Guam Statewide Forest Resource Assessment and Resource Strategy

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Department of Agriculture
Forestry & Soil Resources Division
Mangilao, Guam

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Contents

List of Tables

List of Figures

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Glossary

AAFB	Anderson Air Force Base
CFAA	Cooperative Forestry Assistance Act of 1978 as amended
CFHM	Cooperative Forest Health Management Program (Guam)
CFP	Cooperative Fire Program (Guam)
CWA	Clean Water Act
CZMP	Coastal Zone Management Act
DAWR	Division of Aquatic Wildlife Resources
DOD	Department of Defense
EPA	U.S. Environmental Protection Agency
FEPP	Federal Excess Personal Property
F&SRD	Forestry & Soil Resources Division, Department of Agriculture (Guam)
FLEP	Forest Lands Enhancement Program (USDA Forest Service)
FSP	Forest Stewardship Program (Guam)
FSP	Forest Stewardship Program (USDA Forest Service)
GCMP	Guam Coastal Management Program
NIPF	Non-industrial Private Forestlands
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCE	Natural Resources Education Conservation Program (Guam)
NRCS	National Resources Conservation Service
NWI	National Wetland Inventory
PWSS	Public Water Supply System
SDWA	Safe Drinking Water Act
S&PF	State and Private Forestry (USDA Forest Service)
SWARS	State-Wide Assessment and Resource Strategy
U&CF	Urban & Community Forestry (Guam)
UOG	University of Guam
USACE	U.S. Army Corps of Engineers
USFS	U.S. Department of Agriculture, Forest Service
USGS	U.S. Geological Survey
WERI	Water and Environmental Research Institute

Executive Summary

The forests on Guam have been impacted by typhoons, drought, wildfires, and invasions of introduced insects, plants and ungulate species. These impacts have greatly altered natural communities, and now threaten biodiversity and watershed functions. In addition, Guam is bracing for an unprecedented increase in population associated with the expansion of the U.S. Marine Corps, Navy, Army and Air Force on the island. This assessment recommends strategies for protecting forests, restoring forest ecosystems and reducing pollution to critical reef systems.

Purpose

This document was completed to meet the requirements of the 2008 Farm Bill and the redesign objectives of the USDA Forest Service State and Private Forestry (S&PF) programs. This State-wide Assessment and Resource Strategy (SWARS) provided the Guam Department of Agriculture, Forestry and Soil Resources Division (Guam Forestry) an opportunity to identify the highest priorities for forest resource management and a vision for the future of their forestry program.

Public Involvement

A critical component in completing the Assessment and Resource Strategy was the involvement of local, state, federal agencies and stakeholder representatives on the *SWARS Advisory Committee.* The Committee was consulted in identifying and prioritizing the major issues and threats to Guam forests and landscapes. This identification of issues and threats provided the direction for the assessment and development of strategies.

Forest Conditions and Trends

A fine scale vegetation type map (*SWARS Vegetation Map)* was developed to provide the foundation for evaluating forest conditions and trends, water resources and water quality impacts. At the island scale (~134,000 acres), approximately 42% of the area on Guam has tree cover, either recognized as forest types or as individual tree fragments; 30% of the landscape is in non-forest vegetation community types, 20% is developed or mixed use areas, and 8% is identified as bare ground.

Forest types for this assessment were mapped as either Mixed Forests or Secondary Forest. The Mixed Forest is a composite of forest types, including coconut forest and mixed gallery forest types and native limestone forests. These forests are moderately dense, with

a collection of understory shrub, vine and fern species, along with germinating and young trees. Forest types are relegated to ravines, sheltered depressions and river drainages in southern Guam, and on limestone soils in northern Guam. Secondary Forests occur on the lower edges of slopes above forested valleys and ravines that generally have a border of thickets of native and introduced woody species. These secondary forests are composed of dense, low-stature thickets with low species diversity, or are composed of a single species. This community contains both thickets dominated by the introduced *Leucaena leucocephala* and thickets of the native *Hibiscus tiliaceous*.

Assessing ***Non-Forest Community Types*** on Guam is critical in evaluating threats to forested acres, urban areas, and water quality. Non-Forest Communities include several Savanna Communities, Tall Grass communities, and Mixed Grass communities. The non-forest communities exhibit the highest fire prone risk to forests and communities and are the major source of sediment to waterways and the reef system. Other Cover Types were classified as Bare Ground, Developed Areas and miscellaneous other types.

Forest Health Conditions & Trends

The forest cover conditions were markedly shaped in the period up to and including World War II. The forest cover conditions on Guam do not appear to have changed substantially since the early 1950's. Comparison of forest cover types shows that in general, the forest and non-forest components have been relatively stable for much of the island (where old aerial imagery were available). A significant observation is the change in the urban landscape, with increasing urbanized zones, additional roads, and impervious surfaces (large shopping centers and parking lots). These areas were expanded into mostly non-forest and some forested zones (especially in the north of the island). In the next 5 years, increased urban development is proposed to be a significant disturbance to Guam's forest—the proposed buildup of military resources in the northern section of the island will displace a minimum of 10% of Guam's remaining forests (5,432 acres).

Urbanization and buildup is also a principle vector for disturbances from invasive species. Guam is the primary transportation and shipping hub to greater Micronesia and is expected to import large amounts of materials to accommodate the approximate 80,000 – 125,000 additional people that are likely be working and living on Guam during the buildup phase. This amount of incoming materials, including the estimated 1.1 million tourists per year, allow for ample opportunities for non-native species to arrive and establish on Guam.

Invasive species significantly alter forest structure, composition and resilience to other disturbance processes. Abiotic disturbances, including typhoons and fire contribute to the successful spread and establishment of invasive species, as well as provide points of entry to establish within the interiors of forest fragments. Influxes of equipment from infected areas can also be vectors of spread of invasives to other parts of the island, especially during the construction phases of the buildup.

Little quantitative data are available about the invasive species assemblages, their distribution or the current condition of their effects on forest health at the island-scale. The best-known major insect species that alter forest health on Guam are the Asian cycad scale (*Aulacaspis yasumatsui*) and the coconut rhinoceros beetle (*Oryctes rhinoceros* L.). The health and survival rate of ironwood trees (*Casuarina equisetifolia)* on Guam have been declining since a series of severe typhoons during 2002. A complex of biotic and abiotic factors is believed to be responsible for the dieback including fungi, bacteria, and insects including termites and a newly discovered gall-forming eulophid wasp.

Given the rapid changes associated with the military buildup that are scheduled to occur on Guam in the next 5 years, including the massive influx of raw materials from off-island, it is imperative that Guam Forestry and its partners gain the capacity and resources to help to prevent and detect invasive species before they gain a foothold. Quantitative data, personnel and staff capacity are all gaps in the effective management of a forest health program.

Coral Reef Decline and Ridge-to-Reef Management

Coral reef health as well as water quality in lakes (used as drinking water sources) is in decline where significant chronic sediment plumes occur. Deforestation, invasive species, fire, and land management practices increase the sediment flux from the uplands to the mouths of rivers that empty into the fringing reef and bays. A comprehensive Ridge-to-Reef restoration program is the best way to reduce the damage from peak flows and inputs of sediment sources. A Strategy in this document is to adopt a Ridge-to-Reef assessment and implementation approach to improve water quality and reef protection.

Identification of Issues and Threats to Guam Landscapes

The Stakeholder evaluation was based on eleven environmental attributes mapped at a coarse scale using the PIC Veg Layer developed by the Forest Service in 2005 combined

with other basic topographic spatial layers. The six key issues identified by the SWARS Advisory Council were:

- Issue 1. Wildfire and Public Safety
- Issue 2. Water Quality and Water Supply
- Issue 3. Population Growth and Urbanization
- Issue 4. Deforestation of Nativ
- Issue 5. Urban Forest Sustainability
- Issue 6. Degraded Lands

Following the identification of these issues, the assessment findings were completed to spatially identify areas and rank the severity of the issue. These fine scale spatial layers provided the foundation for identifying forests and forest fragments, modeling fire behavior and modeling sediment sources.

Fire is a keystone issue on Guam that affects many of the natural resources - preventing reestablishment of forests, threatening urban areas and public safety, and maintaining fire prone savanna and grasslands. These fire-prone areas increase sedimentation rates that directly degrade water quality and reef systems. Fire behavior risk was evaluated in 300 ft perimeters around forest fragments and 500 ft buffers around urban areas. Evaluating fire risk in categories from Low to Extreme provided a way to identify the highest priority areas for treatment.

Sediment contributing areas were identified in each watershed using vegetation types and topographic features. This assessment provides the tool to focus on treatment areas that will have the most benefit in reducing sedimentation and improving water quality and reef protection.

A synthesis of the stakeholder issues identifying approximately 13,000 acres of land that are the highest priority areas for treatment, where single treatments of planting forest will decrease sediment loads to reefs, increase forest fragment sizes, and decrease risk of fire to standing forests. (*Synthesis of Issues: Actions Meeting Multiple Objectives*, page 88).

Five-Year Strategic Plan

The Strategic Plan developed to address the stakeholder issues consists of the Resource Strategies, an Approach for Implementation and an evaluation of Guam Forestry's capacity to implement the plan.

Strategies are identified in a sequential order to address restoration, conservation of intact forests, reduce impacts to water quality and the reef system, mitigate the impacts of the military expansion, and address invasive species – all unifying themes developed from stakeholder issues. The strategies are organized to address the following components: Forest Service National Themes for SWARS, Strategy Description, Next Steps, State and Private Forestry Programs that Contribute, Key Stakeholders, Resources Needed, and Measures of Success. The six strategies include:

Strategy 1: Implement Highest Priority Plantings that Meet Multiple Objectives.

Strategy 2: Protect, Conserve and Restore Forests On State, Private, And Other Non-Military Lands

Strategy 3: Work with Military to Avoid Deforestation and Develop Tree Ordinance Laws for New and Old Development Zones

Strategy 4: Improve Fire Prevention, Control, Suppression and Prescribed Fire Activities through Organizing, Training and Equipping Staff and Resources.

Strategy 5: Implement Tree Planting and Monitoring Projects in Developed Areas, Open Space, and Parks In Communities (Urban Forestry).

Strategy 6: Implement a Forest Health Program: Unify Interagency Efforts to Prepare for Buildup

These strategies represent a new approach for Guam Forestry Programs that builds on the priority geographic areas identified in the assessment. The new approach stresses increased planning efforts in all program areas, a step-down approach from an island scale to a watershed and site scale, and a need for increased resources to have the program capacity to carry out these strategies.

Introduction

Guam People and Resources

Guam is the southernmost island in the Mariana Archipelago, located at 13°28' N, 144°45' E. It is the largest island in Micronesia, with a land mass of 560 km^2, and has a maximum elevation of approximately 405 m and a total shoreline length of 244 km. Guam is a volcanic island completely surrounded by a coralline limestone plateau. The relatively flat northern half of the island, which is primarily composed of uplifted limestone, is the site of the island's principle aquifer. The southern half of the island has more topographic relief and is comprised mainly of volcanic rock, with areas of highly erodible lateritic soils. The hilly topography on the southern half of the island creates numerous watersheds drained by 96 rivers.

The climate of Guam is characterized by a dry season that runs from December through June, and a wet season from July through November. Annual rainfall is high, averaging 90 to 110 inches of precipitation. Temperatures average 81 °F annually, with the coolest and least humid period being December through February. Guam is in "Typhoon Alley", and has been impacted by sixteen typhoons since 1970 and was devastated by four typhoons since 1960.[1].

Guam is surrounded by a highly valued reef system that contributes to one of the most species-rich marine ecosystems among U.S. jurisdictions. Over 5,100 marine species have been identified from Guam's coastal waters, including over 1,000 nearshore fish species and over 300 species of scleractinian coral. Guam's reef resources support numerous cultural and traditional uses, tourism, recreation, fisheries, and shoreline and infrastructure protection. Traditionally, coral reef fishery resources formed a substantial part of the local Chamorro community's diet which included finfish, invertebrates and sea turtle.

Guam's Chamorro culture derives from the island's first inhabitants that migrated from the direction of islands in Southeast Asia around 2000 BC. The settlers brought in plants – rice, breadfruit, sugar cane, bananas, coconuts and taro – to balance the heavy protein intake of fish. Being on the trade route between Mexico and the Philippines, islanders mixed with

[1] http://www.publicaffairs.noaa.gov/releases2000/apr00/noaa00r235.

people of Spanish, Mexican and Filipino heritage. Guam was claimed by Spain in 1565, and colonized by Spain beginning in 1668. The United States took control of the island in the 1898 Spanish-American war. During World War II, Guam was invaded by Japan and held by Japan for three years. After the war, Guam was established as an unincorporated territory of the United States[2]. This long history of war, colonization and occupation has shaped the natural resource background of the island, including the introduction of invasive species, and large-scale disturbances from intensive bombing, military operations, and resource exploitation.

Guam is the most heavily populated island in Micronesia, with an estimated population in 2007 of about 173,500. In 2000, the U.S. Census Bureau predicted the population growth rate to steadily decrease over the next 50 years, but this estimate did not take into account the planned movement of approximately 80,000 additional military personnel, their dependents, and peak immigrant labor to Guam by 2014. Such an influx coupled with associated migration to Guam by those seeking economic gain from the expansion, would increase the existing population by up to 38% in less than 10 years, potentially pushing the total population to over 230,000. This scale of disturbance is unique to Guam and represents a serious threat to natural resources and their management in a very short timeframe.

Guam's economy depends primarily on tourism, Department of Defense (DoD) installations, and locally owned businesses. Although Guam receives no foreign aid, it does receive large transfer payments from the general revenues of the U.S. Federal treasury into which Guam pays no income or excise taxes.

Vegetation on Guam has been shaped by frequent tropical storms and typhoons, human-caused grassland and forest fires, ungulate rooting, browsing and trampling, mass soil movements and erosion, nonnative insects and pathogens, invasive weeds, historical military actions, and historical timber harvest. The limestone soils in the north are covered with forest in areas that are not cultivated or urbanized. The southern part of the island features rolling to mountainous terrain in the deeply weathered volcanic soils. The volcanic soils on the southern half of Guam are covered primarily by grasslands and savannas, with forest fragments occurring in sheltered and leeward sites.

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[2] Wikipedia, http://en.wikipedia.org/wiki/Guam#History

The Government of Guam Department of Agriculture is the land management organization for the island; the Forestry and Soil Resources Division (Guam Forestry) [3] is a division of the Department and is the central agency with the responsibility of protecting and restoring the functional forest ecosystems and soil resources on Guam.

Purpose and Scope

The State-wide Assessment and Resource Strategy (SWARS) is a tool for Guam to identify the highest priorities for forest resource management and seek implementation of these strategies with on-island partners and with assistance from the United States Department of Agriculture, Forest Service (USFS).

SWARS is integral to the Forest Service's State and Private Forestry (S&PF) redesign and required as an amendment to the Cooperative Forestry Assistance Act (CFAA), as enacted in the 2008 Farm Bill. Each State, Territory and Freely Associated State receiving funds from S&PF programs is required to complete a SWARS within two years after enactment of the Farm Bill (June 18, 2008) to receive funds under the CFAA. SWARS requires two primary components:

1. **State-wide Assessment of Forest Resources** – provides an analysis of forest conditions and trends on the island and identifies and delineates priority rural and urban forest landscape areas.

2. **State-wide Forest Resource Strategy** – provides long-term strategies for investing state, federal, and other resources to manage priority landscapes identified in the assessment, focusing where federal investment can most effectively stimulate or leverage desired action and engage multiple partners.

The SWARS provides a basis for subsequent annual grant proposals, as authorized under several CFAA programs. The redesign deemphasizes program-by-program planning and emphasizes program integration to meet island priorities, which are in turn tied to one or more broad national themes and objectives. A brief description of the S&PF National Themes and Objectives is described below:

[3] In this document "Guam Forestry" will be used to refer to the Guam Dept. of Agriculture, Forestry and Soil Resources Division.

State and Private Forestry National Themes and Objectives

1. **Conserve Working Forest Lands**
    a. Identify and conserve high priority forest ecosystems and landscapes
    b. Actively and sustainably manage forests
2. **Protect Forests from Harm**
    a. Restore fire-adapted lands and reduce risk of wildlife impacts
    b. Identify, manage and reduce threats to forest and ecosystem health
3. **Protect and Enhance Public Benefits from Trees**
    a. Protect and enhance water quality and quantity
    b. Improve air quality and conserve energy
    c. Assist communities in planning for and reducing wildfire risks
    d. Maintain and enhance the economic benefits and values of trees and forests
    e. Protect, conserve, and enhance wildlife and fish Habitat
    f. Connect people to trees and forests, and engage them in environmental stewardship activities
    g. Manage and restore trees and forests to mitigate and adapt to global climate change

Agencies and Stakeholders

This document provides the technical assessment needed to identify priority landscapes for implementation of S&PF Programs at the island scale. This section briefly identifies the key agencies and stakeholders that have participated or play major collaborative roles in the SWARS.

Guam Forestry and Soil Resources Division (Guam Forestry)

The mission of the Forestry & Soil Resources Division (Guam Forestry) is to conserve, protect and enhance Guam's vegetative environment and sustain the natural resources which are dependent on healthy forests. The agency works with stakeholders to promote healthy and productive forests in both rural and urban areas throughout the island in partnership with the USDA Forest Service and other key stakeholders (see below).

USDA Forest Service, State and Private Forestry Program

The State and Private Forestry (S&PF) organization of the USDA Forest Service provides technical and financial assistance to landowners and resource managers through a variety of programs – Fire Management, Forest Health Program, Forest Legacy Program, Forest Stewardship Program and Urban and Community Forestry Program.

In 2008, the U.S. Forest Service began implementing a "Redesigned" S&PF program. The intent of the redesign is to improving the ability to identify the greatest threats to forest sustainability and accomplish meaningful change in high priority areas. The 2008 Farm Bill codified the main components of Redesign into law by amending the Cooperative Forestry Assistance Act (CFAA). The three national themes (listed in the *Purpose and Scope* section) are now set in law as national priorities and SWARS is required and is central to S&PF program delivery. At present, funding and management direction continues through the discrete S&PF programs and not through a centralized redesign process.

SWARS is intended to identify priority landscape areas through a collaborative approach. The assessment and strategies produced through this planning process will replace the individual program plans that were required for Forest Stewardship, Forest Legacy, and Urban & Community Forestry. In addition, programs that did not have federally-mandated planning requirements, such as Fire Management and Forest Health, will be addressed as part of this plan.

Stakeholder Involvement

Guam Forestry formed the SWARS Advisory Council to participate in issue identification and provide feedback throughout the process. Because Guam is a small community, many of the stakeholders serve on multiple committees and represented those stakeholder groups in the SWARS process. Member organizations are listed in Table 1 with the detailed list provided in **Appendix 1** beginning on page 141.

Table 1. SWARS Advisory Council

Organization
Chamorro Land Trust
Guam Department of Agriculture, Forestry and Soil Resources Division
Guam Department of Agriculture, Aquatic & Wildlife Division
Guam Environmental Protection Agency
Guam Fire Department
Guam Land Management
Office of the Governor, Guam Military Buildup
Guam Bureau of Planning
Guam Waterworks
Natural Resources Conservation Service
Nature Conservancy
NAVFAC Naval Facilities Engineering Command
(Northern) Soil & Water Conservation District
(Southern) Soil & Water Conservation District
University of Guam, Cooperative Extension Service
University of Guam, Water & Energy Research Institute of Western Pacific (WERI)
USDA Natural Resources Conservation Service
U.S. Fish and Wildlife Service

Forest Conditions and Trends

Assessment of existing forest conditions provides the foundation for identifying issues and threats to forests. Native forests of Guam have been extensively altered by conversion to mixed forests of non-native trees, and total conversion of forests to grasslands, savannas and barren lands. Given the extensive conversion of forests, the current condition of the forests is best summarized by accurately identifying where on the landscape forest communities occur in comparison to non-forest vegetation communities, developed areas and barren areas and what the composition of these communities are.

The assessment of the current conditions is summarized by addressing three aspects of the forest ecosystem:

1. A description of the distribution of vegetation communities on the island,
2. A summary of the major forest health issues and disturbances affecting forests, and
3. Connecting forest health and disturbances with watershed-scale effects, including implications for ridge-to-reef management.

The purpose of this section is to compile the base information, major issues and trends, and provide context for forest management that provides benefits for watershed processes (Ridge-to-Reef approach).

Land Ownership & Management

Land ownership on Guam is split between private (53%, 71,093 acres) and public management entities (47%, 63,238 acres). In the public sector, lands managed by the Department of Defense (Air Force and Navy lands) incorporate 34,048 acres, or ~25% of Guam. Approximately 1,814 acres are associated with National Park Service (NPS) and the National Wildlife Refuge (NWR), though the Park also manages marine reserve areas offshore of Agat and Piti/Asan watersheds. Approximately 20% of Guam Island is under local management (GovGuam, 27,376 acres).

The current forest cover conditions were evaluated (see *SWARS Vegetation Map* on page 16) and attributed to land ownership (Figure 1). Overall, all ownerships reflect the approximate distribution of forest cover found on Guam (56,520 acres, or 42% island-

wide). GovGuam, National Park Service, and Private Lands all have approximately 40-42% forest cover, reflecting the island-scale average. The DoD lands combined have 46% tree cover under their management, with Navy lands slightly below the island average (40%) and Air Force much higher than the island average (52% cover). The National Wildlife Refuge lands, while relatively small in a land-area comparison, are mostly forested with 71% tree cover.

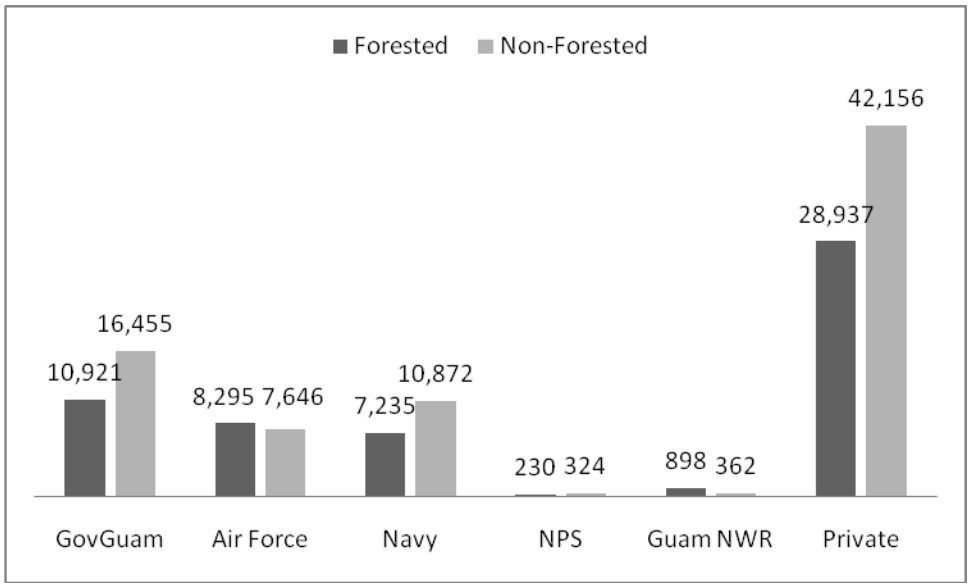

Figure 1. The distribution of forest and non-forested acres under each major ownership on Guam.

At watershed scales (see the *Watersheds on Guam* section on page 41), GovGuam has a management presence in all 19 major watersheds, with over one-half of the land ownership in 5 watersheds in western Guam (Table 2). The DoD has interest in 11 of the 19 watersheds; private ownership is the majority land owner in all but 5 watersheds.

Table 2. The ownership & management distribution of public and private lands on Guam. Public lands are delineated as GovGuam, Air Force, Navy, National Park Service (NPS) and the National Wildlife Refuge (NWR). Values represent the percentage of the land area within each watershed under each management responsibility.

Region	Watershed	Acres	Gov Guam	Air Force	Navy	NPS	NWR	Private
Eastern	Pago	6,683	8%	0%	0%	0%	0%	92%
	Ylig-Togcha	10,067	7%	0%	0%	0%	0%	92%
	Talofofo	15,016	4%	0%	56%	0%	0%	40%
	Ugum	4,851	28%	0%	2%	0%	0%	69%
	Asalonso-Dandan	4,183	25%	0%	0%	0%	0%	75%
	Inarajan	5,564	21%	0%	0%	0%	0%	79%
Western	Manelle	3,107	43%	0%	0%	0%	0%	57%
	Geus	1,120	75%	0%	0%	0%	0%	25%
	Toguan	903	89%	0%	0%	0%	0%	11%
	Umatac	2,447	67%	0%	3%	0%	0%	30%
	Cetti	1,928	71%	0%	1%	0%	0%	28%
	Taelayag	1,639	50%	0%	0%	0%	0%	50%
	Agat	2,511	12%	0%	22%	6%	1%	59%
	Apra	8,283	10%	0%	46%	0%	7%	37%
	Piti/Asan	1,993	34%	0%	12%	14%	0%	40%
	Fonte	1,575	13%	0%	10%	4%	0%	73%
Northern	Agana	8,717	9%	0%	3%	0%	0%	88%
	Mangilao	8,772	24%	2%	14%	0%	0%	60%
	Northern	44,971	23%	35%	7%	0%	1%	33%

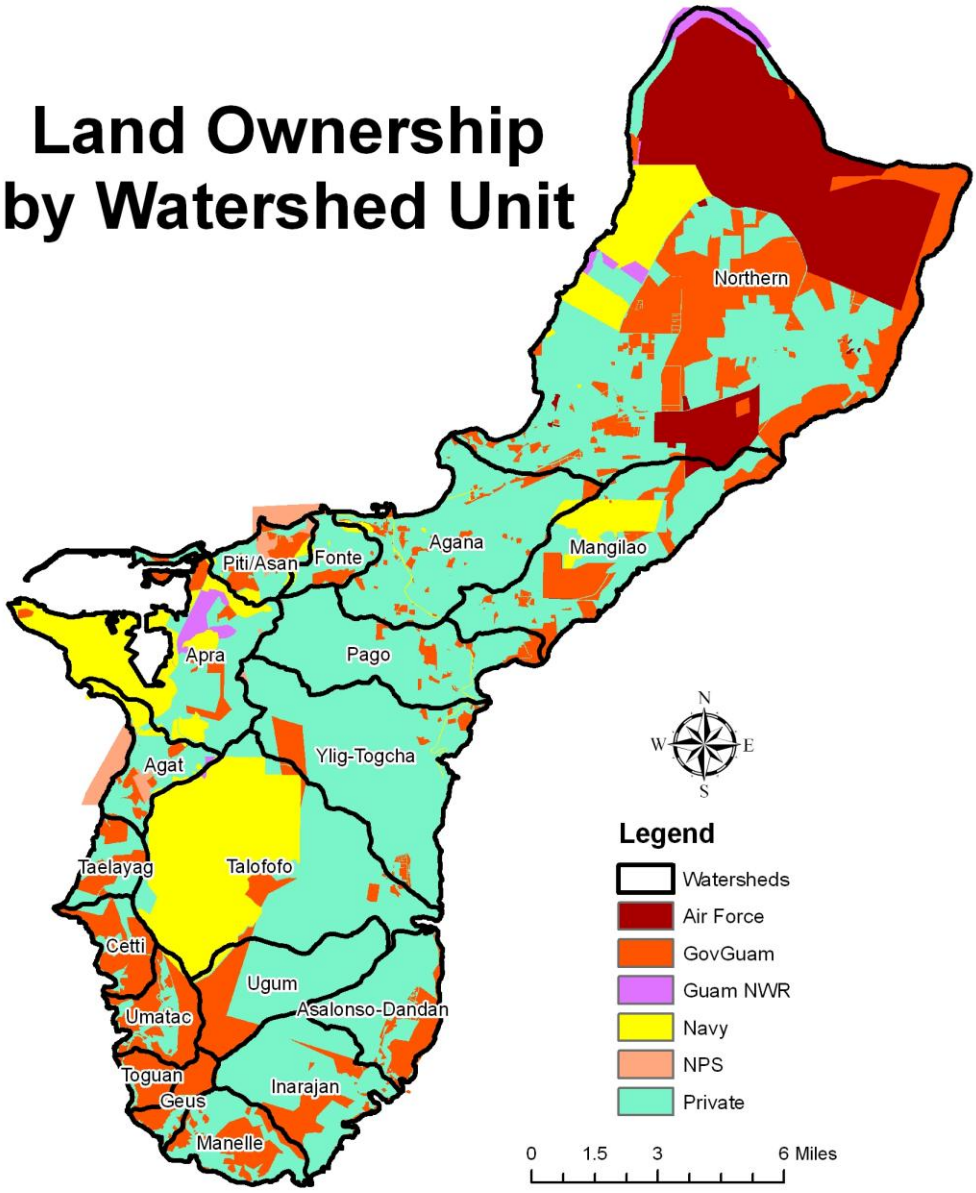

Figure 2. Land ownership distribution on Guam.

Vegetation Maps

Two vegetation and cover type maps were used in this assessment. The first map was created as a general land cover map and was used for identifying broad stakeholder issues. The second map was developed as part of the SWARS to provide fine-scale resolution to identify disturbance potential to forests, including identifying individual trees and forest clusters, risk of hazardous fire behavior, areas of erosion and sediment delivery to streams, and priority areas for active forest management. Both maps are useful for their intended purpose in the SWARS, though the fine-scale map provides more accurate resolution for forest and non-forest vegetation, allowing for strategy development and implementation actions. Brief descriptions of the two major map efforts are described below.

Stakeholder Issue Maps (PIC Veg Layer)

The map used to identify issues during the stakeholder process was developed in 2005 by the USFS and was based on IKONOS imagery from 2003-2004, and field data collected in June 2004 and March 2005. This map is referred to as the "***PIC Veg Layer"***, and characterizes the major land cover contrasts of Guam.

SWARS Vegetation Map

To meet refined objectives of the SWARS in characterizing potential disturbances and priority areas (including watershed processes), an alternate vegetation map was generated using aerial imagery, LiDAR[4] and ground truth data (Appendix 2). This "***SWARS Vegetation Map***" was made with the focus on identifying *individual tree crowns* (forest fragments) and resolution of *non-forested* environments, especially grasses, savannas, and exposed soil types. The mapping of individual tree crowns permitted analyses of affected forest cover, including forest edge effects at fine scales (wind, fire, development). The focus on non-forest types was particularly important for determining fine-scale fire behavior risk (i.e. long flame lengths, fast rates of spread), erosion potential, and feasibility of expanding current forest fragments. The ultimate goal was to gain fine-scale resolution of potential sites for restoration or conversion into forest that meets multiple restoration objectives (fire risk, erosion, etc.).

[4] Light Detection and Ranging imagery provides a fine-scale representation of elevation of bare earth and highest-hit (vegetation and structure heights) features on the landscape.

Methods used for developing *the SWARS Vegetation Map*, and a comparison with the *PIC Veg Layer* is presented in Appendix 2.

Description of Forests and Vegetation Types

At the island scale (~134,000 acres), the *SWARS Vegetation Map* identified that approximately 42% of the area on Guam has tree cover, either recognized as forest types or as individual tree fragments; 30% of the landscape is in non-forest vegetation community types, 20% is developed or mixed use areas, and 8% is identified as bare ground (Table 3).

Table 3. Grouped vegetation classes for the SWARS Vegetation map.

Vegetation Class	Total Acres	Percent of Guam
Bare Ground	10,371	8%
Developed	26,267	20%
Forest	56,520	42%
Non Forest	40,727	30%
Other	446	<1%
Total Acres	**134,331**	

The 19 major watersheds of Guam were divided into three groups: western, eastern and northern regions to capture the major changes in soils and topography. The western and eastern watersheds are mostly relegated to southern Guam. Further discussion on the delineation of watersheds and watershed groups is described in the *Watersheds on Guam* section.

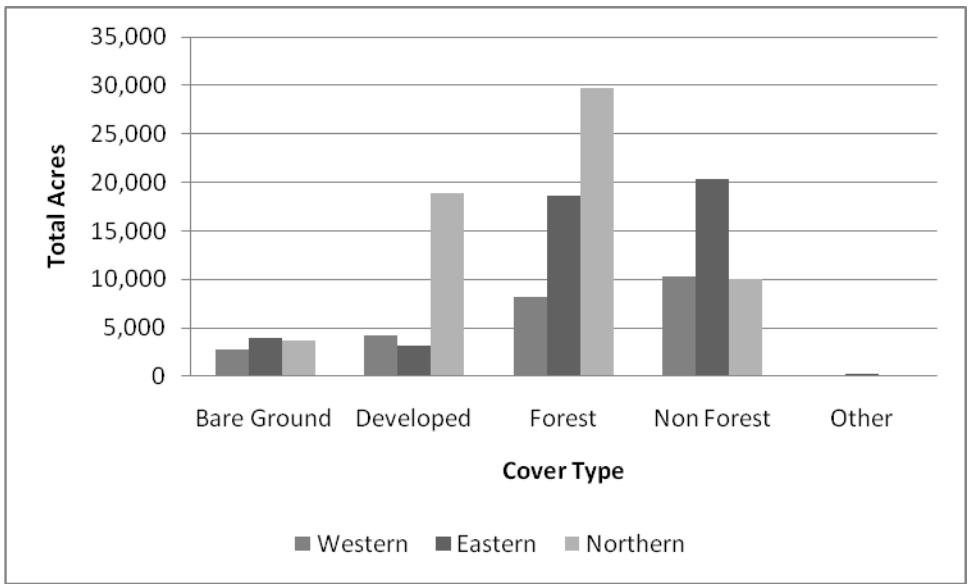

Figure 3. Total acre distribution of the major cover types, aggregated by watershed management group (Western, Eastern and Northern watersheds).

