation	0	14,137	0	1,339	0	43,772	0	0	15,077
Coastal Strand Sparse Vegetation	34,781	0	0	0	0	0	0	21,454	0
Commercial / Light Industry	0	1,526	0	0	0	0	0	0	676
Communications and Utilities	0	0	0	0	0	0	0	6,439	0
Coral Bean Tree Semi-natural Forest Stand	0	65,183	0	3,170	0	0	0	0	0
Exposed Reef and Tidal Pools	955,286	0	0	0	0	0	0	1,268,577	0
Gagu / Neti - Mission Grass Semi-natural Wooded Grassland	0	156,955	0	25,270	2,694	0	0	0	3,687
Gagu Woodland	0	4,768	0	0	0	0	0	3,439	0
Government Facilities	1,599	18,021	0	0	0	2,240	0	812	0
Australian Beardgrass - Inifuk Lawn	105,578	383	1,412	0	0	0	0	18,524	0
Hau (Pago) Woodland	0	172,050	36,550	0	10,303	0	0	25,778	24,517
Karriso Herbaceous Vegetation	0	26,234	0	9,637	0	11,505	0	2,963	46,427
Mango Semi-natural Woodland	0	0	0	0	0	0	0	0	18,914
Mixed Savanna Herbaceous Vegetation	0	433,616	807	125,250	11,763	64,063	0	0	353,640
Mixed Semi-natural / Ornamental Tree Woodland	3,102	18,788	0	0	0	0	0	1,529	1,342
Moreton Bay Fig - (Amahadyan) Woodland Stand	0	62,327	0	0	0	0	0	0	0

[A] not WAPA

[B] non-Mt.Chachao

Table 22 (continued). Vegetation cover by park unit based on C-CAP data from the Vegetation Mapping Inventory Project at War in the Pacific National Historical Park (Cogan 2014). Table updated in April 2017. Values are in square meters. The summary statistics were calculated using geospatial analysis.

Description	Asan Beach	Asan Inland	Fonte Plateau	Piti Guns [A]	Piti Guns	Mt. Tenjo [B]	Guatali Parcel	Agat	Mt. Alifan
Palma Brava Semi-natural Woodland and Forest Complex	12,007	357,486	49,148	11,768	0	4,456	0	0	0
Bare Rock / Sand / Other Bare Ground	2,251	12,736	2,462	0	0	0	0	0	0
Piao Palaoan - (Spiny Bamboo) Semi-natural Forest	0	72,211	0	102	0	0	0	0	5,314
Residential	13,546	12,736	0	1,191	1,037	0	0	1,334	1,784
Sea / Ocean	785,607	0	0	0	0	0	0	937,040	0
Smallflower Chastetree Semi-natural Woodland	0	0	15,516	0	0	0	0	0	26,166
Stream / River	1,600	9,203	0	0	0	0	0	128	0
Submerged Sand and Rock	0	0	0	0	0	0	0	31,544	0
Tangantangan Semi-natural Shrubland	36,374	112,821	2,302	66,599	1,776	17,985	0	17,320	20,906
Tangantangan Semi-natural Woodland Complex	9,412	253,221	19,331	8,237	11,467	2,125	0	0	15,274
Transitional	0	0	305	0	0	0	0	3,318	0
Transportation	26,609	20,195	0	3,003	318	6,315	0	6,375	126
Tronkon Niyok - (Hau) / Mixed Grass Wooded Strand	41,059	6,012	10,065	3,130	0	0	0	35,349	16,523
Uluhe (Mana) Herbaceous Vegetation	0	214,665	0	4,958	0	30,823	0	0	70,981
White Cedar / Dimeria Semi-natural Woodland	0	52,370	0	2,154	0	0	0	0	0
Yellow Poinciana Woodland Stand	0	72,147	2,465	0	0	0	0	0	0
Beaches	46,788	0	0	0	0	0	0	16,882	0

[A] not WAPA

[B] non-Mt.Chachao

Table 22 (continued). Vegetation cover by park unit based on C-CAP data from the Vegetation Mapping Inventory Project at War in the Pacific National Historical Park (Cogan 2014). Table updated in April 2017. Values are in square meters. The summary statistics were calculated using geospatial analysis.

Description	Asan Beach	Asan Inland	Fonte Plateau	Piti Guns [A]	Piti Guns	Mt. Tenjo [B]	Guatali Parcel	Agat	Mt. Alifan
Broad-leaved Mahogany Semi-natural Forest	0	711	0	9,146	32,943	0	0	0	0
Canal / Ditch	0	0	0	0	0	0	0	270	0
Cemeteries	0	0	0	0	0	0	0	5,646	0
Chain-of-love - Guinea Grass Semi-natural Herbaceous Vegetation	0	13,206	0	0	0	0	0	0	86
Total	2,075,598	2,197,999	140,362	296,128	91,308	183,284	0	2,404,722	621,440

[A] not WAPA

[B] non-Mt.Chachao

Appendix C. Provisional checklist of vascular plant species in each unit of War in the Pacific NHP

Table 23. Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

			Abundance															
Family	Species Name	Park Status	Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum	Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concern (Y/N)
Acanthaceae	Asystasia gangetica (L.) T. Anderson	Present	–	Rare	–	–	–	–	–	–	–	Rare	Non-nat.	Persist.	No	No	No
Acanthaceae	Blechum pyramidatum (Lam.) Urb	Present	–	Uncommon	Common	Common	Uncommon	–	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Acanthaceae	Graptophyllum pictum (L.) Griff.	Present	Uncommon	–	–	–	–	–	–	–	–	Rare	Non-nat.	Persist.	No	No	No
Acanthaceae	Hemigraphis reptans (G. Forst.) T. Anders.	Present	–	–	–	–	Common	–	Uncommon	–	Uncommon	Common	Non-nat.	Not cult.	Yes	No	No
Agavaceae	Agave rigida Mill.	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Agavaceae	Cordyline fruticosa (L.) A. Chev.	Present	–	–	–	–	–	Uncommon	–	–	Uncommon	Rare	Non-nat.	Persist.	No	No	No
Agavaceae	Dracaena marginata Lamarck	Present	–	Rare	–	–	–	–	–	–	–	Rare	Non-nat.	Persist.	No	No	No
Agavaceae	Sansevieria trifasciata Prain	Present	–	–	–	–	–	Uncommon	Rare	–	Uncommon	Uncommon	Non-nat.	Persist.	No	No	No
Amaranthaceae	Achyranthes aspera L. var. aspera	Present	Uncommon	–	–	–	–	–	–	–	–	Uncommon	Native	–	–	–	–
Amaranthaceae	Gomphrena serrata L.	Present	–	Common	Abundant	Common	Common	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Anacardiaceae	Mangifera indica L.	Present	–	–	Uncommon	–	Common	Common	Uncommon	–	Uncommon	Uncommon	Non-nat.	Persist.	No	No	No
Annonaceae	Annona muricata L.	Present	–	–	–	–	–	–	Uncommon	–	–	Rare	Non-nat.	Persist.	No	No	No
Annonaceae	Annona reticulata L.	Present	–	–	Uncommon	Common	Uncommon	Common	Uncommon	–	–	Uncommon	Non-nat.	Not cult.	No	No	No
Annonaceae	Annona squamosa L.	Present	no data	–	–	–	–	–	–	–	Uncommon	Uncommon	Non-nat.	Not cult.	No	No	No
Annonaceae	Cananga odorata (Lam.) J.D. Hook & Thomson	Present	–	–	–	–	–	Common	–	–	–	Uncommon	Non-nat.	Not cult.	No	No	No
Annonaceae	Guamia mariannae (Saff.) Merr.	Present	–	–	–	–	–	–	Common	–	–	Uncommon	Native	–	–	–	–
Apiaceae	Centella asiatica (L.) Urban	Present	–	–	–	–	Uncommon	–	Uncommon	Uncommon	–	Uncommon	Native	–	–	–	–
Apocynaceae	Allamanda cathartica L.	Present	–	–	–	–	Uncommon	–	Uncommon	–	Common	Uncommon	Non-nat.	Persist.	No	No	No
Apocynaceae	Cerbera dilitata Markgraf	Present	–	–	–	–	Rare	–	–	–	–	Rare	Native	–	–	–	–
Apocynaceae	Neisosperma oppositifolia (Lamarck) Fosberg & Sachet	Present	–	–	–	–	–	Uncommon	Common	–	–	Common	Native	–	–	–	–
Apocynaceae	Nerium oleander L.	Present	–	–	Uncommon	–	–	–	–	–	–	Uncommon	Non-nat.	Cultivated	No	No	No
Apocynaceae	Plumeria obtusa L.	Present	–	Uncommon	–	–	Common	–	–	–	–	Common	Non-nat.	Cultivated	No	No	No
Araceae	Alocasia macrorrhizos (L.) Schott	Present	–	–	Uncommon	–	Uncommon	–	Uncommon	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Araceae	Dieffenbachia maculata G. Don	Present	–	–	–	–	–	–	–	–	Uncommon	Rare	Non-nat.	Persist.	No	No	No
Araceae	Epipremnum pinnatum (L.) Engl.	Present	Common	–	–	Uncommon	–	–	Uncommon	–	–	Uncommon	Non-nat.	Persist.	Yes	No	No
Araceae	Syngonium angustatum Schott	Present	Common	–	–	–	no data	Common	Uncommon	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Araliaceae	Polyscias grandifolia Volk.	Present	–	–	–	–	Uncommon	Uncommon	–	–	–	Uncommon	Native	–	–	–	–

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

			Abundance														
Family	Species Name	Park Status	Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum	Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concern (Y/N)
Araliaceae	Schefflera sp.	Present	–	–	–	–	–	–	–	Rare	–	Rare	Unknow n	–	–	–	–
Arecaceae	Areca catechu L.	Present	–	–	–	–	–	–	Uncommon	–	Uncommon	Uncommon	Native	–	–	–	–
Arecaceae	Cocos nucifera L.	Present	Common	Common	Common	Common	Common	Common	Common	–	Common	Common	Native	–	–	–	–
Arecaceae	Dypsis lutescens (H. Wendland) Beentje & J. Dransfield	Present	–	–	–	Uncommon	–	–	–	–	–	Uncommon	Non-nat.	Cultivated	No	No	No
Arecaceae	Heterospathe elata Scheffer	Present	–	–	–	Uncommon	Common	Common	–	Uncommon	Common	Common	Non-nat.	Not cult.	Yes	No	No
Arecaceae	Veitchia merrillii (Beccari) H.E. Moore	Present	–	–	–	Uncommon	Uncommon	–	–	–	–	Uncommon	Non-nat.	Cultivated	No	No	No
Asclepiadaceae	Telosma cordata (N.L. Burman) Merrill	Present	–	–	–	–	–	Uncommon	–	–	Uncommon	Rare	Non-nat.	Persist.	No	No	No
Aspleniaceae	Asplenium nidus L.	Present	–	–	–	–	Common	–	Uncommon	–	–	Common	Native	–	–	–	–
Aspleniaceae	Asplenium polyodon G. Forst.	Present	–	–	–	–	–	Uncommon	–	–	–	Common	Native	–	–	–	–
Asteraceae	Bidens alba (L.) DC.	Present	Common	Abundant	Abundant	Common	Common	Common	Common	Common	Common	Abundant	Non-nat.	Not cult.	Yes	No	No
Asteraceae	Calyptocarpus vialis Lessing	Encroaching	–	–	–	–	–	–	–	–	–	NA	Non-nat.	NA	Yes	No	No
Asteraceae	Conyza canadensis (L.) Cronq.	Present	–	–	–	Uncommon	Uncommon	–	–	Uncommon	Common	Common	Non-nat.	Not cult.	Yes	No	No
Asteraceae	Cyathillium cinereum (L) H. Rob.	Present	Common	Common	Common	Common	–	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Asteraceae	Eclipta prostrata (L.) L.	Present	–	Uncommon	Uncommon	Uncommon	–	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Asteraceae	Elephantopus mollis Kunth	Present	–	Common	Common	–	Common	–	–	Common	Common	Common	Non-nat.	Not cult.	Yes	No	No
Asteraceae	Emilia sonchifolia (L.) DC.	Present	–	–	–	Uncommon	Uncommon	–	–	Uncommon	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Asteraceae	Epaltes australis Lessing	Present	–	–	–	–	no data	–	–	–	–	Unknow n	Non-nat.	Unknown	–	No	No
Asteraceae	Erigeron bellioides de Candolle	Encrouch.	–	–	–	–	–	–	–	–	–	NA	Non-nat.	–	–	No	No
Asteraceae	Eupatorium odoratum L.	Present	Common	Abundant	–	Common	Common	Common	Common	Uncommon	Common	Abundant	Non-nat.	Not cult.	Yes	Yes	No
Asteraceae	Glossocardia tenuifolia (Labill.) Cassini	Present	–	–	–	–	–	–	Rare	–	–	Rare	Native	–	–	–	–
Asteraceae	Mikania micrantha Kunth	Present	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Non-nat.	Not cult.	Yes	No	No
Asteraceae	Pluchea carolinensis (Jacq.) G. Don	Present	–	–	–	–	–	Rare	–	–	–	Rare	Non-nat.	Not cult.	Yes	No	No
Asteraceae	Pluchea indica (L.) Less.	Present	–	–	–	Uncommon	–	–	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Asteraceae	Sphagneticola trilobata (L.) Pruski	Present	Common	Common	Common	Common	Common	Common	Uncommon	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Asteraceae	Synedrella nodiflora (L.) Gaertn.	Present	–	–	Common	Common	–	–	–	–	Uncommon	Common	Non-nat.	Not cult.	Yes	No	No
Asteraceae	Tridax procumbens L.	Present	–	–	–	Common	Common	Common	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Bignoniaceae	Catalpa longissima (Jacq.) Dum.-Cours.	Present	–	–	–	–	–	Uncommon	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Bignoniaceae	Spathodea campanulata Beauv.	Present	–	–	–	–	Common	Common	–	–	Common	Uncommon	Non-nat.	Not cult.	No	No	No

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

			Abundance														
Family	**Species Name**	**Park Status**	**Agat-Bangi Pt**	**Agat-Apaca Pt**	**Agat-Gaan Pt**	**Asan Beach**	**Asan Inland**	**Fonte Plateau**	**Mt. Alifan**	**Mt. Chachao-Mt. Tenjo**	**Piti Guns**	**WPNHP Sum**	**Nativ NPSpp**	**Cultivation**	**Weedy (Y/N)**	**Mng Priority (Y/N)**	**Exploit Concer n (Y/N)**
Bignoniaceae	Tabebuia pallida (Lindley) Miers	Present	–	–	–	–	Uncommon	Uncommon	Uncommon	–	Common	Common	Non-nat.	Persist.	No	No	No
Bignoniaceae	Tabebuia rosea (A. Bertoloni) A.P.de Candolle	Present	–	–	–	–	–	–	–	–	Uncommon	Uncommon	Non-nat.	Persist.	No	No	No
Bignoniaceae	Tecoma stans (Linnaeus) Jussieu ex Humboldt, Bonpland, & Kunth	Present	Rare	–	–	–	–	–	–	–	–	Unknow n	Non-nat.	Unknown	No	No	No
Bixaceae	Bixa orellana L.	Present	–	–	–	–	–	Uncommon	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Blechnaceae	Blechnum orientale L.	Present	–	–	–	–	–	–	–	Uncommon	–	Uncommon	Native	–	–	–	–
Bombacaceae	Ceiba petandra (L.) Gaertn.	Present	–	–	–	–	Uncommon	–	–	–	Rare	Uncommon	Non-nat.	Persist.	No	No	No
Boraginaceae	Cordia subcordata Lam.	Present	–	–	–	Uncommon	–	–	–	–	–	Uncommon	Native	–	–	–	–
Boraginaceae	Heliotropium procumbens P. Mill.	Present	Common	–	Common	Common	–	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Boraginaceae	Tournefortia argentea L. f.	Present	–	–	–	Uncommon	–	–	–	–	–	Uncommon	Native	–	–	–	–
Bromeliaceae	Ananas cosmosus (L.) Merrill	Present	–	–	–	–	–	–	Rare	–	–	Rare	Non-nat.	Persist.	No	No	No
Buddlejaceae	Buddleia asiatica Lour.	Present	–	–	–	–	Rare	–	–	–	–	Rare	Non-nat.	Not cult.	Yes	No	No
Cactaceae	Nopalea cochenillifera (L.) Salm-Dyck	Present	–	–	–	Rare	–	–	–	–	–	Rare	Non-nat.	Not cult.	No	No	No
Campanulaceae	Hippobroma longiflora (L.) G. Don	Present	–	–	–	–	Uncommon	Uncommon	Common	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Caricaceae	Carica papaya L.	Present	Common	–	Common	Common	Common	Common	Uncommon	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Casuarinaceae	Casuarina equisetifolia L.	Present	–	Common	Common	Common	Common	Common	Common	Uncommon	Common	Common	Native	–	–	–	–
Celastraceae	Maytenus thompsonii (Merr.) Fosb.	Present	–	–	–	–	–	Uncommon	–	–	–	Uncommon	Native	–	–	–	–
Clusiaceae	Calophyllum inophyllum L.	Present	Rare	Common	–	Common	–	–	–	–	–	Common	Native	–	–	–	–
Combretaceae	Conocarpus erectus L.	Encroaching	–	–	–	–	–	–	–	–	–	NA	Non-nat.	NA	–	No	No
Combretaceae	Terminalia catappa L.	Present	Uncommon	–	–	–	Common	Common	Uncommon	–	–	Common	Native	–	–	–	–
Commelinaceae	Tradescantia spathacea Swartz	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Non-nat.	Cultivated	No	No	No
Convolvulaceae	Ipomoea indica (Burm. f.) Merr.	Present	–	–	–	Common	–	–	–	–	–	Common	Native	–	–	–	–
Convolvulaceae	Ipomoea littoralis Blume	Present	–	–	–	–	Common	–	Common	–	–	Common	Native	–	–	–	–
Convolvulaceae	Ipomoea obscura (L.) Ker-Gawl.	Present	–	–	Common	Common	Uncommon	–	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Convolvulaceae	Ipomoea pes- capre (L.) R. Br.	Present	Common	Common	Common	Common	–	–	Uncommon	–	Common	Common	Native	–	–	–	–
Convolvulaceae	Ipomoea triloba L.	Present	–	Common	Common	Common	–	–	Common	Common	Common	Common	Non-nat.	Not cult.	Yes	No	No
Convolvulaceae	Merremia gemella (Burmann fils) Hallier fils	Encroaching	–	–	–	–	–	–	–	–	–	NA	Non-nat.	–	Yes	No	No
Convolvulaceae	Operculina ventricosa (Bertero) Peter	Present	–	–	–	–	Common	Uncommon	Uncommon	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Convolvulaceae	Stictocardia tiliifolia (Desr.) Hallier f.	Present	–	–	–	–	Common	Common	Uncommon	–	Common	Common	Non-nat.	Not cult.	Yes	No	No

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

			Abundance														
Family	Species Name	Park Status	Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum	Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concer n (Y/N)
Cucurbitaceae	Cucurbita sp.	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Unknow n	–	–	–	–
Cucurbitaceae	Luffa aegyptiaca P. Mill.	Present	–	Uncommon	Uncommon	–	Common	–	–	–	–	Common	Native	–	–	–	–
Cucurbitaceae	Momordica charantia L.	Present	–	–	–	Common	Common	Common	–	–	Common	Abundant	Non-nat.	Not cult.	Yes	No	No
Cycadaceae	Cycas circinalis L.	Present	Uncommon	–	–	–	–	–	Uncommon	Uncommon	–	Uncommon	Native	–	–	–	–
Cyperaceae	Carex fuirenoides Gaud.	Probably Present	–	–	–	–	–	–	–	–	–	NA	Native	–	–	–	–
Cyperaceae	Cyperus alternifolius L.	Present	–	–	Uncommon	–	–	–	–	–	–	Uncommon	Non-nat.	Cultivated	No	No	No
Cyperaceae	Cyperus flavidus Retz.	Present	–	–	–	–	–	–	–	Uncommon	Uncommon	Uncommon	Non-nat.	Not cult.	Yes	No	No
Cyperaceae	Cyperus ligularis L.	Present	–	–	Uncommon	–	–	–	–	–	–	Uncommon	Non-nat.	Not cult.	No	No	No
Cyperaceae	Cyperus polystachyos Rottboell	Probably Present	–	–	–	–	–	–	–	–	–	NA	Non-nat.	–	–	–	–
Cyperaceae	Eleocharis dulcis (Burm. f.) Trin. ex. Hensch	Present	–	–	–	–	–	–	–	Rare	–	Rare	Non-nat.	Not cult.	No	No	–
Cyperaceae	Eleocharis geniculata (L.) Roemer & J.A. Schultes	Present	–	–	Uncommon	–	Uncommon	–	–	–	Uncommon	Common	Native	–	–	–	–
Cyperaceae	Fimbristylis autumnalis (L.) Roemer & J.A. Schultes	Present	–	–	–	–	Uncommon	–	Uncommon	Uncommon	Uncommon	Uncommon	Native	–	–	–	–
Cyperaceae	Fimbristylis cymosa R. Br.	Present	no data	Abundant	Abundant	Common	Common	Common	–	Common	Common	Abundant	Native	–	–	–	–
Cyperaceae	Fimbristylis dichotoma (L.) Vahl	Present	–	Common	Common	Common	Common	Common	–	Common	Common	Abundant	Native	–	–	–	–
Cyperaceae	Fimbristylis littoralis Gaudich.	Present	–	–	–	–	Uncommon	–	–	–	Common	Uncommon	Native	–	–	–	–
Cyperaceae	Fimbristylis ovata (Burm. f.) J. Kern	Present	–	Common	–	–	–	Uncommon	–	Uncommon	–	Common	Non-nat.	Not cult.	Yes	No	No
Cyperaceae	Fimbristylis tristachya R.Br.	Present	–	–	–	–	Common	–	Abundant	Common	Abundant	Abundant	Native	–	–	–	–
Cyperaceae	Kyllinga nemoralis J.R. &	Present	–	–	Common	–	–	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Cyperaceae	G. Forst.) Dandy ex Hutchinson & Dalziel	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cyperaceae	Kyllinga brevifolia Rottb.	Present	–	Uncommon	–	–	–	Uncommon	Uncommon	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Cyperaceae	Machaerina mariscoides (Gaud.) J. H. Kern	Present	–	–	–	–	Common	–	–	Uncommon	–	Uncommon	Native	–	–	–	–
Cyperaceae	Rhynchospora corymbosa Britton	Unconfirme d	–	–	–	–	–	–	–	–	–	NA	Native	–	–	–	–
Cyperaceae	Rhynchospora rubra Domin	Present	–	–	–	–	Common	–	Abundant	Common	Common	Abundant	Native	–	–	–	–
Cyperaceae	Scleria lithosperma (L.) Sw.	Present	–	–	–	–	Common	–	Common	Common	Uncommon	Common	Native	–	–	–	–
Cyperaceae	Scleria polycarpa Boeck.	Present	–	–	–	–	Common	–	Common	Common	–	Common	Native	–	–	–	–
Dennstaediaceae	Microlepia speluncae (L.) T. Moore	Present	–	–	–	–	Rare	–	–	–	–	Rare	Native	–	–	–	–

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

			Abundance															
Family	Species Name	Park Status	Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum	Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concer n (Y/N)
Dioscoreaceae	Dioscorea alata L.	Present	–	–	–	no data	–	–	Uncommon	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Dioscoreaceae	Dioscorea esculenta (Lour.) Burkill var. esculenta	Present	–	–	–	Uncommon	–	–	Uncommon	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Dioscoreaceae	Dioscorea esculenta var. tiliaefolia (Kunth) Fosberg & Sachet	Present	–	–	–	–	–	–	–	–	Uncommon	Uncommon	Non-nat.	Not cult.	No	No	No
Dioscoreaceae	Dioscorea sp.	Present	–	–	–	–	–	–	Uncommon	–	–	Rare	Unknow n	–	–	–	–
Dryopteridaceae	Tectaria crenata Cav.	Present	–	–	–	–	Uncommon	–	Uncommon	–	–	Uncommon	Native	–	–	–	–
Elaeocarpaceae	Elaeocarpus joga	Present	–	–	–	–	–	–	Rare	–	–	Uncommon	Native	–	–	–	–
Elaeocarpaceae	Elaeocarpus sp.	Present	–	–	–	–	–	–	Uncommon	–	–	Rare	Unknow n	–	–	–	–
Euphorbiaceae	Chamaesyce hirta (L.) Millsp.	Present	Common	Common	Abundant	Common	–	Common	–	Uncommon	Common	Abundant	Non-nat.	Not cult.	Yes	No	No
Euphorbiaceae	Chamaesyce hypericifolia (L.) Millsp.	Present	–	Common	Common	Common	–	Common	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Euphorbiaceae	Chamaesyce prostrata (Ait.) Small	Present	–	–	–	Uncommon	–	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Euphorbiaceae	Chamaesyce thymifolia (L.) Millsp.	Present	–	Common	Common	–	–	–	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Euphorbiaceae	Codiaeum variegatum (L.) Blume	Present	–	–	–	Uncommon	Uncommon	–	–	–	Common	Common	Non-nat.	Persist.	No	No	No
Euphorbiaceae	Euphorbia cyathophora Murr.	Present	–	–	–	–	–	Uncommon	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Euphorbiaceae	Euphorbia heterophylla L.	Present	Common	–	Uncommon	Common	Common	Common	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Euphorbiaceae	Glochidion marianum Muell.-Arg.	Present	–	–	–	Common	Common	Common	Common	Common	Common	Common	Native	–	–	–	–
Euphorbiaceae	Jatropha integerrima Jacq.	Present	–	–	–	–	–	–	–	–	Uncommon	Uncommon	Non-nat.	Persist.	No	No	No
Euphorbiaceae	Macaranga thompsonii Merrill	Present	–	–	–	–	–	Uncommon	–	–	–	Uncommon	Native	–	–	–	–
Euphorbiaceae	Manihot esculenta Crantz	Present	–	–	–	–	Uncommon	Common	Uncommon	–	Common	Common	Non-nat.	Persist.	Yes	No	No
Euphorbiaceae	Melanolepis multiglandulosa (Reinwardt) Reichb. f. & Zoll. var. glabrata (Muell.-Arg.) Fosb.	Present	–	–	–	Uncommon	Uncommon	Uncommon	Uncommon	–	–	Uncommon	Native	–	–	–	–
Euphorbiaceae	Phyllanthus acidus (Linnaeus) Skeels	Present	–	–	–	no data	–	–	–	–	–	Unknow n	Non-nat.	Unknown	–	No	No
Euphorbiaceae	Phyllanthus debilis Klein ex Willd.	Present	Common	Common	Common	Common	–	Common	Uncommon	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Euphorbiaceae	Phyllanthus marianus Muell. Arg.	Present	No Abundance Data	–	–	–	–	Uncommon	–	–	–	Uncommon	Native	–	–	–	–
Euphorbiaceae	Phyllanthus saffordii Merrill	Present	–	–	–	–	–	–	Common	Uncommon	Uncommon	Common	Native	–	–	–	–
Euphorbiaceae	Phyllanthus virgatus Forst. f.	Present	–	Common	–	–	–	–	–	–	–	Uncommon	Native	–	–	–	–
Fabaceae	Abrus precatorius L.	Present	–	–	–	–	Uncommon	Uncommon	–	–	Common	Common	Non-nat.	Persist.	Yes	No	No

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

Family	Species Name	Park Status	Abundance										Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concern (Y/N)
			Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum					
Fabaceae	Adenanthera pavonina L.	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Fabaceae	Aeschynomene americana L.	Present	–	Uncommon	Uncommon	no data	–	–	Uncommon	Uncommon	Uncommon	Uncommon	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Albizia lebbeck (L.) Bentham	Present	–	–	–	–	–	–	Uncommon	–	–	Uncommon	Non-nat.	Not cult.	No	No	No
Fabaceae	Alysicarpus vaginalis (L.) DC.	Present	–	Abundant	Common	Abundant	Common	Common	Common	Common	Common	Abundant	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Atylosia scarabaeoides (L.) Benth.	Present	–	–	–	–	–	–	Uncommon	Uncommon	Uncommon	Common	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Bauhinia monandra Kurz	Present	–	–	–	–	Common	Common	–	–	Common	Common	Non-nat.	Persist.	No	No	No
Fabaceae	Calopogonium mucunoides Desvaux	Encroaching	–	–	–	–	–	–	–	–	–	NA	Non-nat.	–	–	No	No
Fabaceae	Canavalia cathartica Thou.	Present	–	–	–	Uncommon	–	–	–	–	–	Uncommon	Native	–	–	–	–
Fabaceae	Canavalia rosea (Sw.) DC.	Present	no data	Uncommon	–	Common	Uncommon	–	–	–	–	Common	Native	–	–	–	–
Fabaceae	Crotalaria pallida Aiton	Present	–	Common	Common	–	–	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Crotalaria retusa L.	Present	–	–	–	–	Common	Uncommon	Common	Common	Common	Common	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Cynometra ramiflora L.	Present	–	–	–	–	Rare	–	–	–	–	Rare	Native	–	–	–	–
Fabaceae	Delonix regia (Bojer ex Hook.) Raf.	Present	Uncommon	Uncommon	–	–	–	Common	Uncommon	–	–	Common	Non-nat.	Persist.	No	No	No
Fabaceae	Derris elliptica (Wallich) Benth.	Present	–	–	–	–	Uncommon	–	Uncommon	–	–	Common	Non-nat.	Persist.	No	No	No
Fabaceae	Derris sp.	Present	–	–	–	–	–	–	–	–	Uncommon	Rare	Unknow n	–	–	–	–
Fabaceae	Derris trifoliata Loureiro	Present	Common	Common	Common	–	–	–	–	–	–	Common	Native	–	–	–	–
Fabaceae	Desmanthus pernambucanus (L.) Thell.	Present	Uncommon	–	–	Uncommon	–	Uncommon	Uncommon	–	Uncommon	Common	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Desmodium tortuosum (Sw.) DC.	Present	–	–	–	–	–	–	–	–	Uncommon	Uncommon	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Desmodium triflorum (L.) DC.	Present	Common	Common	Abundant	Common	Common	Common	–	Uncommon	Common	Abundant	Non-nat.	–	–	–	–
Fabaceae	Desmodium umbellatum (L.) DC.	Present	–	–	–	Common	–	–	–	Uncommon	–	Common	Native	–	–	–	–
Fabaceae	Entada phaseoloides (L.) Merr.	Present	–	–	–	–	no data	Uncommon	Uncommon	–	–	Uncommon	Native	–	–	–	–
Fabaceae	Erythrina variegata L.	Present	–	–	–	Uncommon	Uncommon	–	–	–	–	Uncommon	Native	–	–	–	–
Fabaceae	Flemingia strobilifera (L.) Ait. & Ait. f.	Present	–	–	–	–	Uncommon	–	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Indigofera suffruticosa P. Mill.	Present	–	–	–	–	–	–	Uncommon	–	Rare	Uncommon	Non-nat.	Not cult.	No	No	No
Fabaceae	Intsia bijuga (Colebr.) O. Kuntze	Present	Rare	–	–	Rare	Uncommon	Uncommon	Uncommon	–	–	Uncommon	Native	–	–	–	–
Fabaceae	Leucaena leucocephala (Lam.) de Wit	Present	Common	Abundant	Abundant	Common	Common	Common	Uncommon	Common	Common	Abundant	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Macroptilium atropurpureum (Moc. & Sessé ex DC.) Urban	Present	–	–	Common	Common	–	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Mimosa pudica L.	Present	Common	Common	–	Common	Common	Common	Common	Common	Uncommon	Common	Non-nat.	Not cult.	Yes	No	No