Non-forested cover is mostly found within the western and eastern watersheds of southern Guam; on average, these watersheds have 45% of the land area in non-forested cover. Developed cover types were predominantly found in the northern watersheds, and the western watersheds beginning in Agat and extending to the North and Ylig in the East. Overall, between 20% and 50% of the land area within these watersheds were developed, with a total of 24,053 acres in 8 watersheds, representing 92% of all of the developed land area on Guam (Figure 3 and Table 4).

The highest proportions of forest lands were found in the Northern, Mangilao, and Talofofo watersheds; combined these three watersheds contain 59% of all of the forest cover of Guam. This is of particular importance as they also contain the majority of the proposed military buildup lands (see *Threats to Forests from the Military Build-up*).

A broad overview of the distribution of major cover types from the SWARS Vegetation Map is displayed in Figure 4.

Table 4. Land cover distribution for the 134,331 acres of Guam (source SWARS Vegetation Map). Results from Table 3 and Figure 3 are expanded by watershed and watershed group.

Region	Watershed	Bare Ground	Developed	Forest	Non-Forest	Other
Eastern	Pago	6%	9%	40%	45%	0%
	Ylig-Togcha	6%	14%	43%	37%	0%
	Talofofo	7%	5%	44%	43%	1%
	Ugum	10%	0%	34%	56%	0%
	Asalonso-Dandan	11%	5%	47%	37%	0%
	Inarajan	16%	3%	26%	55%	1%
Western	Manelle	14%	3%	32%	51%	0%
	Geus	5%	10%	44%	41%	0%
	Toguan	8%	4%	22%	65%	1%
	Umatac	9%	3%	36%	51%	0%
	Cetti	15%	1%	22%	62%	0%
	Taelayag	16%	7%	23%	53%	0%
	Agat	10%	28%	35%	27%	0%
	Apra	13%	27%	31%	29%	1%
	Piti/Asan	6%	21%	32%	41%	0%
	Fonte	3%	24%	45%	28%	0%
Northern	Agana	4%	50%	33%	13%	0%
	Mangilao	4%	24%	56%	15%	0%
	Northern	7%	28%	49%	17%	0%

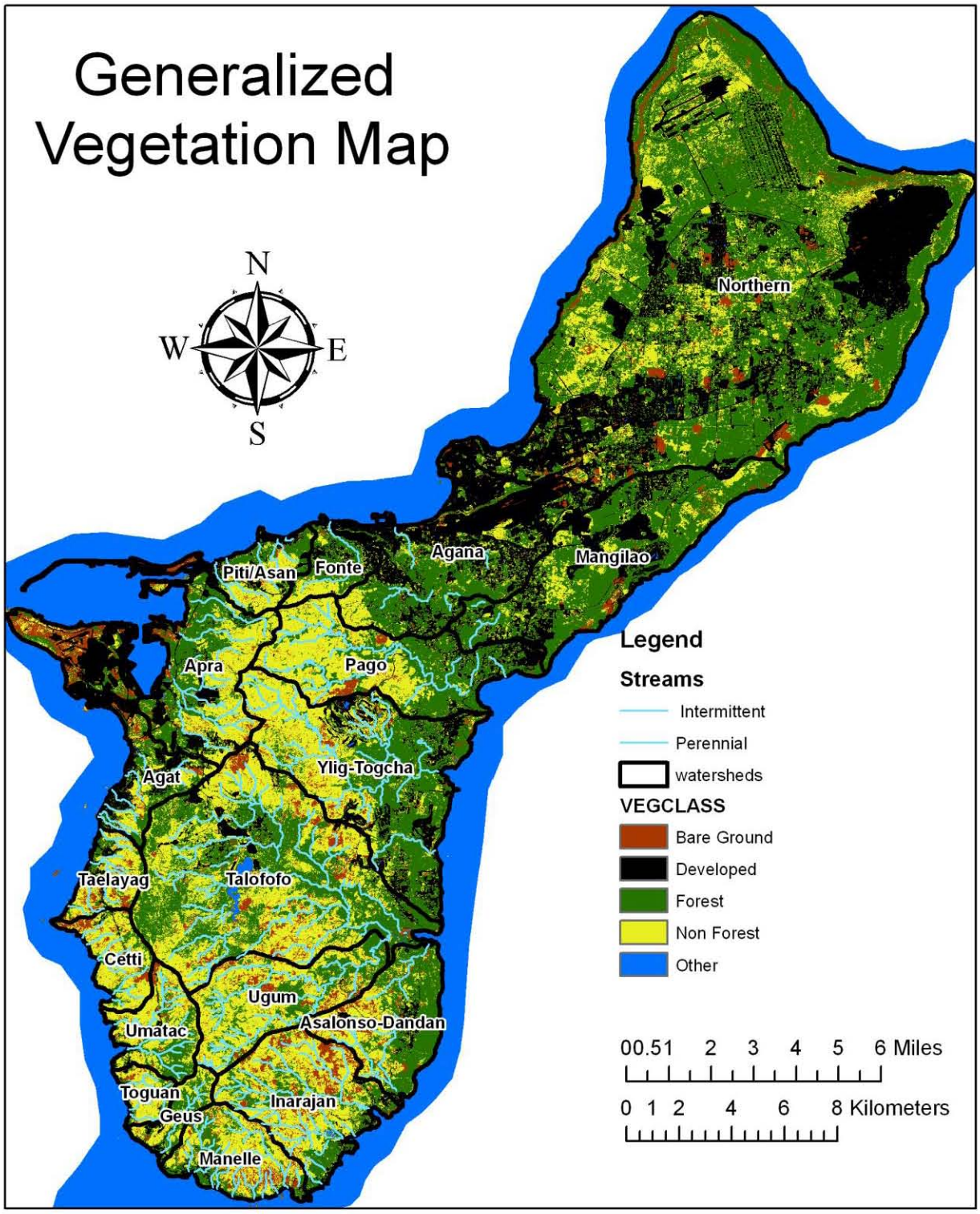

Figure 4. Broad vegetation classifications identified in the fine-scale SWARS Vegetation Map.

Forested Communities

The ground truth data available for the SWARS vegetation map had three major forest types in approximately 76 total acres (approximately 14% of 542 ground truth acres). Sample size was not adequate to scale up coconut forest, and it was grouped with the mixed forest type (see Appendix 2 for further discussion on methodologies). The two mapped forest types include the following:

- **Mixed Forest:** This type is a composite of forest types, including coconut forest and mixed gallery forest types and native limestone forests. These forests are moderately dense, with a collection of understory shrub, vine and fern species, along with germinating and young trees. Forest types are relegated to ravines, sheltered depressions and river drainages in southern Guam, and on limestone soils in northern Guam. Major species include *Pandanus tectorious*, *P. dubious, Ficus prolix, Glochidion mariannensis, Arec catechu, Premna obtusifolia, Cocos nucifera*, and in some areas, *Artocarpus mariannensis, Cananga odorata, Ochrosia oppositifolia, Bleekeria mariannensis, Calophyllum inophyllu, Hernandia labyrinthica* and *Bambusa vulgaris*. Species richness drops toward the forest edges as this forest type transitions out of ravines and into upland savanna or grassland environments.

- **Secondary Forest.** Lower edges of slopes above forested valleys and ravines that generally have a border of thickets of native and introduced woody species. These secondary forests are composed of dense, low-stature thickets with low species diversity, or are composed of a single species. This community contains both thickets dominated by the introduced *Leucaena leucocephala* and thickets of the native *Hibiscus tiliaceous*. Areas dominated by *Pandanus tectorius* (*P. fragrans*), and bamboo, common at forest edges may be included in this mapping unit.

For purposes of the SWARS Vegetation map, forest environments were pooled to have the sole distinction of "Forest" to conduct analyses of tree densities and trees at risk. No comprehensive forest survey is known to exist to identify patches of primary forest remnants (data gap) [5].

[5] See Data Gaps and Recommendations Section for discussion on refining forest mapping.

Non-Forest Communities

Higher numbers of ground truth samples were available to conduct a spatial differentiation of non-forest communities. For the SWARS Vegetation map, the following communities or cover types were observed:

- **Savanna Communities with Trees:** Savanna lands with mid- to tall structure grasses and scattered tree species. Often *Casuarina equisetifolia* are established seedlings that can develop into thickets if fire events are avoided.

- **Savanna with Shrub Component:** Savanna with scattered, generally short-stature native shrubs. The most abundant shrub is *Scaevola taccada*, with the endemic *Glochidion marianum*, *Timonius nitidus* and *Myrtella bennigseniana*; and *Wikstroemia elliptica* also being common.

- **Savanna with Low Grass:** Mostly open savanna types as described above with little tree cover. Mid- to low-grass structures dominate.

- **Eroded Savanna:** Low grass structures and bare soils are interspersed with "clusters" of other savanna types. Expansion of native vegetation from clusters to bare soil areas will require focused soil improvement treatments. Areas of unusually high species diversity can be found in these "clusters" and offer good sources for propagating and direct expansion of native vegetation into neighboring types.

- **Tall Grass:** This community type is dominated by tall grasses, especially the native *Miscanthus floridulus*, a 2-3m tall, flammable coarse cane-like grass called *neti* or swordgrass. Also, in moist communities, this type also contains *Phragmites* marshes; these types are generally monospecific dense patches of *Phragmites karka*, a 2-5m tall grass growing densely in moist depressions (seeps, springs) and along shallow waterways in open areas.

- **Mixed Grass:** Mixed grass communities are dominated by low to medium stature (generally <1m tall) grasses such as the introduced *Pennisetum* spp., *Paspalum* spp., and *Dichanthium bladhii*. *Pennisetum* generally grows admixed with other grasses, sedges and shrubs, while *Dichanthium bladhii* forms extensive, dense, almost monospecific stands on upper slopes. Some fern and herb species (e.g. *Stachtarpheta jamaicensis*, *Hyptis*) also occur within the grass community. *Dimeria* grasslands are also included in this type. *Dimeria chloridiformis* is a short statured

grasses (< 0.5 m), an endemic soft low-growing bunch grass covered with silvery hairs. Dimeria grows in scattered clumps and is often mixed with other species such as the native *Lycopodium cernuum*, *Miscanthus*, and the invasive grass *Pennisetum* spp. *Dimeria* favors level to gently rolling terrain. Often occurs with other grasses on slopes, *Dimeria* meadows generally occur on more level ground where erosion is not as high.

Other Cover Types

Cover types that did not focus on vegetation profiles used a different range of input data that were included into the SWARS Vegetation map. These types included bare ground, developed lands, open water, etc. Significant types are described below:

- **Bare Ground.** Areas designated as Badlands (from *PIC Veg Cover*) were used to characterize exposed soils on the landscape. These are typified by mostly bare soil, with exposed C-horizon, sapprolite or hard bedrock and very little vegetation. Some areas have early successional vegetation, principally *Gleichenia* and *Lycopodium cernuum*. Vegetation occurring on erosion scars of red soils differs somewhat from those on grey soils. This classification was also used to identify signatures of exposed soils between trees, grasses, and other classifications. Exposed rock outcrops and unconsolidated shore (lake and ocean edges) were grouped into this association[6]. Detection limits were set at a 2m resolution.

- **Development.** Areas of development were sourced from the *PIC Veg Cover* and merged into the SWARS vegetation map. These are classified as "High Density" and "Open Space". High density classifications generally followed impervious surface designations, and open space referred to areas that were partially vegetated or otherwise were within close proximity of developed areas.

- **Other Types:** Open water and other designations with low confidence were consolidated. Few instances were lumped into this category.

[6] Resolution for the different bare ground types was maintained in the sediment modeling component of the SWARS, but consolidated here for reporting purposes.

Forest Health Conditions & Trends

"Forest health" [7] is defined as a descriptor for forest conditions and trends, including the resilience of forested environments to a range of biotic (living) and abotic (non-living) disturbances. This section begins with quantitative discussion on the current structure of forests, an analysis of available trend information in forest cover, and a qualitative discussion on a range of abiotic and biotic disturbance regimes and their known status and effects on the forests of Guam.

Forest Structure: Forest Inventory & Analysis (FIA)

In 2002, the Forest Service implemented sampling along a systematic grid of 46 permanent plots evenly distributed to measure species, size, density, and damage to obtain tree- and plot-specific measures, as well as to systematically sample the vegetation structure on Guam (Figure 5). FIA data are useful in regional assessments of general forest condition and can provide base information necessary for conducting site-specific surveys and inventories. In addition, the data provide a useful data source for determining allometric relationships among species sampled, including growth trends, successional dynamics, and disturbance damage upon multiple visits (e.g. every 5 years).

Damage due to disturbances (biotic and abiotic) was reviewed using the pooled plot information available in the FIA dataset (Figure 6). The measured trees in the 46 plots were expanded by FIA to yield a representative total of 76,951,724 trees ≥1 inch diameter at breast height (dbh, 4.5 ft above ground) on Guam. Overall, approximately 87% of the total estimated population of trees had no damage. Of the proportion of damaged trees (13% of the population), approximately one-third (4% of population) were observed to have weather damage (storm events), another third (4% of population) had damage due to completion from other plant species (most notably vines), and the final third had insect damage, diseases, or were damaged from other falling trees. A small fraction of trees (0.3% of the population) had damage from animals, tree cutting or other unknown causes.

[7] "Forest health" (in sentence capitals) is used here as being analogous to overall condition. "Forest Health" (capital letters) refers to the specific S&PF program and activities that it funds.

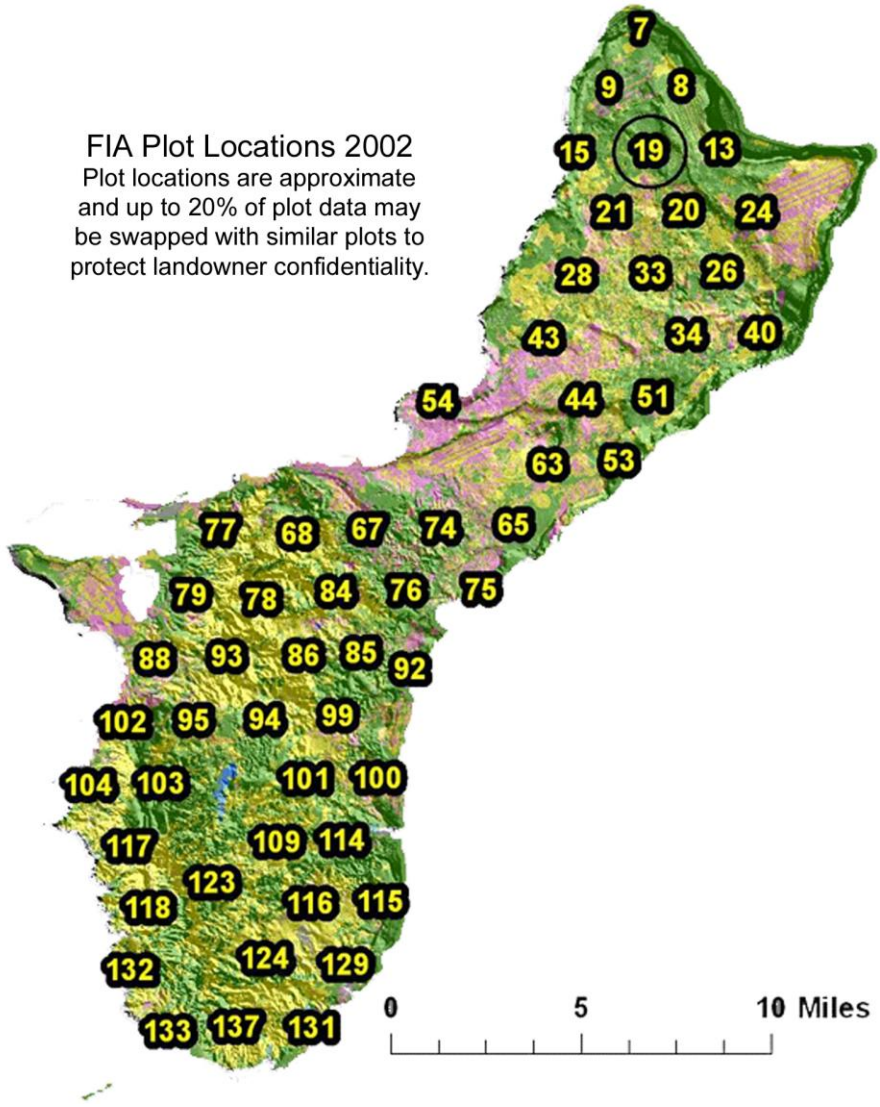

Figure 5. Approximate locations of FIA plots on Guam, 2002. Source: Donnegan 2002.

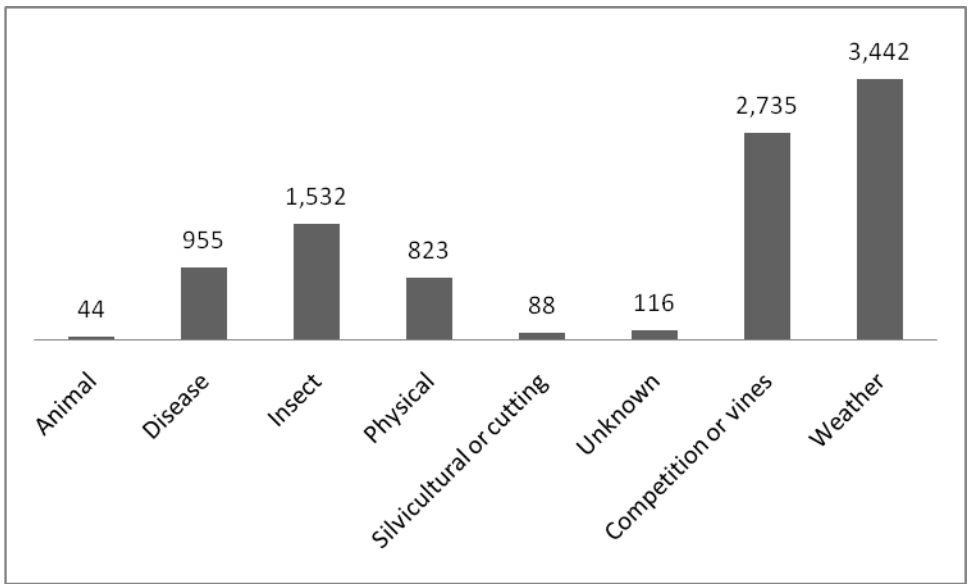

Figure 6. The number of representative trees (in 1,000s of trees) having sampled damage. Approximately 13% of the total population were sampled to have damage. This represents the distribution of each major damage code.

The FIA data projected a total of ~1.5 million tons of biomass, within 46 tree species. Overall approximately 89% of the forest structure – measured as tree biomass – was found represented in the 1 – 15 inch dbh size classes (Figure 7), with the highest species diversity (37 species, or 80% of all measured species) represented in the 5 – 10 inch dbh tree size class. This relatively small-diameter and short-statured forest reflects the disturbance regime inherent on Guam, with high winds associated with tropical storms, and very high forest edge to contiguous patch ratios that increase a condition of "biomass collapse", or generally lower capacity for larger trees near to the edges of remnant stands (Laurance and Bierregaard 1997). Increased pressures from shade intolerant vine species on or near forest edges increases the damage potential for these stands, which in turn decreases resilience to windthrow and storm effects. Combined, this competitive pressure and weather-related disturbance accounted for 6,177,000 damaged trees within the population (Figure 6), or approximately 8% of the total tree population estimated for Guam. Expansion of forest edges to increase resilience from edge-effect disturbances is a key management goal for increasing overall forest health.

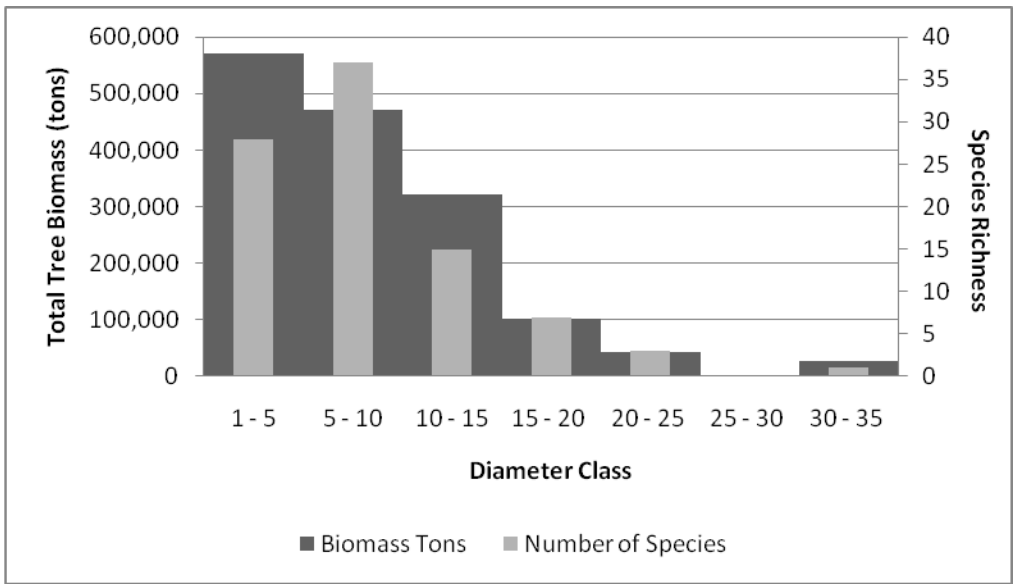

Figure 7. Total biomass (dark grey) by size class, and the number of species (species richness, light grey) represented from FIA data for Guam Island. The majority of the diversity and forest structure is captured in relatively small diameter classes (1 – 15 inches dbh), with the 5-10 inch size class being the most representative for Guam's tree species.

Observed Trends in Forest Cover

Since western colonization, and in particular up through and including World War II, Guam's forests have been dramatically altered from their native state, from a mostly forested environment to a highly fragmented landscape, especially in southern Guam. The current northern limestone vegetation has been described as being mostly second growth. A long history of disturbance by Guamanians and by frequent typhoons coupled with the effects of World War II and post-war military activities has left little undisturbed primary forest on the island. Primary forests, though not surveyed or mapped, are believed to be in scattered patches, mostly on cliffs and relatively inaccessible terraces on the northern half of Guam. In southern Guam, the older successional forests are more commonly found in ravines, valley bottoms and on steep (isolated) slopes (Mueller-Dombois & Fosberg, 1998).

Post-war forest trends were examined using aerial photographs. A partial set of existing aerial imagery from 1953 was qualitatively compared with the recent (2005) digital orthoquad imagery to compare forest cover and general land use (example, Figure 8). In a large part, the forest fragments had shown little change in cover, with perhaps areas with very minor forest expansion in the 2005 as compared with the 1953 images, especially in the riparian zones. Badland areas were also observed to be relatively constant in the two

images; urban development appeared to be the major land cover change when comparing the two photo series.

Figure 8. View of southwestern Guam (Near Cetti Bay and the village of Umatac) in 1953 (left) and 2005 (right). Note there have been little changes to vegetative cover over this 52 year time period. Bright "badland" areas can also be seen in both photographs—the total land area does not appear to differ greatly during the time series.

The relative constancy of forest cover can be mostly attributed to a long history of fire (arson based), with forest fragments being relegated to areas of low access, topographic isolation, and/or increased moisture regimes. Despite the relatively constant forest cover, the *condition* of the forest has declined over the past 50 years, in response to continuous abiotic disturbance pressures and a number of non-native species being introduced (biotic pressures).

Observed Trends in Urban Environments

Population growth on Guam has nearly tripled since 1960, as documented by the World Bank estimates of populations for *residents* of Guam (Figure 9). Population growth has generally increased from approximately 1,800 per year in the 1960s to approximately 2,500 per year in the last decade (World Bank, 2010). These values do not reflect the numbers of non-resident aliens. Based upon arrival statistics, approximately 1.1 million people enter Guam each year, the majority (61%) for holiday or sightseeing in the urban areas--mostly in Tumon--for a 3-4 day visit (Guam Visitor Bureau Statistics, 2009).

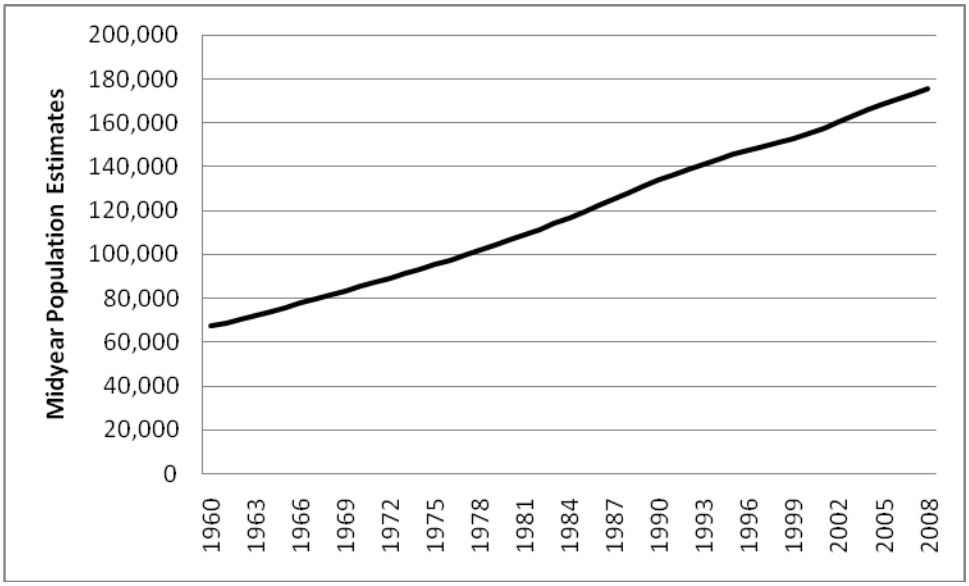

Figure 9. The midyear population estimates for residents of Guam (1960 - 2008). Source: World Bank

Viewing total population expressed as a percentage living in urban zones (Figure 10), the population of Guam has shifted markedly from rural environments (~50% - 60% in the 1960s) to a static proportion exceeding 90% of the population living in urban areas since 1978. It is not known if this surge was more the result of building additional townships in the 1970s (i.e. change in classification from rural to urban without relocation), or if residents left rural areas for the cities and towns. Both factors likely contributed; the current distribution of residents in the urban zones has remained fairly stable, at approximately 93% of the island's population. This suggests that the trends in urban populations mirror similar rates of increase as the island-wide population growth over the past three decades.

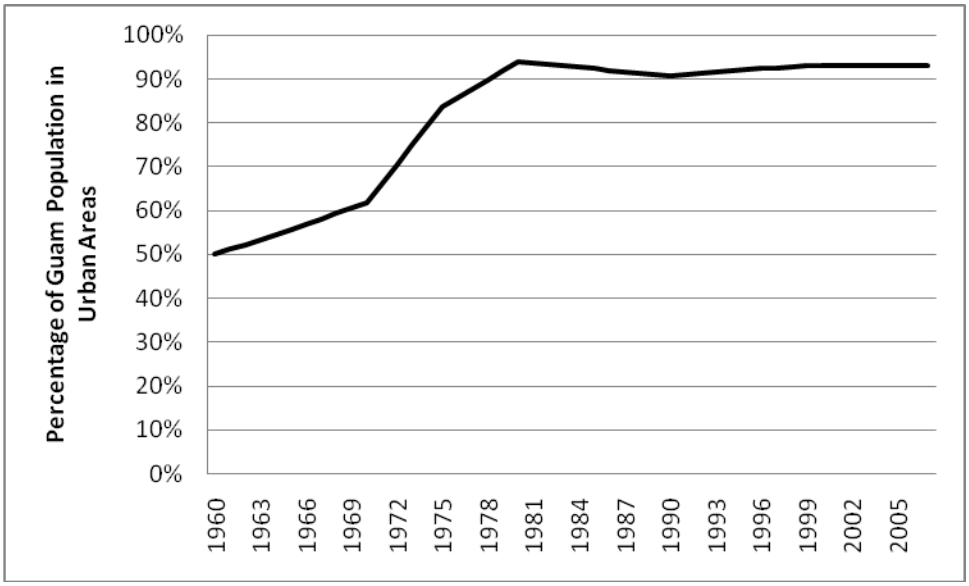

Figure 10. The estimated midyear percentage of Guam's total population living in urban areas. Source: World Bank.

Guam's population was viewed as a percentage of greater Micronesia (CNMI, FSM, RMI, and Guam combined, Figure 11)[8], there was a general decline in the proportion of the population of greater Micronesia on Guam between 1976 and 1995, with a steady proportion of approximately 41% of Micronesians residents of Guam over the last decade. The relatively high proportion of Micronesian residents in Guam, coupled with Guam's importance as the regional hub for commerce and travel, underscores Guam's vulnerability to urban expansion and a vector for non-native species invasions on Guam and to other islands in Micronesia.

The population values are predicted to change markedly over the next 5 years with the scheduled military expansion of approximately 8,000 military personnel to be relocated from Okinawa, Japan to Guam by 2015 (see the *Threats to Forests from the Military Build-up* section on page 69). The proposed permanent personnel are likely to only be a fraction of the total number of people involved with the military expansion, including families, contract labor, merchants, and other support staff. As such, the projected changes to Guam's population and urban environment is most likely not to follow historical trends of steady increase (as in Figure 9), as there will likely be a surge in off-island labor and other population pressures that will necessitate expansion of urban areas, newly developed

[8] Population data for Palau was not available until 1981 and was excluded from this analysis.

housing, shopping centers, increases in road density, and other factors that will permanently alter the urban landscape of Guam.

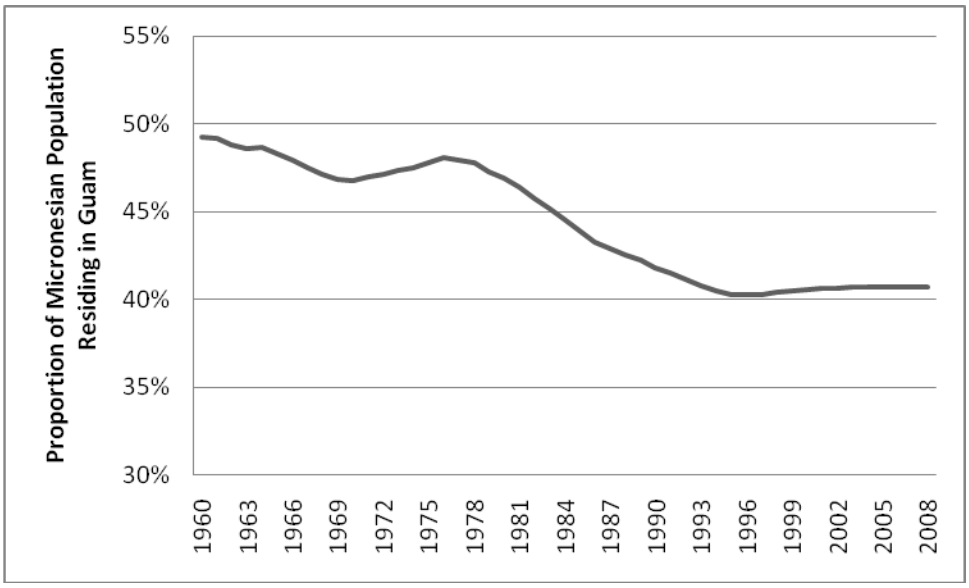

Figure 11. The proportion of Guam residents to those within greater Micronesia (CNMI, FSM, RMI, and Guam combined). Data from Palau were excluded because they were not available until 1981. Source: World Bank.

Development has often involved the near-complete clearing of a parcel's forests and vegetation, followed by the planting of trees for primarily beautification and landscaping. There is evidence of native tree species that are either retained, or planted at later times to increase forest cover within the urban zones (especially by Guam Forestry). Given the large influx of population that is expected to enter Guam in the next 5 years, and that most of the population resides in urban areas, it is important to consider methods to avoid deforestation and plan for green spaces in urban planning designs (i.e. tree ordinances and open space requirements), including examples of "urban growth boundaries", where urban areas must be contained within a set boundary to allow development for a set period of time (~20 or 50 years worth of growth) with appropriate green space prior to the annexation and development of additional rural lands (examples are found in Oregon[9], Washington and Tennessee).

[9] For example, Portland, Oregon requires 20,000 acres, or approximately 20% of the urban zone, to be in vacant land (parks, greenspace, etc.) within a delineated 50-year urban growth boundary before expanding development outside the area.

Guam Forestry has implemented tree planting projects with willing stakeholders in urban environments to move toward increased urban forest cover and public awareness of urban and community forestry activities. These activities have involved planting in public and private schools, public parks, Government agencies, and private businesses. Public activities have included Arbor Day community planting activities, pest eradication, assistance and advice to communities within the wildland-urban interface, coordination with non-profit volunteer groups for planting activities, and public education projects to emphasize the importance of trees in the urban setting.