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

			Abundance														
Family	Species Name	Park Status	Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum	Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concer n (Y/N)
Fabaceae	Peltophorum pterocarpum (DC.) Backer ex K. Heyne	Present	–	–	–	–	Common	–	Uncommon	–	Common	Common	Non-nat.	Cultivated	No	No	No
Fabaceae	Pithecellobium dulce (Roxb.) Benth.	Present	Common	–	Uncommon	Common	Common	Uncommon	Uncommon	–	Common	Common	Non-nat.	Cultivated	No	No	No
Fabaceae	Pueraria lobata (Willd.) Ohwi	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Native	–	–	–	–
Fabaceae	Samanea saman (Jacq.) Merr.	Present	–	Uncommon	–	Uncommon	–	Uncommon	Uncommon	–	–	Uncommon	Non-nat.	Cultivated	No	No	No
Fabaceae	Senna alata (L.) Roxb.	Present	–	–	–	–	–	Uncommon	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Fabaceae	Senna surattensis (Burm. f.) Irwin & Barneby	Present	–	–	–	–	Rare	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Stylosanthes guianensis (Aubl.) Sw.	Present	–	Abundant	–	Common	Common	Common	–	Common	–	Abundant	Non-nat.	Not cult.	Yes	No	No
Fabaceae	Teramnus labialis (L. f.) Sprengel	Present	Uncommon	–	–	–	Uncommon	–	–	–	–	Rare	Non-nat.	Not cult.	No	No	No
Fabaceae	Zornia gibbosa Span.	Encroaching	–	–	–	–	–	–	–	–	–	NA	Non-nat.	–	–	–	–
Flacourtiaceae	Xylosma nelsonii Merrill	Present	–	–	–	Uncommon	Uncommon	Uncommon	–	–	–	Common	Native	–	–	–	–
Flagellariaceae	Flagellaria indica L.	Present	–	–	–	Common	Uncommon	Common	Common	Uncommon	Common	Abundant	Native	–	–	–	–
Gleicheniaceae	Dicranopteris linearis (Burm.) Underwood	Present	–	–	–	–	Common	–	Common	Common	Common	Common	Native	–	–	–	–
Goodeniaceae	Scaevola sericea Vahl	Present	–	no data	–	Common	Common	Common	Common	Common	Common	Common	Native	–	–	–	–
Heliconiaceae	Heliconia bihai (L.) L.	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Hernandiaceae	Hernandia sonora L.	Present	–	–	Uncommon	–	Common	Uncommon	–	–	–	Common	Native	–	–	–	–
Lamiaceae	Hyptis capitata Jacq.	Present	–	–	–	–	Uncommon	–	Common	Uncommon	Common	Abundant	Non-nat.	Not cult.	Yes	No	No
Lamiaceae	Hyptis pectinata (Linnaeus) Poitier	Present	no data	–	–	–	–	–	–	–	–	Unknow n	Non-nat.	Not cult.	–	Yes	Yes
Lamiaceae	Hyptis suaveolens (L.) Poit.	Present	–	–	–	–	Common	–	Uncommon	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Lamiaceae	Ocimum tenuiflorum L.	Present	–	–	Rare	–	–	–	–	–	–	Rare	Non-nat.	Cultivated	Yes	No	No
Lauraceae	Cassytha filiformis L.	Present	–	–	–	Common	Common	Common	Common	Common	Common	Common	Native	–	–	–	–
Lauraceae	Persea americana P. Mill.	Present	–	–	–	–	Uncommon	–	Uncommon	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Lecythidaceae	Barringtonia asiatica (L.) Kurz	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Native	–	–	–	–
Lentibulariaceae	Utricularia bifida L.	Present	–	–	–	–	no data	–	–	–	–	Unknow n	Native	–	–	–	–
Liliaceae	Crinum sp.	Present	–	–	–	Uncommon	–	–	–	–	–	Uncommon	Unknow n	Cultivated	No	No	No
Liliaceae	Curculigo orchioides Gaertn.	Present	–	–	–	–	Common	–	Uncommon	Common	–	Uncommon	Native	–	–	–	–
Liliaceae	Dianella saffordiana Fosb. & Sachet	Present	–	–	–	–	Common	–	Common	Common	Uncommon	Common	Native	–	–	–	–
Liliaceae	Hymenocallis littoralis (Jacq.) Salisb.	Present	Common	Common	Common	Rare	–	–	–	–	Uncommon	Common	Non-nat.	Cultivated	No	No	No

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

Family	Species Name	Park Status	Abundance										Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concer n (Y/N)
			Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum					
Lindsaeaceae	Lindsaea ensifolia Sw.	Present	–	–	–	–	Common	–	–	Common	Common	Common	Native	–	–	–	–
Lindsaeaceae	Sphenomeris chinensis (L.) Maxon	Present	–	–	–	–	–	–	–	Uncommon	–	Rare	Native	–	–	–	–
Loganiaceae	Geniostoma micranthum A. DC.	Present	–	–	–	–	–	–	–	Uncommon	–	Uncommon	Native	–	–	–	–
Lycopodiaceae	Lycopodiella cernua (L.) Pic. Serm.	Present	–	–	–	–	Common	–	Common	Common	–	Common	Native	–	–	–	–
Lythraceae	Ammannia multiflora DC. var. parviflora Koehne	Present	–	–	Uncommon	–	–	–	–	–	–	Uncommon	Non-nat.	Not cult.	No	No	No
Lythraceae	Pemphis acidula Forst. & Forst.	Present	–	no data	Uncommon	Uncommon	–	–	–	–	–	Uncommon	Native	–	–	–	–
Malvaceae	Abelmoschus moschatus Medik.	Present	–	–	–	–	–	–	Uncommon	Uncommon	–	Uncommon	Non-nat.	Not cult.	No	No	No
Malvaceae	Abutilon indicum (L.) Sweet	Present	Rare	–	–	–	–	–	–	–	–	Unknow n	Non-nat.	Not cult.	Yes	No	No
Malvaceae	Hibiscus rosa- sinensis L.	Present	–	–	–	Common	Uncommon	–	–	–	Common	Common	Non-nat.	Cultivated	No	No	No
Malvaceae	Hibiscus tiliaceus L.	Present	Common	Common	Common	Common	Common	Common	Common	Uncommon	Common	Common	Native	–	–	–	–
Malvaceae	Malvastrum coromendelianu m (L.) Garcke	Present	–	–	Uncommon	Uncommon	–	–	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Malvaceae	Sida acuta Burm. f.	Present	Common	Common	Uncommon	Common	–	–	Uncommon	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Malvaceae	Sida rhombifolia L.	Present	–	–	–	–	–	–	–	Uncommon	Uncommon	Uncommon	Non-nat.	Not cult.	Yes	No	No
Malvaceae	Thespesia populnea (L.) Soland. ex Correa	Present	Common	Common	–	Common	Common	–	–	–	–	Common	Native	–	–	–	–
Malvaceae	Urena lobata L.	Present	–	–	–	–	Uncommon	–	Uncommon	Uncommon	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Marattiaceae	Angiopteris evecta (J.R. Forst.) Hoffmann	Present	–	–	–	–	–	–	Uncommon	Uncommon	–	Uncommon	Native	–	–	–	–
Melastomataceae	Dissotis rotundifolia (Sm.) Triana	Present	–	–	–	–	–	–	Rare	–	–	Rare	Non-nat.	Persist.	No	No	No
Melastomataceae	Medinilla rosea Gaudichaud	Present	–	–	–	–	–	–	–	Uncommon	–	Rare	Native	–	–	–	–
Melastomataceae	Melastoma malabathricum L. var. mariannum (Naudin) Fosb. & Sachet (ined.)	Present	–	–	–	–	Uncommon	–	Common	Common	Uncommon	Common	Native	–	–	–	–
Meliaceae	Aglaia mariannensis Merrill	Present	–	–	–	–	Uncommon	Uncommon	Uncommon	–	–	Uncommon	Native	–	–	–	–
Meliaceae	Swietenia macrophylla King	Present	–	–	–	Common	–	–	–	–	Common	Uncommon	Non-nat.	Persist.	No	No	No
Meliaceae	Xylocarpus moluccensis (Lamarck) Roemer	Present	–	–	–	no data	–	–	–	–	–	Unknow n	Native	–	–	–	–
Menispermaceae	Tinospora homosepala Diels	Present	–	–	–	Rare	–	–	–	–	–	Rare	Native	–	–	–	–
Moraceae	Artocarpus altilis (Parkinson) Fosberg	Present	–	–	–	Common	Uncommon	–	Uncommon	–	–	Common	Non-nat.	Not cult.	No	No	No
Moraceae	Artocarpus heterophyllus Lamarck	Encroaching	–	–	–	–	–	–	–	–	–	NA	Non-nat.	NA	No	No	No

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

			Abundance														
Family	**Species Name**	**Park Status**	**Agat-Bangi Pt**	**Agat-Apaca Pt**	**Agat-Gaan Pt**	**Asan Beach**	**Asan Inland**	**Fonte Plateau**	**Mt. Alifan**	**Mt. Chachao-Mt. Tenjo**	**Piti Guns**	**WPNHP Sum**	**Nativ NPSpp**	**Cultivation**	**Weedy (Y/N)**	**Mng Priority (Y/N)**	**Exploit Concer n (Y/N)**
Moraceae	Ficus benjamina L.	Present	–	–	–	–	Rare	–	–	–	–	Rare	Non-nat.	Cultivated	No	No	No
Moraceae	Ficus elastica Roxb. ex Hornem.	Present	Rare	–	–	Uncommon	–	–	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Moraceae	Ficus microcarpa L. f. var. saffordii (Merr.) Corner	Present	–	–	–	–	–	Common	–	–	–	Common	Native	–	–	–	–
Moraceae	Ficus prolixa Forst. f.	Present	no data	–	–	–	–	Uncommon	–	Uncommon	–	Uncommon	Native	–	–	–	–
Moraceae	Ficus tinctoria Forst. f. var. neo-ebudarum (Summerh.) Fosb.	Present	Rare	Uncommon	Uncommon	Uncommon	Uncommon	Uncommon	–	Uncommon	–	Uncommon	Native	–	–	–	–
Moringaceae	Moringa oleifera Lamarck	Present	–	–	Rare	–	–	–	–	–	–	Rare	Non-nat.	Cultivated	No	No	No
Musaceae	Musa sp.	Present	Uncommon	–	Uncommon	Uncommon	Common	–	–	–	–	Common	Non-nat.	Cultivated	No	No	No
Myrtaceae	Decaspermum fruticosum J.R. & G. Forster	Present	–	–	–	–	Uncommon	–	–	Uncommon	–	Uncommon	Native	–	–	–	–
Myrtaceae	Eugenia javanica Lam.	Present	–	–	Uncommon	–	–	Uncommon	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Myrtaceae	Eugenia palumbis Merrill	Present	no data	–	–	Uncommon	–	–	–	–	–	Uncommon	Native	–	–	–	–
Myrtaceae	Eugenia reinwardtiana (Blume) DC.	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Native	–	–	–	–
Myrtaceae	Eugenia uniflora L.	Present	–	–	–	–	–	–	–	–	Uncommon	Uncommon	Non-nat.	Persist.	No	No	No
Myrtaceae	Myrtella bennigseniana (Volkens) Diels	Present	–	–	–	–	Uncommon	–	Common	Common	–	Common	Native	–	–	–	–
Myrtaceae	Pimenta racemosa (Willd.) J.W. Moore	Present	–	–	–	–	–	Uncommon	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Myrtaceae	Psidium guajava L.	Present	Uncommon	–	–	–	Uncommon	Uncommon	Uncommon	Uncommon	Uncommon	Common	Non-nat.	Not cult.	Yes	No	No
Nephrolepidaceae	Nephrolepis biserrata (Sw.) Schott	Present	–	–	–	–	Common	Common	–	–	Common	Common	Native	–	–	–	–
Nephrolepidaceae	Nephrolepis hirsutula (J.R. Forst.) K. Presl	Present	–	–	–	–	Common	Common	Common	Common	–	Common	Native	–	–	–	–
Nephrolepidaceae	Nephrolepis multiflora (Roxburgh) C.V. Morton	Present	–	–	–	Common	–	–	–	–	–	Common	Native	–	–	–	–
Nephrolepidaceae	Nephrolepis multiflora X Biserrata	Present	–	–	–	–	–	–	Common	–	–	Common	Native	–	–	–	–
Nyctaginaceae	Boerhavia repens L.	Present	no data	–	–	–	–	–	–	–	–	Unknow n	Native	–	–	–	–
Nyctaginaceae	Bougainvillea spectabilis Willd.	Present	–	–	Uncommon	Uncommon	Uncommon	–	–	–	Uncommon	Uncommon	Non-nat.	Cultivated	No	No	No
Olacaceae	Ximenia americana L.	Present	–	–	–	–	–	Uncommon	Uncommon	–	–	Uncommon	Native	–	–	–	–
Oleaceae	Jasminum marianum DC.	Present	–	–	–	Uncommon	Uncommon	Uncommon	–	–	–	Uncommon	Native	–	–	–	–
Oleaceae	Jasminum multiflorum (Burm. f.) Andr.	Present	–	–	–	–	–	–	Uncommon	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Orchidaceae	Arundina graminifolia (D. Don) Hochr.	Present	–	–	–	–	Common	–	Common	Common	Common	Common	Non-nat.	Not cult.	Yes	No	No