Abiotic Disturbances Affecting Forest Health Conditions

In addition to urban development, abiotic factors including fire, typhoons, development, wars, and other "non-living" disturbance vectors have affected Guam's forest structure, composition, and resilience to withstand future disturbances—both biotic and abiotic.

Typhoon and tropical storm damage typically results in pruned branches, patch-scale (or larger) defoliation events, and salt water inundation mortality due to storm surges (Kerr 2000). This results in damaged trees and wind throw (gap disturbances) and lower overall leaf area for the forest following the storm event. Decreased leaf area promotes opportunities for "pioneer" species to establish within forest fragments – providing opportunities for aggressive non-native plants to fragment native species distributions deep within larger forest patches. Winds and leaf debris also promote expansion of invasive pests, including colonization originating from urban areas and spreading to non-infected forest fragments. Increased incident sunlight heat energy from lower leaf area also decreases available moisture for the recovering forests, which leads to drought stress (especially for native shade intolerant species) and higher success for invasive pests to establish and cause mortality.

Wind damage effects have also likely contributed to lower resistance in native forest against pests, including cycad scale, coconut rhinoceros beetle, and potentially *Casaurina* decline (see sections below). In addition, wind damage generally lowers the overall canopy stature along the forest edge, which allows for higher potential flame lengths and active crown fire activity (higher mortalities) during fire events and additional wind shear stress further inside forest fragments.

Increased fine fuels generated from wind thrown leaves and small sticks and branches (e.g. 1-100 hour fuels) also contribute to increased flame lengths, heat, and rate of spread of fires post-storm. These factors combine to cause mortality to forest edges and further

fragment the remaining forests. Fire is a non-native disturbance to Guam that has been introduced to increase hunting opportunities for deer and other wildlife. Frequent fires perpetuate a cycle of sprouting grasses and mortality to fire intolerant species (most trees on Guam). Most fires typically do not penetrate deep within large forest fragments; the primary damage and mortality occurs on the outer edges, with heat damage that lowers resistance of surviving trees to other invasive pests. In addition to damage to the forest, fire also increases erosion and delivery of sediment to water sources, including domestic water supplies.

Urban development affects forests in three different ways: direct removal (deforestation), fragmentation and access (for pests, fire, etc.) through roads and inter-development areas, and degradation through loss of habitat characteristics (through compaction, pollution, vandalism, fire access, and other factors). Approximately 93% of the population of Guam lives in urban zones, and there is predicted to be a surge of population growth associated with the military buildup (see further discussion of these potential impacts in the *Threats to Forests from the Military Build-up* section on page 69). Deforestation of native forests and replacement with ornamentals changes the species diversity and seed source pool for native species on Guam. Degradation associated with urbanization also decreases overall resilience for neighboring forests to wind damage, non-native species, and limits overall restoration opportunities through active planting. Pests including CRB and cycad scale were first discovered in the Tumon Bay area, the highest population of tourists on Guam. Further development associated with the impending spike of residents and off-island laborers will potentially increase the influx of additional non-native insects and diseases. The influx of new pests will affect urban forests and potentially increase the spread to native forests outside the urban zone.

Biotic Disturbances Affecting Forest Health

The impacts of biota-induced disturbances to forests are often increased by the accompanying aboitic disturbances on Guam. The majority of biota-induced forest health concerns on Guam can be attributed to invasive species that significantly alter the forest structure, composition, and resilience to other disturbance processes. Guam is a central pass-through point for the transport of goods and people (including military operations) from Asia and North America, and represents the local consolidation hub for the rest of Micronesia (e.g. approximately 1.1 million people enter Guam per year and Guam is the primary shipment hub for cargo). As such, Guam is often the first island of introduction of non-native species entering Micronesia and represents the geographic first line of defense

for invasive species prevention in many of the US-affiliated islands in the western Pacific as well as for preventing potential introduction pathways westward from Asia to Hawaii and North America. There is an enormous potential for the rapid and large-scale introduction of new invasive species to Guam in the next 5 years, particularly through the proposed military buildup, which will involve personnel, support staff, off-island contractors, and increased cargo traffic from Okinawa and other parts of Asia, Hawaii and the Mainland US. There are critical needs for adequate prevention, quarantine and early detection programs on Guam.

Guam is a participant of the Micronesian Regional Invasive Species Council (RISC), which has developed a strategic plan and bylaws for the group in 2007. The goal of RISC is to prevent the introduction of invasive alien species to islands across the region and to control and reduce existing populations, or (when feasible) eradicate populations through coordination with efforts throughout Micronesia. The strategic plan outlines 5 main goals, including increasing public awareness, increase communication among RISC partners, provide policy and management recommendations, develop human and financial resources to implement goals, and to expand membership to greater Micronesia. This plan contains some of the building blocks for regional collaboration, including detection, isolation and control.

Beginning in 2009, the DoD has funded the development of a Micronesia Biosecurity Plan (MBP) to identify key species and pathways for increased risk to introduction and establishment of invasive species in Micronesia (Palau, Guam, CNMI, FSM and RMI). To date, Guam Forestry has not been an active participant in the plan, through as part of the SWARS strategies (see Strategies chapter), and there are planned actions to work with APHIS to assist with the terrestrial pest risk assessment to ensure significant forestry pests are included in the overall MBP.

Though there is some quantitative data for few species (discussed below[10]), few quantitative data are available about the broader invasive species assemblage, distributions or the current condition of the distributed effects on forest health. This is a critical data gap for Guam Forestry and partner organizations in the effective management of a forest health program, including integrated pest management (IPM), and for contributing (and potentially leading efforts) for regional efforts such as RISC and the MBP.

[10] Further discussion of animal species is in the *State Wildlife Plan* section, beginning on page 52.

This section briefly summarizes the best known major invasive species that alter forest health conditions. It is important to note there are synergies associated with other abiotic factors discussed above, and the establishment, spread, and success for these biotic stressor species.

Asian Cycad Scale

The Asian cycad scale (*Aulacaspis yasumatsui*) was detected in 2003 on the ornamental king sago (*Cycas revolute*) in Tumon Bay and rapidly spread on the common ornamental within urban areas. The scale also affects native species of cycads (*C. mironesica*) that is a co-dominant species in the native limestone and riparian forests. In 2005, the cycad blue butterfly (*Chilades pandava*) was detected; this species further decreases resilience of native cycads through loss of leaf area and resistance to the effects of the scale. Mortality rates of native cycad between 2004 and 2007 have been estimated to be approximately 9% per year on permanent transects (Marler and Lawrence 2010), suggesting the threat of extirpation within the decade. In 2006, native *Cycas micronesica* was placed on the IUCN Red List of Threatened Species.

In response to the explosion of cycad scale and high mortality rates, a coccinellid beetle (*Rhyzobius lophanthae*) was introduced as a biocontrol agent for cycad scale. Effectiveness of the biocontrol appeared promising by late 2006, with increasing scale-free native cycads in monitoring plots in 2007 and 2008, on mostly taller, mature cycads. However, a decline in beetle populations occurred in late 2008, and an explosion of cycad scale led to heavily infested plants during early 2009. As of January 2010, the scale population has been brought under control for a second time and few plants show signs of heavy infestation. Seedling mortality continues to be high as the beetles apparently do not feed or occupy small, immature plants.

Coconut Rhinoceros Beetle

The coconut rhinoceros beetle (CRB) (*Oryctes rhinoceros* L.) was detected at Tumon Bay and FaiFa'i beach in September 2007[11]. This scarab beetle is native of SE Asia and was thought to be accidentally introduced via cargo (building supplies) deliveries to Guam as early as 2005. CRB is a serious pest that affects palms, including coconut (*Cocos nucifera*), betelnut (*Areca catechu*) and native *Pandanus* species. CRB also is known to attack banana,

[11] A. Moore, http://guaminsects.net/uogces/kbwiki/index.php?title=Oryctes_rhinoceros

taro, pineapple and sugar cane. Past outbreaks of CRB elsewhere in the Pacific have caused widespread damage: nearly 50% of palms in Palau were killed soon after its introduction there in 1942, and has direct implications for islands within Micronesia that rely on these plants (especially coconut) as a major food source.

The high number of palms in urban settings and significant stands of coconut and beetle nut palms found in Guam's forests are currently threatened by CRB. Habitat for this large scarab beetle is plentiful; larvae live in litter and debris, of which there is abundance due to the presence of high levels of dead and dying coconut palms generated from typhoons and tropical storms. Potential native vertebrate predators of beetles, including birds, have been largely reduced or extirpated on Guam by the brown tree snake.

An interagency incident command team has been in place since the initial stages of the infestation on Guam with a cooperative eradication program between the USDA (APHIS and the USFS), the Guam Department of Agriculture, and the University of Guam. The initial quarantine area was 5,000 acres. Early eradication efforts met with limited success and by October of 2008, the quarantine area had been expanded to over 28,000 acres. Early strategies included sanitation and removal of breeding sites, trapping adults, and prophylactic tree treatments. Pesticide treatments were ineffective in causing significant mortality in adult CRB at field application rates. Sanitation is not effective without a means to detect breeding sites and adult CRB in live trees. Acoustic methods for detection of adult CRB in live trees were also studied but considered beneficial only toward the latter stage of eradication. Traps and lures tested were largely ineffective and were discontinued for eradication purposes. Treatment and disposal of infested or potentially infested material also proved to be problematic.

Monitoring traps have been installed since October 2007 to sample the distribution, abundance and rate of spread for CRB[12]. The data indicate a cyclical seasonal trend, with a long-term increase in the total abundance. The distribution of CRB collected from monitoring traps appears to be within the containment area of Tumon Bay. Monitoring traps are positioned along roadsides throughout Guam, with a focus on the urban centers.

[12] A. Moore, http://guaminsects.net/oryctes/monthly_trap_catch.php

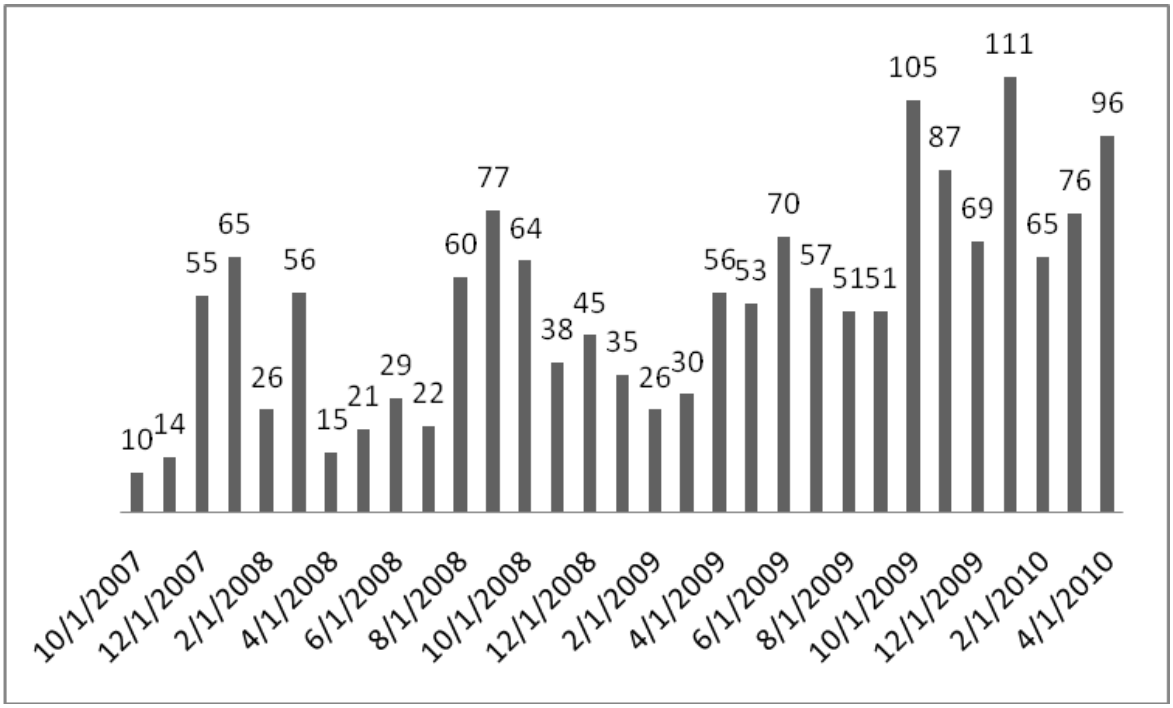

Figure 12. Monthly CRB trap catch values for Guam since detection. Source: A. Moore, UOG.

There is some consensus by UOG and NRCS scientists that eradication is still possible if CRB infestations remain in the open beach areas, if CRB inhabits only primary host (coconut) material, and if the clusters of infestation remain small and limited in geographic scope. CRB has also been observed on other hosts (fan palms), which is a critical signal of further CRB spread and crossing system boundaries. In many countries, two diseases have been used as biocontrol agents – one fungal (*Metarhizium anisopliae*) and one viral (*Oryctes sp.*), and these may prove to be an important component in an Integrated Pest Management (IPM) strategy on Guam. If eradication efforts fail, or biocontrol agents are not successfully deployed, Guam may expect consequences similar to Palau, with ~50% mortality of coconut palms. This would have high economic consequences for re-establishment in the urban areas (estimated ~$2.5 million), and would greatly increase the risk of escape to other islands in Micronesia that are reliant on coconuts for a primary food source, and even westward to Hawaii through tourism and cargo pathways[13].

Managing CRB spread on Guam is of imperative concern for subsistence communities that are reliant on coconut for a major food source elsewhere in Micronesia. Guam's

[13] A. LaRosa, 2008 Forest Health Highlights Communication, State & Private Forestry.

importance as a central hub for travel and exchange of goods and services allows for potential vectors of spread to other islands that are not infected. This is particularly important with the CRB populations in and around the major hotel districts on Guam—areas where ~1.1 million tourists per year or residents of other islands often stay en route to or from other islands in Micronesia.

Casuarina Dieback on Guam

Casuarina equisetifolia (gago or ironwood) is a hardy, pioneer, salt-resistant tree that occurs on both limestone and volcanic soils. Its ability to fix free nitrogen allows it to thrive on coastal sands where few other plants can survive. Native to the Marianas, including Guam, ironwood is widely used and propagated for windbreaks, reforestation and erosion protection programs on southern Guam's volcanic soils. Although normally a hardy species, widespread dieback of ironwood is occurring on Guam. The health and survival rate of ironwood trees on Guam have been declining since a series of severe typhoons during 2002. Chata'an (July, 2002) and Pongsona (December, 2002) caused widespread limb breakage and defoliation. The USFS FIA program estimated that Guam had 116,000 ironwood trees 5 inches in diameter and greater, during a 2002 forest inventory and that trees were generally healthy. Today, tens of thousands of these trees are dying on Guam. The decline is exacerbated with frequent fires in the savanna grass areas.

At the international Ironwood Tree Decline Conference held in Guam in January 2009, an international team of scientists concluded that the dieback was most likely due to a complex of biotic and abiotic factors. According to conference participants, possible biotic factors include: fungi of the genera *Ganoderma*, *Pestalotia*, *Botryosphaeria*, and *Fusarium*, several yet unidentified fungi and bacteria and insects, including termites and a newly discovered gall-forming eulophid wasp. Specimens of the wasp, tentatively identified by John LaSalle of Australia as belonging to the genus *Selitrichodes* (Eulophidae: *Tetrastichinae*), were collected at Ritidian Point in January, 2009. Although any causal connection between wasp damage and Casuarina decline is currently undetermined, infested trees have also been found elsewhere on Guam. In some trees almost 100% of branchlet tips show feeding damage and exit holes. In addition to typhoons, abiotic factors include severe drought and proximity to urban development. Many of the dead trees are from plantings in urban areas and parks. The healthiest ironwood trees are located in native stands of the trees on Cocos Island, 1.6 miles off the southern tip of Guam, and at Ritidian Point, a National Wildlife Refuge located on the northern tip of Guam. The wasp and the corresponding damage on Casuarina have recently been found in Palau and on

Rota, CNMI (LaRosa, 2008). The decline appears to be distributed randomly across Guam and is also reported from Rota but not Saipan or the FSM, where it is native, nor Hawaii where it has been introduced and widely planted.

Invasive Plants

Invasive plants are one of the most serious threats to the long-term viability of Guam's forests. Regionally, there is the Pacific Islands Ecosystems at Risk project (PIER)[14], which has an interactive online database that lists 495 plant species that are profiled as invasive or potentially invasive that occur in Guam. It includes those plants of environmental concern (including those that are probably of threat only to islands with high elevations) as well as agricultural and pioneer (ruderal) weeds. There are current efforts by Guam Forestry and affiliates (UOG and GISAC[15]) to identify the "highest priority" (top 10 – 20 species) that are the most prolific within native forests and have the capacity to radically affect forest health and function in a short period of time.

In general, priority species are controlled through mechanical, chemical and biological methods. Weeds of widespread importance in the western Pacific that are currently under control actions include cogon grass (*Imperata cylindrica*), mile-a-minute vine (*Mikania micrantha*), Siam weed (*Chromolaena odorata*), Koster's curse (*Clidemia hirta*), giant sensitive plant (*Mimosa invisa*), root beer plant (*Piper auritum*). Trees such as Molucca albizia (*Falcataria moluccana*), African tulip (*Spathodea campanulata*) and vitex (*Vitex parviflora*) grow at rapid rates and hinder growth and establishment of native forests. Biocontrol programs currently in place (UOG) for four species are listed in Table 5.

Quantitative data on invasive plant distribution is sparse, as is a unified island-scale strategy for invasive species detection and management on Guam. A coordinated effort among stakeholders, including GISAC , UOG, APHIS, CAPS (Cooperative Agricultural Pest Survey), etc. is needed to centralize information and strategies to address invasive species information. There is currently no clear island-scale strategy for invasive weed species management on Guam, though stakeholders have been engaged through the SWARS process to develop a strategy for addressing invasive plants (see *Strategy 6: Implement a Forest Health Program: Unify Interagency Efforts to Prepare for Buildup*). Refinement of the

[14] http://www.hear.org/Pier/locations/pacific/guam/specieslist.htm

[15] Guam Invasive Species Advisory Committee (GISAC)

priority species, their effects, distribution, and magnitude of disturbance requires focused effort, local capacity, leadership, and targeted funding to pursue.

Table 5. The active biocontrol programs currently in operation on Guam (source: UOG).

Plant Species	Agents Released	Order : Family	Year of Release	Established	Year of Establishment
Chromolaena odorata	*Acalitus adoratus*	Acarina: Eriophyidae	Fortuitously	Yes	NA
	Cecidochares connexa	Diptera: Tephridae	2002	Yes	2003
	Pareuchates pseudoinsulata	Lepidoptera: Arctiidae	1985	Yes	1985
Coccinia grandis	*Acythopeus cocciniae*	Coleoptera: Curculionidae	2003	Yes	2003
	Acythopeus burkhartorum	Coleoptera: Curculionidae	2004	No	NA
	Melittia oedipus	Lepidoptera: Sesiidae	2007	Yes	2007
Lantana camara	*Teleonemia scrupulosa*	Hemiptera: Tingidae	NA	Yes	NA
	Uroplata girardi	Coleoptera: Chrysomelidae	NA	Yes	NA
	Ophiomyia lantanae	Diptera: Agromyzidae	NA	Yes	NA
	Calcomyza lantanae	Diptera: Agromyzidae	NA	Yes	NA
	Zizula hylax	Lepidoptera: Lycaenidae	NA	Yes	NA
	Hypena strigata	Lepidoptera: Noctuidae	NA	Yes	NA
	Lantanophaga pusillidactyla	Lepidoptera: Pterophoridae	Fortuitously	Yes	NA
	Epinotia lantana	Lepidoptera: Tortricidae	Fortuitously	Yes	NA
Mimosa diplotricha	*Heteropsylla spinulosa*	Homoptera: Psyllidae	2008	Yes	2008

Forest Management Using a Ridge-to-Reef Approach

Coral reefs are degraded by sediment runoff from watersheds, particularly from the steep landscapes in southern Guam. Deforestation, invasive species, fire, and land management practices increase the sediment flux from the uplands to the mouths of rivers that empty into the fringing reef and bays. Coral reef health as well as water quality in lakes is in decline where these significant and chronic sediment plumes occur.

The **Ridge-to-Reef** management approach provides an important connection between land management practices and the health of the fringing reef of Guam. Guam Forestry provides a critical role in abating the threat of declining water quality issues to waterways and coral reefs through forest health, forest stewardship, fire control programs and watershed-scale restoration efforts. Organizing spatial information and issues by watershed provides a powerful tool in developing multi-objective strategies to abate the pollution of these critical water resources.

Watersheds on Guam

The island of Guam has been subdivided into 19 watersheds (WERI, undated)[16]; Figure 13 and Figure 14. For the purposes of this report we divided these nineteen watersheds into three groupings; Eastern, Western and Northern Guam watersheds (Table 6). Watersheds on the eastern or leeward side, of Guam are generally larger in size and gentler in slope then those found on the western (windward) side of the island. The three northern Guam watersheds are generally without significant stream systems, reflecting the porous nature of the limestone geology of the northern half of the island. Precipitation increases with elevation in all of the watersheds.

[16]Note: the "Manelle Watershed" is also called the Merizo watershed, but is labeled as Manelle in current data products.

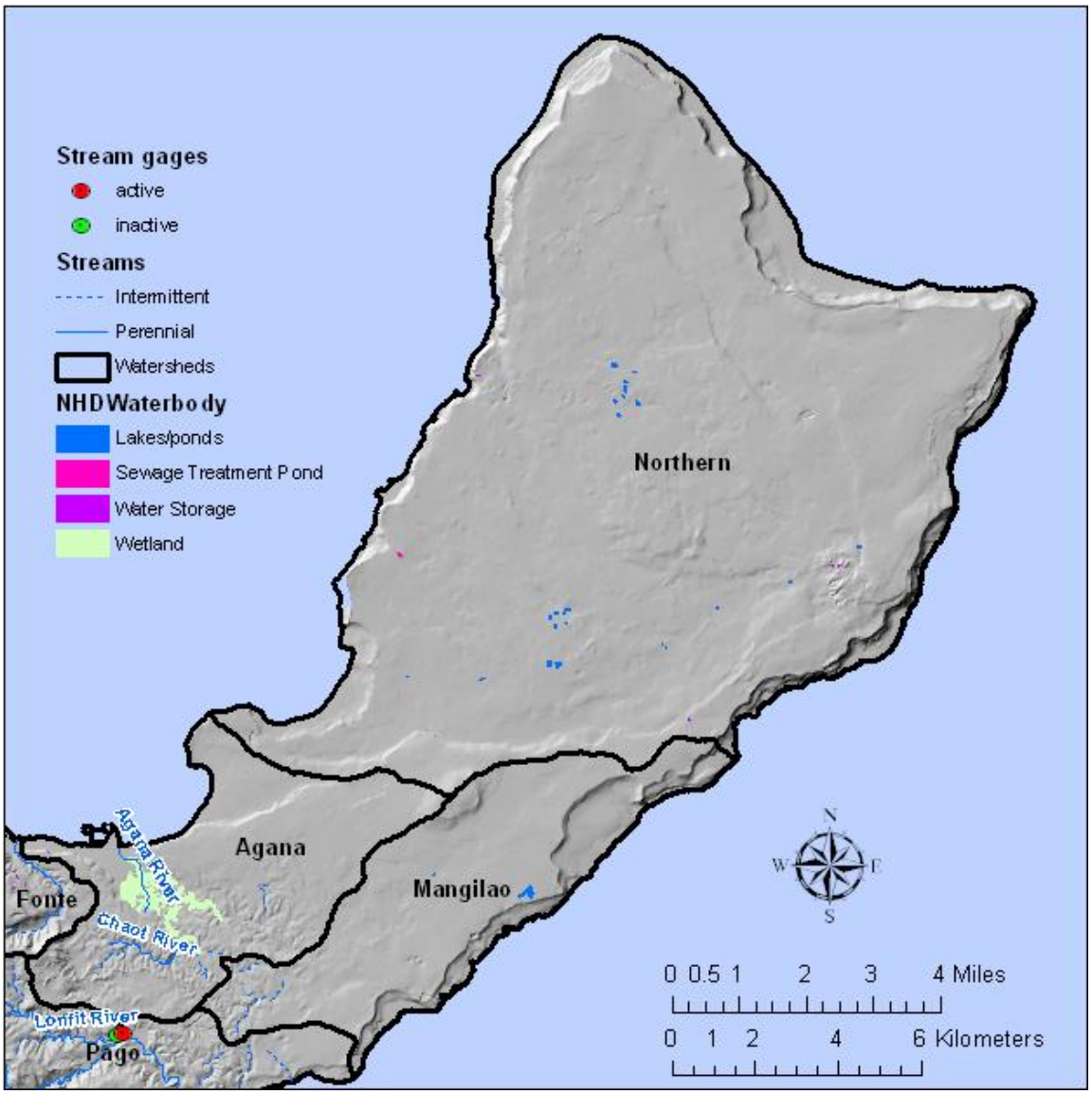

Figure 13. Water features of northern Guam.

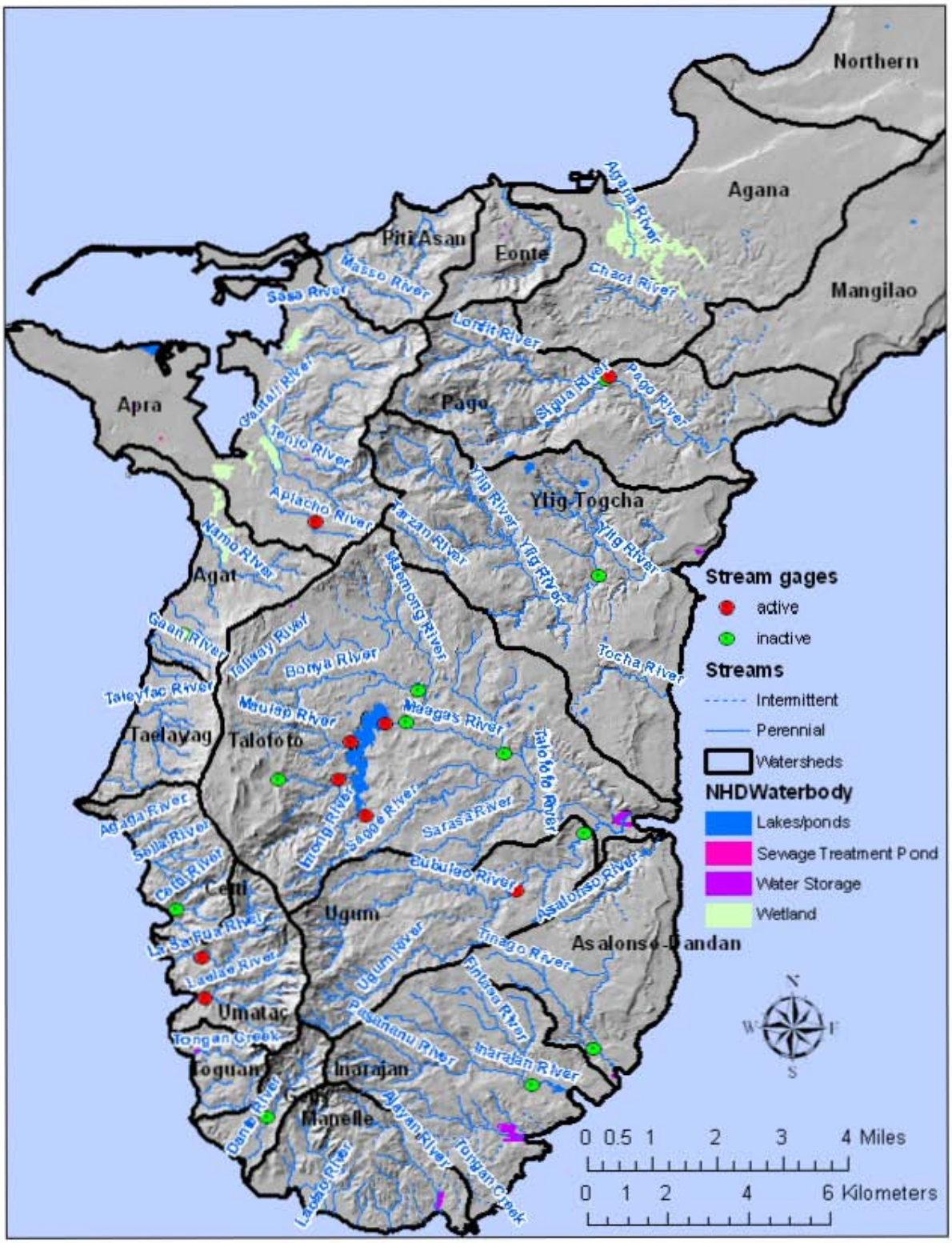

Figure 14. Water features of southern Guam. Data are summarized in Table 7.

Table 6. Watershed characteristics.

Region	Watershed	Area		Mean elevation		Max elevation		Mean slope	Mean annual precip.	
		mi²	km²	ft	m	ft	m	%	in	cm
Eastern	Pago	10.4	27.0	288	88	1,066	325	21	97	247
	Ylig-Togcha	15.7	40.7	262	80	1,001	305	18	101	256
	Talofofo	23.5	60.8	347	106	1,322	403	18	105	266
	Ugum	7.6	19.6	419	128	1,238	377	20	107	271
	Asalonso-Dandan	6.5	16.9	207	63	425	129	13	102	258
	Inarajan	8.7	22.5	264	81	1,096	334	16	100	254
Western	Manelle	4.9	12.6	226	69	1,106	337	27	96	244
	Geus	1.7	4.5	331	101	1,122	342	33	100	253
	Toguan	1.4	3.7	234	71	1,036	316	24	99	251
	Umatac	3.8	9.9	408	124	1,233	376	36	106	270
	Cetti	3.0	7.8	361	110	1,286	392	31	107	271
	Taelayag	2.6	6.6	244	74	1,117	341	20	104	265
	Agat	3.9	10.2	152	46	756	231	12	97	247
	Apra	12.9	33.5	158	48	1,045	319	13	92	235
	Piti/Asan	3.1	8.1	243	74	725	221	20	93	237
	Fonte	2.5	6.4	320	97	706	215	20	95	242
Northern	Agana	13.6	35.3	162	49	666	203	9	93	237
	Mangilao	13.7	35.5	277	85	655	200	8	94	238
	Northern	70.3	182.0	419	128	832	254	7	94	238

Table 7. Water features of Guam

Region	Water-shed	Length of streams						Area of water bodies							
		Perennial		Inter-mittent		Total		Lake/ Pond		Sewage Treat. Pond		Water Storage		Wetland	
		mi	km	mi	km	mi	km	ac	ha	ac	ha	ac	ha	ac	ha
Eastern	Pago	13.8	22.1	9.0	14.5	22.7	36.6	3.3	1.3	-	-	-	-	-	-
	Ylig-Togcha	28.5	45.9	3.4	5.5	31.9	51.4	15.6	6.3	-	-	1.9	0.8	3.3	1.4
	Talofofo	42.9	69.1	8.8	14.1	51.7	83.2	195.3	79.0	-	-	15.9	6.4	-	-
	Ugum	21.0	33.8	2.2	3.6	23.2	37.4	0.7	0.3	-	-	-	-	-	-
	Asalonso-Dandan	10.1	16.2	0.9	1.5	11.0	17.7	4.0	1.6	-	-	0.5	0.2	-	-
	Inarajan	19.6	31.6	6.3	10.2	26.0	41.8	2.2	0.9	-	-	30.3	12.2	-	-
Western	Manelle	12.7	20.5	3.6	5.8	16.3	26.3	-	-	-	-	8.6	3.5	-	-
	Geus	3.3	5.3	-	-	3.3	5.3	-	-	-	-	-	-	-	-
	Toguan	4.3	6.9	-	-	4.3	6.9	0.3	0.1	-	-	1.1	0.4	-	-
	Umatac	10.8	17.4	0.4	0.6	11.2	18.0	-	-	-	-	-	-	-	-
	Cetti	7.4	12.0	-	-	7.4	12.0	-	-	-	-	-	-	-	-
	Taelayag	7.7	12.4	-	-	7.7	12.4	-	-	-	-	-	-	-	-
	Agat	8.3	13.4	-	-	8.3	13.4	-	-	0.2	0.1	0.3	0.1	64.1	25.9
	Apra	15.9	25.5	2.3	3.6	18.1	29.1	18.8	7.6	0.4	0.2	2.0	0.8	124	50.1
	Piti/ Asan	4.8	7.8	2.7	4.3	7.5	12.1	-	-	-	-	0.2	0.1	-	-
	Fonte	1.9	3.0	1.3	2.1	3.1	5.1	-	-	-	-	0.7	0.3	-	-
Northern	Agana	2.7	4.3	2.1	3.4	4.8	7.7	-	-	-	-	-	-	268	108.4
	Mangilao	-	-	1.8	2.9	1.8	2.9	6.5	2.6	-	-	-	-	-	-
	Northern	-	-	-	-	-	-	15.6	6.3	0.6	0.2	0.8	0.3	-	-
Totals		**216**	**347**	**49**	**72**	**261**	**419**	**262**	**106**	**1.2**	**0.5**	**62**	**25**	**459**	**186**

Approximately 260 miles of streams are mapped on the island of Guam; the majority are identified as having perennial flow (Table 7). Few streams occur in the limestone-dominated northern Guam watersheds, and none in the Northern watershed itself. The largest water body on the island is the human-made Fena Reservoir located in the Talofofo watershed (195 acres). Large, primarily estuarine wetland areas occur in the Agana, Apra and Agat watersheds.

Reef Resources

Guam is surrounded by an extensive and species-rich reef system that provides many services including cultural and traditional uses, tourism and recreation, fisheries, and shoreline and infrastructure protection[17]. Over 38 square miles of shallow coral reef are found within 3 miles of Guam's coastline. Guam's reef resources are currently in decline due to degradation of water quality, chronic crown of thorns seastar (COTS) outbreaks, and low abundance of major herbivorous (algae-eating) fishes. There is also a documented decline on coral recruitment rates over the past few decades.

Primary threats to Guam's coral reefs include sedimentation and pollutants associated with terrestrial runoff, and over fishing. Secondary threats include COTS outbreaks, coral diseases, dredging, boat groundings, marine debris, coral bleaching, and recreational misuse and overuse. Storm activity can also cause direct damage to reef structure, and coral bleaching is emerging as a potential threat which will likely become more severe with increasing sea surface temperatures associated with global climate change.

Linkages between Guam's coral reef communities and Guam Forestry objectives are directly related activities that affect the quantity and quality of water and sediment pollution runoff to the reef communities. In particular, reef resources are affected by fire and post-fire management, and quality and health of forested upland and riparian systems that can increase sediment trapping from grass or bare ground hill slopes.

[17] The following discussion is summarized from Burdick et al., 2008.

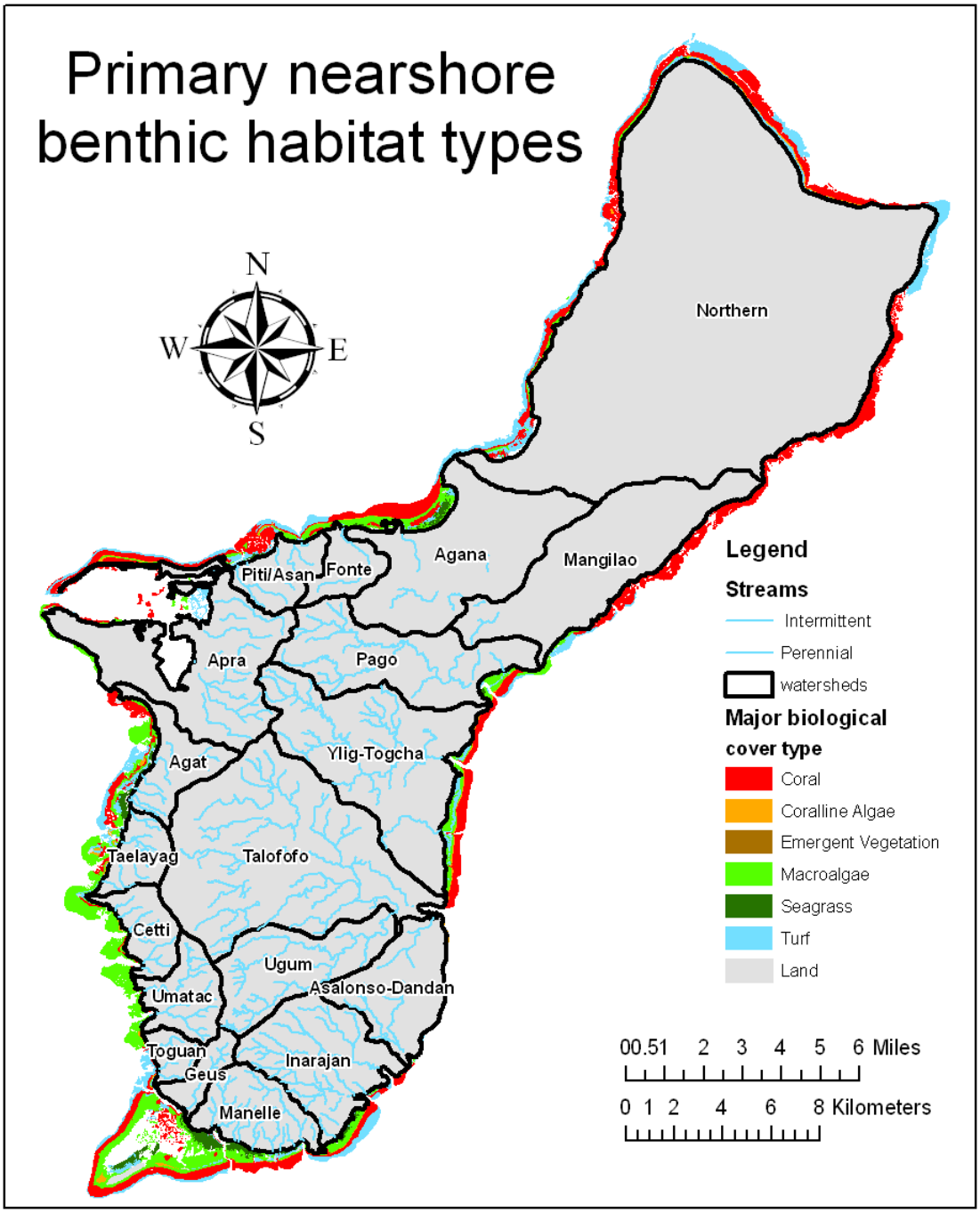

Figure 15. Primary nearshore benthic habitat types around Guam. Source: Burdick (2009).

State Wildlife Plan

The 2008 Farm Bill and national guidance require that the SWARS evaluate commonalities with the state wildlife action plan. The ***Guam Comprehensive Wildlife Conservation Strategy*** (Guam Division of Aquatic and Wildlife Resources) completed September 2005 identified 63 species of terrestrial, aquatic and marine organisms at risk.

The Wildlife Conservation Strategy identifies limestone forests, scrub (secondary forests), and ravine forests as important for all of Guam's native avian, invertebrate, reptilian and mammalian species. Limestone forests are found on the northern limestone plateau and on large limestone outcroppings in southern Guam. These habitats are vital for almost all of Guam's native forest birds, snails, insects, lizards, and two fruit bat species. Typhoons, loss of pollinators, loss of habitat due to development, and introduction of aggressive invasive plant species are all factors that lower forest resilience that can ultimately support critical habitats.

The scrub forest is described as a degraded, yet diverse, brush-type forest, generally with an open canopy under 10 m high and a dense understory. The plant species are similar to those in more mature limestone forests, but are at an earlier stage of development. In northern Guam, this habitat is often dominated by *Vitex parviflora*, an introduced species from the Philippines. However, within this forested area native plants can be found as understory cover. The same factors impacting limestone forests are changing the structure of scrub forest (feral deer and pigs, invasive plant species, development and typhoons). In the absence of deer, pigs, and invasive plants, scrub forest could be restored to support primary limestone forest habitat. Guam Forestry has implemented fencing projects to exclude ungulates in some restoration areas (e.g. Cetti Bay).

Guam's ravine forests of southern Guam are highly degraded and contain many non-native species including betelnut palm (*Areca cathecu*) and palma brava (*Heterospate elata*). The ravine forests been reduced in quality and quantity by damage from deer, pigs, fire, and introduced plant species.

The goal of the Wildlife Conservation Strategy to restore these terrestrial habitats aligns with the mission of Guam Forestry to reclaim badlands and restore native forests. Rehabilitation of the native forests is a necessary step in the management and recovery of the species of concern.

Issues & Threats to Forest Ecosystems

Approach

As described under the ***Forest Conditions and Trends*** section, vegetative cover on Guam can be classified coarsely as Forest, Non-Forest (savanna and grasslands), Developed and Bare Ground. Because of the high degree of loss and conversion of forests and the mosaic of cover types on the landscape, it is important to evaluate issues and threats at the landscape scale, rather than focus only on the current forest cover. For example, the threat of fire to existing forests occurs on the edge of forest in the grasslands and savannas. For this reason, the threats to forest ecosystems should focus not only within forest boundaries, but needs to address all landscape cover types to determine the best actions for management.

The identification of issues and threats followed a two-step process. The first step was a Stakeholder process that identified six major related issues developed for Guam. The second-step involved fine-tuning the location of threats on the landscape, where feasible using fine-scale vegetation mapping and modeling of vegetation, soils and hydrology.

Step 1: The Stakeholder Process

The Stakeholder evaluation was based on eleven environmental attributes mapped at a coarse scale using the PIC Veg Layer developed by the Forest Service in 2005, with other basic coverages (e.g. slope, protected areas, etc.). The eleven key issues included: 1) Wildfire Risk , 2) Proximity to Protected and Managed Area, 3) Public Water Supply/Priority Watersheds, 4) Wetlands, 5) Riparian Areas, 6) Slope, 7) Threat of Development, 8) Native Forests, 9) Threatened & Endangered Species, 10) Population at risk of fire and 11) Private Forest Lands.

The stakeholders ranked and weighted these individual attributes to establish a relative value on the landscape for each of the six issues. The outcome of this assessment is a qualitative evaluation of the stakeholder's perception of natural resource priorities at the island-wide spatial scale, and helped to focus data and assessment needs on the island. Metrics are expressed as "500" being a "high priority" and "100" being a "low priority". See Appendix 2 for more details regarding the stakeholder ranking system.

Step 2: Fine-Scale Assessment

The underlying data sources used for the Stakeholder Process were evaluated for their utility in quantifying and describing threats on the landscape. This involved a scientific approach to determining (at fine scales) potential threats to trees and forests in the rural and urban areas, fire behavior potentials, mechanisms for addressing stakeholder issues and threats. This approach also expanded to a watershed-science based approach to quantify erosion and sediment delivery, with prioritized areas on the landscape for active forestry and reforestation management. Base information included the fine-scale SWARS vegetation map, LiDAR surface elevation models, soils mapping, and hydrology datasets.

Stakeholder Identification of Issues

Guam Forestry, in coordination with the Guam Bureau of Statistics and Plans (BSP), completed the spatial analysis involving stakeholder ranking of environmental attributes. Six issues were identified by the SWARS Advisory Council:

1. **Wildfire and Public Safety**: The threat of wildland fire on human life and infrastructure.
2. **Water Quality and Supply**: The threat to water quality and quantity from human development and forest degradation.
3. **Population Growth and Urbanization:** The threat posed by an expanding population on important ecosystem services provided by Guam's forest resources.
4. **Deforestation of Native and Old Forests**: The threat posed to unique forest environments on Guam.
5. **Urban Forest Sustainability:** The threat posed to Guam's urban forest resources by development and other stressors.
6. **Degraded Lands**: Identification of threats to ecosystem health posed by lands currently identified as being in a degraded condition.

The process of using spatial layers and ranking these layers by the SWARS Advisory Council is described in Appendix 2.

The following sections detail each of the issues above, summarizing the stakeholder issue review and fine-scale assessment outcomes. Beginning on page 88, a *Synthesis of Issues* section describes how the stakeholder issues are related to on-the-ground threats, and displays prioritized areas where single treatments meet multiple objectives.

Issue 1. Wildfire and Public Safety

Introduction

Wildfire is a primary disturbance that affects forest and watershed health, and is a keystone issue that is linked with other identified stakeholder issues. Fire is a non-native disturbance and directly interferes with the establishment and expansion of native forests, threatens standing forests, leads to accelerated erosion, the delivery of sediment pollution to surface waters and domestic water supplies, and contributes to the decline of the coral reef system. Hence, the issue of "wildfire and public safety" includes other stakeholders' issues (e.g. *Issue 2. Water Quality and Water Supply, Issue 4. Deforestation of Native Forests*, and *Issue 6. Degraded Lands*).

A fire risk assessment (Neill and Rea 2004) conducted in 2004 identified the key vegetation types and topographic influences that would likely contribute to hazardous burn conditions in a given climate scenario. In general, fires are more difficult to suppress when flame lengths exceed 3-6 ft, and when they are located in difficult to reach terrain. Flame lengths and rates of spread increase proportionally with slope. The conclusion from the fire assessment was to focus on changing the fuels structure by planting forest and conducting other treatments, such as fuel breaks on grass and savanna cover types on steep slopes. The assessment report did not provide sufficient spatial data detail to identify specific land areas that should be treated to improve fire protection, though provided maps of potential high risk fire behavior.

Since wildfire is so prevalent and is a threat on multiple levels (safety, forests, water quality) in wildland and urban areas, a more detailed potential fire behavior map was produced for this assessment using the SWARS vegetation map and LiDAR-derived ground surface information. The output is designed to identify specific sites of hazardous fire behavior potentials that can be prioritized for pre-disaster treatment in watersheds and communities at risk, as intended by the Farm Bill and USFS agency guidance.

The results of the fire behavior risk assessment are summarized below; additional details of the assessment are described in Appendix 2.

Potential Fire Risk

Fire behavior risk was calculated to "scale" the potential risk factors combining vegetation types and slope. These scales were divided into four generalized risk assessment

categories (Table 8). These risk codes correspond to areas that would have potential high rates of spread and long flame lengths.

Table 8. Generalized criteria in defining fire behavior risk – associated with vegetation/ cover types and slope.

Fire Behavior Risk	Description (any combination)	Risk Code
Low	Forest, bare soils, water & urban development, <50% slopes	0
Moderate	Open areas near development, secondary or patch forest, 50 - 100% slopes	1
High	Long leaf grass or savanna types, 100 - 200% slopes; short grass types with >200% slopes	2
Extreme	Long leaf grass or savanna types, extreme slopes >200%	3

Potential fire behavior based on slope and fuel structures is depicted on the map and rated into four categories – Low, Moderate, High and Extreme Fire Risk. These fire risks are further categorized as risks to forest fragments and urban environments in the following sections.

Fire Risk to Forest Fragments

Fire risk to forests and urban environments was determined by calculating a 300 ft buffer distance from all forest edges. These buffers were chosen as areas most likely to have "edge effects" for fire risk to standing forests. The total area of fire behavior risks (0-3) was calculated within each zone for all watersheds (Table 9). Figure 16 displays the forest fragments at risk for Guam. Yellow and red colors highlight areas of moderate and high risk; their proximity to forest edges identifies these areas as high priority for fuel breaks and conversion to forest.

At watershed scales, the eastern watershed management areas contribute the largest number of acres that pose a moderate or higher fire risk within this forest edge interface zone (8,187 acres), mostly relegated to the central uplands in Talofofo, Ylig and Pago, with upper reaches of Apra in the western watershed management area. Though smaller in land area, the western watersheds all exhibit approximately one-quarter of the land area having moderate or higher fire risk to standing forests, including the Manelle (Merizo) watershed, which contains a marine preserve at the outlet of the watershed. Overall, these priority

areas pose the highest concentrated direct risk to forests from fires that are likely to exhibit fire behavior that is difficult and potentially dangerous to suppress (Figure 16).

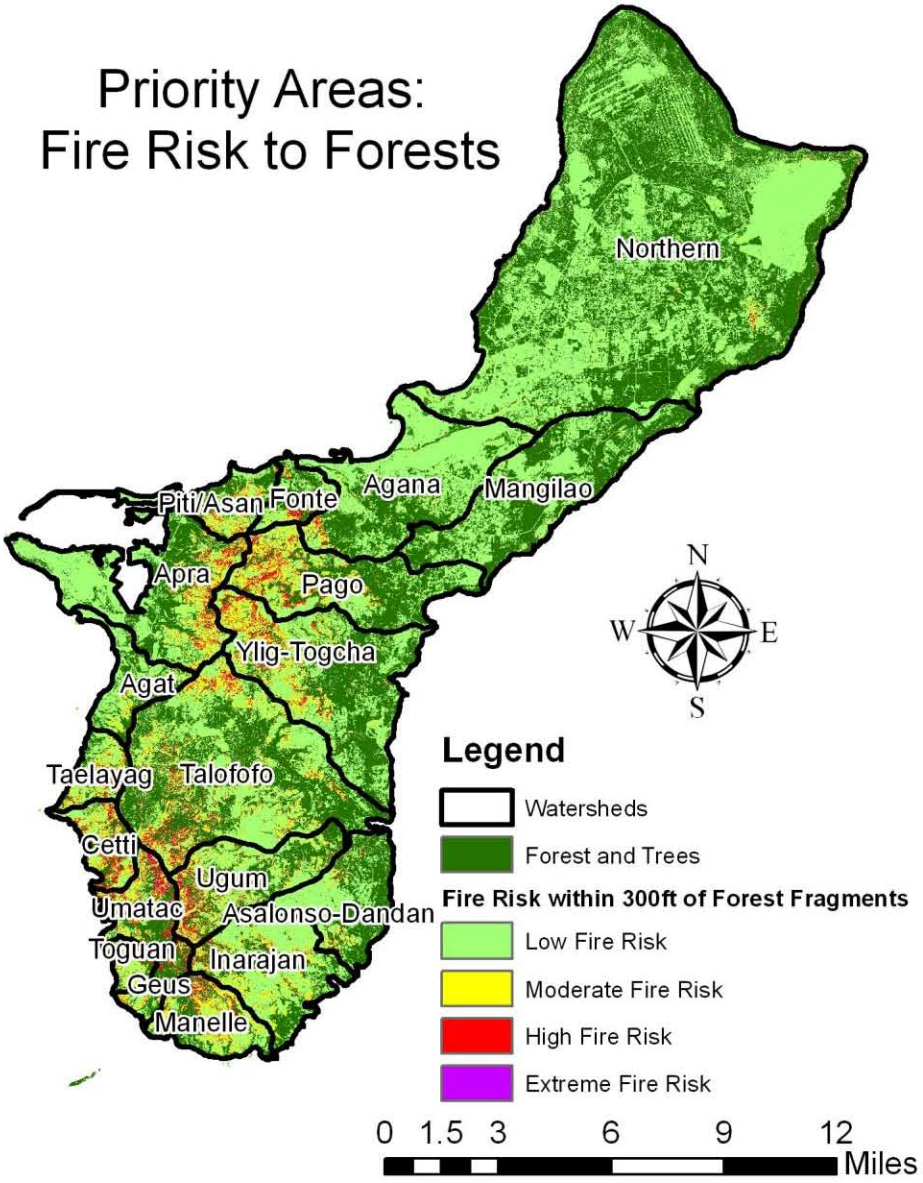

Figure 16. Priority areas for fuels treatments to reduce risk of fire damage to standing forests. Areas were prioritized on the basis of potentially long flame lengths and/or fast rates of spread near to forest edges (300 ft). Priorities increase with increase in risk. Data are summarized in Table 9.

Table 9. The priority areas summarized by watershed for risk of severe fires in the 300 ft perimeter of forest fragments. Values are expressed in acres and percentage of the total watershed. All acres are in non-forest fuel types.

Region	Watershed	Watershed Acres	Low		Moderate		High		Extreme	
			Acres	%	Acres	%	Acres	%	Acres	%
Eastern	Pago	6,683	2,456	37%	1,045	16%	471	7%	25	0%
	Ylig-Togcha	10,067	4,066	40%	1,212	12%	480	5%	18	0%
	Talofofo	15,016	5,860	39%	1,806	12%	756	5%	43	0%
	Ugum	4,851	2,037	42%	726	15%	388	8%	28	1%
	Asalonso-Dandan	4,183	1,972	47%	174	4%	54	1%	3	0%
	Inarajan	5,564	3,155	57%	750	13%	200	4%	8	0%
Western	Manelle	3,107	1,139	37%	681	22%	278	9%	18	1%
	Geus	1,120	284	25%	155	14%	162	14%	24	2%
	Toguan	903	427	47%	193	21%	75	8%	5	1%
	Umatac	2,447	673	28%	453	19%	374	15%	55	2%
	Cetti	1,928	696	36%	479	25%	314	16%	18	1%
	Taelayag	1,639	823	50%	309	19%	123	8%	3	0%
	Agat	2,511	1,385	55%	198	8%	39	2%	1	0%
	Apra	8,283	4,415	53%	864	10%	404	5%	11	0%
	Piti/Asan	1,993	894	45%	334	17%	126	6%	3	0%
	Fonte	1,575	678	43%	118	7%	64	4%	6	0%
Northern	Agana	8,717	5,459	63%	275	3%	72	1%	4	0%
	Mangilao	8,772	3,709	42%	106	1%	24	0%	6	0%
	Northern	44,971	22,373	50%	455	1%	140	0%	31	0%

Fire Risk to Communities: Urban Intermix

Similar to assessing fire risk to forest fragments, urban areas, including highly developed and open space areas, were evaluated within 500 ft buffer areas (*Urban Intermix*) for potential fire behavior fuel types. The Urban Intermix is not to be confused with the Wildland Urban Interface (WUI) definitions (USFS, Fire & Aviation Management) [18]. For purposes of the SWARS, the Urban Intermix is the area where potentially hazardous fuels conditions are within 500 ft of the developed (and developed "open space") boundaries. This area provides areas for increasing Urban Forestry objectives and reducing hazardous fuels.

Figure 17 shows the prioritized areas having potential fire behavior risk in urban zones and associated buffer areas. The areas in yellow and red are the priority areas that require fuels treatment or conversion to forests.

The percent of each watershed that is mapped as falling within the Urban Zone and Buffer is listed in Table 10. The percent of the watershed in these urban and buffer zones varies from 12% at the low end for Ugum to 95% at the extreme end for the Agana watershed. Through urban environments are dominant in the northern watersheds, the majority of the fire risk is within the Urban Intermix zones is concentrated in the western and eastern watershed regional groups (Table 11). Areas targeted as having moderate or higher fire behavior risks represent priority areas for converting fuels types to forest, or for creating fire breaks (reduction in fuels). This is especially true along the road areas in the western and eastern watershed regions, as they provide the highest access for arson starts and cover a broad geographic area (Cross Island Road and Highway 2 from Agat to Merizo).

[18] Under the USFS WUI definitions, the entire island of Guam would be categorized as within WUI boundaries.

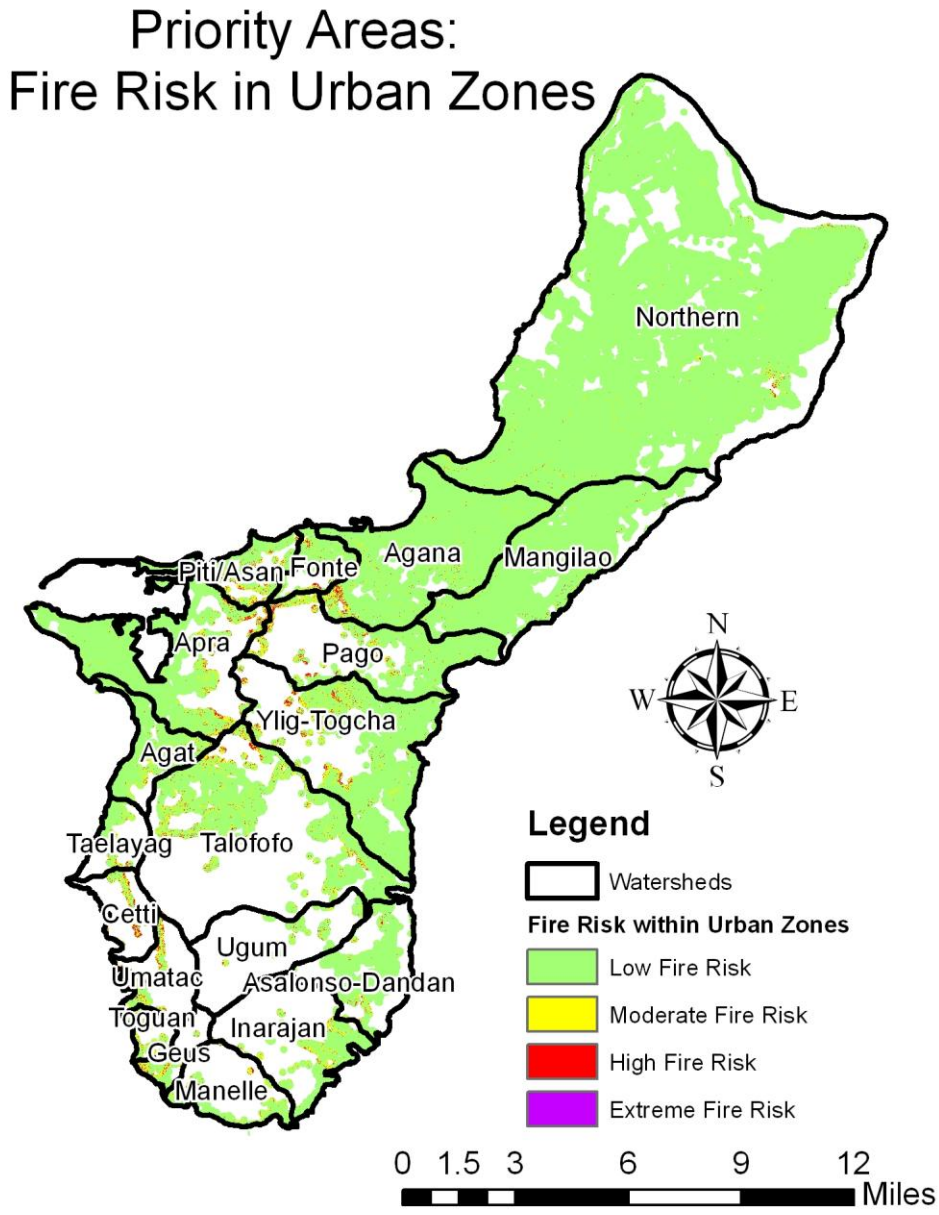

Figure 17. The prioritized areas and fire risk based on potential flame length and rate of spread and within a 500 ft proximity to urban classified lands (including roads, urban open space, and developed lands). Area under each fire risk classification is summarized in Table 11.

Table 10. Urban areas and the 500 ft intermix areas, expressed as total acres and proportion of the watershed.

Region	Watershed	Watershed Acres	Area within the Urban Zone and Buffer (acres)	Percent of Watershed
Eastern	Pago	6,683	3,746	56%
	Ylig-Togcha	10,067	6,558	65%
	Talofofo	15,016	6,084	41%
	Ugum	4,851	600	12%
	Asalonso-Dandan	4,183	2,319	55%
	Inarajan	5,564	1,698	31%
Western	Manelle	3,107	999	32%
	Geus	1,120	526	47%
	Toguan	903	555	61%
	Umatac	2,447	773	32%
	Cetti	1,928	429	22%
	Taelayag	1,639	646	39%
	Agat	2,511	2,121	84%
	Apra	8,283	6,202	75%
	Piti/Asan	1,993	1,599	80%
	Fonte	1,575	1,265	80%
Northern	Agana	8,717	8,316	95%
	Mangilao	8,772	7,636	87%
	Northern	44,971	36,205	81%

Table 11. Fire behavior risk Priority Areas within the urban zones (including open space) and a 500 ft buffer surrounding them. Values are expressed as total acres and as a percentage of the watershed.

Group	Watershed	Watershed Acres	Low		Moderate		High		Extreme	
			Acres	%	Acres	%	Acres	%	Acres	%
Eastern	Pago	6,683	3,286	49%	333	5%	118	2%	8	0%
Eastern	Ylig-Togcha	10,067	5,969	59%	442	4%	139	1%	8	0%
Eastern	Talofofo	15,016	5,320	35%	601	4%	158	1%	6	0%
Eastern	Ugum	4,851	537	11%	50	1%	12	0%	1	0%
Eastern	Asalonso-Dandan	4,183	2,217	53%	78	2%	23	1%	1	0%
Eastern	Inarajan	5,564	1,484	27%	177	3%	36	1%	1	0%
Western	Manelle	3,107	855	28%	109	4%	34	1%	2	0%
Western	Geus	1,120	399	36%	92	8%	33	3%	2	0%
Western	Toguan	903	389	43%	131	14%	35	4%	0	0%
Western	Umatac	2,447	517	21%	176	7%	77	3%	3	0%
Western	Cetti	1,928	247	13%	109	6%	69	4%	4	0%
Western	Taelayag	1,639	564	34%	62	4%	18	1%	1	0%
Western	Agat	2,511	1,954	78%	140	6%	25	1%	1	0%
Western	Apra	8,283	5,727	69%	344	4%	126	2%	5	0%
Western	Piti/Asan	1,993	1,287	65%	222	11%	87	4%	3	0%
Western	Fonte	1,575	1,149	73%	79	5%	34	2%	3	0%
Northern	Agana	8,717	7,969	91%	273	3%	71	1%	4	0%
Northern	Mangilao	8,772	7,526	86%	89	1%	17	0%	4	0%
Northern	Northern	44,971	35,785	80%	351	1%	64	0%	6	0%

Fire Risk Summary

Treatments in the urban zones (planting trees) readily correspond with Urban and Community Forestry program objectives as well as Cooperative Fire for fuels treatment operations. Converting non-forest high-risk areas to forested areas will help to slow the rate of spread of fire and ultimately fragment fire-prone areas, especially along the major road networks. Immediate edge effects (roads, community boundaries, etc.) that contribute to risk can be treated using direct fuel break treatments (mowing, flailing) to minimize spread to other high-risk areas. A program designed to *isolate*, *contain* and *prevent* fires in the urban intermix zone will offer the highest preventative protections at lowest overall cost. A community-assessment of fire resources, risk areas, and community involvement in a program such as FireWise[19] (National Fire Protection Program, NFPA) can assist Guam Forestry and stakeholders with strategies to address urban fire risk through preventative action and outreach.

Issue 2. Water Quality and Water Supply

Water quality is monitored and regulated by Guam EPA programs. Guam Forestry has a critical role in water quality programs in providing surface conditions that allow for the safe capture and storage of water within the key watersheds (surface and groundwater resources). Movement of sediment from erosion into waterways is one of the most pervasive problems associated with poor land cover, which degrades surface waters, domestic water supplies, and the fragile reef systems. Guam Forestry programs can reduce erosion through forest stewardship, fire management, and restoration activities to protect water quality and domestic water supplies (plant trees in areas prone to erosion and soil delivery to streams). Further, Guam Forestry can assist in the protection of groundwater resources through avoiding deforestation and degradation in the northern watershed zone of contribution areas (e.g. Stewardship, Legacy, Urban Forestry and Forest Health Programs).

This section describes the water resources on Guam, the stakeholder evaluation of water quality and water supply, and the assessment of sediment source and transport by watershed area.

[19] http://www.firewise.org/

Surface and Groundwater Resources

The climate of Guam is characterized by a dry season that runs from December through June, and a rainy season from July through November. Annual rainfall is high, averaging 90 to 110 inches (229 cm to 280 cm) of precipitation (Table 6). Temperatures are warm all year, with the coolest least humid period being December through February (Daly and Halbleib, 2006).

Water resources on the island of Guam vary spatially due to the distinctive geologies of northern and southern Guam. The volcanic-dominated geology of the south has a relatively low permeability, and the hydrologic regime is dominated by surface water processes (e.g., streams and lake impoundments). In contrast, the limestone-dominated geology of the northern watersheds is highly permeable, and groundwater recharge processes dominate. Refer to Appendix 2 for a characterization of the hydrology and stream flow conditions.

Stakeholder Evaluation of Water Quality and Water Supply Issue

The stakeholder evaluation of this issue relies on the estimate of the threat posed by human development and forest degradation. Five environmental attribute layers were identified as being relevant to this issue, and are discussed in Appendix 2. The dominant issue rating was heavily dependent on whether the watershed was rated as a public water supply priority watershed or as an aquifer (Figure 18). As such, the Talofofo, Asalonso-Dandan and Ugum watersheds in the south were rated as high risk, as were the portions of the northern watersheds that overlay the primary aquifers.