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

Family	Species Name	Park Status	Abundance										Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concern (Y/N)
			Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum					
Orchidaceae	Geodorum densiflorum (Lamarck) Schlechter	Present	–	–	Rare	Rare	–	–	Uncommon	Uncommon	Uncommon	Uncommon	Native	–	–	–	–
Orchidaceae	Nervilia aragoana Gaudichaud	Present	–	–	–	–	–	Uncommon	–	–	–	Uncommon	Native	–	–	–	–
Orchidaceae	Spathoglottis plicata Blume	Present	–	–	–	–	–	Common	Common	Common	Uncommon	Common	Non-nat.	Not cult.	Yes	No	No
Orchidaceae	Taeniophyllum marianense Schltr.	Present	–	–	–	Rare	Uncommon	Uncommon	Uncommon	–	Common	Common	Native	–	–	–	–
Oxalidaceae	Averrhoa bilimbi L.	Present	–	–	Uncommon	–	Uncommon	Uncommon	Uncommon	–	Common	Common	Non-nat.	Cultivated	–	–	–
Oxalidaceae	Averrhoa carambola Linnaeus	Present	no data	–	–	–	–	–	–	–	–	Rare	Non-nat.	Unknown	No	No	No
Oxalidaceae	Oxalis corniculata L.	Present	–	–	Uncommon	–	–	–	–	–	–	Rare	Native	–	–	–	–
Pandanaceae	Freycinetia reineckei Warb.	Present	–	–	–	–	–	–	Uncommon	–	–	Common	Native	–	–	–	–
Pandanaceae	Pandanus dubius Sprengel	Present	–	–	–	–	Uncommon	Uncommon	Common	–	–	Common	Native	–	–	–	–
Pandanaceae	Pandanus tectorius Parkinson ex Zucc.	Present	no data	Common	Common	Common	Common	Common	Common	Common	Uncommon	Common	Native	–	–	–	–
Passifloraceae	Passiflora foetida L.	Present	Uncommon	Common	–	Common	Common	–	Common	Common	Common	Common	Non-nat.	Not cult.	Yes	No	No
Passifloraceae	Passiflora suberosa L.	Present	Common	Abundant	Abundant	Common	Common	Common	Common	Uncommon	Common	Common	Non-nat.	Not cult.	Yes	No	No
Piperaceae	Piper betle L.	Present	–	–	–	–	Common	–	–	–	–	Common	Non-nat.	Persist.	No	No	No
Piperaceae	Piper guahamense DC.	Present	–	–	–	–	–	–	Uncommon	–	–	Common	Native	–	–	–	–
Poaceae	Axonopus compressus (Sw.) Beauv.	Present	–	–	Common	–	–	–	–	Uncommon	Common	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Bambusa blumeana Schultes fils	Present	–	–	–	–	no data	–	–	–	–	Uncommon	Non-nat.	Unknown	–	No	No
Poaceae	Bambusa vulgaris J.C. Wendl.	Present	Uncommon	–	–	–	Uncommon	Uncommon	Common	–	Uncommon	Common	Non-nat.	Persist.	No	No	No
Poaceae	Cenchrus echinatus L.	Present	–	Common	Common	Common	–	Common	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Centosteca lappacea (L.) Desv.	Present	no data	–	–	–	Common	–	Common	Uncommon	–	Common	Native	–	–	–	–
Poaceae	Chloris barbata (L.) Sw.	Present	–	Common	Common	Common	Common	Uncommon	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Chloris radiata (L.) Sw.	Present	–	–	–	–	–	–	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Chrysopogon aciculatus (Retz.) Trin.	Present	Abundant	Abundant	Abundant	Common	Common	Common	Common	Common	Common	Abundant	Native	–	–	–	–
Poaceae	Cynodon dactylon (L.) Pers.	Present	Abundant	Common	Abundant	Common	–	–	–	Common	Common	Abundant	Non-nat.	Not cult.	Yes	No	No
Poaceae	Dactyloctenium aegypticum (L.) Willd.	Present	–	Common	Common	Common	–	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Dichanthium bladhii (Retz.) Clayton	Present	–	–	Common	Common	Abundant	–	Common	–	Abundant	Abundant	Non-nat.	Not cult.	Yes	No	No
Poaceae	Dichanthium caricosum (Linnaeus) A. Camus	Encroaching	–	–	–	–	–	–	–	–	–	NA	Non-nat.	NA	–	No	No
Poaceae	Digitaria bicornis (Lam.) Roemer & J.A. Schultes ex Loud.	Present	–	–	–	Common	–	Uncommon	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

Family	Species Name	Park Status	Abundance										Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concer n (Y/N)
			Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum					
Poaceae	Digitaria ciliaris (Retz.) Koel.	Present	–	Common	–	–	–	–	–	–	–	Common	Native	–	–	–	–
Poaceae	Digitaria insularis (L.) Mez ex Ekman	Present	–	–	–	–	–	Uncommon	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Poaceae	Digitaria setigera Roth	Present	no data	–	–	Common	–	–	–	–	–	Common	Native	–	–	–	–
Poaceae	Digitaria violascens Link	Present	–	–	Abundant	Common	Common	–	Common	–	Common	Abundant	Non-nat.	Not cult.	Yes	No	No
Poaceae	Dimeria chloridiformis (Gaud.) K. Shum. & Lauterbach	Present	–	–	–	–	Common	–	Common	Common	Common	Common	Native	–	–	–	–
Poaceae	Echinochloa colona (L.) Link	Present	–	Abundant	Uncommon	–	–	–	–	Uncommon	–	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Eleusine indica (L.) Gaertn.	Present	–	Common	Abundant	Common	–	Uncommon	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Eragrostis amabilis (L.) Wight & Arn.	Present	Common	Common	–	–	–	Common	–	Common	Common	Common	Native	–	–	–	–
Poaceae	Eragrostis atrovirens	Present	–	–	–	–	–	–	–	Uncommon	Common	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	(Desv.) Trin. ex Steud.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Poaceae	Eragrostis brownei (Kunth) Nees ex Steud.	Present	–	–	–	–	–	Common	–	Uncommon	Uncommon	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Eriochloa procera (Retz.) Hubb.	Present	–	–	–	Uncommon	–	–	–	–	–	Uncommon	Native	–	–	–	–
Poaceae	Eustachys petraea (Sw.) Desv.	Present	–	–	–	Common	–	Uncommon	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Heteropogon contortus (L.) Beauv. ex Roemer & J.A. Schultes	Present	–	–	–	–	Common	–	–	–	–	Uncommon	Native	–	–	–	–
Poaceae	Hyparrhenia rufa (Nees) Stapf	Encroaching	–	–	–	–	–	–	–	–	–	NA	Non-nat.	NA	–	No	No
Poaceae	Imperata conferta (J.S. Pesl) Ohwi	Present	–	–	–	–	–	–	–	–	Uncommon	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Isachne miliacea var. minutula (Gaudichaud) Fosberg & Sachet	Present	–	–	–	–	no data	–	–	–	–	Unknow n	Native	–	–	–	–
Poaceae	Lepturus repens (G. Forst.) R. Br.	Present	Uncommon	no data	–	Common	–	–	–	–	–	Common	Native	–	–	–	–
Poaceae	Miscanthus floridulus (Labill.) Warburg ex. Schum. & Lauterb.	Present	–	–	–	–	Abundant	Common	Abundant	Common	Abundant	Abundant	Native	–	–	–	–
Poaceae	Oplismenus compositus (L.) Beauv.	Present	–	–	–	–	Common	–	Uncommon	–	–	Common	Native	–	–	–	–
Poaceae	Panicum ambiguum Trin.	Present	–	–	Uncommon	–	–	–	–	–	–	Uncommon	Native	–	–	–	–
Poaceae	Panicum geminatum Forsk.	Present	–	–	Common	Common	–	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Panicum maximum Jacq.	Present	Common	Common	Common	Common	–	Common	–	–	Common	Abundant	Non-nat.	Not cult.	Yes	No	No
Poaceae	Panicum reptans L.	Present	–	–	Uncommon	–	–	–	–	Uncommon	–	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Panicum subquadriparum Trin.	Present	–	Uncommon	–	Uncommon	Uncommon	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

			Abundance															
Family	Species Name	Park Status	Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum	Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concern (Y/N)
Poaceae	Paspalum ciliatifoliatum Michx.	Present	Common	–	Common	Common	–	Uncommon	–	Common	–	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Paspalum conjugatum Berg.	Present	–	Common	Common	–	Uncommon	–	Uncommon	Uncommon	–	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Paspalum longifolium Roxb.	Present	–	–	–	–	–	–	–	–	Common	Common	Native	Not cult.	Yes	No	No
Poaceae	Paspalum paniculatum L.	Present	–	Common	Abundant	Uncommon	Uncommon	Common	–	Uncommon	Uncommon	Abundant	Non-nat.	Not cult.	Yes	No	No
Poaceae	Paspalum scrobiculatum L.	Present	–	–	–	–	–	–	Uncommon	–	Uncommon	Uncommon	Native	–	–	–	–
Poaceae	Pennisetum polystachion (L.) J.A. Schultes	Present	Common	Common	Common	Common	Common	Common	Common	Common	Common	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Phragmites karka (Retz.) Trin. ex Steud.	Present	Abundant	–	Common	–	–	–	Common	Common	Common	Abundant	Native	–	–	–	–
Poaceae	Pogonatherum crinitum (Thunb.) Kunth	Present	–	–	–	–	–	–	Common	Uncommon	Common	Common	Native	–	–	–	–
Poaceae	Polytrias amaura (Büse ex Miq.) Kuntze	Present	–	Common	–	–	–	–	–	–	–	Common	Native	–	–	–	–
Poaceae	Saccharum spontaneum L.	Present	–	Common	Common	Common	Common	Common	Common	Common	Common	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Sacciolepis indica (L.) Chase	Present	–	–	–	–	–	–	Uncommon	Uncommon	–	Uncommon	Native	–	–	–	–
Poaceae	Sorghum halepense (L.) Pers. s.f.	Present	–	–	–	–	–	–	Abundant	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Sporobolus diander (Retz.) Beauv.	Present	–	Abundant	Abundant	Uncommon	Common	Uncommon	Common	Common	Common	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Sporobolus farinosus Hosok.	Present	–	–	–	Uncommon	–	–	–	–	–	Common	Native	–	–	–	–
Poaceae	Sporobolus fertilis (Steudel) Clayton	Present	Common	–	Common	Uncommon	Common	–	–	Uncommon	–	Common	Native	–	–	–	–
Poaceae	Sporobolus virginicus (L.) Kunth	Present	Common	Common	Common	Common	–	–	–	–	–	Common	Native	–	–	–	–
Poaceae	Stenotaphrum micranthum (Desv.) Hubb.	Present	–	Common	–	Common	–	–	–	–	–	Common	Native	–	–	–	–
Poaceae	Thuarea involuta (G. Forst.) Roemer & J.A. Schultes	Present	Common	–	Abundant	Common	–	–	–	–	–	Abundant	Native	–	–	–	–
Poaceae	Tripsacum laxa Nash	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Poaceae	Urochloa mutica (L.) Stapf	Present	–	Common	–	Uncommon	Common	–	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Poaceae	Zoysia matrella (L.) Merr.	Present	–	Abundant	Common	–	Uncommon	–	Common	–	–	Abundant	Native	–	–	–	–
Polygalaceae	Polygala paniculata L.	Present	–	Common	–	Uncommon	Common	–	Common	Uncommon	Common	Common	Native	–	–	–	–
Polygonaceae	Antigonon leptopus Hook. & Arn.	Present	–	–	–	–	Common	Common	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Polypodiaceae	Acrostichum aureum L.	Present	–	–	–	–	–	–	Rare	–	–	Rare	Native	–	–	–	–
Polypodiaceae	Antrophyum plantagineum (Cav.) Kaulf.	Present	–	–	–	–	Uncommon	–	Uncommon	–	–	Common	Native	–	–	–	–
Polypodiaceae	Belvisia spicata (Linnaeus f.) Mirbel ex Copeland	Present	–	–	–	–	–	–	Uncommon	Uncommon	–	Uncommon	Native	–	–	–	–

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

			Abundance														
Family	**Species Name**	**Park Status**	**Agat-Bangi Pt**	**Agat-Apaca Pt**	**Agat-Gaan Pt**	**Asan Beach**	**Asan Inland**	**Fonte Plateau**	**Mt. Alifan**	**Mt. Chachao-Mt. Tenjo**	**Piti Guns**	**WPNHP Sum**	**Nativ NPSpp**	**Cultivation**	**Weedy (Y/N)**	**Mng Priority (Y/N)**	**Exploit Concer n (Y/N)**
Polypodiaceae	Davallia solida (Forster f.) Swartz	Present	–	–	–	–	Common	Common	Uncommon	Uncommon	Uncommon	Common	Native	–	–	–	–
Polypodiaceae	Phymatosorus grossus (Langsd. & Fisch.) Brownlie	Present	Common	Common	–	Common	Common	Common	Common	Common	Common	Common	Native	–	–	–	–
Polypodiaceae	Polypodium punctatum (L.) Swartz	Present	–	–	–	–	Uncommon	–	Uncommon	–	–	Common	Native	–	–	–	–
Polypodiaceae	Pyrrosia lanceolata (L.) Farw.	Present	no data	Uncommon	Uncommon	Common	Uncommon	Uncommon	Common	Uncommon	–	Common	Native	–	–	–	–
Portulacaceae	Portulaca oleracea L.	Present	–	–	Common	Uncommon	–	Uncommon	–	–	–	Common	Non-nat.	Not cult.	No	No	No
Psilotaceae	Psilotum nudum (L.) Beauv.	Present	–	–	–	Uncommon	Uncommon	–	Uncommon	–	Uncommon	Common	Native	–	–	–	–
Pteridaceae	Adiantum philippense L.	Present	–	–	–	–	Common	–	–	–	–	Common	Native	–	–	–	–
Pteridaceae	Adiantum tenerum Sw.	Present	–	–	–	–	Common	–	–	–	Common	Common	Non-nat.	Not cult.	No	No	No
Pteridaceae	Cheilanthes tenuifolia (Burmann f.) Swartz	Present	–	–	–	–	Uncommon	–	Common	Uncommon	Uncommon	Common	Native	–	–	–	–
Pteridaceae	Pityrogramma calomelanos (Linnaeus) Link	Probably Present	–	–	–	–	–	–	–	–	–	NA	Native	–	–	–	–
Pteridaceae	Pteris ensiformis Burm. f.	Present	–	–	–	–	–	–	Uncommon	Uncommon	–	Uncommon	Native	–	–	–	–
Pteridaceae	Pteris quadriaurita auct. non Retz.	Present	–	–	–	–	Common	–	Uncommon	Uncommon	–	Common	Native	–	–	–	–
Pteridaceae	Pteris spinescens Presl.	Present	–	–	–	–	Common	–	Uncommon	Uncommon	–	Uncommon	Native	–	–	–	–
Pteridaceae	Pteris tripartita Sw.	Present	–	–	–	–	–	Uncommon	Uncommon	–	–	Uncommon	Native	–	–	–	–
Pteridaceae	Pteris vittata L.	Present	no data	–	Uncommon	–	Uncommon	Uncommon	Uncommon	–	Uncommon	Common	Non-nat.	Not cult.	No	No	No
Rhamnaceae	Colubrina arborescens (Mill.) Sarg.	Present	–	–	–	–	–	Rare	–	–	–	Rare	Non-nat.	Not cult.	No	No	No
Rhamnaceae	Colubrina asiatica (L.) Brongn.	Present	Common	Abundant	Common	Common	Uncommon	Common	Uncommon	–	–	Abundant	Native	–	–	–	–
Rubiaceae	Aidia racemosa (Cav.) Tirveng	Present	–	–	–	Uncommon	Uncommon	Uncommon	–	–	–	Uncommon	Native	–	–	–	–
Rubiaceae	Dentella repens Forster	Present	–	–	–	Rare	–	–	–	–	–	Rare	Non-nat.	Not cult.	No	No	No
Rubiaceae	Guettarda speciosa L.	Present	–	–	–	–	–	–	Uncommon	–	–	Common	Native	–	–	–	–
Rubiaceae	Hedyotis biflora (L.) Lam.	Present	–	Common	–	–	–	–	–	–	–	Common	Native	–	–	–	–
Rubiaceae	Hedyotis corymbosa (L.) Lam.	Present	–	–	–	Uncommon	no data	–	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Rubiaceae	Hedyotis laciniata Kaneh.	Present	–	–	–	–	–	–	–	Uncommon	–	Uncommon	Native	–	–	–	–
Rubiaceae	Hedyotis megalantha Merrill	Probably Present	–	–	–	–	–	–	–	–	–	NA	Native	–	–	–	–
Rubiaceae	Hedyotis strigulosa Bartling ex de Candolle) Fosberg	Present	–	no data	–	–	–	–	–	–	–	Unknow n	Native	–	–	–	–
Rubiaceae	Ixora finlaysoniana Wall.	Present	–	–	–	–	–	–	Rare	–	–	Rare	Non-nat.	Persist.	–	–	–
Rubiaceae	Ixora triantha Volk.	Present	–	–	–	–	–	–	Common	–	–	Common	Native	–	–	–	–
Rubiaceae	Morinda citrifolia L.	Present	Common	Common	–	Common	Common	Common	Common	Common	Common	Common	Native	–	–	–	–