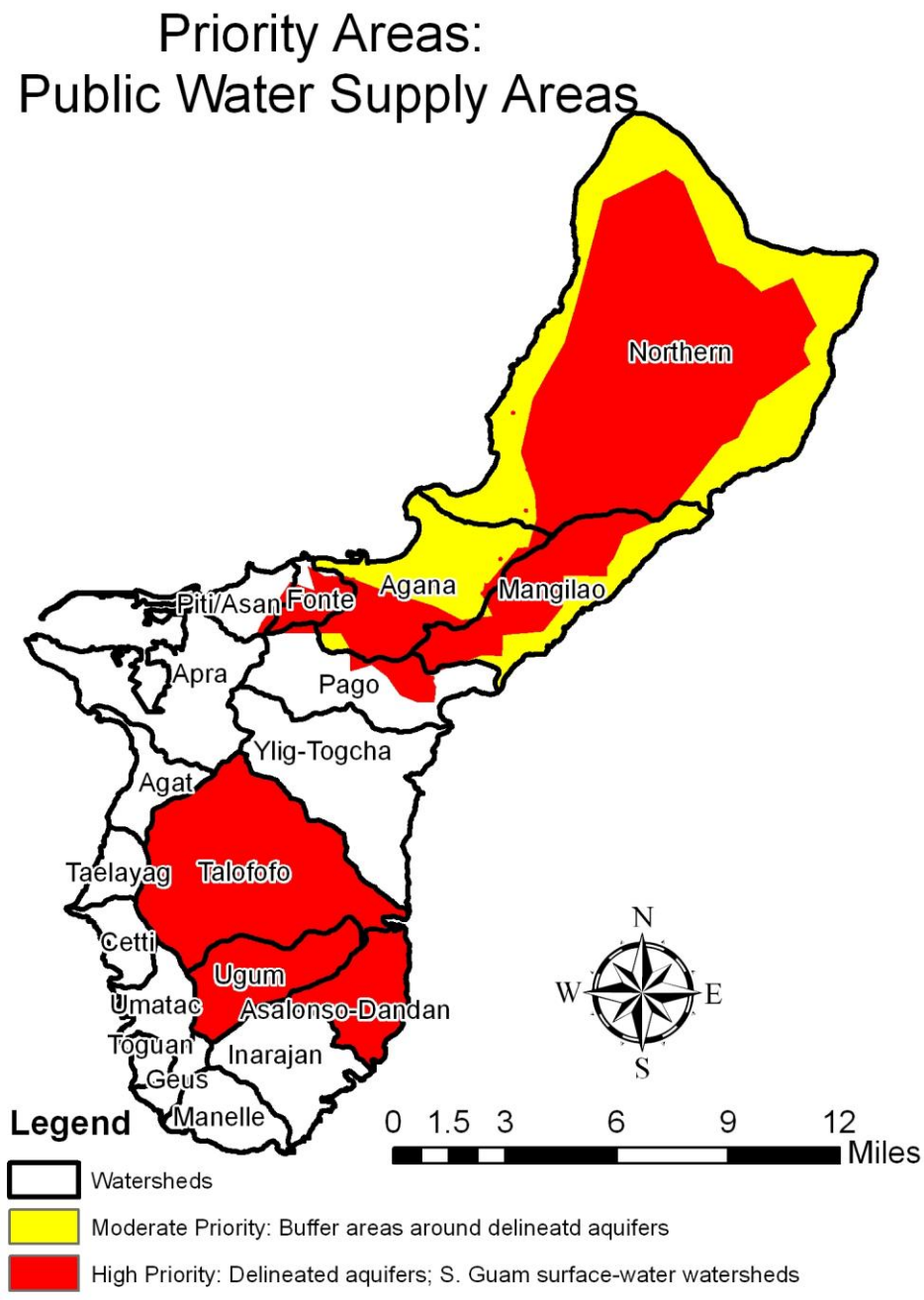

Figure 18. The prioritized areas for sourcing public water supplies. In the Northern region, the priority areas are zones of contribution for groundwater resources; in Southern Guam, three watersheds were prioritized for surface water.

Water Quality Priorities: Soil Erosion and Sedimentation

Soil erosion is an important issue in Guam, particularly in the southern half of the island. The combination of steep slopes, heavily weathered volcanic soils, and frequent and often intense rainfall provides conditions for erosion of soils in exposed cover types (low canopy grasses, exposed soils, road fill, etc.). Increasing population in the past 25 years has lead to changes in vegetation, road construction, and urbanization that increase erosion. Soil erosion on Guam results in loss of soil productivity, degradation of water quality in streams and drinking water sources, and degradation of coral reefs and fisheries resources around the island.

Land uses that contribute to increased erosion include those that remove ground cover and expose soil to erosive forces or land uses that reduce infiltration and increase surface runoff. Prevalent land uses associated with increased runoff and/or erosion include:

- Burning and removal of native vegetation (removes ground cover, increases runoff)
- Road construction and use (increases and channelizes runoff, removes ground cover if road is unpaved, focuses high-energy runoff directly to streams at crossings)
- Off-road vehicle use (disturbs soil, rutting leads to rills and gully erosion)
- Construction sites/urbanization (removes ground cover during construction, increases runoff)

Due to the high infiltration rates and low erosion potential of the limestone-based soils on the northern half of the island, there is little surface runoff and no streams. As a result, erosion hazard is minimal and is not a soil erosion high priority area. The low infiltration rates, high erosion potential, and steep slopes in southern Guam result in a high potential for soil erosion and delivery of eroded sediments to streams, which flags this area as a high priority zone for erosion and sedimentation.

To narrow site-specific areas to prioritize for potential treatments, the Nonpoint Source Pollution and Erosion Comparison Tool (N-SPECT) GIS model (Eslinger et al., 2005) was chosen to characterize relative erosion hazard areas in southern Guam. This model estimates surface and rill erosion and does not account for mass wasting, gully erosion, or streambank erosion. However, the factors affecting surface and rill erosion (slope gradient, vegetation cover, soil permeability) are the same that affect mass wasting and gully erosion.

Loss of soil and degradation of soil productivity can affect all areas of the landscape. The N-SPECT output map showed average annual erosion rates, which provide an estimate of the relative risk of soil/productivity loss (also identifies priority areas for *Issue 6. Degraded Lands*). Areas with the highest erosion risk occur in the headwaters of most of the watersheds in southern Guam. In general, these areas have steeper slopes, sparser vegetation, and higher rainfall rates.

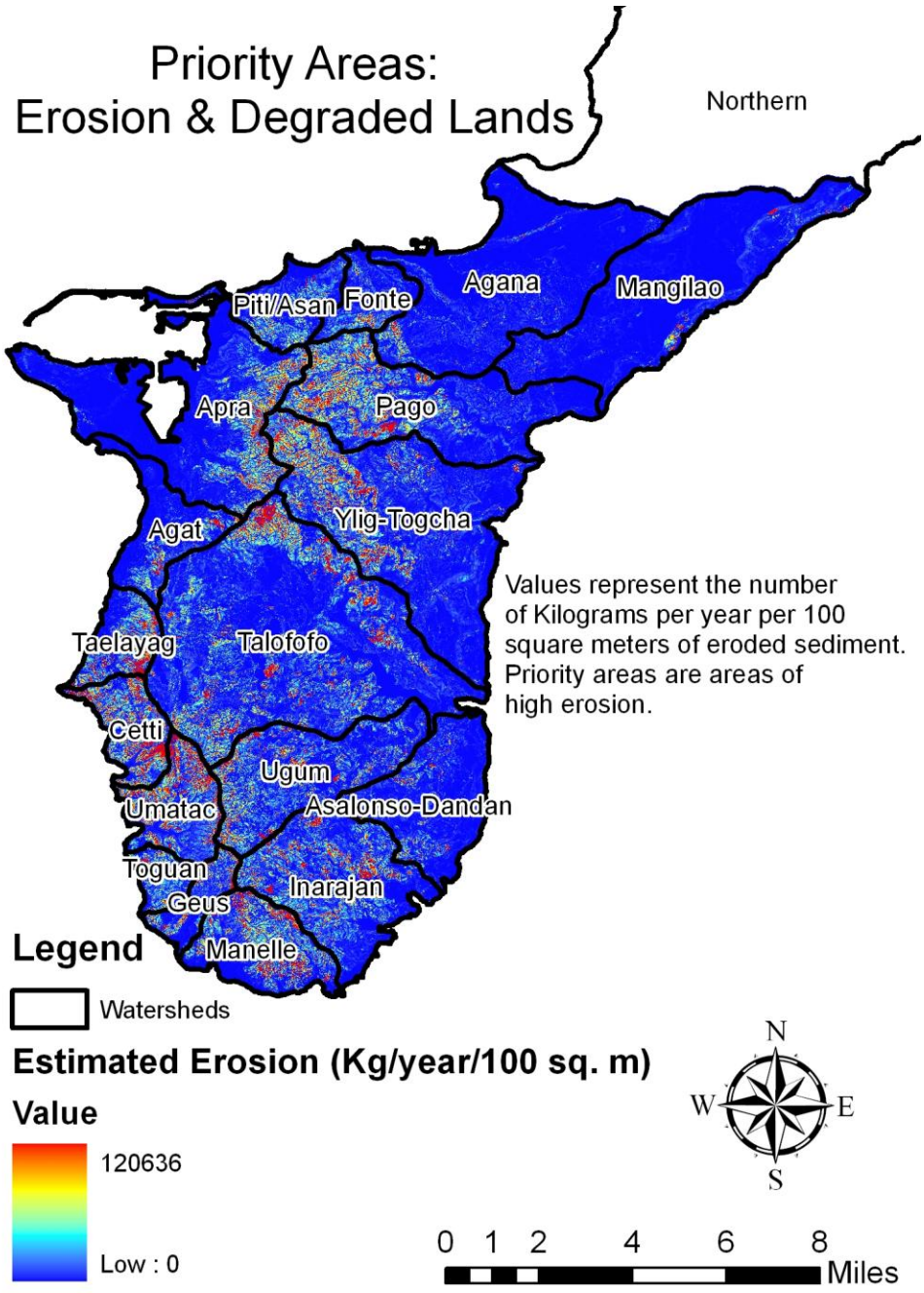

Figure 19. Priority areas for degraded lands, expressed areas that are undergoing erosion. Values are absolute (Kg/year/100 m²); prioritization follows for targeting areas of high erosion (light blue, yellow, red).

Fire plays a large role in altering the native forest vegetation cover in Guam. Due to the moist conditions, fire is not a prevalent natural process. However, fires are intentionally lit

to improve hunting success as animals are drawn to new shoots that sprout following the fire. Human-induced fires have affected Guam for several thousand years. Intentionally lit fires continue today, and the resulting altered vegetation cover of savanna and grasslands are adapted to the current fire regime. These altered vegetation types result in an increase of erosion following a fire; as much as 4-5 times more sediment can be eroded from burned land as from savanna; savanna/grasslands produce more sediment than heavily forested areas.

Erosion of the upper soil horizons is a particular issue on the volcanic soils prevalent in southern Guam because underlying material is saprolite. Saprolite is clay-rich, extremely decomposed rock that has low pH, low fertility, and a stiff structure. Once the upper soil horizons are eroded and the underlying saprolite is exposed, vegetation has an extremely difficult time becoming established and thriving. These un-vegetated areas can remain bare for long periods of time, and are referred to locally as badlands (for example, see badland areas in Figure 8 on page 28).

Eroded sediment is an issue for water quality, aquatic habitat, and reef communities if the sediment is delivered to streams. Sediment that is eroded far from streams has a lower probability of reaching the stream because much of it is caught in small topographic depressions or behind vegetation or other roughness elements. An estimate of the risk of eroded sediment reaching streams was made based on the N-SPECT model results and a linearly decreasing delivery assumption (i.e. less sediment delivers the farther away erosion is from a stream) within a 1,000 foot buffer around mapped streams. The resulting map shows the risk of erosion *and* delivery of sediment across the southern half of Guam (Figure 20).

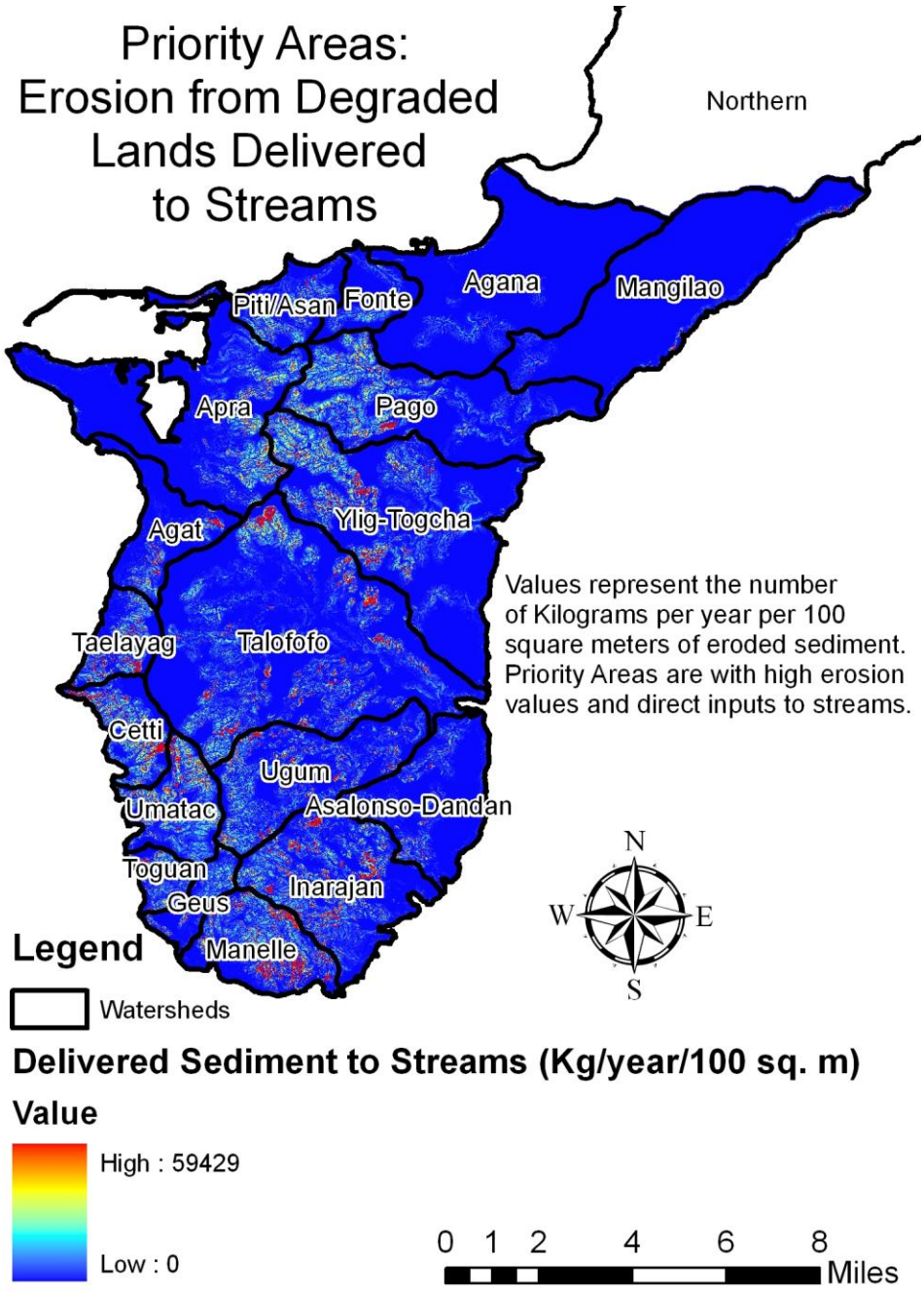

Figure 20. The priority areas for erosion and degradation that is producing sediment to streams and other waterways (including the reef system at the outlets). These priority areas are expressed in absolute measures—targeting high sediment delivery sites are prioritized for treatment and conversion to forests. Data are summarized in Table 12.

The estimated sediment delivered to streams in each watershed is shown in Table 12. Watersheds with the highest relative sediment yield are those on the steeper west and southern coast; the Cetti, Manelle (Merizo), Taelayag, and Umatac.

Table 12. Estimated Delivered Sediment Yield by Watershed. Priorities are defined by high numbers of delivered sediment, expressed as the total and as tons per acre. Planting priorities follow those acres that have high delivered sediment yield in watersheds that produce high volumes of sediment.

Watershed	Estimated Delivered Sediment Yield (average tons/yr)	Watershed Area (sq mi)	Delivered Sediment Yield (tons/acre/yr)
Agana	5,238	13.62	0.6
Agat	15,785	3.92	6.3
Apra	40,330	12.94	4.9
Asalonso-Dandan	16,082	6.54	3.8
Cetti	43,395	3.01	22.5
Fonte	4,140	2.46	2.6
Geus	8,822	1.75	7.9
Inarajan	64,601	8.69	11.6
Manelle	63,147	4.86	20.3
Mangilao	12,983	13.71	1.5
Pago	55,427	10.44	8.3
Piti/Asan	13,609	3.11	6.8
Taelayag	25,376	2.56	15.5
Talofofo	103,149	23.46	6.9
Toguan	11,736	1.41	13.0
Ugum	39,076	7.58	8.1
Umatac	49,771	3.82	20.3
Ylig-Togcha	81,928	15.73	8.1

Erosion on Guam, particularly the southern half of the island, has resulted in degraded soil productivity, water quality, aquatic habitat, and reef communities. Based on existing data

and studies, areas with the highest risk for erosion and delivery of eroded sediment to streams/reefs have been identified. N-SPECT, or a similar erosion prediction tool (e.g. DHSVM[20]) can be used to determine the relative decrease in erosion under different erosion control or re-vegetation effort scenarios and to help to select locations where improvements would be most effective.

Groundwater Infiltration

In northern Guam, the primary influence of water quality and quantity is related to the zone of contribution in the limestone aquifer (Figure 18). Principle activities that limit water absorption are roads, development, increases in impervious surfaces, and changes in forest cover that increase overland flow (and decrease absorption); these processes affect the *quantity* of water that is likely to be absorbed. Point source pollution, runoff from roads, and changes from native forest to industrial uses alters the *quality* of the water. In the northern region, Guam Forestry can provide tree ordinances along roads and developments to filter road and impervious surface runoff as well as provide greenspace to increase absorption (avoid conversion to impervious surfaces).

Water Quality and Erosion Priority Summary

The Stakeholder evaluation stressed the importance of protecting public water supplies and priority watersheds. Urban development and development associated with the military buildup is a threat to public water supplies on the island. Sediment modeling demonstrates the relationship between the altered vegetation types, fire frequency and the increase in erosion following a fire. Areas that show moderate to high sediment *delivery* rates are highlighted as priority areas in the south of the island. In the north of the island the development of greenspace ordinances in urban (or scheduled to be urban areas) represent high priority areas (see priorities in *Issue 3. Population Growth and Urbanization, Issue 4. Deforestation of Native Forests* and *Issue 5. Urban Forest Sustainability* sections).

Forest management strategies that direct resources toward reestablishing native forests, preventing and reducing fire frequency, and providing rehabilitation of degraded landscapes will improve water quality and assure safe water supplies for the future.

[20] Distributed Hydrology, Soils and Vegetation Model (DHSVM)

Issue 3. Population Growth and Urbanization

The expanding population provides a threat to the ecosystem resources which are already stressed by legacy impacts and existing population pressure. For example, the US EPA describes Guam's drinking water infrastructure as fragile and chronically at risk of contamination from wastewater[21]. Guam is facing an unprecedented increase in population associated with the military buildup. Though the estimated total population increase to Guam is varied and unknown, the high estimates suggest the population (temporary and permanent residents) will increase by 80,000 people in 2020, with a high interim peak increase of 125,000 in 2014 (Executive Summary, Dept. of Navy 2009).

Stakeholder Evaluation of Threats of Development to Forests

The threat of population growth was evaluated by the SWARS Advisory Council and by a specific evaluation of the effect of military expansion on forest resources (next section). The SWARS Advisory Council evaluated the threats of population increase based on the current distribution of cities and towns, with the threats of increased impervious surfaces (from roads, buildings, etc.). Population growth was assessed as having the highest threats and urban development within the northern watersheds. These are also the areas with the highest likelihood of development associated with the proposed military buildup.

This section discusses in quantitative and qualitative detail the treats to forests and urbanization in the next 5 years.

Threats to Forests from the Military Build-up

The population growth associated with the military buildup represents the greatest immediate threat to Guam's environment, especially forests. The primary threat from the buildup is the direct removal of forests by direct land conversion, such as housing and new roads. These effects will occur in specific locations as documented in the Guam and CNMI Military Relocation Draft EIS. In addition to the direct effects, secondary effects are anticipated with changes to land use. Increased access to the forest can cause a range of disturbances, including increasing fire frequency (barbeques, increased off-road vehicle use, military operations), spread of invasive species (direct establishment or importation of new species from increased off-island transportation of goods and transport of existing

[21] U.S. EPA. Territory of Guam background. http;//www.epa.gov/region09/islands/guam.html

invasive species to other parts of the island via road networks), and compaction or other physical damage to soils (increasing erosion and reducing forest health). Another secondary effect is the increased risk to disturbances. Smaller forest fragments are more vulnerable to wind throw, flood damage, fire mortality, compaction, firewood harvest, and invasive species.

Primary Effects of the Buildup

The primary threat from the military buildup is the direct displacement of currently forested landscapes. This effect was measured as the potential displacement of trees within the major areas of development identified in the Draft EIS. For this analysis, the proposed areas considered were limited to the Proposed USMC Main Cantonment & Family Housing compounds ("Housing"), the proposed Andersen South Training grounds and associated firing ranges ("Andersen"). A map of the proposed development zones is shown in Figure 21. Other areas may also exist, though additional spatial information was not immediately available at the time of this assessment. These areas represent the largest areas currently proposed for construction.

The proposed Housing development areas include approximately 5,055 acres in two major locations and an additional 3,870 acres of affected areas within and adjacent to the proposed Andersen training grounds. In total, the primary disturbance area included approximately 9,375 acres that would be directly influenced by development or other activities.

Examining only the area within the 9,373 acres of proposed development, up to a total of 5,432 forested acres are at risk of deforestation due to direct effects associated with the proposed development (removal of forest for development). This represents 10% of the total 56,496 acre forested environment on Guam (Table 13). This does not include roadways, transmission lines, or other features outside of the boundaries that will directly service the development areas.

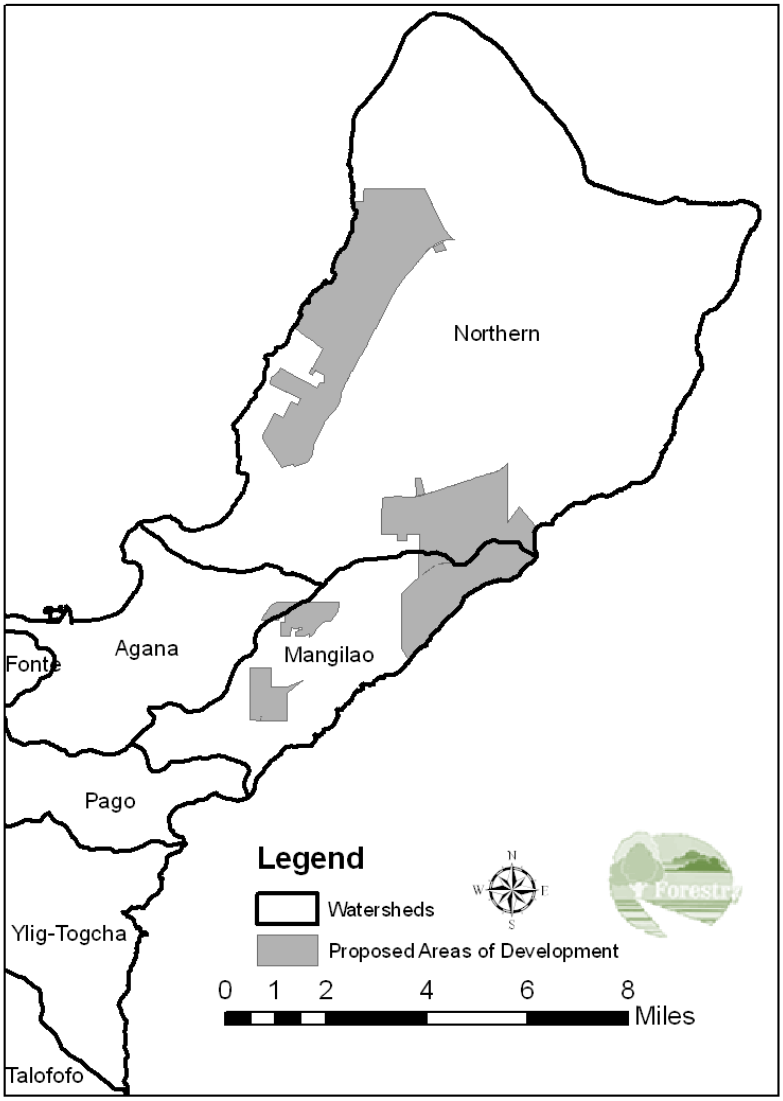

Figure 21. Locations of the proposed development areas of the military buildup. These areas represent 9,375 acres, and do not consider secondary development areas (roads, services, etc. data were not available).

The proposed reduction of forest cover of up to 10% of the total forest cover of Guam is a significant impact that affects the viability of Guam's forests, including reductions in the benefits of forests: groundwater infiltration, potential habitat, biodiversity, and water quality. The additional residents and uses of these landscapes also increases the threats of insects, disease and invasive plants to existing forests.

Table 13. Priority areas at risk from development. These priority areas are within the proposed military buildup parcels to and the island-scale effect on the forested environment.

Location	Total of Forested Acres	Total Acres Affected	% Affected Forest within Development	% Total Forest on Guam
Andersen	2,733	3,868	71%	5%
Housing	2,699	5,505	49%	5%
Totals	**5,432**	**9,373**	**58%**	**10%**

Given a minimum of a 10% reduction in forest cover for all of Guam, the areas of development are high priority regions to lower the risk of urbanization. A table and map of these areas with crown cover is presented in Table 13 and Figure 22. Actions for within these areas include development of a tree ordinance to minimize risk of deforestation of native forest (work with military on design and use of properties) as well as developing possible mitigation options for expanding forest elsewhere in Guam (see *Synthesis of Issues* section on page 88).

Secondary Threats of Development

There are a range of other secondary effects of development that can cause harm to forests, decrease their productivity, and limit their resilience to natural disturbances. Though not directly quantified in terms of acres, the major secondary threats to development include:

- **Military Buildup: Roads, Shopping Centers, Other Infrastructure.** Inherent with the projected population increases for Guam, there will likely be a need over the next 5 years to increase roads and transportation networks and increase business services for families and residents (military or civilian). These needs would likely expand other areas into potentially forested zones within and beyond the 500 ft urban intermix zone. New areas for development would directly displace trees and forest fragments. These areas will likely increase fire ignition points and complicate the fire risks to forests and urban zones on the island.

- **Edge Effects and Degradation around Developments.** Forest fragments, and their resilience to disturbance, are related to the amount of forest edge associated with the environment (Laurance and Bierregaard 1997). Increases in forest edge increases wind-driven disturbance (windthrow), invasive species establishment,

and fire edge effects. All of these factors contribute to mechanisms that increase edge size (decrease fragment size), resulting in long-term disturbances related the initial development.

- **Urban Areas and Transportation Routes are Vectors for Invasive Species.** Increasing urban areas and fragmenting the forest also serves as potential vectors of spread for invasive species to travel to relatively intact forests elsewhere in the development area. Increased traffic, additional people on Guam, and cargo container and equipment deployments in development zones are all opportunities for invasive species to enter Guam and/or for infestations located on other parts of Guam to enter the development sites. Washing equipment prior to entry into a site for development is one example that will aide in the reduction of spread to neighboring forests, particularly from equipment that has been within CRB and cycad scale containment areas (e.g. Tumon).

Threat and Priority Summary

The threats to development from population growth and expansion is a serious issue for Guam in the near-term. At least 10% of Guam's forests are scheduled for development, not including the transportation, transmission lines, shopping centers and other infrastructure that will be associated with the military buildup. Priorities areas include the areas of development currently proposed (Figure 22), as well as synergies with other issue priorities. *Issue 4. Deforestation of Native Forests* outlines where potential native forest is in relation to the planned urbanization (Figure 23) and provides a tree map with associated ownerships so that Guam Forestry can work with UCF, Stewardship, Legacy, and Forest Health programs to identify potential willing landowners when additional roads and infrastructure is proposed for the military development (Figure 24). In addition, *Issue 5. Urban Forest Sustainability* priorities identify potentials for planting new trees in Urban Zones to increase cover in especially the northern (urbanized) region (Figure 26). Development of pro-active tree ordinances, including urban growth boundaries and greenspace requirements, are strategies to increase forest cover and better plan for development *with* healthy forests.

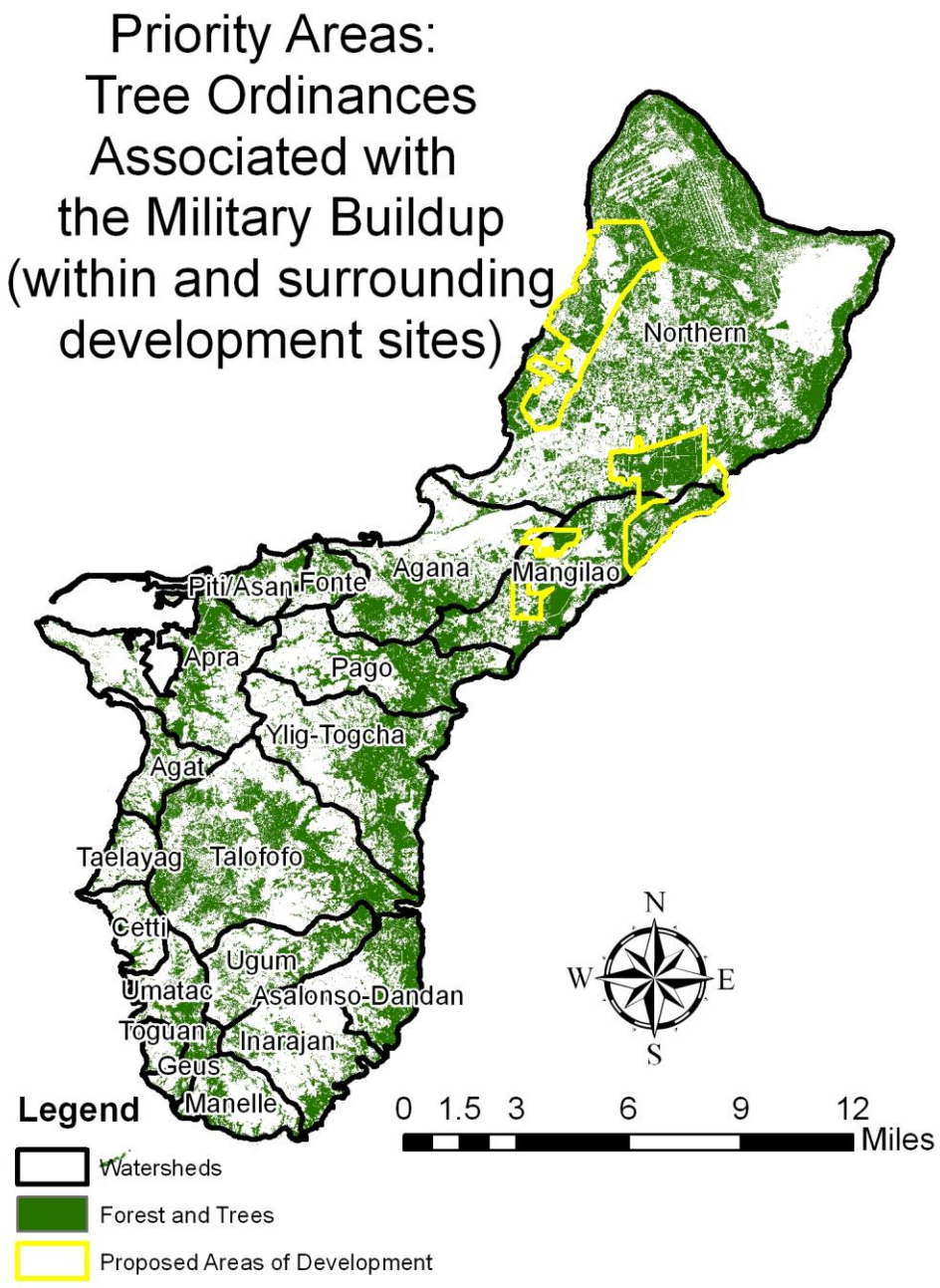

Figure 22. The priority areas to work with the Military to develop tree ordinances and development codes to avoid deforestation within the proposed boundaries of development (10% of Guam's forests are within these boundaries). Work with the military and local governments to ensure greenspace and tree ordinances for connecting roadways and future developments that will service the area. Data within the proposed areas of development are summarized in Table 13. Also refer to Figure 23 and Figure 24 for native forest and priority ownerships (i.e. private lands) that can be compared with the urban plan for military development (not completed).

Issue 4. Deforestation of Native Forests

The evaluation of Deforestation of Native Forests (especially old forests) is an estimate of the threat posed to unique forest environments on Guam. The stakeholder evaluation (Appendix 2) identified a qualitative grouping of where old native forests were most likely to occur and coupled outcomes from *Issue 3, Stakeholder Evaluation of Threats of Development* to evaluate threats.

Figure 23 displays a hybrid of the stakeholder-driven identification of native forests coupled with the tree crown map associated with the SWARS vegetation layer. These forests have not been have surveyed for forest structure, composition and overall health, though the SWARS process has identified these areas as priority areas for conservation and gathering of ground-truth information through inventory surveys.

The stakeholder evaluation was qualitative in nature and identified potential deforestation threats to native and old growth stands in the headwater portions of southern Guam watersheds, and the coastal fringe in northern Guam (Figure 23). Many of these areas also have a high likelihood of development associated with the proposed military buildup, particularly in the area scheduled to be converted to the Andersen Training grounds and Housing in Mangilao and immediately north (see *Issue 3, Stakeholder Evaluation of Threats of Development*).

Avoiding deforestation is highly dependent upon willing stakeholders and the capacity of land management agencies to administer and facilitate local conservation and conservation groups. Figure 24 represents the priority areas (all trees) for Guam for potential evaluation and conservation projects. Private lands provide opportunities for identifying potential Forest Legacy participants, as well as Forest Stewardship, Cooperative Fire and Forest Health projects for improving forest conditions, expanding forests and fuels conversion projects to minimize risk to forests. In addition, the existing forest fragments can be coupled with areas delivering sediment to streams. Avoiding deforestation (and planting trees, and increasing forest health) is extremely relevant to all Stakeholder Issues on Guam. Coordinating stakeholders that are willing to implement conservation (and enhancement projects) is paramount to the success of the project (see *Land Ownership & Management* on page 12 for further discussion on ownership and forest cover).

Figure 24 identifies key landowner types—the critical data gap is to inventory these lands and identify native forest reserves and potential candidate sites for conservation and enhancement programs. Native forest tree ordinances would enhance conservation efforts.