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

Family	Species Name	Park Status	Abundance										Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concern (Y/N)
			Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum					
Rubiaceae	Psychotria mariana Bartl. ex DC.	Present	–	–	–	–	Uncommon	Uncommon	Common	–	–	Uncommon	Native	–	–	–	–
Rubiaceae	Psydrax odorata (G. Forst.) A.C. Sm. & S.P. Darwin	Present	–	–	–	Rare	–	–	–	–	–	Rare	Native	–	–	–	–
Rubiaceae	Spermacoce assurgens Ruiz & Pavón	Present	Common	Common	Common	Common	–	Common	–	Common	–	Common	Non-nat.	Not cult.	Yes	No	No
Rubiaceae	Spermacoce ernstii Fosb. & Powell (ined.)	Present	Common	Common	–	–	Uncommon	–	–	–	Common	Common	Non-nat.	Not cult.	Yes	No	No
Rubiaceae	Tarenna sambucina (Forster) Durand ex Drake	Present	–	–	–	–	–	–	–	no data	–	NA	Native	–	–	–	–
Rubiaceae	Timonius nitidus (Bartl. Ex DC.) F.-Vill.	Present	–	–	–	–	Common	Uncommon	Common	Common	Common	Common	Native	–	–	–	–
Rutaceae	Citrus aurantiifolia (Christm.) Swingle	Present	–	–	–	–	–	Uncommon	–	–	Uncommon	Uncommon	Non-nat.	Cultivated	–	–	–
Rutaceae	Citrus aurantium L.	Present	–	–	Rare	–	–	–	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Rutaceae	Citrus limon (Linnaeus) N.L. Burman	Present	–	–	–	–	–	Rare	Rare	Rare	–	Rare	Non-nat.	Persist.	No	No	No
Rutaceae	Citrus macroptera Montr.	Present	–	–	–	–	–	Uncommon	–	–	–	Rare	Non-nat.	Persist.	No	No	No
Rutaceae	Citrus reticulata Blanco	Present	no data	–	–	–	–	–	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Rutaceae	Triphasia trifolia (Burm. f.) P. Wils.	Present	no data	Common	Common	Common	–	Common	Common	Uncommon	Common	Abundant	Non-nat.	Not cult.	Yes	No	No
Sapindaceae	Allophylus timoriensis (de Candolle) Blume	Present	no data	no data	–	–	–	–	–	–	–	NA	Native	–	–	–	–
Sapindaceae	Cardiospermum halicacabum L.	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Sapindaceae	Dodonaea viscosa (L.) Jacq.	Present	–	–	–	–	–	–	–	–	Uncommon	Uncommon	Native	–	–	–	–
Sapotaceae	Chrysophyllum cainato L.	Encroaching	–	–	–	–	–	–	–	–	–	NA	Non-nat.	NA	–	–	–
Sapotaceae	Pouteria obovata (R. Br.) Baehni	Present	–	–	–	Uncommon	Rare	Uncommon	–	–	Common	Common	Native	–	–	–	–
Schizaeaceae	Lygodium auriculatum (Will.) Alston	Present	–	–	–	–	Uncommon	–	–	–	Rare	Uncommon	Native	–	–	–	–
Schizaeaceae	Lygodium microphyllum (Cav.) R. Br.	Present	–	–	–	–	Common	–	Common	Common	Uncommon	Common	Native	–	–	–	–
Scrophulariaceae	Bacopa monnieri (L.) Pennell	Present	–	–	–	Rare	no data	–	–	–	–	Uncommon	Native	–	–	–	–
Scrophulariaceae	Buchnera floridana Gandog.	Present	–	–	–	–	–	–	–	–	Uncommon	Uncommon	Non-nat.	Not cult.	Yes	No	No
Scrophulariaceae	Lindernia antipoda (L.) Alst.	Present	–	Uncommon	Uncommon	–	–	–	–	–	–	Uncommon	Native	–	–	–	–
Scrophulariaceae	Scoparia dulcis L.	Encroaching	–	–	–	–	–	–	–	–	–	NA	Non-nat.	Unknown	No	No	No
Solanaceae	Capsicum frutescens L.	Present	Uncommon	–	–	–	–	Uncommon	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Solanaceae	Cestrum diurnum L.	Present	–	–	–	–	–	–	–	Uncommon	–	Uncommon	Non-nat.	Not cult.	No	No	No

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

Family	Species Name	Park Status	Abundance										Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concern (Y/N)
			Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum					
Solanaceae	Physalis angulata L.	Present	–	–	Rare	–	–	Uncommon	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Sterculiaceae	Heritiera littoralis Dryand.	Present	–	Uncommon	–	–	–	–	–	–	–	Uncommon	Native	–	–	–	–
Sterculiaceae	Melochia villosissima (Presl) Merrill var. villosissima (Hochr.) Fosb.	Present	–	–	–	–	Uncommon	–	–	Common	–	Uncommon	Native	–	–	–	–
Sterculiaceae	Melochia villosissima var. compacta Fosberg	Present	Uncommon	–	–	–	–	–	–	–	–	Common	Native	–	–	–	–
Sterculiaceae	Waltheria indica L.	Present	–	Common	–	–	Common	–	Common	Common	Common	Common	Non-nat.	Not cult.	No	No	No
Taccaceae	Tacca leontopetaloides (L.) Kuntze	Present	–	–	–	–	Uncommon	–	Uncommon	–	Uncommon	Uncommon	Native	–	–	–	–
Thelypteridaceae	Christella parasitica (L.) H. Lev.	Present	–	–	–	–	Common	–	Uncommon	Common	Common	Common	Native	–	–	–	–
Thelypteridaceae	Cyclosorus interruptus (Willd.) H. Ito	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Native	–	–	–	–
Thelypteridaceae	Thelypteris guamensis (Holttum) Fosberg & Sachet	Present	–	–	–	–	Uncommon	–	–	Uncommon	–	Uncommon	Native	–	–	–	–
Thelypteridaceae	Thelypteris opulenta	Present	–	–	–	–	Uncommon	Uncommon	Uncommon	Common	Common	Common	Native	–	–	–	–
Thelypteridaceae	(Kaulfuss) Fosberg	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thelypteridaceae	Thelypteris torresiana (Gaudichaud) Alston	Present	–	–	–	–	no data	–	–	–	–	NA	Native	–	–	–	–
Thelypteridaceae	Thelypteris unita (L.) C.V. Morton	Present	–	–	–	–	Uncommon	–	–	Uncommon	–	Uncommon	Native	–	–	–	–
Thymelaeaceae	Wikstroemia elliptica Merrill	Present	–	–	–	–	Uncommon	–	–	Uncommon	–	Uncommon	Native	–	–	–	–
Tiliaceae	Corchorus aestuans L.	Present	–	–	–	Uncommon	–	Uncommon	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	Yes
Tiliaceae	Muntingia calabura L.	Present	–	–	–	Uncommon	Uncommon	–	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Tiliaceae	Triumfetta rhomboidea Jacq.	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Urticaceae	Maoutia australis Weddell	Present	–	–	–	–	no data	–	–	–	–	Unknow n	Native	–	–	–	–
Urticaceae	Pilea microphylla (L.) Liebm.	Present	–	Uncommon	Uncommon	Common	–	Uncommon	–	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Urticaceae	Pipturus argenteus (G. Forster) Weddell	Present	no data	–	–	–	–	–	–	–	–	Unknow n	Native	–	–	–	–
Verbenaceae	Callicarpa candicans (Burm. f.) Hochr.	Present	no data	Uncommon	–	Uncommon	Uncommon	–	–	–	–	Uncommon	Native	–	–	–	–
Verbenaceae	Clerodendrum inerme (L.) Gaertn.	Present	–	–	–	Uncommon	Uncommon	–	Common	–	Uncommon	Uncommon	Native	–	–	–	–
Verbenaceae	Clerodendrum quadriloculare (Blanco) Merr.	Present	Rare	–	–	–	–	–	–	–	–	Rare	Non-nat.	Persist.	No	No	No
Verbenaceae	Lantana camara L.	Present	–	–	–	–	–	–	–	–	Uncommon	Uncommon	Non-nat.	Not cult.	No	No	No
Verbenaceae	Phyla nodiflora (L.) Greene	Present	Common	Abundant	Abundant	Common	Common	Common	–	Uncommon	–	Abundant	Non-nat.	Not cult.	Yes	No	No
Verbenaceae	Premna obtusifolia R. Br.	Present	–	–	Common	Uncommon	Uncommon	Common	Uncommon	Common	Uncommon	Common	Native	–	–	–	–

Table 23 (continued). Specific species information includes nativity, cultivation, weediness, management property, and exploitation concern. Data are from NPSpecies - the National Park Service biodiversity database. Website. Report - Certified Species List Snapshot for Vascular Plants in War in the Pacific National Historical Park: Date Certified 12/21/2010. https://irma.nps.gov/NPSpecies/. Date Accessed:11/29/2011.

Family	Species Name	Park Status	Abundance										Nativ NPSpp	Cultivation	Weedy (Y/N)	Mng Priority (Y/N)	Exploit Concern (Y/N)
			Agat-Bangi Pt	Agat-Apaca Pt	Agat-Gaan Pt	Asan Beach	Asan Inland	Fonte Plateau	Mt. Alifan	Mt. Chachao-Mt. Tenjo	Piti Guns	WPNHP Sum					
Verbenaceae	Stachytarpheta jamaicensis (L.) Vahl	Present	Common	Common	–	Common	Common	Common	Common	Common	Common	Common	Non-nat.	Not cult.	Yes	No	No
Verbenaceae	Stachytarpheta urticifolia Sims	Present	–	Common	Common	–	–	Common	Common	–	–	Common	Non-nat.	Not cult.	Yes	No	No
Verbenaceae	Tectona grandis Linnaeus filius	Present	–	–	–	–	–	–	–	–	no data	Unknow n	Non-nat.	Unknown	No	No	No
Verbenaceae	Vitex parviflora Juss.	Present	–	–	–	Uncommon	Uncommon	Uncommon	Uncommon	Uncommon	–	Uncommon	Non-nat.	Not cult.	Yes	No	No
Vitaceae	Cayratia trifolia (L.) Domin	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Non-nat.	Persist.	Yes	No	No
Vittariaceae	Vittaria incurvata Cavanilles	Present	–	–	–	–	–	–	Rare	–	–	Rare	Native	–	–	–	–
Zingiberaceae	Alpinia purpurata (Vieill.) K. Schum.	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Zingiberaceae	Alpinia zerumbet (Pers.) Burtt & R.M. Sm.	Present	–	–	–	–	Common	–	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Zingiberaceae	Costus speciosus (Koenig) Sm.	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Zingiberaceae	Costus woodsonii Maas	Present	–	–	–	–	Uncommon	–	–	–	–	Uncommon	Non-nat.	Persist.	No	No	No
Zingiberaceae	Curcuma longa L.	Present	–	–	–	–	–	–	Uncommon	–	–	Uncommon	Native	–	–	–	–
Zingiberaceae	Zingiber zerumbet (L.) Sm.	Present	–	–	–	–	–	–	Rare	–	–	Rare	Non-nat.	Persist.	No	No	No

Appendix D. Checklist of Reptiles and Amphibians

Table 24. Checklist of reptiles and amphibians on Guam reported from War in the Pacific NHP. Data are from Rodda and Dean-Bradley (2001), and NPS (unpublished). N = native; I = Invasive.

Class	Order	Family	Species	Status
Reptiles	Squamata	Colubridae	*Boiga irregularis*	I
	Squamata	Gekkonidae	*Gehyra mutilate*	N
	Squamata	Gekkonidae	*Hemidactylus frenatus*	N
	Squamata	Gekkonidae	*Lepidodactylus lugubris*	N
	Squamata	Polychrotidae	*Anolis carolinensis*	I
	Squamata	Scincidae	*Carlia ailanpalai*	I
	Squamata	Scincidae	*Emoia caeruleocauda*	N
	Squamata	Typhlopidae	*Ramphotyphlops braminus*	I
	Squamata	Varanidae	*Varanus tsukamotoi*	N
	Testudines	Cheloniidae	*Chelonia mydas*	N
	Testudines	Cheloniidae	*Eretmochelys imbricata bissa*	N
Amphibians	Anura	Bufonidae	*Rhinella marina*	I
	Anura	Hylidae	*Litoria fallax*	I

Appendix E. Checklist of Birds

Table 25. Checklist of birds reported from War in the Pacific NHP. Data are from NPS (unpublished; War in the Pacific NHP). P = present, PP = probably present, T = terrestrial, A = aquatic or shorebird, M = marine, I = invasive, W = wanderer.