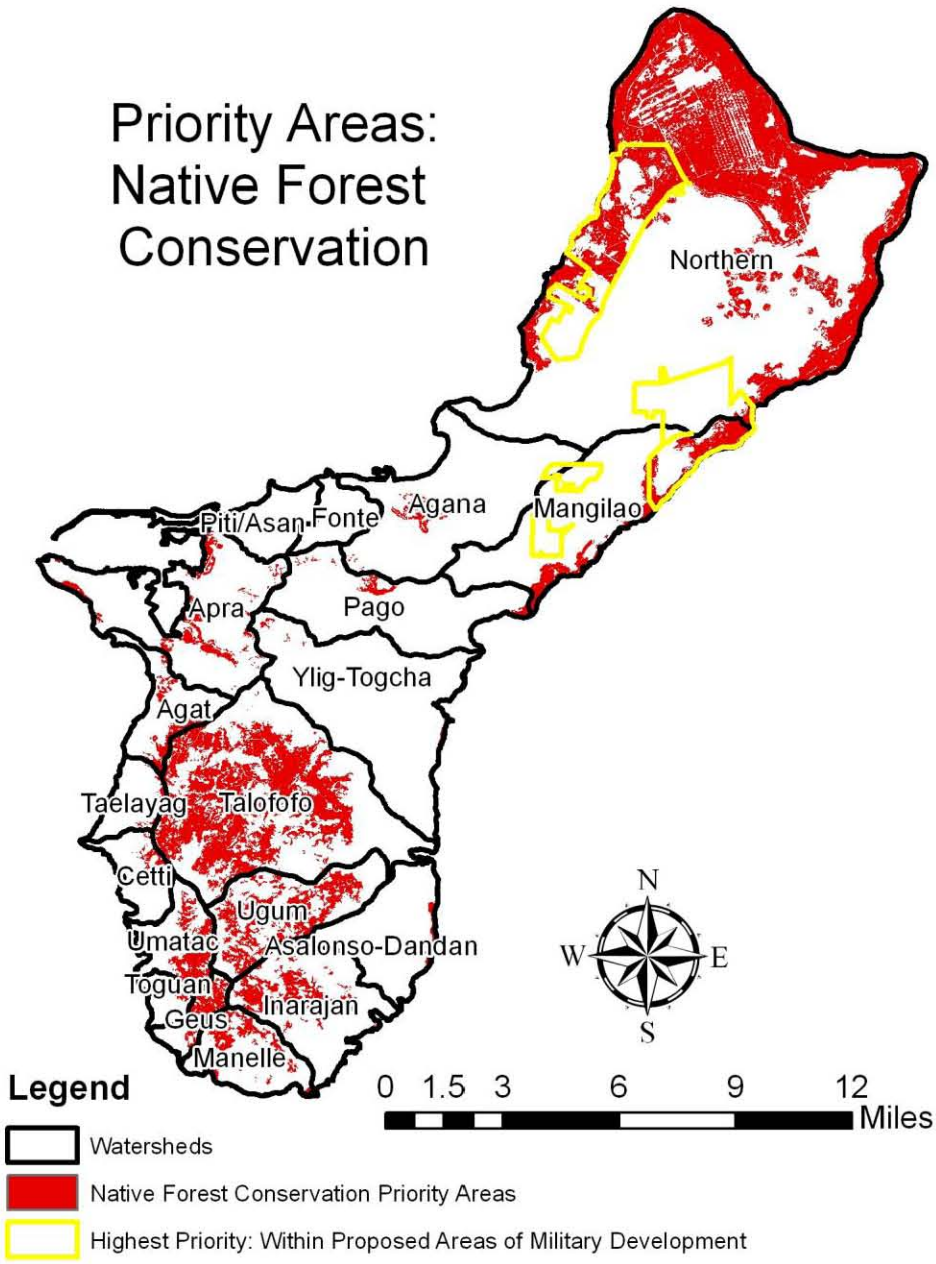

Figure 23. Priority forest fragments for conservation actions that are suspected to be native forest. The highest priorities are within the current military development properties. Ground-based surveys are needed to better identify native forest locations, composition and health.

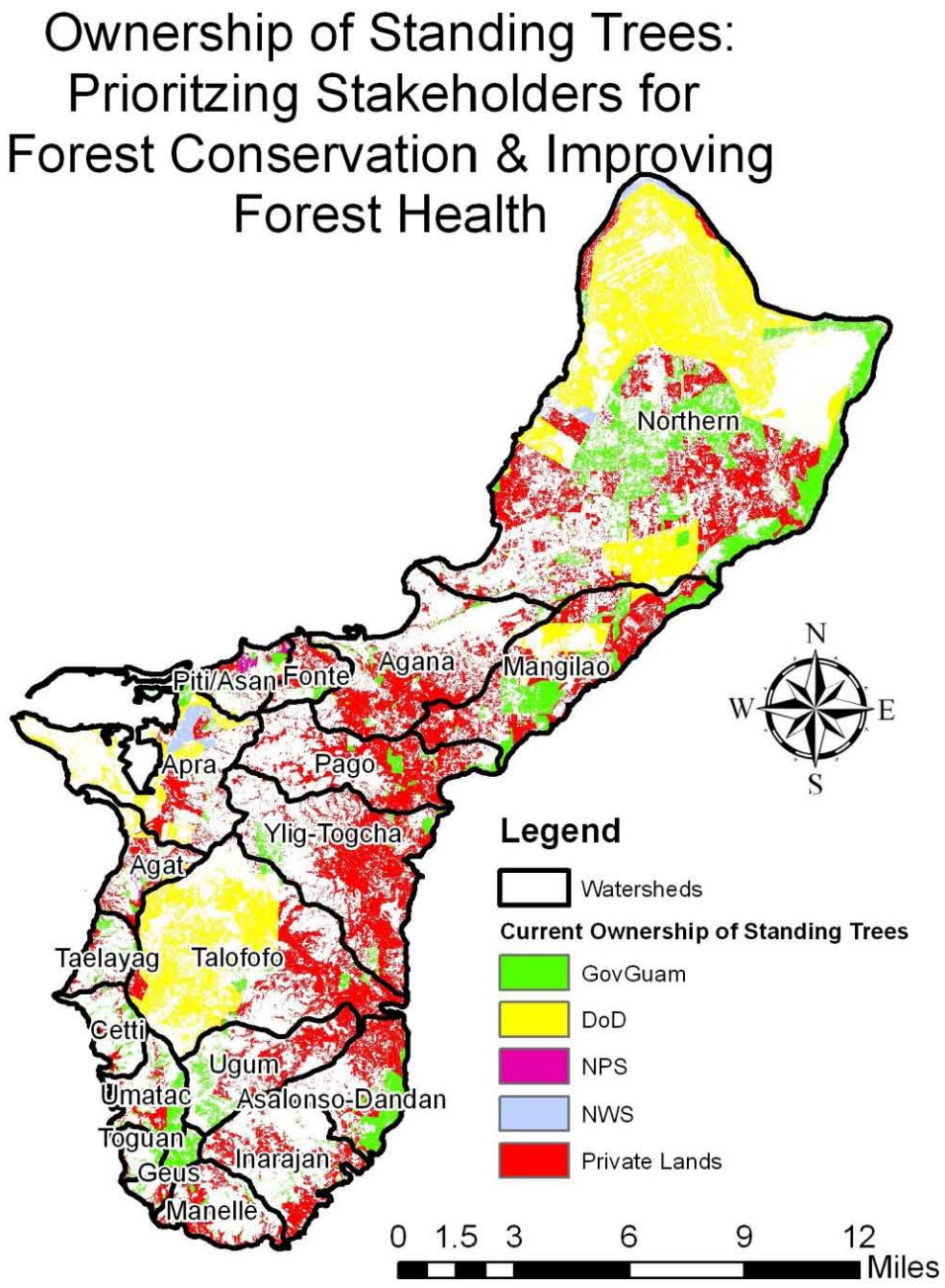

Figure 24. The tree crown map with forest fragments identified by current ownership. Private forest fragments (red) are priorities for programs such as Stewardship, Legacy and Forest Health. Contiguous stands are high priorities for Forest Legacy programs (e.g. lower Ylig watershed) and coordinating forest health improvement projects.

Issue 5. Urban Forest Sustainability

This issue differs from *Issue 3. Population Growth and Urbanization* in that it focuses on the establishment and use of urban forests in planning within an urban intermix zone, rather than on the direct threats of development to forests. This issue was evaluated using two methods. The first was by the SWARS Advisory Council using qualitative measures of threat of development as identified from the *PIC Veg layer*. The second involved a fine-scale assessment of the current urban forest conditions using the SWARS vegetation map. Results for both of these assessments are presented below.

Stakeholder Evaluation of Urban Forest Sustainability

The SWARS Advisory Council identified that the threat to Guam's urban forest resources was primarily associated with development. The environmental attribute layer used to evaluate this issue was a measure of the proximity to areas of existing development, and whether or not the land is in private ownership.

The threats and priorities for urban forestry, as evaluated by the SWARS Advisory Council is depicted in Figure 25. The shades of red on the map show where existing development is heaviest and therefore where the continued threat to urban forests will occur ("500" ranking, see Appendix 2). Stakeholder evaluation shows wide-spread threats to urban forest sustainability, with heavy emphasis following road networks.

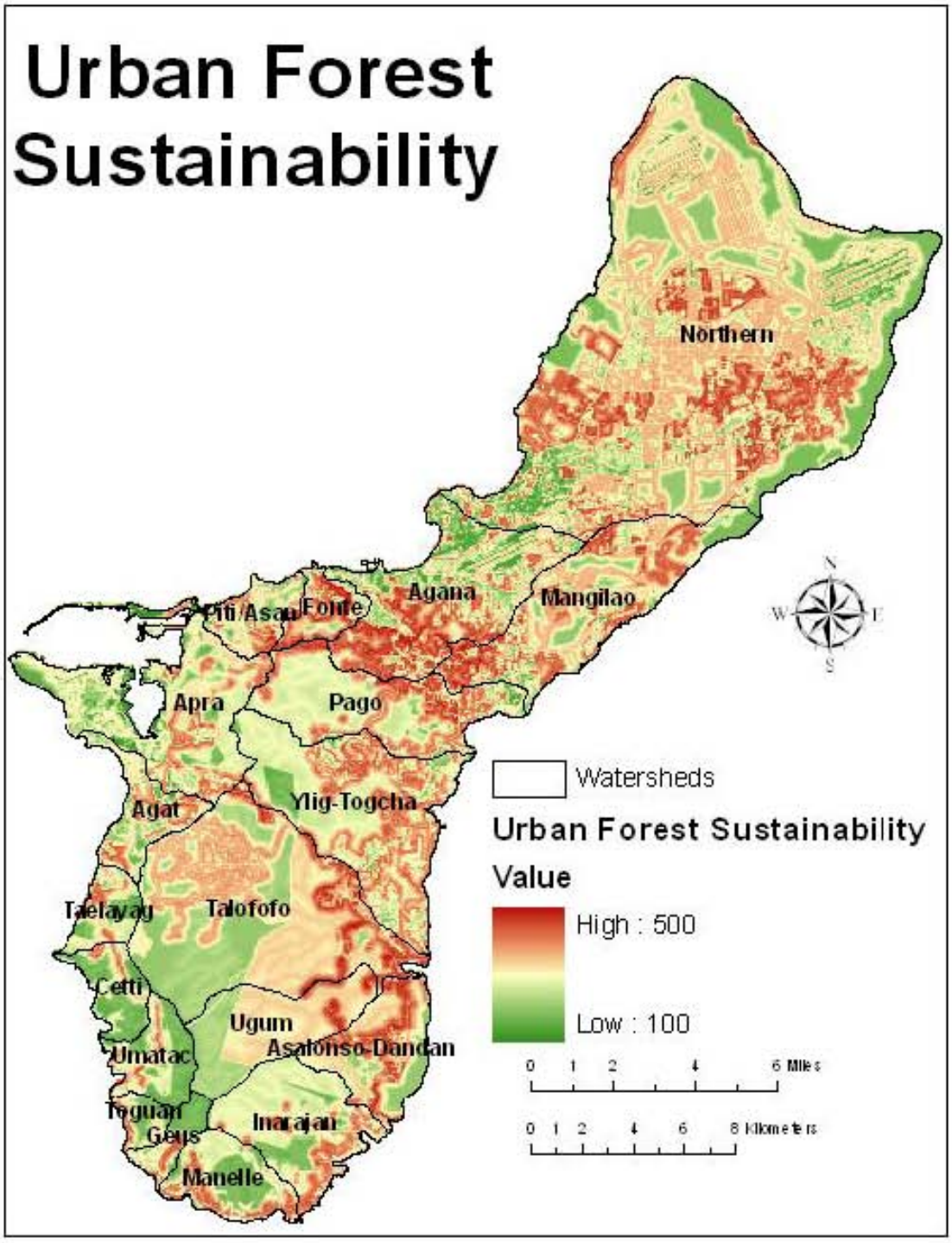

Figure 25. Priority areas identified by stakeholders for urban forest sustainability. These areas depict priorities for threats to development of near-urban areas on private land (in red). Values between 100 (low priority) and 500 (high priority) indicate the stakeholder priorities. Further discussion on the development of this map is found in Appendix 2.

Urban Forest Assessment and Priority Areas

The fine-scale SWARS Vegetation map provides a more detailed method of identifying the current conditions and threats to the urban forest environment. Specifically, the objective was to identify the current forest structure that are within the urban areas (forest versus non-forest, based on LiDAR analysis), and identify key data gaps and recommendations associated with conducting an Urban & Community Forestry projects that increase urban forest sustainability and minimize risk to new plantings.

As stated in prior sections, the SWARS Vegetation map allowed for the mapping of *individual tree crowns*, and was used to determine the existing conditions of the Urban Intermix zones (500 ft buffer of urban zones, including highly developed and open urban areas)[22]. "Forest" areas are described as individual trees, or forest fragments located within the Intermix.

Urban forestry projects were prioritized on the basis of municipality, with emphasis in the northern districts encompassing the majority of the high density urban zones: Agana Heights, Barrigada, Dededo, Hagåtña, Mangilao, Mongmong-Toto-Maite, Tamuning, and Yigo. Within the Urban Intermix, two priorities were further delineated. The first was areas of existing forest—these areas are prioritized for conservation projects, including maintenance and monitoring for tree pests and diseases, and for developing inventories of existing trees in the urban zone. The second priority is for areas that have the *potential* to be planted to trees with native/local trees through community events (e.g. Arbor Day), and implement and integrate a Tree Ordinance or greenspace design. These priorities are displayed in two separate maps: Figure 26 represents the prioritizes within urban zones on all ownerships, and Figure 27 identifies those on private lands only.

An important outcome with the Urban Intermix is the areas that surround roads are also included into the urban zone. This is important because tree planting within road buffer areas can decrease other threats, including fire threat and sediment delivery sourced directly from roads. Use of bioswales and similar forested structures in strategic points can serve as areas to slow stormwater runoff energy and help to improve water quality in stormwater moving to streams, water supplies and the reefs. These sets of standards in using trees along transportation networks and urban areas represent criteria that can be incorporated into Tree Ordinance or greenspace regulations for development.

[22] See the *Fire Risk to Communities: Urban Intermix* section for further discussion on the urban intermix zone.

Though addressed by municipality, forested acres were calculated for consistency at the watershed scale. Total tree cover by watershed is summarized in Table 14, with the breakdown of forest cover (priorities for conservation, maintenance, monitoring priorities) and non-forest cover (priorities for community projects, planting and implementing tree ordinance) within the urban areas.

The northern watersheds region has the highest proportion of acres within the Urban Intermix zone. In addition to the northern watersheds, Apra, Agat, Piti and Fonte in western Guam had over75% of the watershed area within the urban zones. Approximately 52,000 acres are non-forested within urban zones, representing approximately 59% of the classified Urban Intermix of Guam. There is a large potential for increasing overall forest cover in urban zones across all ownerships.

Planting efforts have focused on the northern (priority) municipalities (Figure 26) in public parks including Ypao Park, Matapang Park, Adelup Park, Agana Heights Park and Paseo Stadium Beach Park. Planting projects have also been conducted at numerous elementary schools (Astumbo, Talofofo, Price, Untalan, FBLG Elementary Schools) and high schools (Okudu, Father Duenas, Simon Sanchez High Schools) as well as all village Mayor's offices, the University of Guam and the Governor's office building complex. Planting success has varied on the basis of the ability for each community to maintain the plants. The lack of maintenance, fire and infestation by insects has been the primary limiting factors associated with the urban forestry projects. Obtaining additional support for a certified arborist is within the 5 year strategy.

Some ongoing issues include generating more involvement from the UCF committee, as well as developing future development criteria including a tree ordinance, greenspace standards, and integration of urban forestry into the implementation/development plan associated with the Military buildup and secondary development that is expected in the next 5 years.

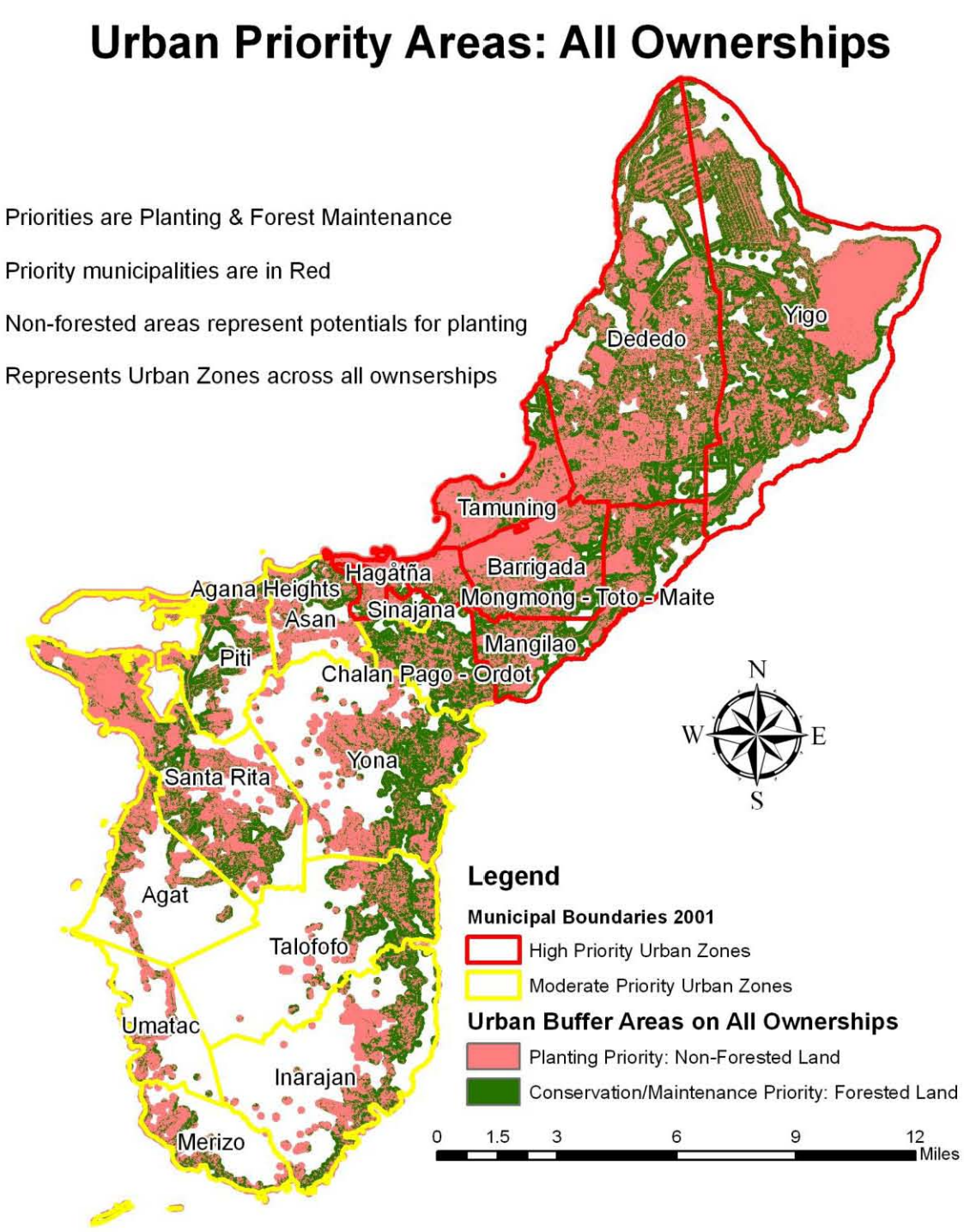

Figure 26. Urban priorities for <u>all ownerships</u>. Priority municipalities are located in the north. Areas for potential planting and multiple stakeholder involvement are in pink; priorities for conservation of existing forest are in green.

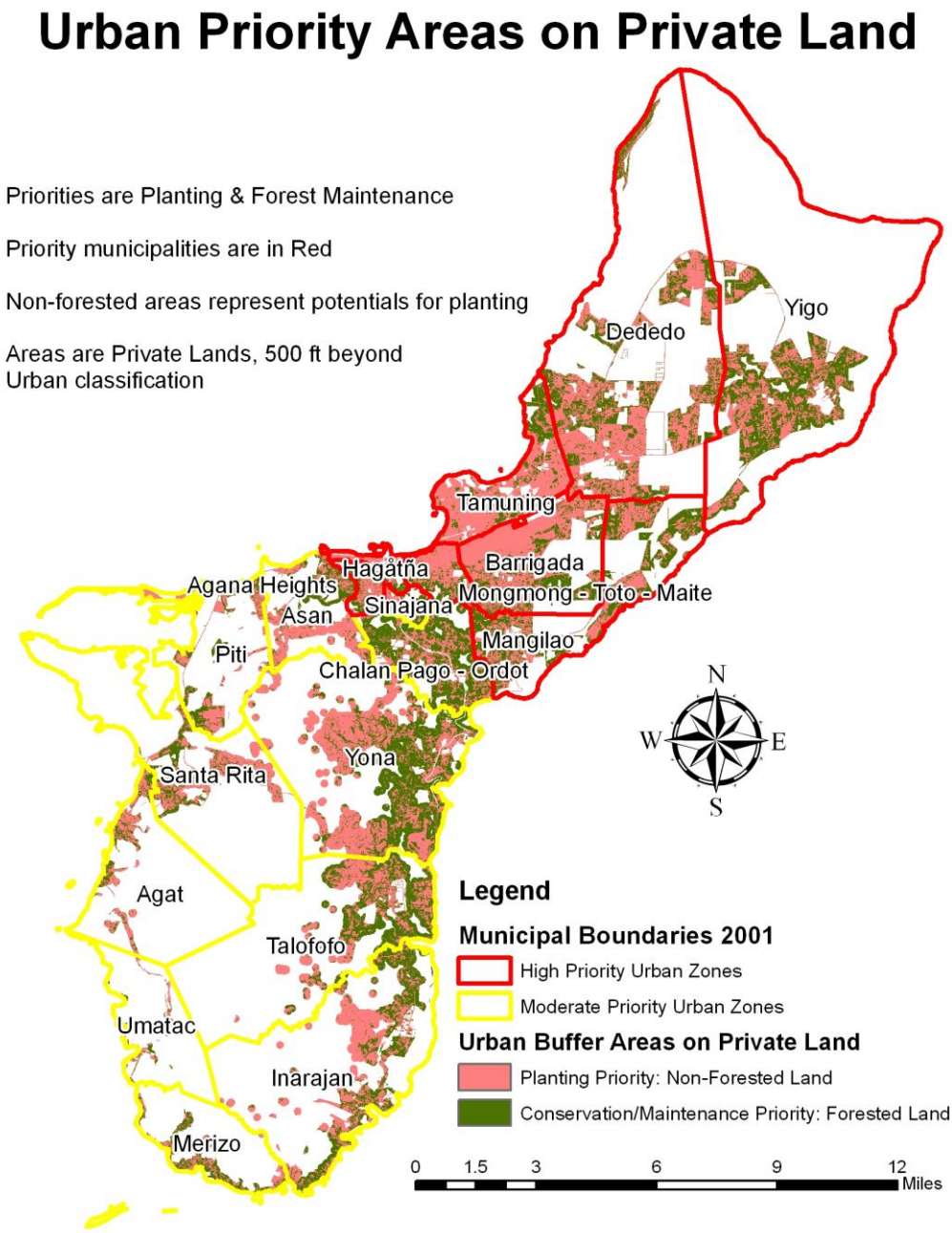

Figure 27. Priority areas on <u>private lands</u> within urban zones and 500 ft buffer surrounding them. Priority municipalities are located in the north. Two major action priorities are depicted: the first is potential areas to prioritize planting projects in urban zones (find specific locations, willing landowners, etc.). The second priority is for conservation and maintenance of existing forests in the urban zone (urban classified areas and a 500 ft buffer). Potential Forest Legacy projects can couple on private ownership with UCF objectives to increase and protect overall forest cover.

Table 14. Forest and non-forest acres within the Urban Intermix. Acres of forest and non-forested areas are expressed as the percentage of the urban intermix area. Forested area priorities are conservation, monitoring and maintenance. Non-forest area represents potentials areas for community planting projects to enhance urban forest.

Region	Water-shed	Watershed Acres	Urban		Non Forest		Forested	
			Acres	% Water shed	Acres	% Urban Intermix	Acres	% Urban Intermix
Eastern Watersheds	Pago	6,683	3,748	56%	2,000	53%	1,748	47%
	Ylig-Togcha	10,067	6,561	65%	3,502	53%	3,059	47%
	Talofofo	15,016	6,085	41%	3,460	57%	2,625	43%
	Ugum	4,851	600	12%	354	59%	246	41%
	Asalonso-Dandan	4,183	2,321	55%	1,288	55%	1,033	45%
	Inarajan	5,564	1,707	31%	1,140	67%	567	33%
Western Watersheds	Manelle	3,107	1,000	32%	583	58%	417	42%
	Geus	1,120	527	47%	349	66%	178	34%
	Toguan	903	556	62%	453	81%	103	19%
	Umatac	2,447	776	32%	607	78%	169	22%
	Cetti	1,928	430	22%	327	76%	103	24%
	Taelayag	1,639	647	39%	435	67%	212	33%
	Agat	2,511	2,131	85%	1,439	68%	692	32%
	Apra	8,283	6,230	75%	4,287	69%	1,943	31%
	Piti/Asan	1,993	1,604	80%	1,068	67%	536	33%
	Fonte	1,575	1,266	80%	694	55%	572	45%
Northern Watersheds	Agana	8,717	8,322	95%	5,733	69%	2,589	31%
	Mangilao	8,772	7,638	87%	3,599	47%	4,039	53%
	Northern	44,971	36,242	81%	20,601	57%	15,641	43%

Summary

The Stakeholder-developed map (Figure 25) highlighted the urban zones where the threat of continued degradation through development is expected to occur. Specific priority areas have been identified that can be used for two major priority actions: (i) conserve, protect, maintain and monitor standing trees, and (ii) identify additional areas on all urban lands (Figure 26) and engage private landowners (Figure 27) to participate in urban forestry projects on non-forested lands. Strategically, the implementation actions on the ground should be aimed at increasing fragment size, converting areas along roadsides to forests to minimize fire risks (meeting multiple stakeholder objectives, see prior Issue discussions) as well as developing tree ordinances and greenspace criteria to meet a desired future condition of trees in the urban environment.

Strategy considerations should include estimating the *potential* for forest growth, specifically targeting areas where trees can provide multiple benefits, including recreation, abatement of sediment, reduction of hazardous fuels, urban habitat, and open space aesthetic values. Overall, the non-forest acres presented in Table 14 identify the *potential* areas for planting trees in the urban environment. Ground truthing is needed to evaluate areas that have the highest value for the planting project, selecting stakeholder groups that will be most likely to maintain the plantings and ensure successful implementation.

A current implementation gap is incorporation of planting requirements into current urban development plans. Potential for planting trees could include roadways, parks, greenways, and "functional areas" to offset runoff (e.g. bioswales to capture stormwater). Additionally, Guam does not currently have a tree ordinance that defines Best Management Practices (BMPs) or other regulatory considerations to address road runoff, sediment abatement, and parks and open space. This is a programmatic action that should be considered in implementing Urban and Community Forestry programs that would continue to meet multiple stakeholder objectives..

An important strategy as part of the Urban and Community Forestry program is to work with the DoD during the proposed expansion phase for new developments. Use of tree ordinances that focus on *retaining standing forest* rather than *replacing* lost trees would help to increase the use of native species in urban forestry planning.

Issue 6. Degraded Lands

The SWARS Advisory Council identified areas that are considered a threat to future ecosystem health, with lands that have limited vegetative cover or are barren areas. The Degraded Lands map was developed from several environmental attribute layers during the Stakeholder evaluation period – fire risk, proximity to protected and managed areas, riparian areas, wetlands, public water supply/priority watersheds and threats associated with development and slope. Threats are concentrated primarily in the headwaters and higher elevation areas of the Cetti, Piti/Asan, Ugum and Talofofo watersheds (Figure 28).

This issue overlaps with many of the other issues described in the assessment. In particular, the rate of potential recovery from degraded lands status is dependent upon the ability to successfully be reforested, while maintaining a fire-free environment for several years following planting. Because degraded lands have larger areas of exposed soils, and can contribute to higher amounts of eroded sediment to streams and reefs, prioritization of degraded lands is similar to the prioritization of high risk fire-prone areas that are within a delivery distance to streams.

The priority areas and rational discussed in *Issue 2. Water Quality and Water Supply*, specifically the *Water Quality Priorities: Soil Erosion and Sedimentation* beginning on page 61, is especially relevant to this Stakeholder Issue. Priority Areas for degraded lands are mapped for sites to plant having high erosion (Figure 19), with higher priorities set for those eroding areas where sediment is being delivered to streams (Figure 20).

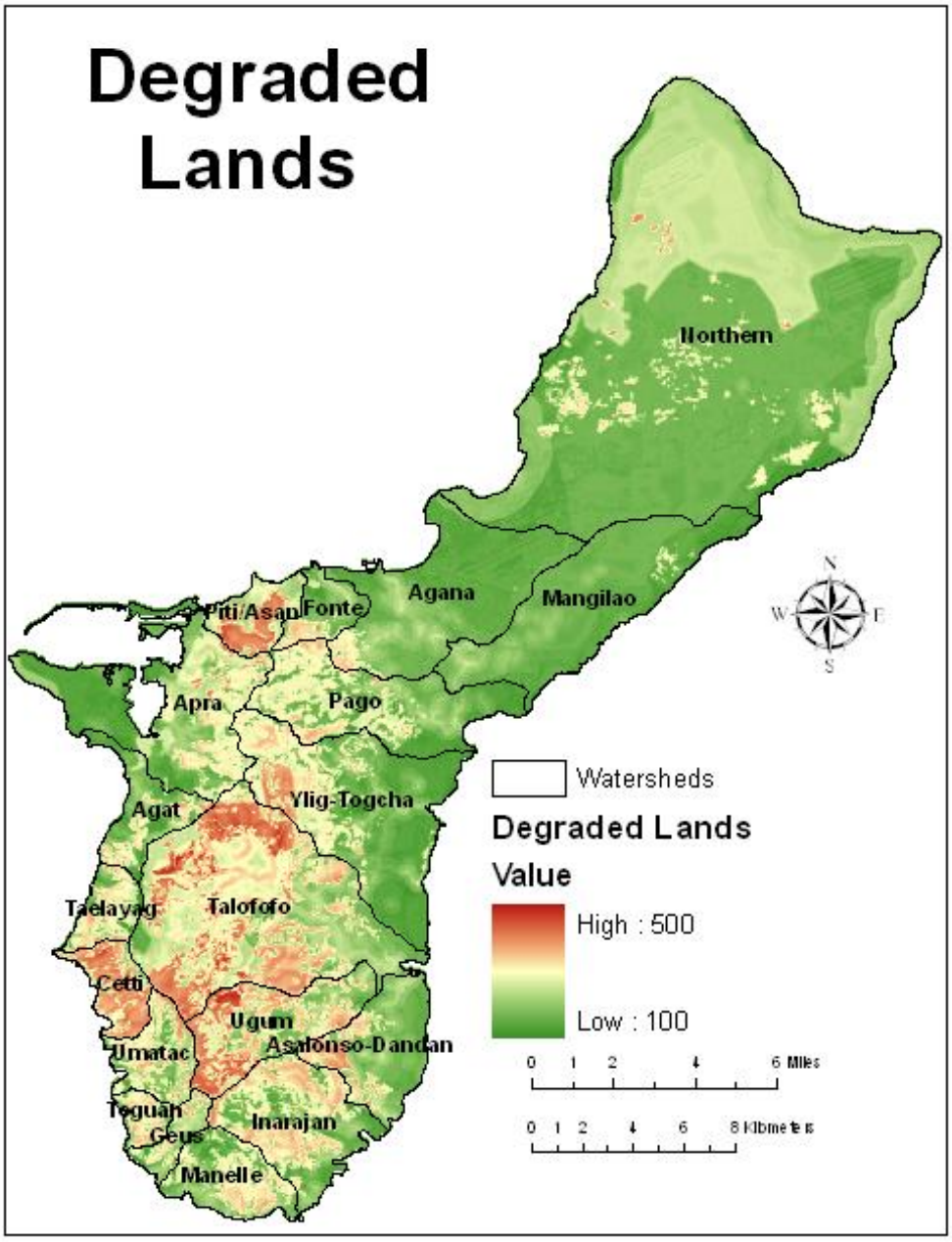

Figure 28. Prioritized degraded lands issue map developed from the Stakeholder evaluation. Values between 100 (low priority) and 500 (high priority) indicate the stakeholder priorities. Further discussion on the development of this map is found in Appendix 2. A refined (quantitative approach) priority area map of degraded lands was developed in Issue #2, on the basis of erosion and sediment to streams, as shown in Figure 19 and Figure 20.

Synthesis of Issues: Actions Meeting Multiple Objectives

As mentioned in the Stakeholder Issues sections above, each of the 6 Stakeholder Issues are interlaced with each other in how single, targeted actions in resource management can meet multiple objectives identified by stakeholders. Likewise, objectives and funds from multiple S&PF Programs can be applied to single activities on the landscape, and used to increase efficiencies in implementation, maintenance and monitoring.

This section synthesizes the threats and processes and identifies specific locations of planting and treatment activities that are the Highest Priority Areas For Treatment[23] to satisfy the broadest range of threats, over the broadest range of issues, under the broadest range of S&PF Programs and National Themes. This section maps the Highest Priority Areas in the urban zones and around forested areas, and does not preclude the importance of the Priority Areas in prior sections. These areas are in fact a subset of Priority Areas from multiple issues, and represent the framework to conduct the first implementation actions for treatments on the landscape in the next 5 years.

Bringing Broad Stakeholder Issues to Specific Threats

The six issues identified by stakeholders are linked to major island-scale risk factors that meet the three National Themes. The three major drivers include: fragmented forests, risk of severe fire behavior, and large-scale population growth associated with the military buildup. Table 15 displays the primary drivers of degradation on Guam and how they are related to the stakeholder issues.

[23] "Highest priority" areas are not the only priorities for treatment. These areas represent the most critical threats and should be considered the first areas to apply treatment.

Table 15. Synthesis of Threats and Major Drivers to Issues Identified by Stakeholders.

	Major Drivers Affecting Stakeholder Issues		
Stakeholder Issues	**Fragmented Forests and Conversion to Grasslands & Savannas**	**Fire Risk**	**Development and Military Build-up**
1. Wildfire and Public Safety	Increases fire risk	Associated with altered veg. cover	Fire risk increases expansion into forests
2. Water Quality and Supply	Reduces water capture & increases sedimentation	Removal of veg. cover increases sedimentation	Construction and development directly impacts water quality; increased water supply demand
3. Population Growth and Urbanization	Increased population contributes to forest removal and pressure on remaining forests	Fire risk increases with increase in Urban Intermix Zone	Direct population increase due to Military Buildup
4. Deforestation of Native Forests	Limited (and unknown) intact forests remaining	Fire threat to remaining intact forest	Direct risk of deforestation by construction – represents minimum of 10% of total forested area on Guam
5. Urban Forest Sustainability	Altered forests threatened from invasive plants, insects and disease	Direct threat of fire in urban areas	Increased population - removal of forest canopy in developed areas.
6. Degraded Lands	Conversion to non-forest communities increases amount of degraded lands	Increased fire frequency is a primary cause of degraded lands	Increased development and population is a factor for increasing amount of degraded lands

Management options or strategies associated with the stakeholder issues are fundamentally tied to mitigating the threats or risks on natural resources. In many cases, these involve similar treatments (e.g. tree planting); targeting specific areas that meet multiple objectives is a cost-effective method for land management that accomplishes goals of multiple programs and is met with broad stakeholder agreement (and potentially matched funds).

Overall, there is a need to protect forests from fire risk, reduce fragmentation, and degradation: these landscapes have been spatially identified as the Highest Priority Areas. Areas have been identified that are within a narrow edge to standing forests where fire behavior risk is moderate to high, posing a threat to standing stocks from fires that are

difficult to suppress. A program designed to prevent, isolate and control fires requires pro-active treatments, rather than "reactive" treatments (suppression only). Treatments designed to expand forest fragments to make large, contiguous blocks of forest will increase forest resilience to fire, decrease fire size, and isolate the opportunity for future fires to exist. This is particularly true along the road edges, where easy access allows to ignition sites.

Pro-active fuels treatments (tree planting, fuel breaks, etc.) to prevent, isolate or control fires will also aide in meeting water quality objectives. Burned areas are more susceptible to sediment runoff. Grassland/savanna areas identified as known sediment delivery sites pose additional threats to water quality should these sites burn.

Population growth on Guam is a serious concern and poses potentially severe impacts to natural resources. The military expansion is scheduled to construct housing and training facilities on approximately 9,500 acres. The fine-scale tree crown mapping (SWARS vegetation map) quantified approximately 5,300 acres of trees are *within* the bounds of the proposed facilities – these trees represent 10% of the remaining forests of Guam, and are within areas that are suspected to be old forest types. Secondary effects of the military expansion are less quantifiable, and involve the creation of new roads, power lines, increased recreation, increased traffic and potential new secondary civilian developments (housing, shopping centers, etc.). There is a need to organize the Urban and Community Forestry program to engage the DoD and communities to develop tree ordinances and other mechanisms to *avoid* deforestation as well as plant additional trees to meet other objectives (water quality, etc.).

The magnitude and extent of the key threats are summarized in two sections: one for the the urban environment and the other for the forested areas outside of the urban zone. The information is presented in this way to facilitate the relationship between a threat and the S&PF program that best addresses the threat. *In many instances, S&PF Programs that are currently managed separately are combined in the strategy to fully address the issue.*

The following two sections outline a total of 13,098 acres that are the Highest Priority Areas for treating multiple objectives. Approximately 4,178 acres are in the urban areas and 8,920 acres are located around forest fragments. Detailed tables and maps are provided in these sections.

Meeting Multiple Objectives: The Urban Environment Highest Priority Areas

Table 16 summarizes the extent of the urban area by watershed and identifies critical areas that are the Highest Priority for treatment. This does not preclude priorities for other issues, but provides on-the-ground locations for how a single treatment (tree planting) can mitigate multiple threats and meet objectives for multiple stakeholder issues.

These areas focus on the combined effects of fire risk (Issue #1), increasing water quality through reducing sediment delivery (Issue #2), mitigating secondary effects of the Military buildup (Issue #3), increasing urban forest (Issue #5), and minimizing degraded lands (Issue #6). Planting trees in these areas are within the UCF program, Stewardship, Cooperative Fire. Monitoring the plantings and expanding existing fragments also falls within the objectives of Forest Health programs.

A total of 4,178 acres were identified in the urban areas and associated 500 ft buffer zone for treatment to meet these multiple objectives (Table 16). These acres are mapped in the Priority Area map in Figure 29. The columns in the table describe the following:

- **Watershed Acres**. Total acres in the watershed.
- **Area Classified as Urban Acres**. The mapped areas included in the urban zone. The urban zone include spatial layers (from the PIC Veg layer) identified as: 1) Urban Built-up, primarily mapped impervious surfaces such as buildings, parking lots, and roads, and 2) Areas mapped as Urban Open Space, which are areas within the urban zone that are not identified as forested.
- **Urban Buffer Acres**. This is the total number of acres within the 500 ft. buffer zone mapped around the Urban Zone.
- **Forested Acres within the Urban Buffer:** The area within the within the 500 ft. buffer that is classified as forested (includes individual trees plus forest fragments).
- **Highest Priority Area for Planting Treatments in the Urban Buffer**: This is the land area that is currently not forested (but potentially will support trees) in the urban zone, where fire risk is moderate or higher and the location was identified as delivering sediment to streams. These are considered the first line of planting for urban forestry, based on an ecosystem threat basis. These acres are mapped in Figure 29.

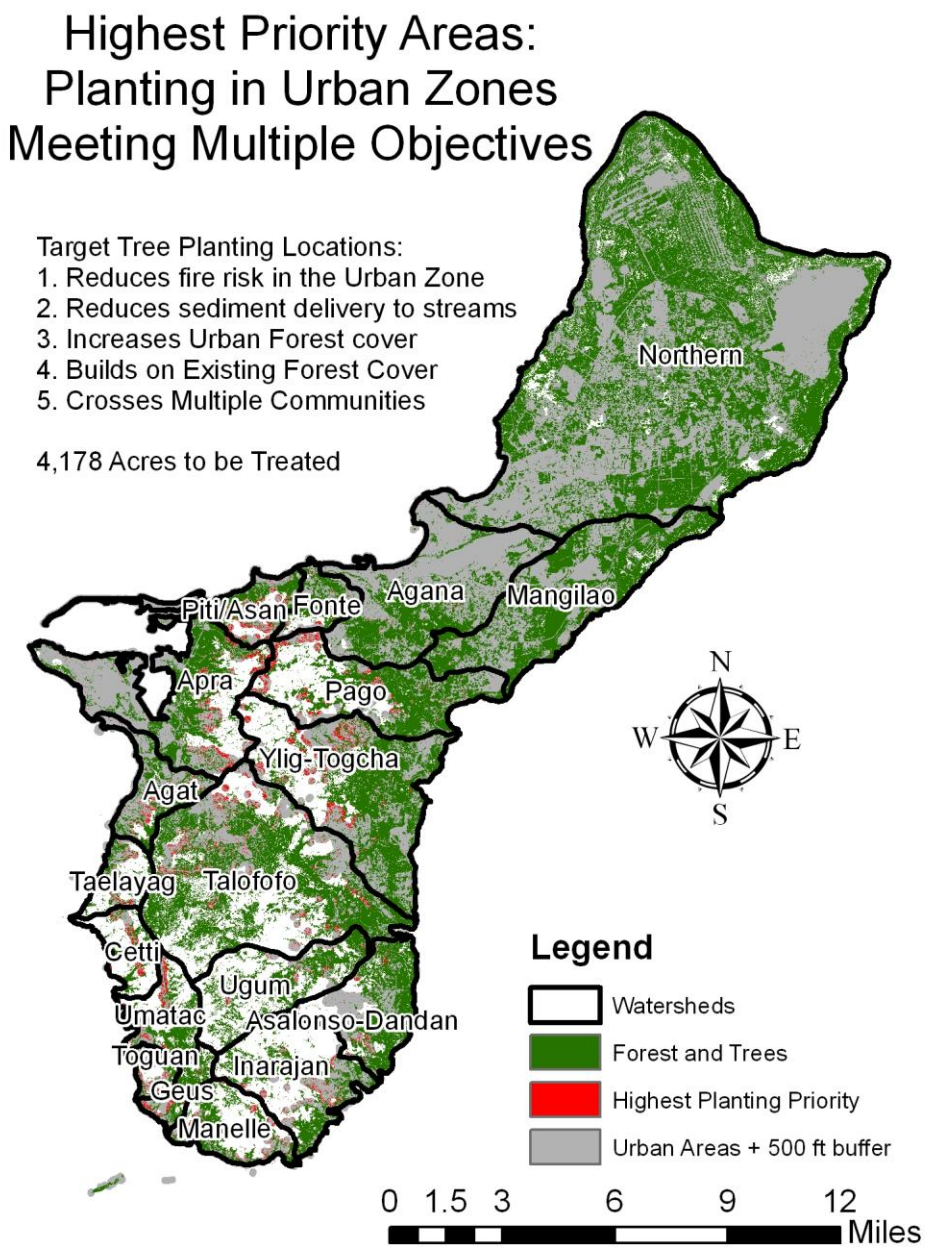

Figure 29. The 4,178 acres targeted for the Highest Priority for treatment through targeted tree planting. These areas meet multiple objectives of reducing fire risk in urban areas, reducing sediment delivery to streams by changing vegetative cover, increases urban forest cover, builds on standing urban forest, and crosses multiple communities for a unified tree planting campaign. Data are summarized in Table 16.

Table 16. Highest Priority Urban Planting Treatment Areas to meet multiple objectives within the Urban Intermix Zone.

Region	Watershed	Watershed Acres	Area classified as Urban (Acres)	Urban Buffer (500 ft. buffer in acres)	Forested Area within the Urban Buffer (acres)	Highest Priority Treatment Areas for Fire Risk and Areas Producing Sediment to Streams (acres)
Eastern	Pago	6,683	1,536	2,907	1,371	289
	Ylig-Togcha	10,067	3,038	5,773	2,735	397
	Talofofo	15,016	3,007	5,283	2,276	652
	Ugum	4,851	189	301	111	29
	Asalonso-Dandan	4,183	755	1,477	720	50
	Inarajan	5,564	946	1,502	560	174
Western	Manelle	3,107	525	931	406	118
	Geus	1,120	330	498	169	112
	Toguan	903	302	391	90	89
	Umatac	2,447	549	705	156	232
	Cetti	1,928	280	361	81	135
	Taelayag	1,639	428	641	214	78
	Agat	2,511	1,378	2,036	660	145
	Apra	8,283	4,137	5,951	1,813	466
	Piti/Asan	1,993	1,033	1,555	522	282
	Fonte	1,575	669	1,224	556	102
Northern	Agana	8,717	5,679	8,192	2,513	324
	Mangilao	8,772	3,406	6,810	3,400	101
	Northern	44,971	19,987	34,682	14,671	403

Meeting Multiple Objectives: The Forest Environment Highest Priority Areas

Table 17 provides similar information for the forested environment outside of the urban zones. The purpose of this table is to illustrate the extent of forests in the watershed and identify the Highest Priority Treatment areas based on addressing multiple objectives.

The primary objectives met by these priorities cover all of the following: reducing fire risk to forests (Issue #1), water quality and water supply (Issue #2), mitigation of the secondary effects to the military buildup (replacing lost forest, Issue #3), increasing forest fragment sizes (Issue #4), and abatement of degraded lands (Issue #5). These cross multiple S&PF programs: Cooperative Fire, Forest Health, Forest Stewardship and Forest Legacy.

A total of 8,920 acres have been identified as Highest Priority areas where planting activities can be conducted to meet these multiple objectives (Table 17). Planting in these areas will increase resilience of forest fragments to invasive species, storm events and fire. These acres are mapped in Figure 30 and should be considered the starting place and justification for building planting projects with stakeholders.

The columns in Table 17 describe the following information for each watershed:

- **Forested Acres/Watershed Total Acres**: This column illustrates the extent of forested areas within the watershed. "Forest" refers both to contiguous areas of forest types but also to forest fragments.

- **High Priority Area for Fire Treatment to Protect Forests**: These areas are the acres in the 300 ft. buffer around forest fragments that are in need of treated within each watershed. These acres are the sum of the areas identified as Moderate, High, and Extreme risk for fire. This approach identifies the magnitude of fire prone areas within each watershed.

Sediment delivery is identified in the table in two ways, because both the total delivered sediment and the sediment yield can be used as dimensions of the sediment issue in prioritizing for different objectives:

- **Estimated Delivered Sediment**: This is the estimated annual total sediment delivered at the mouth of the watershed expressed as tons per year. This estimate is influenced by two factors: the number of acres identified as contributing areas,

and the total watershed area. For example, a larger watershed with a lower percentage of contributing areas and low erosion rates per acre can produce more total sediment than a smaller watershed with more severe erosion. The total delivered sediment is a critical factor to consider when setting priorities for reduction of sediment to reefs.

- **Delivered Sediment Yield**: The delivered sediment yield as expressed in tons per acre per year provides an indicator of the severity of erosion and sediment delivery in the watershed. Acres targeted for planting will reduce delivered sediment for that acre.

The final column in the summary table represents areas where multiple threats exist, and planting trees will mitigate these risks and threats (Highest Priority Treatment Areas).

- **Highest Priority Treatment Areas to Address Multiple Objectives:** This column identifies the acres where one would get the most benefit for the cost of treatment – the highest priority areas that will meet multiple objectives. These acres combine risks to meet multiple objectives by: (1) being within 300 ft of a forest edge (forest at risk of fire and fragmentation), (2) delivering sediment to streams, and (3) having moderate - extreme fire behavior risk. The acres represented here are a conservative estimate for actual treatment needed, as actual project implementation will include neighboring areas.

Current efforts toward planting restoration projects to meet some of these objectives are in Cetti Bay, with a 500 acre planting project to mitigate reef damage from Kilo Wharf Expansion Project. These priority area maps will assist in the refinement of planting to target those areas producing the most sediment.

Similar watershed restoration projects can be brokered using these Priority Areas with stakeholders and partners, including the DoD, US EPA, NOAA Fisheries, and the National Park Service.

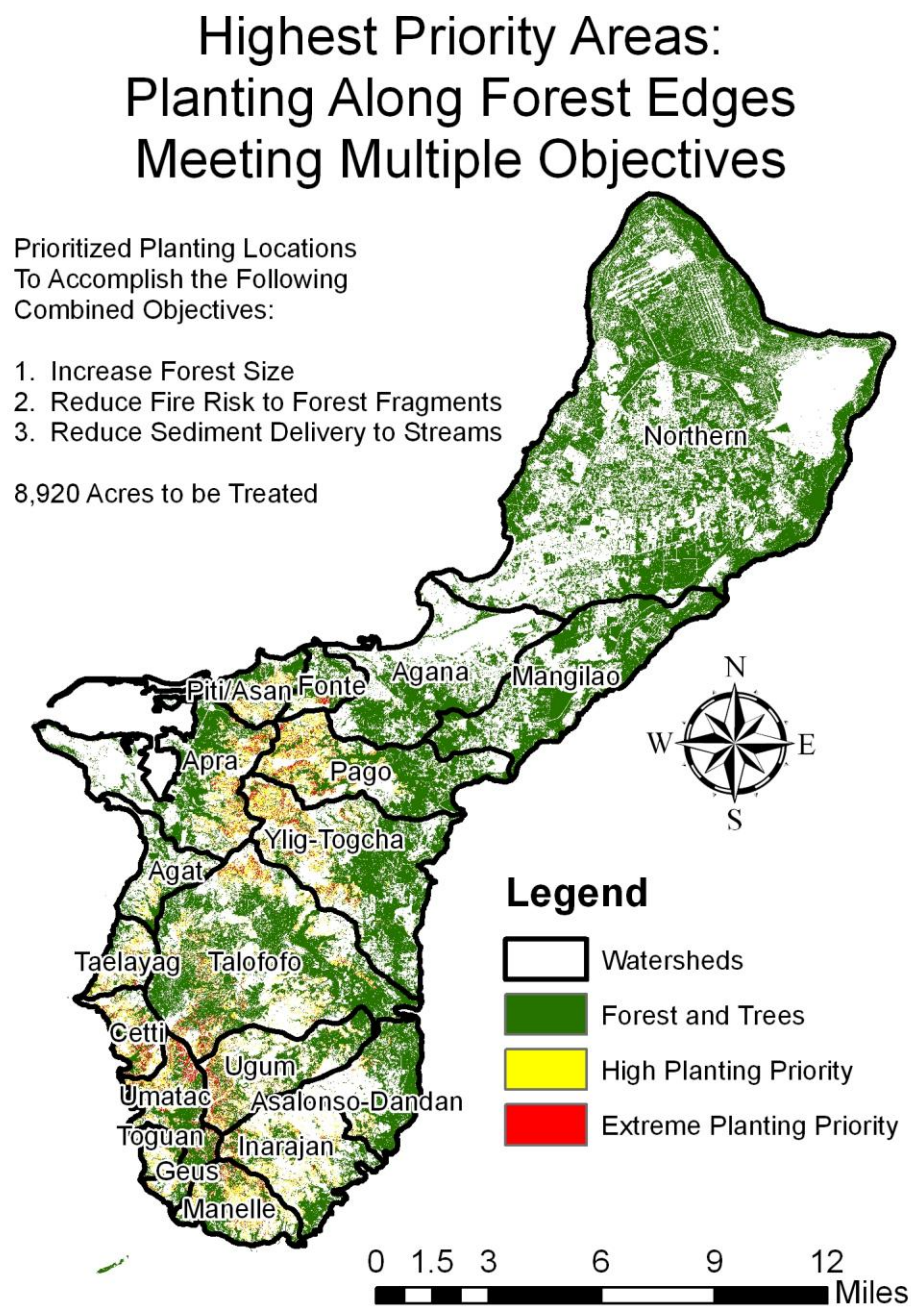

Figure 30. The 8,920 acres of Highest Priority Areas where planting trees will meet three major objectives: increase forest fragment size, lower high risk of fire to existing trees, and reduce delivered sediment to streams. "Extreme Planting Priority" (red) indicates areas where fire risk and sediment delivery is most severe. Acres are summarized by watershed in Table 17. A full-scale map is located in the digital appendix.

Table 17. Highest priority areas for planting, fuels treatment, delivered sediment, and where multiple objects are met: increasing forest fragment size, reducing fire risk to current forests, and treating areas delivering sediment to streams.

Region	Watershed	Forested Acres/ Total Acres	High Priority Area for Fuels Treatment to Protect Forests (Fire Risk rated Moderate to Extreme in acres)	Estimated Delivered Sediment (tons/yr)	Delivered Sediment Yield (tons/acre/yr)	Highest Priority Treatment Areas – Multiple Objectives (acres)
Eastern	Pago	2,680/6,683	1,541	55,427	8.3	973
	Ylig-Togcha	4,281/10,067	1,710	81,928	8.1	1,101
	Talofofo	6,544/15,016	2,605	103,149	6.9	1,478
	Ugum	1,670/4,851	1,142	39,076	8.1	717
	Asalonso-Dandan	1,968/4,183	231	40,330	4.9	141
	Inarajan	1,440/5,564	958	64,601	11.6	658
Western	Manelle	988/3,107	977	63,147	20.3	689
	Geus	493/1,120	341	8,822	7.9	206
	Toguan	201/903	273	11,736	13.0	192
	Umatac	889/2,447	882	49,771	20.3	584
	Cetti	420/1,928	811	43,395	22.5	478
	Taelayag	378/1,639	435	25,376	15.5	263
	Agat	875/2,511	238	15,785	6.3	142
	Apra	2,556/8,283	1,279	40,330	4.9	803
	Piti/Asan	631/1,993	463	13,609	6.8	317
	Fonte	707/1,575	188	4,140	2.6	79
Northern	Agana	2,897/8,717	351	5,238	0.6	36
	Mangilao	4,916/8,772	136	12,983	1.5	51
	Northern	21,909/44,971	626	Not analyzed	Assumed Low	12

Data Gaps and Recommendations

During the course of the Assessment several data gaps were noted. Addressing these data gaps would improve the technical assessment and conclusions that guide management decisions. The following is a brief summary of the data gaps.

1. **Primary Forests.** No comprehensive forest survey is known to exist to identify patches of native/primary ("pristine" or "old growth") forest remnants. For purposes of the SWARS Vegetation map, forest environments were pooled to have the sole distinction of "Forest" to conduct analyses of tree densities and trees at risk. Further differentiation of forest types, including secondary forest types, is required to improve the SWARS Vegetation Map. A dedicated survey is needed to evaluate contiguous patches of potential primary forest. These primary forests serve as a reservoir of native species for plants, wildlife and all connected biota.

2. **Invasive Species.** Few quantitative data are available about the invasive species assemblages, distributions or the current condition of the distributed effects on forest health. This is a critical data gap for Guam Forestry in the effective management of a forest health program, including integrated pest management (IPM).

3. **Sediment Modeling.** The Nonpoint Source Pollution and Erosion Comparison Tool, (N-SPECT) was chosen to characterize relative erosion hazard areas in southern Guam. This model estimates surface and rill erosion but does not account for mass wasting, gully erosion, or streambank erosion. Sediment impacts from these other processes may be an important contributor which may impact water resources. Concentrated effort is needed to evaluate sediment sources and develop a comprehensive model that includes these sources (e.g. monitoring and DHSVM).

4. **Forest Health Conditions.** No direct surveys have been conducted to evaluate forests or forest fragments for age or forest health conditions. An estimate of the old or primary (pristine) forest was qualitative and delineated without survey information. The SWARS Vegetation Map generated from this assessment provides a map of individual tree crowns, which are to be used as priority areas to survey and identify Forest Status for identifying primary and old forest types. This is a critical data gap in proactive conservation that affects urban development, including urban and community forestry objectives, forest legacy, and other programs.

Strategies for Addressing Threats

Introduction

The purpose of this section is to transition the assessment of stakeholder issues and data synthesis into a 5-year strategic plan that achieves the desired outcomes. Specifically in this section, the following are outlined:

- **Resource Strategies (5 years).** Seven major strategies are presented, including a description, action plan of next steps, Forest Service programs that could be leveraged, key stakeholders, resources needed (staff and funding) and an overall timeline with internal performance measures of success.

- **Strategy Implementation Approach.** An outline of how project planning and implementation can be prioritized to take a proactive "vision to outcome" approach. This assures that resources are expended at maximum efficiencies and individual projects fit within the overarching Resource Strategies.

- **Program Capacity Plan.** An assessment of the current resources and programs within Guam Forestry, with a summary of the needed resources and allocation of staff to accomplish the 5-year strategy.

Collectively, this section outlines the overall Guam Forestry Strategy, the relationship with the S&PF programs, and the future program needs.

Guam Forestry Current Program Activity

It is important to evaluate the accomplishments and challenges of what Guam Forestry has achieved when implementing a 5-year strategy. This section describes the current activities and performance measures associated with each of the S&PF-compatible programs that Guam Forestry has been or is currently engaged in. Following this section, specific strategies are outlined, future plans and goals are described, and the current program is contrasted to the current program capacity to evaluate what is needed to implement each strategy.

The mission Guam Forestry is to conserve, protect and enhance Guam's vegetative environment and sustain the natural resources, which are dependent on healthy forests. The agency works with stakeholders to promote healthy and productive forests in both

rural and urban areas throughout the island in partnership with the USDA Forest Service and other Federal and GovGuam partners. The Assessment section of this SWARS identified stakeholder inputs and a science-based assessment of priority areas to address stakeholder issues that are affecting Guam Forestry's healthy forest mission.

Guam Forestry's program is currently comprised of five program elements that parallel the USFS S&PF organization. The current activities of the Guam Forestry's programs and their performance measures are described below.

Forest Health Protection

The Cooperative Forest Health Management Program (Forest Health Protection) targets enhancement of native forests that have been impacted by the effects of typhoons, drought and the influx and of invasive species and forest pests. Guam Forestry's Forest Health Management Program can use cost-share funds from the USFS for activities such as monitoring any outbreaks of invasive pest and plants at island scales, as well as with conservation areas and plant nurseries. Guam Forestry has close working relationship with the University of Guam, however the MOU has yet to be completed. Typically, if any outbreaks are present Guam Forestry seeks the assistance of UOG University on identification of the pests or plants as well as assistance to prioritize species and control methodologies. While not an exhaustive inventory of insect and disease pests for Guam, detail is known for some pests, including CRB and cycad scale, as well as gaining understanding the mechanisms associated with Casuarina decline[24]. However, more information regarding the distribution and abundance of these pests (and pests not yet evaluated) is needed along with information regarding invasive plants (distribution, abundance, effects of invasion, maps) to develop an effective strategy for Forest Health Protection with stakeholders and partners.

Future plans: Work with partners to increase capacity Island-wide to actively participate in Regional programs (e.g. RISC, Micronesia Biosecurity Plan); develop an island-wide strategy for species-based and site-based prevention, detection, eradication, containment and/or control mechanisms for invasive species; secure interagency leadership position to act as an Invasive Species Coordinator to develop and implement the program. Build

[24] Additional details are described in the *Forest Health Conditions & Trends* section, beginning on page 37.

partnerships on-island and with other agencies (e.g. Global Environment Facility—GEF) to increase on-island capacity and implement the program. See *Strategy 6: Implement a Forest Health Program: Unify Interagency Efforts to Prepare for Buildup,* beginning on page 123.

Performance Measures: Number of acres surveyed, types of species identified, biocontrol success, treated acres.

Forest Stewardship Program

Under the Forest Stewardship Program, Guam Forestry provides technical assistance and planting materials to private landowners for establishing forests, managing forests or for agroforestry practices. The FSP supports the Guam Forestry nursery which provides native and non-native plants for erosion control projects and other uses such as establishment of wind breaks and Urban and Community Forestry planting programs.

Currently, the program encourages private landowners to adopt conservation practices on their land by converting non-native species to desired native plants, by educating the public on the importance of protecting and expanding the surrounding forest on their lands, by propagating native plants to accommodate Forest Stewardship plans and by participating with volunteer planting.

Performance Measures: Number of acres planted, Number of Stewardship Plans implemented per year, Number of new Stewardship Plans written, Number of plants planted that survive from previous year.

Reforestation, Nursery and Genetic Resources:

Plant nursery operations are directly related to all programs, especially UCF and FSP. The numbers of plants to be propagated are determined by the number of cooperators who signed up for the stewardship program. UCF plants are determined the by the planting activities from the prior year. For example, the First Lady's Arbor Day activities, plantings in public parks, and specific requests from Government agencies (village Mayors, schools, etc.). These are all reoccurring activities each year.

Performance Measures: Total number of plants propagated from the nursery operation.

Urban & Community Forestry

Guam Forestry participates in urban planting in public and private schools, public parks, government agencies and private businesses. Guam Forestry coordinates with public and private entities on planting in the urban landscape, with Arbor Day planting activities, pest eradication efforts, and assists and advises communities about wildfire risk and treatments in the urban interface zones. Guam Forestry also coordinates with nonprofit volunteer groups in planting activities and educating the public on the importance of planting trees in the urban setting.

Performance Measures: Number of plants planted, Number of organizations participated, Number of volunteer groups participated, Distribution of UCS and related material to the public, Number of UCF meetings held per year.

Cooperative Fire

Guam Forestry is responsible for fire fighting on conservation areas in the initial attack, and supports Guam Fire when requested. Guam Forestry's primary responsibilities are within its conservation reserves (GovGuam lands), more specifically Cotal reserve which covers approximately 500 acres. Primary activities include fuel load reduction, fire breaks and greenbelt establishment, fire patrol, public education and outreach. Other fire suppression activities occur during fire patrols on GovGuam lands outside the reserve areas or when Guam fire Department requests assistance. Other activities include Smokey Bear school presentations and public outreach. In the future Guam Forestry will like to establish an Interagency Fire Coordinating Committee.

Performance Measures: Number of fire outbreaks, Number of acres burned, Number of firebreaks established/maintained, Number of Smokey Bear presentations, Number of public outreach activities, acres treated for fuels reduction.

Resource Strategies: 5 Year Plan

The assessment identified forestry-related issues at the island and watershed scales, identified a range of needs to address stakeholder issues and identified a synthesis of the priority acres where multiple objectives can be addressed in each watershed. While this information is important for planning purposes, and for understanding the extent and locations of resource concerns, there is a need to develop *strategies* that describe the approach to the problems within the context of the realistic capacity of Guam Forestry (personnel, infrastructure, and available skills). In addition, a strategy is needed that addresses building program capacity within Guam Forestry to meet the challenges of implementing the strategic plan.

The strategies described below are intended to lay out the road map for Guam Forestry to move forward with assistance from the USFS State & Private Forestry as well as other partner organizations. This section describes seven major strategies in detail; further discussion of capacity needs is presented in the *Program Capacity* section.

Strategies are described in the following order to address restoration, conservation of intact forests, reduce impacts to water quality and the reef system, mitigate for the impact of the military expansion, and address invasive species – all unifying themes developed from stakeholder issues. The 6 strategies are:

Strategy 1: Implement Highest Priority Plantings that Meet Multiple Objectives.

Strategy 2: Protect, Conserve and Restore Forests On State, Private, And Other Non-Military Lands

Strategy 3: Work with Military to Avoid Deforestation and Develop Tree Ordinance Laws for New and Old Development Zones

Strategy 4: Improve Fire Prevention, Control, Suppression and Prescribed Fire Activities through Organizing, Training and Equipping Staff and Resources.

Strategy 5: Implement Tree Planting and Monitoring Projects in Developed Areas, Open Space, and Parks In Communities (Urban Forestry).

Strategy 6: Implement a Forest Health Program: Unify Interagency Efforts to Prepare for Buildup

An overview and description of each strategy is organized in the following narrative format:

- **Title**
- **National Themes Addressed**
- **Overview**
- **Scale**
- **Maps**
- **Acres Treated**
- **Stakeholder Issues Addressed**
- **Description**
- **Next Steps and Actions**
- **State and Private Forest Programs that Contribute**
- **Key Stakeholders**
- **Resources Needed Including Staff And Project Funding**
- **Performance Measures**

A table (Table 18) summarizing these components are provided at the end of this section to provide the reader a synopsis of the strategies that comprise the Five-Year Plan (see page 133).

Strategy 1: Implement Highest Priority Plantings that Meet Multiple Objectives.

National Themes Addressed: Theme 1. Conserve Working Forest Lands, Theme 2. Protect Forests from Harm, Theme 3. Protect and Enhance Public Benefits from Trees

Overview: Implement planting projects around forest fragments and in urban zones that have been identified as the SWARS Highest Priority Areas to plant where multiple objectives can be met. These objectives are include (i) expand forest fragments to increase resilience, (ii) convert hazardous fuels that threaten forest edges, (iii) convert non-forest areas that are delivering sediment to streams to healthy forest to reduce erosion and delivery, (iv) increase overall forest cover.

Scale: Island Scale, to be implemented as local projects

Maps and Tables: Forest lands: Figure 30 & Table 17. Urban zones: Figure 29 & Table 16

Acres to Be Treated: 13,098 acres (8,920 in Forest Zones, 4,178 in Urban Zones).