Order	Family	Species	Status in War in the Pacific NHP
Accipitriformes	Accipitridae	*Butastur indicus*	PP-T-W
Accipitriformes	Accipitridae	*Milvus migrans*	PP-T-W
Apodiformes	Apodidae	*Aerodramus vanikorensis bartschi*	PP-T
Charadriiformes	Charadriidae	*Pluvialis dominica fulva*	P-A
Charadriiformes	Charadriidae	*Pluvialis squatarola*	PP-A
Charadriiformes	Laridae	*Anous stolidus*	PP-M
Charadriiformes	Laridae	*Gygis alba*	P-M
Charadriiformes	Scolopacidae	*Actitis hypoleucos*	PP-A
Charadriiformes	Scolopacidae	*Arenaria interpres*	PP-A
Charadriiformes	Scolopacidae	*Calidris alba*	PP-A
Charadriiformes	Scolopacidae	*Heteroscelus brevipes*	PP-A
Charadriiformes	Scolopacidae	*Heteroscelus incanus*	PP-A
Charadriiformes	Scolopacidae	*Limosa lapponica*	PP-A
Charadriiformes	Scolopacidae	*Numenius phaeopus*	PP-A
Charadriiformes	Scolopacidae	*Numenius tahitiensis*	PP-A
Columbiformes	Columbidae	*Columba livia*	PP-T-I
Columbiformes	Columbidae	*Streptopelia bitorquata*	PP-T-I
Galliformes	Phasianidae	*Coturnix chinensis*	PP-T-I
Galliformes	Phasianidae	*Francolinus francolinus*	PP-T-I
Gruiformes	Rallidae	*Gallinula chloropus guami*	PP-T
Passeriformes	Dicruridae	*Dicrurus macrocercus*	PP-T-I
Passeriformes	Passeridae	*Passer montanus*	PP-T-I
Pelecaniformes	Ardeidae	*Egretta sacra*	PP-M
Pelecaniformes	Ardeidae	*Ixobrychus sinensis*	PP-T-A
Phaethontiformes	Phaethontidae	*Phaethon lepturus*	PP-M
Procellariiformes	Procellariidae	*Puffinus pacificus*	PP-M
Suliformes	Fregatidae	*Fregata minor*	PP-M
Suliformes	Sulidae	*Sula leucogaster*	PP-M
Suliformes	Sulidae	*Sula sula*	PP-M

Appendix F. Checklist of Terrestrial Mammals

Table 26. Checklist of terrestrial mammals reported from War in the Pacific NHP. Data are from NPS (unpublished). I = invasive.

Order	Family	Species	Status
Artiodactyla	Cervidae	*Cervus mariannus*	I
Artiodactyla	Suidae	*Sus scrofa*	I
Carnivora	Canidae	*Canis familiaris*	I
Carnivora	Felidae	*Felis silvestris*	I
Rodentia	Muridae	*Mus musculus*	I
Rodentia	Muridae	*Rattus exulans*	I
Rodentia	Muridae	*Rattus norvegicus*	I
Rodentia	Muridae	*Rattus tanezumi*	I
Soricomorpha	Soricidae	*Suncus murinus*	I

Appendix G. Checklist and Distribution of Aquatic Plants and Invertebrates

Table 27. Checklist and distribution of aquatic plants and invertebrates in streams of War in the Pacific NHP. Data are from B. Tibbatts, Guam Division of Aquatic and Wildlife Resources (unpublished). N = native, I = invasive/introduced. Streams are: 1 = Asan, 2 = Atantano, 3 = Big Guatali, 4 = Finile, 5 = Ga'an, 6 = Masso, 7 = Matgue, 8 = Namo, 9 = Paulana, 10 = Salinas, 11= Taguag, 12 = Tenjo.

Aquatic Plants/ Invertebrates	**Species**	**Stream**											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Aquatic Plants	*Avicennia alba*	–	N	–	–	–	–	–	–	–	–	–	–
	Chara sp.	N	N	–	–	–	–	–	–	–	–	–	–
	Echinodorus sp	–	–	–	–	–	–	–	–	–	–	–	–
	Hydrilla verticillate	–	I	–	–	–	–	–	–	–	–	–	–
	Nypa fruticans	–	N	–	–	–	–	–	–	–	–	–	–
	Rhizophora apiculate	–	N	–	–	–	–	–	–	–	–	–	–
Aquatic Invertebrates — Crustaceans	*Atyoida pilipes*	N	–	–	N	–	N	–	–	N	–	–	–
	Atyoida spinipes	–	–	–	–	–	–	–	N	–	–	–	–
	Caridina mertoni	N	–	–	–	–	–	–	–	–	–	–	–
	Caridina nilotica	–	–	–	N	–	–	N	N	–	–	–	–
	Caridina serratirostris	–	N	–	–	–	–	–	–	–	–	–	–
	Caridina typus	N	–	–	–	–	–	–	–	–	–	–	–
	Caridina sp.	–	N	–	–	N	N	–	–	N	–	–	–
	Macrobrachium lar	N	N	–	N	N	N	N	N	N	–	N	–
	Macrobrachium latidactylus	N	–	–	–	–	–	–	–	–	–	–	–
Aquatic Invertebrates — Aquatic Insects	*Paraplea puella*	N	–	–	–	–	–	–	–	–	–	–	–
Aquatic Invertebrates — Mollusks	*Clithon coronatum*	–	–	–	–	–	–	–	N	–	–	–	–
	Gyraulus chinensis	–	–	–	–	–	–	I	–	–	–	–	–
	Neritina petiti	N	–	–	–	–	N	–	–	–	–	–	–

Table 27 (continued). Checklist and distribution of aquatic plants and invertebrates in streams of War in the Pacific NHP. Data are from B. Tibbatts, Guam Division of Aquatic and Wildlife Resources (unpublished). N = native, I = invasive/introduced. Streams are: 1 = Asan, 2 = Atantano, 3 = Big Guatali, 4 = Finile, 5 = Ga'an, 6 = Masso, 7 = Matgue, 8 = Namo, 9 = Paulana, 10 = Salinas, 11= Taguag, 12 = Tenjo.

Aquatic Plants/ Invertebrates	**Species**	**Stream**											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Aquatic Invertebrates — Mollusks (continued)	*Neritina pulligera*	N	–	–	–	–	N	–	–	N	–	–	–
	Neritina squamipicta	–	N	–	–	–	N	–	–	–	–	–	–
	Neritina variegate	N	–	–	–	–	N	–	N	–	–	–	–
	Nerites sp.	–	–	–	N	–	–	–	–	–	–	N	–
	Pila conica	–	–	–	–	–	I	–	–	–	–	–	–

Appendix H. Checklist of Fishes Reported from Streams and Estuaries

Table 28. Checklist of fishes reported from streams and estuaries in the War in the Pacific National Historical Park (data from Myers 1999 and B. Tibbatts, Guam Division of Aquatic and Wildlife Resources unpublished). N = native freshwater, E = euryhaline, and I = invasive/introduced.

Order	Family	Species	Status
Elopiformes	Megalopidae	*Megalops cyprinoides*	E
Anguilliformes	Anguillidae	*Anguilla bicolor*	N
Anguilliformes	Anguillidae	*Anguilla marmorata*	N
Siluriformes	Clariidae	*Clarias batrachus*	I
Cyprinodontiformes	Poeciliidae	*Gambusia affinis*	I
Cyprinodontiformes	Poeciliidae	*Poecilia reticulata*	I
Mugiliformes	Mugilidae	*Moolgarda seheli*	E
Mugiliformes	Mugilidae	*Mugilogobius cavifrons*	E
Mugiliformes	Mugilidae	*Neomyxus leuciscus*	E
Beloniformes	Zenarchopteridae	*Zenarchopterus dispar*	E
Perciformes	Chandidae	*Ambassis buruensis*	E
Perciformes	Carangidae	*Caranx sexfasciatus*	E
Perciformes	Lutjanidae	*Lutjanus fulvus*	E
Perciformes	Monodactlyidae	*Monodactylus argenteus*	E
Perciformes	Kuhliidae	*Kuhlia rupestris*	N
Perciformes	Cichlidae	*Oreochromis mossambicus*	I
Perciformes	Eleotridae	*Eleotris fusca*	N
Perciformes	Gobiidae	*Awaous guamensis*	N
Perciformes	Gobiidae	*Mugilogobius cavifrons*	E
Perciformes	Gobiidae	*Periophthalmus argentilineatus*	E
Perciformes	Gobiidae	*Redigobius bikolanus*	E
Perciformes	Gobiidae	*Sicyopus sp.*	N
Perciformes	Gobiidae	*Sicyopterus lagocephalus*	N
Perciformes	Gobiidae	*Stenogobius sp.*	N
Perciformes	Gobiidae	*Stiphodon sp.*	N

Appendix I. Known Distribution of Fishes in Streams and Estuaries

Table 29. Known distribution of fishes in streams and estuaries of the War in the Pacific National Historical Park by unit. Data are after B. Tibbatts, Guam Division of Aquatic and Wildlife Resources (unpublished) and Myers (1999). N = native freshwater, E = euryhaline, and I = invasive/introduced. Streams are: 1 = Asan, 2 = Atantano, 3 = Big Guatali, 4 = Finile, 5 = Ga'an, 6 = Masso, 7 = Matgue, 8= Namo, 9 = Paulana, 10 = Salinas, 11= Taguag, 12 = Tenjo.

	Stream											
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Megalops cyprinoides	–	–	–	–	–	–	E	–	–	–	–	–
Anguilla bicolor	–	–	–	–	–	–	–	–	–	–	–	–
Anguilla marmorata	–	N	–	N	–	N	N	–	–	–	N	–
Clarias batrachus	–	I	–	–	–	I	–	–	–	–	–	–
Gambusia affinis	–	I	–	–	–	I	–	–	–	–	–	–
Poecilia reticulata	–	I	–	I	–	I	–	I	–	I	–	–
Moolgarda engeli	–	–	–	–	E	–	E	E	–	–	–	–
Moolgarda seheli	–	E	–	–	–	–	–	–	–	–	–	–
Mugilogobius cavifrons	–	N	–	–	–	–	–	–	–	–	–	–
Neomyxus leuciscus	–	–	–	–	–	–	E	–	–	–	–	–
Zenarchopterus dispar	–	E	–	–	–	–	–	–	–	–	–	–
Ambassis buruensis	–	E	–	–	–	–	–	–	–	–	–	–
Caranx sexfasciatus	–	E	–	–	–	E	–	–	–	–	–	–
Lutjanus fulvus	–	E	–	–	–	–	–	–	–	–	–	–
Monodactylus argenteus	–	E	–	–	–	–	–	–	–	–	–	–
Kuhlia rupestris	N	N	–	–	N	N	N	N	–	N	N	N
Oreochromis mossambicus	I	–	I	–	–	I	I	I	–	–	–	–
Eleotris fusca	N	N	–	–	–	N	N	–	–	–	N	–
Awaous guamensis	–	–	–	–	–	N	N	N	–	–	N	–
Mugilogobius cavifrons	–	E	–	–	–	–	–	–	–	–	–	E

Table 29 (continued). Known distribution of fishes in streams and estuaries of the War in the Pacific National Historical Park by unit. Data are after B. Tibbatts, Guam Division of Aquatic and Wildlife Resources (unpublished) and Myers (1999). N = native freshwater, E = euryhaline, and **I** = invasive/introduced. Streams are: 1 = Asan, 2 = Atantano, 3 = Big Guatali, 4 = Finile, 5 = Ga'an, 6 = Masso, 7 = Matgue, 8= Namo, 9 = Paulana, 10 = Salinas, 11= Taguag, 12 = Tenjo.

	Stream											
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Periophthalmus argentilineatus	–	N	–	–	–	–	–	–	–	–	–	–
Redigobius bikolanus	–	E	–	–	–	–	–	–	–	–	–	E
Sicyopus sp.	–	–	–	N	–	N	–	N	–	–	N	–
Sicyopterus lagocephalus	–	–	–	–	–	N	–	N	–	–	N	–
Stenogobius sp.	N	N	–	–	–	–	N	–	–	–	–	–
Stiphodon sp.	N	–	–	N	–	N	N	N	N	–	N	–
No. native freshwater species	4	6	0	3	1	7	6	5	1	1	7	1
No. euryhaline species	0	8	0	0	1	1	3	1	0	0	0	2
No. invasive/introduced species	1	3	1	1	0	4	1	2	0	1	0	0
Total species	5	17	1	4	2	12	10	8	1	2	7	3

Appendix J. Checklist of Marine Fishes Found in the War In the Pacific National Historical Park

Species observed in coastal marine habitats of the Asan Beach and Agat Units are arranged alphabetically by family. Data are from Brown and Capone (2014), Donaldson (2008a), and Donaldson (unpublished data). Species names follow www.fishbase.org and common names from Myers (1999).

Acanthuridae-Surgeonfishes

Acanthurus blochii Valenciennes, 1835, Ringtail surgeonfish *Acanthurus guttatus* (Forster, 1801), White-spotted surgeonfish *Acanthurus lineatus* (Linnaeus, 1758), Blue-banded surgeonfish *Acanthurus nigricans* (Linnaeus, 1758), White-cheek surgeonfish *Acanthurus nigrocauda (*Dunker & Mohr, 1929), Epaulette surgeonfish *Acanthurus nigrofuscus* (Forsskal, 1775), Brown surgeonfish *Acanthurus nigroris (*Valenciennes, 1835), Blue-lined surgeonfish *Acanthurus olivaceus (*Bloch and Scneider, 1801), Orange-band surgeonfish *Acanthurus pyroferus (*Kittlitz,, 1834), Chocolate surgeonfish

Acanthurus thompsoni (Fowler, 1923), Thompson's surgeonfish

Acanthurus triostegus (Linnaeus, 1758), Convict tang

Acanthurus xanthopterus Valenciennes, 1835, Yellowfin surgeonfish

Ctenochaetus binotatus Randall, 1955, Two-spot bristletooth

Ctenochaetus cyanocheilus Randall & Clements, 2001, Blue-lipped bristletooth

Ctenochaetus hawaiiensis Randall, 1955, Black surgeonfish *Ctenochaetus striatus* (Quoy & Gaimard, 1825), Striped bristletooth *Naso brevirostris* (Valenciennes, 1835), Spotted unicornfish

Naso caesius Randall & Bell, 1992, Gray unicornfish *Naso lituratus* (Forster, 1801), Orange-spine unicornfish *Naso unicornis* (Forsskal, 1775), Blues-pine unicornfish

Naso vlamingii (Valenciennes, 1835), Big-nose unicornfish *Zebrasoma flavescens* (Bennett, 1828), Yellow tang *Zebrasoma scopas* (Cuvier, 1829), Brown tang

Zebrasoma veliferum (Bloch, 1797), Sailfin tang

Atherinidae-Silversides

Atherinomorus lacunosus (Schneider, 1801), Hardyhead silverside

Apogonidae-Cardinalfishes

Cheilodipterus macrodon (Lacepede, 1802), Large-toothed cardinalfish *Cheilodipterus quinquelineata* (Cuvier, 1828), Five-lined cardinalfish *Ostorhinchus angustatus* (Smith & Radcliffe, 1911), Broad-striped cardinalfish *Ostorhinchus luteus* (Randall & Kulbicki, 1998), Yellow cardinalfish

Ostorhinchus nigrofasciatus (Lachner, 1953), Black-striped cardinalfish *Ostorhinchus novemfasciatus* (Cuvier, 1828), Seven-striped cardinalfish *Ostorhinchus savayensis* (Quoy & Gaimard, 1825), Gray cardinalfish *Ostorhinchus trimaculatus* (Cuvier, 1828), Three-spot cardinalfish *Pristiapogon exostigma* (Jordan & Starks, 1906), Eyeshadow cardinalfish *Pristiapogon kallopterus* (Bleeker, 1878), Iridescent cardinalfish *Pristiapogon taeniophorus* (Bennett, 1825), Band-fin cardinalfish

Aulostomidae-Trumpetfish
Aulostomus chinensis (Linnaeus, 1766), Trumpetfish

Balistidae-Triggerfishes
Balistapus undulatus (Mungo Park, 1797), Orange-striped triggerfish *Balistoides conspicillum* (Bloch & Schneider, 1801), Clown triggerfish *Balistoides viridescens* (Bloch & Schneider, 1801), Titan triggerfish *Melichthys vidua* (Solander, 1844), Pink-tail triggerfish

Odonus niger (Ruppell, 1837), Redtooth triggerfish

Rhinecanthus aculeatus (Linneaus, 1758), Picassofish

Rhinecanthus rectangulus (Bloch & Schneider, 1801), Wedge picassofish

Sufflamen bursa (Bloch & Schneider, 1801), Scythe triggerfish *Sufflamen chrysoptera* (Bloch & Schneider, 1801), Halfmoon triggerfish *Xanthichthys auromarginatus* (Bennett, 1831), Guilded triggerfish

Blenniidae-Blennies
Aspidontus taeniatus (Quoy & Gaimard, 1834), Cleaner mimic

Blenniella chrysospilos (Bleeker, 1857), Red-spotted blenny

Blenniella periophthalmus (Valenciennes, 1836), Blue-dashed rockskipper

Cirripectes castaneus (Valenciennes, 1836), Chestnut blenny *Cirripectus fuscoguttata* (Schultz & Schultz, 1953), Spotted blenny *Cirripectus variolosus* (Valenciennes, 1836), Red-speckled blenny *Ecsenius bicolor* (Day, 1888), Bicolor blenny

Ecsenius opsifrontalis (Chapman & Schultz, 1960), Comical blenny

Exallias brevis (Kner, 1868), Leopard blenny

Meiacanthus atrodorsalis (Gunther, 1877), Poison-fang blenny *Petroscirtes xestus* (Jordan & Seale, 1906), Xestus sabretooth blenny *Plagiotremus laudandus* (Whitley, 1961), Poison-fang blenny mimic *Plagiotremus tapeinosoma* (Bleeker, 1857), Piano blenny

Salarias fasciatus (Bloch, 1786), Jeweled blenny

Caesionidae-Fusiliers

Caesio caerulaurea (Lacepede, 1801), Scissor-tailed fusilier

Caesio tile (Cuvier, 1830), Bluestreak fusilier

Carangidae-Jacks and Trevallys

Alectis ciliaris (Bloch, 1788), Threadfin pompano

Caranx melampygus (Cuvier, 1833), Bluefin trevally

Caranx sexfasciatus (Quoy & Gaimard, 1824), Bigeye trevally *Elegatis bipinnulata* (Quoy & Gaimard, 1824), Rainbow runner *Scombroides lysan* (Forsskal, 1775), Leatherback

Carcharhinidae-Requiem sharks

Carcharhinus melanopterus (Quoy & Gaimard, 1824), Reef blacktip shark

Chaetodontidae-Butterflyfishes

Chaetodon auriga (Forsskal, 1775), Threadfin butterflyfish *Chaetodon bennetti* (Cuvier, 1831), Bennett's butterflyfish *Chaetodon citrinellus* (Cuvier, 1831), Speckled butterflyfish *Chaetodon ephippium* (Cuvier, 1831), Saddled butterflyfish *Chaetodon kleinii* (Bloch, 1790), Klein's butterflyfish *Chaetodon lunula* (Lacepede, 1803), Raccoon butterflyfish

Chaetodon lunulatus (Quoy & Gaimard, 1825), Redfin butterflyfish *Chaetodon melannotus* (Bloch & Schneider, 1801), Black-backed butterflyfish *Chaetodon mertensii* (Cuvier, 1831), Merten's butterflyfish

Chaetodon ornatissimus (Cuvier, 1831), Ornate butterflyfish *Chaetodon punctatofasciatus* (Cuvier, 1839), Spot-banded butterflyfish *Chaetodon quadrimaculatus* (Gray, 1833), Fourspot butterflyfish *Chaetodon reticulatus* (Cuvier, 1831), Reticulated butterflyfish

Chaetodon trifascialis (Quoy & Gaimard, 1825), Chevroned butterflyfish *Chaetodon ulietensis* (Cuvier, 1831), Pacific double saddle butterflyfish *Chaetodon unimaculatus* (Bloch, 1787), Teardrop butterflyfish

Forcipiger flavissimus (Jordan & McGregor, 1898), Long-nosed butterflyfish *Forcipiger longirostris* (Broussonet, 1782), Big long-nosed butterflyfish *Hemitaurichthys polylepis* (Bleeker, 1857), Pyramid butterflyfish

Heniochus monocerus (Cuvier, 1831), Masked bannerfish *Heniochus acuminatus* (Linneaus, 1758), Long-fin bannerfish *Heniochus chrysostomus* (Cuvier, 1831), Pennant bannerfish

Heniochus singularus (Smith & Radcliffe, 1911), Singular bannerfish

Heniochus varius (Cuvier, 1829), Humphead bannerfish

Cirrhitidae-Hawkfishes

Cirrhitus pinnulatus (Bloch & Schneider, 1801), Stocky hawkfish

Cirrhitichthys falco (Randall, 1963), Falco hawkfish

Neocirrhites armatus (Castlenau, 1873), Flame hawkfish *Paracirrhites arcatus* (Cuvier, 1829), Arc-eye hawkfish *Paracirrhites forsteri* (Schneider, 1801), Freckled hawkfish

Dasyatidae-Stingrays

Himantura fai (Jordan & Seale, 1906), Pink whipray

Taeniura meyeni (Müller & Henle, 1841), Black-spotted stingray

Diodontidae-Porcupinefish

Diodon hystrix (Linnaeus, 1758), Porcupinefish

Epinephelidae-Groupers

Cephalopholis argus (Schneider, 1801), Peacock grouper

Cephalopholis spiloparaea (Valenciennes, 1828), Orange-red pygmy grouper

Cephalopholis urodeta (Forster, 1801), Flagtail grouper *Epinephelus fasciatus* (Forsskal, 1775), Black-tipped grouper *Epinephelus hexagonatus* (Forster, 1801), Hexagon grouper *Epinephelus maculatus* (Bloch, 1790), Highfin grouper *Epinephelus merra* (Bloch, 1790), Honeycomb grouper

Fistulariidae-Cornetfish

Fistularia commersonii (Ruppell, 1838), Cornetfish

Gerreidae-Mojarras

Gerres oyena (Forsskal, 1775), Oyena mojarra

Gobiidae-Gobies

Amblyeleotris fasciata (Herre, 1953), Red-banded prawn-goby *Amblyeleotris guttata* (Fowler, 1938), Spotted prawn-goby *Amblygobius nocturnus* (Herre, 1945), Nocturn goby *Amblygobius phalaena* (Valenciennes, 1837), Brown-barred goby *Asterropteryx semipunctatus* (Rüppell, 1830), Bluespotted goby *Bryaninops amplus* (Larson, 1985), Gorgonian goby

Bryaninops sp. Whip goby

Fusigobius duospilus (Hoese & Reader, 1985), Twospot goby *Fusigobius inframaculatus* (Randall, 1994), Innerspotted sand goby *Fusigobius signipinnis* (Hoese & Obika, 1988), Signal-fin goby *Cryptocentrus strigilliceps* (Jordan & Seale, 1906), Target goby *Ctenogobiops feroculus* (Lubbock & Polunin, 1977), Sandy prawn-goby *Eviota albolineata* (Jewett & Lachner, 1983), Spotted fringe-fin goby *Eviota guttata* (Lachner & Karnella, 1978), Spotted pygmy goby

Eviota prasina (Klunzinger, 1871), Green bubble goby

Eviota prasites (Jordan & Seale, 1906), Prasites pygmy goby

Eviota punctulata (Jewett & Lachner, 1983), Pepperfin pygmy goby *Eviota sebreei* (Jordan & Seale, 1906), Sebree's pygmy goby *Exyrias belissimus* (Smith, 1959), Mud reef-goby

Gobiodon citrinus (Rüppell, 1828), Lemon coral goby *Gnatholepis anjerensis* (Bleeker, 1851), Eye-bar goby *Istigobius decoratus* (Herre, 1927), Decorated goby

Lotilia graciliosa (Klausewitz, 1960), Graceful prawn-goby *Oplopomus oplopomus* (Valenciennes, 1837), Blue-spotted hole goby *Trimma caesiura* (Jordan & Seale, 1906), Caesiura goby

Trimma macropthalmum (Tomiyama, 1936), Bigeye dwarf-goby *Trimma naudei* (Smith, 1956), Naude's rubble goby *Valenciennea puellaris* (Tomiyama, 1956), Maiden goby *Valenciennea strigata* (Brousonet, 1782), Blue-streak goby

Vanderhorstia ambanoro (Fourmanoir, 1957), Ambanoro prawn-goby

Haemulidae-Sweetlips

Plectorhincus pictus (Tortonese, 1936), Spotted sweetlips

Hemiramphidae-Halfbeaks

Hyporamphis dussumieri (Valenciennes, 1847), Dussumier's halfbeak

Holocentridae-Soldierfishes & Squirrelfishes

Myripristis adusta (Bleeker, 1853), Bronze soldierfish

Myripristis berndti (Jordan & Evermann, 1903), Big-scale soldierfish

Myripristis kuntee (Cuvier, 1831), Pearly soldierfish *Myripristis murdjan* (Forsskal, 1775), Red soldierfish *Myripristis pralinia* (Cuvier, 1824), Scarlet soldierfish *Neoniphon sammara* (Forsskal, 1775), Bloodspot squirrelfish

Sargocentron caudimaculatum (Ruppell, 1838), Tail-spot squirrelfish *Sargocentron diadema* (Lacepede, 1802), Crown squirrelfish *Sargocentron microstoma* (Gunther, 1859), Fine-lined squirrelfish *Sargocentron spiniferum* (Forsskal, 1775), Long-jawed squirrelfish *Sargocentron tiere* (Cuvier, 1829), Blue-lined squirrelfish

Labridae-Wrasses

Anampses twistii (Bleeker, 1856), Yellow-breasted wrasse *Bodianus axillaris* (Bennett, 1831), Axilspot hogfish *Cheilinus chlorourus* (Bloch, 1791), Floral wrasse *Cheilinus fasciatus* (Bloch, 1791), Red-breasted wrasse

Cheilinus oxycephalus (Bleeker, 1853), Snooty wrasse *Cheilinus trilobatus* (Lacepede, 1801), Tripletail wrasse *Cheilinus undulatus* (Rupell, 1835), Humphead wrasse *Cheilio inermis* (Forsskal, 1775), Cigar wrasse *Cirrhilabrus exqusitus* (Smith, 1857), Exquisite wrasse

Cirrhilabrus katherinae (Randall, 1992), Katherine's wrasse

Coris aygula (Lacepede, 1801), Clown coris

Coris gaimard (Quoy & Gaimard, 1824), Yellowtail coris

Epibulus brevis (Carlson & Randall & Dawson, 2008), Dwarf slingjaw wrasse

Epibulus insidiator (Pallas, 1770), Slingjaw wrasse *Gomphosus varius* (Lacepede, 1801), Bird wrasse *Halichoeres biocellatus* (Schultz, 1960), Two-spotted wrasse

Halichoeres hortulanus (Lacepede, 1801), Checkerboard wrasse *Halichoeres margaritaceus* (Valenciennes, 1839), Weedy surge wrasse *Halichoeres marginatus* (Rupell, 1835), Dusky wrasse

Halichoeres ornatissimus (Garrett, 1863), Ornate wrasse

Halichoeres trimaculatus (Quoy & Gaimard, 1824), Three-spot wrasse *Hemigymnus fasciatus* (Bloch, 1792), Barred thicklip wrasse *Hemigymnus melapterus* (Bloch, 1791), Blackedge thicklip wrasse *Hologymnosus doliatus* (Lacepede, 1801), Longface wrasse *Labrichthys unilineatus* (Guichenot, 1847), Tubelip wrasse

Labroides bicolor (Fowler & Bean, 1928), Bicolor cleaner wrasse *Labroides dimidiatus* (Valenciennes, 1839), Bluestreak cleaner wrasse *Labropsis xanthonota* (Randall, 1981), Wedge-tailed wrasse *Macropharyngodon meleagris* (Valenciennes, 1839), Leopard wrasse *Novaculichthys taeniourus* (Bloch, 1791), Rockmover wrasse *Oxycheilinus digramma* (Lacepede, 1801), Bandcheeked wrasse *Oxycheilinus orientalis* (Gunther, 1862), Oriental wrasse

Oxycheilinus unifasciatus (Streets, 1877), Ringtail wrasse *Pseudocheilinus evanidus* (Jordan & Evermann, 1903), Striated wrasse *Pseudocheilinus hexataenia* (Bleeker, 1857), Six-line wrasse *Pseudocheilinus tetrataenia* (Schultz, 1960), Four-line wrasse *Pteragogus cryptus* (Randall, 1981), Cryptic wrasse

Pteragogus enneacanthus (Bleeker, 1853), Cockerel wrasse *Stethojulis bandanensis* (Bleeker, 1851), Red-shoulder wrasse *Stethojulis strigiventer* (Bennett, 1832), Three-ribbon wrasse *Thalassoma amblycephalum* (Bleeker, 1856), Twot-one wrasse *Thalassoma hardwicke* (Bennett, 1830), Six-bar wrasse *Thalassoma lutescens* (Lay & Bennett, 1839), Sunset wrasse *Thalassoma purpureum* (Forsskal, 1775), Surge wrasse

Thalassoma quinquevittatum (Lacepede, 1801), Five-stripe surge wrasse

Labridae: Scarinae-Parrotfishes

Calotomus carolinus (Valenciennes, 1839), Bucktooth parrotfish *Cetoscarus bicolor* (Rüppell, 1829), Bicolor parrotfish *Chlorurus spilurus* (Valenciennes, 1840), Daisy parrotfish

Hipposcarus longiceps (Valenciennes, 1839), Pacific longnose parrotfish *Leptoscarus vaigiensis* (Quoy & Gaimard, 1824), Seagrass parrotfish *Scarus altipinnis* (Steindachner, 1879), Filament-finned parrotfish *Scarus dimidiatus* (Bleeker, 1859), Turqoise-capped parrotfish

Scarus forsteni (Bleeker, 1861), Forsten's parrotfish *Scarus flavipectoralis* (Schultz, 1958), Rainbow parrotfish *Scarus frenatus* (Lacepède, 1802), Vermiculate parrotfish *Scarus niger* (Forsskål, 1775), Black parrotfish

Scarus psittacus (Forsskål, 1775), Pale-nose parrotfish

Scarus schlegeli (Bleeker, 1861), Yellow-band parrotfish

Lethrinidae-Emperors & Breams
Gnathodentex aureolineatus (Lacepede, 1802), Yellow-spot emperor

Lethrinus harak (Forsskal, 1775), Black-spot emperor *Lethrinus rubrioperculatus* (Sato, 1978), Red-gill emperor *Lethrinus* sp. Unidentified emperor

Lethrinus xanthochilus (Klunzinger, 1870), Yellowlip emperor

Monotaxis grandoculis (Forsskal, 1775), Bigeye emperor

Lutjanidae-Snappers
Aphareus furca (Lacepede, 1802), Blue small-tooth jobfish *Aphareus virescens* (Valenciennes, 1830), Jobfish *Lutjanus bohar* (Forsskal, 1775), Red snapper

Lutjanus fulvus (Schneider, 1801), Flametail snapper *Lutjanus kasmira* (Forsskal, 1775), Blue-lined snapper *Lutjanus monostigmus* (Cuvier, 1828), One-spot snapper *Macolor niger*(Forsskal, 1775), Black snapper

Malacanthidae-Tilefishes
Malacanthus brevirostris (Guichenot, 1848), Quakerfish

Malacanthus latovittatus (Lacepede, 1798), Striped blanquillo

Microdesmidae-Wormfishes
Gunnelichthys pleurotaenia (Bleeker, 1858), One-stripe wormfish

Monocanthidae-Filefishes
Amanses scopas (Cuvier, 1829), Broom filefish

Oxymonocanthus longirostris (Bloch & Schneider, 1801), Longnose filefish

Paraluteres prionurus (Bleeker, 1851), Black-saddle mimic

Pervagor janthinosoma (Bleeker, 1854), Black-bar filefish

Mugilidae-Mullets
Crenimugil crenilabis (Forsskal, 1775), Fringe-lip mullet

Moolgarda engeli (Bleeker, 1858), Engel's mullet

Mullidae-Goatfishes
Mulloidichthys flavolineatus (Lacepede, 1801), Yellow-stripe goatfish *Mulloidichthys vanicolensis* (Valenciennes, 1831), Yellowfin goatfish *Parupeneus barberinus* (Lacepede, 1801), Dash-and-dot goatfish *Parupeneus crassilabris* (Valenciennes, 1831), Two-barred goatfish *Parupeneus cyclostomus* (Lacepede, 1801), Yellow-saddle goatfish *Parupeneus multifasciatus* (Quoy & Gaimard, 1824), Multi-barred goatfish

Muraenidae-Moray eels
Echidna nebulosa (Ahl, 1789), Snowflake moray

Gymnothorax buroensis (Bleeker, 1837), Buro moray

Gymnothorax flavimarginatus (Rüppell, 1828), Yellow-margined moray *Gymnothorax fuscomaculatus* (Schultz, 1953), Brown-spotted moray *Gymnothorax picta* (Ahl, 1789), Peppered moray

Gymnothorax thyrsoideus (Richardson, 1845), White-eyed moray

Uropterygius supraforatus (Regan, 1909), Many-toothed snake moray

Myliobatidae-Eagle and Manta Rays
Aetobatis narinari (Euphrasen, 1790), Spotted Eagle ray

Manta birostris (Walbaum, 1792), Manta ray

Nemipteridae-Monocle Breams
Scolopsis lineatus Quoy & Gaimard, 1824, Black-and-white spinecheek

Ostraciidae-Boxfish
Ostracion meleagris Shaw, 1796, Spotted boxfish

Pempheridae-Sweepers
Pempheris oualensis Cuvier, 1831, Bronze sweeper

Pinguipediidae-Sandperch
Parapercis clathrata Ogilby, 1910, Latticed sandperch

Pomacanthidae-Angelfishes
Apolemichthys trimaculatus (Cuvier, 1831), Three-spot angelfish *Centropyge flavissimus* (Cuvier, 1831), Lemonpeel angelfish *Centropyge heraldi* (Woods & Schultz, 1953), Herald's angelfish

Centropyge multifasciatus (Smith & Radcliffe, 1911), Multi-barred angelfish *Centropyge shepardi* (Randall & Yasuda, 1979), Shepard's angelfish *Pomacanthus imperator* (Bloch, 1787), Emperor angelfish

Pygoplites diacanthus (Boddaert, 1772), Regal angelfish

Pomacentridae-Damselfishes

Abudefduf septemfasciatus (Cuvier, 1830), Banded sergeant *Abudefduf sexfasciatus* (Lacepede, 1801), Scissor-tail sergeant *Abudefduf sordidus* (Forsskal, 1775), Black-spot sergeant *Abudefduf vaigiensis* (Quoy & Gaimard, 1825), Sergeant-major *Amblygyphidodon curacao* (Bloch, 1787), Staghorn damsel *Amblygyphidodon ternatensis* (Bleeker, 1853), Ternate damsel *Amphiprion chrysopterus* (Cuvier, 1830), Orange-fin anemonefish *Amphiprion clarki* (Bennett, 1830), Clark's anemonefish *Amphiprion melanopus* (Bleeker, 1852), Dusky anemonefish *Amphiprion perideraion* (Bleeker, 1855), Pink clownfish

Chromis acares (Randall & Swerdloff, 1973), Midget chromis

Chromis agilis (Smith, 1960), Bronze reef chromis *Chromis alpha* (Randall, 1987), Yellow-speckled chromis *Chromis amboinensis* (Bleeker, 1873), Ambon chromis

Chromis atripectoralis (Welander & Schultz, 1951), Black-axil chromis

Chromis margaritifer (Fowler, 1946), Bicolor damsel *Chromis ternatensis* (Bleeker, 1856), Ternate chromis *Chromis viridis* (Cuvier, 1830), Blue-green chromis *Chromis xanthura* (Bleeker, 1854), Black chromis *Chrysiptera brownriggii* (Bennett, 1828), Surge demoiselle *Chrysiptera glauca* (Cuvier, 1830), Grey demoiselle

Chrysiptera traceyi (Woods & Schultz, 1960), Tracey's demoiselle

Dascyllus aruanus (Linneaus, 1758), Humbug dascyllus *Dascyllus reticulatus* (Richardson, 1846), Reticulated dascyllus *Dascyllus trimaculatus* (Ruppell, 1828), Three-spot dascyllus *Plectroglyphidodon dickii* (Lienard, 1839), Dick's damsel

Plectroglyphidodon imparipennis (Vaillant & Sauvage, 1875), Bright-eye damsel *Plectroglyphidodon johnstonianus* (Fowler & Ball, 1925), Johnston Island damsel *Plectroglyphidodon lacrymatus* (Quoy & Gaimard, 1825), Jewel damsel *Plectroglyphidodon leucozonus* (Bleeker, 1859), White-band damsel *Pomacentrus amboinensis* (Bleeker, 1868), Ambon damsel

Pomacentrus brachialis (Cuvier, 1830), Charcoal damsel *Pomacentrus pavo* (Bloch, 1787), Sapphire damsel *Pomacentrus* sp. Unidentified damsel juvenile

Pomacentrus vaiuli (Jordan & Seale, 1906), Princess damsel *Pomachromis guamensis* (Allen & Larson, 1975), Guam damsel *Stegastes albifasciatus* (Schlegel & Muller, 1839), White-bar gregory *Stegastes nigricans* (Lacepede, 1803), Dusky farmerfish

Priacanthidae-Bigeye

Priacanthus hamrur (Forsskal, 1775), Google-eye

Pseudochromidae-Dottybacks

Pseudochromis cyanotaenia (Bleeker, 1857), Surge dottyback

Ptereleotridae-Dartfishes
Nemateleotris magnifica (Fowler, 1938), Fire dartfish *Ptereleotris evides* (Jordan & Hubbs, 1925), Blackfin dartfish *Ptereleotris heteroptera* (Bleeker, 1855), Spot-tail dartfish *Ptereleotris microlepis* (Bleeker, 1956), Pearly dartfish

Scombridae-Tunas and Mackerels
Gymnosarda unicolor (Rüppell, 1836), Dogtooth tuna *Katsuwonus pelamis* (Linneaus, 1758), Skipjack tuna

Scorpaenidae-Scorpionfishes
Caracanthus unipinna (Gray, 1831), Pygmy croucher *Pterois antennata* (Bloch, 1787), Spot-fin lionfish *Pterois radiolata* (Cuvier, 1829), Clear-fin lionfish *Pterois volitans* (Linneaus, 1758), Lionfish

Scorpaenopsis papuensis (Cuvier, 1829), Papuan scorpionfish

Scorpanodes guamensis (Quoy & Gaimard, 1824), Guam scorpionfish

Serranidae-Sea Basses and Basslets
Pseudanthias pascalus (Jordan & Tanaka, 1927), Purple queen

Pseudanthias pleurotaenia (Bleeker, 1857), Square-spot fairy basslet

Siganidae-Rabbitfishes
Siganus argenteus (Quoy & Gaimard, 1825), Forktail rabbitfish

Siganus spinus (Linneaus, 1758), Scribbled rabbitfish

Siganus vermiculatus (Valenciennes, 1835), Vermiculated rabbitfish

Synanceiidae-Stonefish
Synanceia verrucosa Bloch & Schneider, 1801, Stonefish

Syndontidae-Lizardfishes
Saurida gracilis (Quoy & Gaimard, 1824), Graceful lizardfish

Synodus binotatus (Schultz, 1953), Two-spot lizardfish

Synodus jaculum (Russell & Cressey, 1979), Black-blotch lizardfish

Synodus variegatus (Lacepede, 1803), Variegated lizardfish

Syngnathidae-Pipefishes
Corythoichthys intestinalis (Ramsay, 1881), Scribbled pipefish

Doryrhamphus excisus (Kaup, 1856), Blue-stripe pipefish

Sphyraenidae-Barracudas

Sphyraena barracuda (Walbaum, 1792), Great barracuda

Sphyraena flavicauda (Rüppell, 1838), Yellowtail barracuda

Tetraodonidae-Puffers

Arothron manilensis (Proce, 1822), Narrow-lined puffer

Arothron meleagris (Lacepède, 1798), Guineafowl puffer

Arothron nigropunctatus (Bloch & Schneider, 1801), Black-spotted puffer

Canthigaster bennetti (Bleeker, 1854), Bennett's toby

Canthigaster janthinoptera (Bleeker, 1855), Honeycomb sharpnose puffer

Canthigaster papua (Bleeker, 1848), Papuan toby

Canthigaster solandri (Richardson, 1844), Spotted sharpnose puffer

Canthigaster valentini (Bleeker, 1853), Valentini's sharpnose puffer

Tripterygidae-Triplefins

Helcogramma sp. Unidentified triplefin

Ucla xenogrammus (Holleman, 1993), Largemouth triplefin

Zanclidae-Moorish Idol

Zanclus cornutus (Linnaeus, 1758), Moorish idol

Appendix K. Photos of Fish Species

Representative fish species found in marine (M), estuarine (E), and freshwater (F) habitats of War in the Pacific NHP. Species are arranged phylogenetically following Myers (1999); note that phylogenetic arrangement at the level of order is currently in flux. See Appendix I and Appendix J for family names (Figures 47–62, photographs from www.fishbase.org).

Figure 47. *Carcharhinus melanopterus* (M) (left); *Gymnothorax javanicus* (M) (right).

Figure 48. *Anguilla marmorata* (F) (left); *Ellochelon vaigiensis* (M, E, F) (right).

Figure 49. *Synododus dermatogenys* (M) (left); *Myrpristis kuntee* (M) (right).

Figure 50. *Corythoichthys intestinalis* (M) (left); *Pterois volitans* (M) (right).

Figure 51. *Epinpehelus merra* (M) (left); *Paracirrhites arcatus* (M) (right).

Figure 52. *Ostorhinchus novemfasciatus* (M) (left); *Caranx melampygus* (M) (right).

Figure 53. *Selar crumenophthalmus* (M) (left); *Lutjanus fulvus* (M) (right).

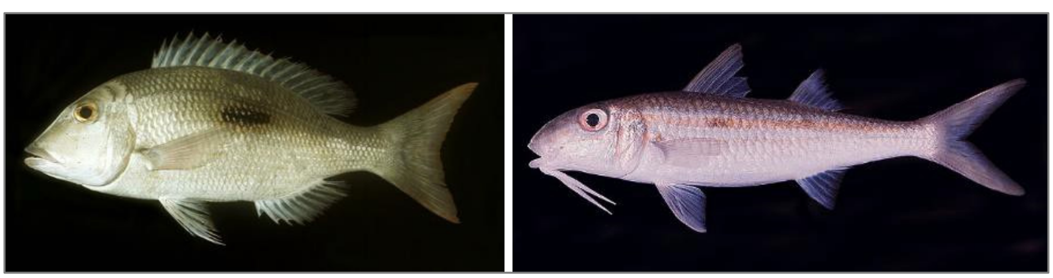

Figure 54. *Lethrinus harak* (M) (left); *Mulloidichthys flavolineatus* (M) (right).

Figure 55. *Chaetodon citrinellus* (M) (left); *Centropyge flavissima* (M) (right).

Figure 56. *Kuhlia rupestris* (F) (left); *Chrysiptera brownriggii* (M) (right).

Figure 57. *Chrysiptera brownriggii amabilis* (M) (left); *Halichoeres trimaculatus* (M) (right).

Figure 58. *Chlororus spilurus* (M) (left); *Salarias fasciatus* (M) (right).

Figure 59. *Eleotris acanthopoma* (F) (left); *Sicyopterus lagocephalus* (F) (right).

Figure 60. *Siganus spinus* (M) (left); *Acanthurus nigrofuscus* (M) (right).

Figure 61. *Zanclus cornutus* (M) (left); *Odonus niger* (M) (right).

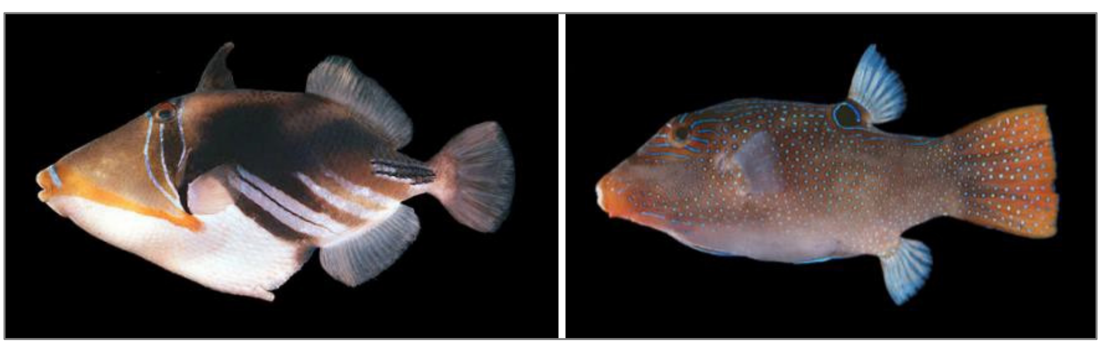

Figure 62. *Rhinecanthus aculeatus* (M) (left); *Canthigaster solandri* (M) (right).

Appendix L. Marine Mammals

Table 30. Marine mammals reported from Guam that may be found within waters of War in the Pacific NHP or just offshore. Data are from Eldredge (2003). Status denoted by P = present, PP = observed in Guam's waters and probably present, and S = straggler to Guam.

Order	Family	Species	Status
Mysticeti	Balaenopteridae	*Balaenoptera edeni*	PP
	Balaenopteridae	*Balaenoptera borealis*	PP
	Balaenopteridae	*Megaptera novaeangiliae*	PP
Odontoceti	Ziphiidae	*Ziphius cavirostris*	PP
	Physteridae	*Physeter microcephalus*	PP
	Delphinidae	*Peponocephala electra*	PP
	Delphinidae	*Orcinus orca*	PP
	Delphinidae	*Globicephala macrorhynchus*	P
	Delphinidae	*Grampus griseus*	PP
	Delphinidae	*Stenella longirostris*	P
	Delphinidae	*Stenella coeruleoalba*	PP
Sirenia	Dugongidae	*Dugong dugon*	S

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