Stakeholder Issues Addressed: All stakeholder issues are addressed in this strategy.

- *Issue 1. Wildfire and Public Safety*: Increasing forest fragment size, reducing risk of fire to forests and urban communities, fuels conversions, strategies to isolate and contain future fires by increasing forests through greenbelts.

- *Issue 2. Water Quality and Water Supply*: Converting non-forest types that are producing sediment to stream systems to forests, minimizing erosion processes and direct delivery to waterways, increasing zone of contribution health to filter potential hazards to waterways through use of healthy forest, strategic plantings to filter runoff from roads.

- *Issue 3. Population Growth and Urbanization*: Mitigation of secondary threats of development by planting trees along roadways and increasing existing forest fragment sizes (increasing resilience), mitigation sites for Military Buildup that meets watershed restoration objectives.

- *Issue 4. Deforestation of Native Forests*: Highest Priority planting acres are targeted around suspected native forest sites; plantings at forest edges will increase diversity

and fragment sizes of native forest (i.e. allow to expand) while also meeting other objectives of reducing fire risk and water quality.

- *Issue 5. Urban Forest Sustainability*: Over 4,000 acres are within urban zones to increase current diversity of native trees while reducing community fire risk and mitigating storm runoff. Incorporate the primary planting acres into Tree Ordinance to ensure plantings are met with new developments, and current developments can be enhanced.

- *Issue 6. Degraded Lands*: High priority plantings target sites that are currently eroding and delivering sediment to streams. Conversion to forest is primary treatment for reducing degradation.

Description: The resource assessment illustrated the relationship between the expansion of fire prone grassland/savanna lands, increased fire risk, sediment delivery to streams through hillslope erosion, and the resulting degradation of the reef system. These altered landscapes are extensive in the steep volcanic lands in southern Guam. Areas meeting the criteria of (a) being within 300 ft of forest fragments, (b) having moderate or higher fire behavior risk, and (c) are in areas that are delivering sediment to streams (and the reef) were identified and mapped. Approximately of 9,000 acres were identified in southern Guam having all three of these criteria (Figure 30 and Table 17, final column). Likewise, an additional 4,000 acres were identified in urban zones that meet multiple criteria described above (Figure 29 and Table 16, final column). Because these areas are so extensive, there is a need for Guam Forestry to communicate the results with stakeholders and lobby their assistance in prioritizing implementation action areas. This involves identifying willing landowners, defining project area boundaries, identifying nursery needs, public outreach components, and implementation staffing (and volunteer coordination). Implementation of this strategy is the next logical step in implementing the SWARS process (e.g. immediate post-SWARS action item, see *Step-Down Approach for Landscape Management* on page 129 for mechanisms to "drill down" to the project scale).

Efforts in this strategy will likely need to address landowner concerns about fire risk to property and an education/ outreach component that involves the importance of forests to protect other natural resources (clean water, reefs, etc.).

Next Steps and Actions

- Identify willing stakeholder and landowner groups to implement planting projects.

- Identify willing participants and groups to build a Southern Guam Watershed Enhancement Partnership association or similar group to coordinate local priorities, volunteers, education and outreach, and implementation.

- Submit grants for competitive funding to the Forest Service, and seek funding from other groups (Navy, EPA, NOAA, conservation innovation grants, NRCS, NGO's) to implement the Restoration Plans.

- Meet with State and Federal Agencies to discuss overlapping missions and begin prioritizing landscapes that meet joint objectives such as the Ridge-to-Reef approach to restoring degraded reef systems (marine protected area watersheds, proposed mitigation areas, water systems, etc.). Seek interagency or outside additional funds for large-scale restoration projects to meet the acres required.

- Meet with stakeholders in their communities to inform and facilitate cooperation about reducing fire risk and improving urban forests and open space.

- Follow a structured large-scale restoration implementation processes (e.g. *Step-Down Approach for Landscape Management* on page 129) to identify how activities in priority lands can merge with other activities to increase efficiencies and overall restoration success.

- Implement fire suppression activities that will access grants available in SFA programs by expanding Fire Watch suppression staff, apparatus and training. Increase local capacity to prevent, control, suppress and prescribe fires to meet project goals through organizing, training and equipping personnel to protect project areas.

- Meet with stakeholders to develop Community Wildfire Protection Plans (CWPP) and leverage these activities to hold community meetings, provide fire prevention education and outreach, and build local support for successful restoration activities.

State and Private Forest Program Areas that Contribute: Cooperative Fire, Forest Stewardship, Urban and Community Forestry, Education

Key Stakeholders: Bureau of Statistics & Plans, Guam Fire Department, Guam Environmental Protection, Guam Aquatic and Wildlife Division, Soil and Water Conservation Districts, US Fish and Wildlife Service, National Park Service (Agat and Asan

Watersheds), Community Councils and Mayors, UCF Committee, SWARS Advisory Committee, Key Private Landowners

Resources Needed Including Staff and Project Funding: Professional Foresters, GIS and Spatial Analysis Technical Support, Nursery operational funds and staff, Funding and staffing to support community meetings, Education & outreach coordination with existing programs, fire assistance (prevention, protection, control).

Performance Measures: Number of meetings held with communities, Number of meetings with SWARS Advisory Council and UCF Committee, Number of acres treated included in the Highest Prioirty Areas, Number of fire outbreaks, Number of acres burned, Number of surviving trees, Number of firebreaks established/maintained, Number of Smokey Bear presentations, Number of Public Outreach events, number of S&PF competitive grants submitted per year (target 1 per year for treating Highest Priority Areas), number of acres restored.

Strategy 2: Protect, Conserve and Restore Forests On State, Private, And Other Non-Military Lands

National Themes Addressed: ***Theme 1. Conserve Working Forest Lands, Theme 2. Protect Forests from Harm, Theme 3. Protect and Enhance Public Benefits from Trees***

Overview*:* This strategy emphasizes identification of lands outside of the military boundaries since Guam Forestry has the ability to implement projects in these lands directly. The approach is to identify candidate forest fragments that can be conserved and expanded to increase forest size to increase forest resiliency. These can be done in urban zones as well as in upland environments. Conservation is achieved through two avenues: (i) reduce stressors to existing forest through enhancement of current stands (e.g. forest health and protection from deforestation through Legacy) and (ii) expansion of current stands to treat external "edge" threats of disturbance (fire, wind, etc.).

Candidate sites could be used to mitigate for the forest acres directly lost or impacted within the military development footprint to meet the obligations of the military to mitigate for forest removal. These areas include those Highest Priority Areas identified in Strategy #1 but are expanded to all forest fragments on Guam and not just those meeting

combined threats. Primary activities are planting trees by expanding existing forest edges, fuels treatments, forest health treatments within standing forests, and conservation.

Scale: Watershed-Level and Local Land Parcels

Maps: Threat to Fire Priorities (Figure 16 & Figure 17), Native Forest Conservation and Expansion Priorities (Figure 23), Urban Forest Planting and Conservation Priorities (Figure 27), Reference standing forest classifications by ownership (Figure 24). A subset of these is also in Strategy #1.

Acres to be Treated: Areas overlap. Fire Priorities (treat fuels and/or plant approximately 20,284 acres), Native Forest Conservation Priorities (conserve approximately 25,000 acres), Urban zones (~35,000 potential planting area in non-forest and ~30,000 acres for conservation in forest). These all provide off-site mitigation locations of trees scheduled for deforestation on Military lands (5,400 acres).

Stakeholder Issues Addressed:

- *Issue 1. Wildfire and Public Safety:* Addresses treating hazardous fuels around perimeters of forest fragments and in urban areas. Increases fragment size through planting trees and/or protects forests from hazardous fire behavior through fuels treatments.

- *Issue 3. Population Growth and Urbanization*. Increases forest cover through UCF plantings, increases resilience of forest fragments through increasing forest size, improves forest health and potential degradation of forest in urban environments as well as spread of invasives to other forests on the island.

- *Issue 4. Deforestation of Native Forests*: Conservation of native forests through Legacy and volunteer programs, or through removing disturbance events (fire, off road vehicle use, barbeques, etc.) will prevent deforestation and degradation of native forests.

- *Issue 5. Urban Forest Sustainability*: Planting in prioritized urban zones will increase forest cover; conservation efforts in current forest will increase resilience and sustainability of standing stocks. Education and outreach will continue to increase awareness of the importance of Guam's native trees.

Description: This strategy is an extended set from Strategy 1 of areas to be planted or conserved because of direct threat or opportunity for enhancement. In many cases, single areas can meet multiple objectives, though the purpose is to identify areas where activities can be done for potential watershed enhancement projects designed to (i) improve forest health and resilience, (ii) increase urban forest cover, (iii) protect standing forests from fire, (iv) protect native forests from deforestation and degradation. Activities are largely planting opportunities, outreach and education, and forest health treatments and fuels treatments (through converting high risk fuel types to forest, through mechanical fuel breaks and protection and suppression efforts). The general goal is to increase forest fragment sizes while increasing forest health in standing forest (especially native forest).

Locations for immediate opportunity will highly depend on the outcome of the proposed military development. Currently, the proposed military development footprint for their housing and training areas is expected to impact a *minimum* of ~9,400 acres of land area, of which ~5,400 acres are forested. This represents 10% of Guam's standing forestland. Mitigation for the reduction of forest acreage should focus on expanding forest cover in areas outside of the military boundaries (on both state and private lands). The strategy will identify candidate sites and willing landowners to expand existing forest cover in forests that have beneficial species, structure, and conditions. Areas identified in this strategy may also overlap with areas in Strategy 1, as they are within close proximity of the forest edge. Implementation of this strategy will require much of the same stakeholder involvement and process as described in Strategy 1.

Next Steps and Actions

- Conduct on-site surveys of existing forests on state and private lands in the priority zones (by program or by watershed) to determine the current status of forest health and identify potential needs and prescriptions. Classify forest types by fragment size, targeting the largest fragments, or clusters of forest fragments that are relatively close to one another.

- Identify ground based opportunities and stakeholder willingness to participate in forest expansion and forest health projects.

- Prioritize potential areas to establish a pool of candidate sites that can be further investigated for purchase/conservation easement as potential military mitigation sites.

- Complete the objectives of the Assessment of Need under the Forest Legacy Program to meet the conditions for participation in the Forest Legacy Program.
- Work with landowners to identify their interest in protecting or expanding the candidate forest sites through purchase, easement, or other programs.
- Identify a short list of likely landowners that would be willing to participate in a forest protection program.
- Work with the DoD, EPA, and other agency partners to develop long term funding for watershed mitigation and monitoring (especially forest health monitoring).
- Examine viability of "forest credits" for maintaining standing forest and promoting growth (e.g. Office of Ecosystem Services in 2008 Farm Bill).

State and Private Forest Programs that Contribute: Urban and Community Forestry, Forest Stewardship, Forest Legacy, Forest Health

Key Stakeholders: Private landowners, Soil and Water Conservation Districts, Community Councils and Mayors, DoD, EPA, NOAA Fisheries, GovGuam Interagency Partners, UOG

Resources Needed Including Staff and Project Funding:

- Guam Forestry professional foresters & community outreach personnel, including GIS resources and staff and nursery operations to supply needed trees.
- Funding to support staff and meetings for the required outreach to inventory and identify forest health concerns and willing participants/ landowners to design and implement projects
- Staff to complete the Forest Legacy Assessment of Need including public outreach. There is interest to select the "State Option" for Forest Legacy; stakeholder involvement has begun as part of the SWARS process.
- Funding for building landowner relationships to purchase land, create easements, facilitate land trades, or other mechanisms to assure long-term protection of forests (e.g. Forest Legacy).

- Fire program support for new plantings and high priority areas: protection, control, suppression and prescribed fire as well as capacity and apparatus for organizing, training and equipping additional fire watch crews.

Performance Measures: Number of inventories (or acres surveyed) to confirm forest conditions (forest health, potential prescriptions, and identify native forest), number of candidate sites evaluated, Assessment of Need for Forest Legacy completed, priorities of willing landowners established for purchase/conservation easements, number of landowners in the program for purchase/easements, meetings held with or MOU's secured with funding partners, number of acres planted, number of acres of forest monitored.

Strategy 3: Work with Military to Avoid Deforestation and Develop Tree Ordinance Laws for New and Old Development Zones

National Themes Addressed: ***Theme 1. Conserve Working Forest Lands, Theme 2. Protect Forests from Harm, Theme 3. Protect and Enhance Public Benefits from Trees***

Overview: Guam Forestry is the appropriate agency within GovGuam to advise the military on specifications to *avoid* deforestation and incorporate urban design within the development areas so that as many of the trees and forest areas can be maintained as possible. Further, the development of Tree Ordinances or Greenspace designs that have legal backing will decrease losses of native forest in development zone as well as increase numbers of native trees in the urban areas. This involves Guam Forestry to advise GovGuam leadership to develop a legal framework for future development by the Military and other third-party businesses and private lands. The overall goal is to incorporate native forest into the urban design to conserve existing forest (i.e. not replace with different trees).

Scale: Proposed Military Buildup areas, planned development areas and current village communities.

Maps: Priority areas for military buildup (Figure 22), Native forest distribution priorities to not deforest (Figure 23), Priority communities and villages and urban buffer areas (Figure 26), reference ownership of current trees (Figure 24).

Acres to be Treated: Current military footprint for proposed construction activities for the housing and training areas is ~9,000 acres, of which 5,432 acres are in forest (mostly primary forest, Figure 23). Deforestation of these acres is 10% of Guam's standing stock.

Future development zones by third parties is not known at the time of this document. Current urban forest cover is 36,472 acres. A 5% increase in urban cover Guam-Wide through ordinances would be approximately 2,000 acres of planted (or retained) trees.

Stakeholder Issues Addressed

- *Issue 1. Wildfire and Public Safety*: Increase in urban forest cover can be targeted in areas with high risk of fires (Strategy 1 and 2), increased plantings of blocks of trees along roadways limits access to start additional fires (green belts).

- *Issue 2. Water Quality and Water Supply*: Increases in forest cover in development zones aids in maintaining contributing area to aquifers (by not converting to impervious surface); increased trees along roadsides buffers runoff to surface water streams and improves water quality to the aquifer and surface lakes.

- *Issue 3. Population Growth and Urbanization*: Provides legal precedent and statute that native trees of Guam are a priority in planning population growth, and that native tree species are part of the urban environment.

- *Issue 4. Deforestation of Native Forests*: Working with military and other developers, as well as enforcement of tree ordinances, will decrease deforestation of native forests for conversion to development. Currently no protection laws exist.

- *Issue 5. Urban Forest Sustainability*: Increases in urban forest cover improves quality of life aspects for residents as well as increases general forest conditions and awareness through implementation of planting programs and monitoring for invasive species during the maintenance process. Tree ordinances and funded programs designed to incorporate monitoring will increase overall forest health on Guam.

Description: This strategy focuses on the standing forest fragments within the proposed military buildup areas. In particular, this strategy targets collaboration with the military to avoid deforestation of existing forests in areas scheduled for construction of housing areas and training grounds. As described in Strategy 2, a total of ~9,400 acres is within the footprint of housing and training grounds, of which ~5,400 acres is forested. This represents 10% of the remaining forest on Guam. This does not include areas that will likely be developed to service the influx of new people on Guam (shopping centers, roads, etc.), which is currently unknown.

Negotiations are currently underway between the Whitehouse Council on Environmental Quality, EPA, and DoD regarding the requirement to for DoD to conduct a supplemental DEIS before continuing to the Final EIS. Regardless of the outcome of these negotiations, construction and development will occur on military lands. It is the goal of this strategy to partner with the military in their design for the new housing developments and to identify high quality forest areas to retain in parks, greenspace, and areas to avoid during active training exercises. These practices can be applied to the effects of the buildup, with new ordinances in place for new developments, as well as targeted programs within existing villages to improve urban forest cover and integrate urban forestry into state implementation plans.

Next Steps and Actions

The next steps will depend on the outcome of negotiations for the Final EIS and Record of Decision. As part of these negotiations and during the construction phase, Guam Forestry can provide professional forestry advice to lessen the impacts on the forest cover and maintain diverse forest types. Development can be planned to preserve as much forested open space as feasible, identify planting guidelines for housing development and roadways, and plan for protected forest areas on the periphery of developed areas (see also Strategy 6).

- Work with military to conduct surveys of forested land in the proposed developments
- Work with GovGuam interagency offices to identify new developments that are planned
- Survey forests around new development programs
- Work with GovGuam legal counsel and other interagency groups to define criteria for maintaining native trees where possible, as well as install planting requirements for new developments. Follow the legal framework for addressing criteria into law.

State and Private Forest Programs that Contribute: Urban and Community Forestry, Forest Stewardship, Forest Health, Forest Legacy (private lands).

Key Stakeholders: DoD, GovGuam interagency urban planning departments, Attorney General Guam, Guam Aquatic and Wildlife Division, US Fish and Wildlife Service, Community Councils and Mayors, private developers.

Resources Needed Including Staff and Project Funding: Urban/ landscape forester that is dedicated to liaison during the military expansion period, GIS technician, policy support from other GovGuam resources for developing tree ordinance criteria.

Performance Measures: MOU developed and signed by all parties, Number of operational activities completed with the military, Tree Ordinance developed and transmitted to military, implement planning partnership with DOD, Number of acres protected from deforestation within the military development zones, number of private developers that are willing participants during the Ordinance development process.

Strategy 4: Improve Fire Prevention, Control, Suppression and Prescribed Fire Activities through Organizing, Training and Equipping Staff and Resources.

National Themes Addressed: ***Theme 2. Protect Forests from Harm***

Overview: There is an urgent need to increase the capabilities and capacities of Guam Forestry staff to manage fire. This strategy focuses on applying prevention and control measures on the priority landscapes addressed in other strategies so that planting projects can be implemented successfully without harm of fire, and that current standing forests are not further threatened or decreased by fire. Preventative measures include public awareness, education and outreach, and pro-active measures of prescribed fire activities (in addition to planting) to change the fuels profile prior to fire events. Control measures involve additional attack and suppression resources and training, including additional law enforcement initiatives. Overall, the goal is to reduce arson-based fire incidents though active outreach, education and enforcement, as well as minimize the potential perimeters of fires that do start through preventative prescriptions, and finally to provide well-trained and staffed crews to respond, attack and suppress fires when they do occur.

Scale: Island, watershed and project-level.

Maps: Priority fire risks to forests and urban areas (treatment areas and also attack zones (Figure 16 and Figure 17), standing forests on Guam, by ownership type (Figure 24).

Acres to be Treated: Approximately 20,000 acres bordering forest edges with high fire risk (prevention through prescribed burns, mechanical treatment, protection of newly planted trees from Strategy 1 and 2); Island-wide responses to fires to protect 56,000 acres of standing forestland on Guam with interagency partners.

Stakeholder Issues Addressed

- *Issue 1. Wildfire and Public Safety*: First response with Guam Fire Department to fires that threaten infrastructure, forest, and other properties. Reduction in hazardous fuels and integration with Guam Forestry planting activities will provide long-term smaller footprints for potential large fires. Increases in capacity to attack/ suppress and control fires will improve public safety and protect resources. Increases in staffing and response training will decrease incident time and prevent reported fires from growing in size. Education and outreach, coupled with Law Enforcement, will decrease the number of arsonists and likelihood of further ignitions.

- *Issue 2. Water Quality and Water Supply*: Decreasing the number of fires will decrease erosion and sediment delivery to streams, reefs and impoundments. This is especially true for areas with high erosion inputs to streams, as identified in priority areas in Issue 2.

- *Issue 5. Urban Forest Sustainability*: Decreasing fires (size, frequency and intensity) will decrease mortality to urban forestry programs, especially in areas that border native forest and are in the intermix between rural and urban communities.

- *Issue 6. Degraded Lands*: Similar to Issue 2, the decrease in fires on Guam will decrease the number of degraded lands by allowing for vegetative regrowth; protection of new plantings that are specifically designed to restore degraded lands and have high fire risk (Strategy 1) will reduce overall degradation on Guam.

Description: Guam Forestry has an active Cooperative Fire Protection Program that provides fire protection for Guam's wildland areas and conservation reserves. The Division also cooperates with the Guam Fire Department, Federal Fire Department (Navy) and Anderson Air Force Base Fire Department for the protection of other wildlands and rural areas not within Guam Forestry's protection areas. The current capacity of Guam Forestry Fire program is limited to incident response (reactive treatment) rather than a pro-active

fire prevention program to minimize high-risk fire behavior, including long flame lengths, fast rates of spread, and ignition success and access on the island before fires occur.

Illegal arson fires account for up to 80 percent of the fires annually on Guam, predominantly used by hunters to attract deer to feed on new growth. Previous efforts to reduce arson have focused on developing educational materials, briefing materials, and public education and outreach. Additional efforts to update and design a fire prevention plan through active vegetation treatments will provide means for limiting the ignition success, isolating the fires that do burn, maintaining small fire perimeters, and decreasing the cost for fire suppression. The Department can build on existing relationships to expand fire prevention activities and take advantage of other federal programs to reduce the incidence of fire.

Program capacity to respond to fires is very low, particularly when incidents are large, or when there are multiple incidents occurring at the same time. There is a need to increase capacity for prevention, control, suppression and prescribed fire through a focused organization, training and equipping personnel. Increasing the ability to suppress fires is of importance as is the ability to prevent them through fuels treatments, education and working with law enforcement.

Next Steps and Actions

- Secure Fire Management Officer position to consolidate existing fire plans, conducting a summary review of resources among stakeholders (staff, apparatus and collaborative agreements) and identify gaps for prevention and control procedures.

- Develop a model Community Wildfire Prevention Plan (CWPP) with willing communities (see Strategy 1) and use the public meetings as an opportunity to extend fire prevention awareness programs

- Ground-truth high priority areas for fire risk (urban and risk to fire in Model Community) and develop mechanical treatments to minimize fire spread success.

- Develop fire protection and outreach methods and first response actions with forest expansion efforts identified in Strategy 1 and 2. This could involve pre-treatment, prescribed burning, and first response and incorporate attack and suppression points with the planting design to protect the plantings.

- Investigate FEMA – Pre-Disaster Mitigation Grant program with stakeholders, focused on priority areas.
- Develop a Fire Fighter Certification Program
- Work with Interagency Fire Coordination Committee
- Continue to conduct Fire Suppression Activities; build on coordination efforts with other fire departments
- Implement fire prevention Education and Outreach Activities
- Implement pre-suppression (fuels reduction) with other enhancement projects (other strategies)
- Improve initial attack capability and ability to suppress fires through training, organization and equipment.

State and Private Forest Programs that Contribute: Cooperative Fire Program, Forest Stewardship, Urban and Community Forestry

Key Stakeholders: Guam Fire Department, Federal Fire Department (Navy), Anderson Air Force Base Fire Department, Guam Coastal Management Program, Community Councils and Mayors where arson predominates, Guam Aquatic and Wildlife Division, Soil and Water Conservation Districts

Resources Needed Including Staff and Project Funding

- Fire Management Officer (or operational equivalent) is needed to lead efforts to improve prevention, control, suppression, and prescribed fire
- Organize, train and equip additional crew resources to improve prevention, control, suppression and prescribed fire activities
- Build crew capacity to respond to multiple fire incidents and improve fire watch coverage
- Additional patrol units to detect and enforce anti-arson laws, especially during hunting season (Law Enforcement)

- Additional public outreach staff, or coordination of outreach fire training needed to implement other Strategies.

- Additional fire vehicles, equipment, and personal protective equipment (PPE) to outfit additional crews, patrols, etc.

- Fire and safety training for additional personnel.

Performance Measures: Fire Fighter Certification Program developed, number of communities/acres addressed by a Community Wildfire Prevention Plan, Number of fire outbreaks, Number of acres burned, Number of firebreaks established/maintained, Number of Smoky Bear presentations, Number of public outreach events, number of certified fire fighters, number of outreach meetings involving fire that are incorporated with other Strategies (cross-over involvement).

Strategy 5: Implement Tree Planting and Monitoring Projects in Developed Areas, Open Space, and Parks In Communities (Urban Forestry).

National Themes Addressed: ***Theme 3. Protect and Enhance Public Benefits from Trees***

Overview: This strategy focuses on planting projects in the urban areas. This complements Strategy 3, in that it focuses on non-forest areas for all urban areas, not just those scheduled for development. This strategy also ties with Strategies 1 and 2, where specific priorities meeting multiple objectives would benefit from plant trees in the urban environment. The purpose of this strategy is to be inclusive of all urban lands on Guam and tie Urban programs into Forest Health and Stewardship program goals.

Scale: Island-wide, practiced at the Community Level

Maps: Urban planting priorities for all ownerships (Figure 26) and for private lands only (Figure 27)

Acres to be Treated: Approximately 88,400 acres are eligible for UCF planting and monitoring, of which 52,000 acres are currently non-forested in the urban intermix.

Stakeholder Issues Addressed (notwithstanding the overlap with Strategy 1)

- *Issue 2. Water Quality and Water Supply*: Tree ordinances that focus on zones of contribution or areas that deliver sediment to streams will increase overall

efficiencies of gaining benefits from Urban Forestry programs to water quality and supply. Planting programs designed to provide more infiltration of rainwater in parks, near roadways, schools, buildings and other development will increase overall water quality and aide to slow and filter runoff.

- *Issue 3. Population Growth and Urbanization*: Development of Tree Ordinance in other communities beyond the Military buildup (Strategy 3) will increase overall forest cover in urban environments. Model ordinance "pilot" projects will provide adaptive management advice in the development of Tree Ordinanaces and regulations that work for all of Guam, including the rural towns and villages that are still "urbanized". This is especially important with the large influx of people in the next 5 years that will likely live in smaller communities that will ultimately become large cities.

- *Issue 5. Urban Forest Sustainability*: Planting more native trees in the urban zones increases overall urban forest sustainability. Increased attention to the current urban forest landscape and designing treatments to expand these forest fragments (as in Strategy 2 and 3) will increase forest health through monitoring and early detection. Increased public involvement in the value of native trees will increase Forest Health success (through detection of pests like Cycad Scale and CRB) as well as increase volunteer maintenance of planted trees.

Description: Approximately 93% of the resident population has occupied the urban zones and as such, the urban and community forestry program provides the largest needs for interaction with the public, coupled with the poorest environment for growing forests (urban settings, impervious surfaces, compaction, etc.). There is a need to manage all of Guam's urban areas for sustained development from the impending influx of people regarding the Military Buildup. This involves developing and implementing a tree planting program to increase forest cover in the existing urban environment and to develop protocols and guidelines that ensure future development will incorporate native trees into the design.

To accommodate the large need for preparedness for urban influx in the next 5 years (and conversion of rural areas to urban zones), there requires a focused effort with attainable goals to implement a UCF program that couples with other objectives and strategies. Goals previously identified in previous UCF plans are still relevant to this strategy. These include:

1. Enhance the environment by planting trees along roadsides, parks, school grounds and areas further inland to satisfy Clean Water Act requirements (as in Strategy 1 and 2).

2. Use more local species, such as, *Intsia bijuga* (Ifit), the island's territorial tree in promoting local culture awareness.

3. Strengthen relationships within the community through a cooperative island-wide tree planting campaign.

4. Provide communities the opportunity to get involved in making Guam a better place to live by promoting tree planting.

5. Involvement with the Guam Visitors Bureau in promoting tourism by greening Tumon and all island communities, through the Tourist Attraction Projects Village Beautification Program.

6. Address storm water problems in urban areas through green infrastructure (e.g. bioswales and plantings near stream crossings).

7. Provide technical assistance to organizations, socio-civic clubs, associations and communities.

8. Provide media, technical and educational materials promoting Urban Forestry Practices.

9. Require and maintain International Society of Arboriculture (ISA) standards for Guam.

The above requires dedicated staff time to increase collaboration with private businesses, village councils, and other agencies to be successful. It is important to increase efforts in this program to ensure that future development falls within guidelines to increase the sustainability of the urban environment. Further, public awareness campaigns for residents of Guam as well as the 1.1 million tourists that visit every year (mostly in Tumon) will increase overall exposure to the importance of balance between the built and natural environments.

Next Steps and Actions

- Develop Tree Ordinances for communities that will assist in protecting, enhancing and expanding the tree canopy in the community (also see Strategy 3)

- Develop of guidelines for community and volunteer groups on the use of native and local trees to enhance wildlife habitat, native ecosystems and cultural awareness, and integration of these components into a state implementation plan. Work with GovGuam to incorporate into law.

- Increase monitoring of forest health concerns, particularly CRB and cycad scale in the urban environments (as well as invasive plants). Maintain an early detection program and create materials for local hotels, schools and business custodians and groundskeepers to assist with early detection and monitoring.

- Develop an urban tree inventory database (with Forest Health monitoring, above)

- Develop an inventory of communities, population, acres, and community groups that are potential cooperators for implementing planting and maintenance goals

- Prioritize these communities within watersheds to develop a strategic approach at delivering services where efforts would meet multiple objectives and where communities have demonstrated an interest improving tree and forest resources with their community.

- Work with Fire personnel (Strategy 4) to address fire risk as part of implementing tree plantings within the urban areas and the buffer area surrounding urban areas

- Build staff capacity to increase the delivery capability of urban and community forestry services (nursery stock, planting, outreach, education and arborist services) to become prepared for the dramatic increase in population and urban zones associated with military buildup.

- Plan for development of parks and open space both within communities and as regional parks that not only address human needs but have multiple benefits for wildlife, watershed protection and water quality improvement. Identify locations for future parks, targeting areas with native forest.

- Work with landowners and Forest Legacy programs to establish set-asides and greenspace for expanding urban zones (new parks, open areas, etc).

State and Private Forest Programs that Contribute: Urban and Community Forestry, Forest Health, Forest Stewardship, Cooperative Fire

Key Stakeholders: UCF Committee, Community Councils and Mayors, Community Volunteer Organizations and Schools, Guam Fire Department, Private Landowners and Developers, Guam Visitor's Bureau, Hotel Associations, private landscape businesses, private businesses in urban zones

Resources Needed Including Staff and Project Funding: Professional foresters, certified arborists, forestry aides, public involvement and extension specialists, increased nursery capacity, legal liaison for discussing ordinance procedure for creating legal responsibilities.

Performance Measures: Number of community groups recruited as cooperators, Number of community Tree Ordinances developed, State-wide implementation plan for tree ordinances and development, Number of trained personnel added to the program to deliver services to communities, Number of acres of open space, parks and regional park area planned or developed (as set asides or after the fact), Number of Landowners receiving technical assistance, Number of Landowners participating in educational programs, Number of acres covered by new or revised Forest Stewardship Plans, Number of acres in Important Forest Resource Areas, Number of acres that are confirmed as being managed sustainably, number of educational material releases and agreements targeting professional cross-over positions (e.g. hotel, school and business groundskeepers to assist in monitoring as part of their job).

Strategy 6: Implement a Forest Health Program: Unify Interagency Efforts to Prepare for Buildup

National Themes Addressed: ***Theme 2. Protect Forests from Harm***

Overview: Forest health is a serious concern on Guam and the capacity of Guam Forestry to respond to all forest health concerns as a single agency is severely limited. The purpose of this strategy is to pool human, funding and infrastructure resources with other agencies, groups, and interagency task forces to actively target species-based strategies and site-based control mechanisms for invasive species. The need for focused prevention and early detection will become critical in the next 5 years, with the military buildup and influx of 80,000-125,000 people and cargo materials that will arrive on (and travel through) Guam.

This strategy aims to connect other strategies identified above for Guam Forestry, as well as helping to create a unified, cross-agency platform for invasive species prevention, detection, control and monitoring with other stakeholder groups.

Forest health concerns associated with fragmentation, compaction, fire risk and degradation are addressed in other Strategies.

Scale: Island Wide Scale, Regional Micronesia, Local Communities

Maps & Figures: Map of all forests and ownerships identifies forested environments and stakeholders for forest health (Figure 24). Current trends for Coconut Rhinoceros Beetle (CRB, Figure 12). Few spatial data exist on the distribution of invasive species.

Acres to be Treated: Island-wide. Focus on 56,000 acres of current forest for monitoring. Urban areas and ports of entry monitoring.

Stakeholder Issues Addressed:

- *Issue 1. Wildfire and Public Safety*: Invasive species and forest fragmentation increase wildland fire risk through fuels loading and forest degradation. Scorching by fire weakens tree health and can create openings for establishment of pests. Fires also increase bare soil, allowing for rapid establishment and spread of ruderal species.

- *Issue 3. Population Growth and Urbanization*: Applying a unified strategy to increase invasive species prevention, detection, control and monitoring on Guam is of paramount importance in preparation for the large number of people, cargo and resources coming to Guam in the next 5 years. Increased preventions and involvement with APHIS and other agencies will increase control at points of entry. Increasing monitoring stations and incorporating Tree Ordinance measures (Strategies 3 and 5) to detect invasive species will aide to lower spread and establishment.

- *Issue 4. Deforestation of Native Forests*: Deforestation proposed in the military buildup areas (Strategy 3) will increase edge effects with other native species, which will deepen infestations into native forests. Building codes and Best Management Practices (preventative measures) to ensure equipment is washed and maintained prior to entry will decrease likelihood that equipment is not vector of spread for pests found in other urban zones (e.g. Tumon) that will spread to native forest.

Active monitoring programs will assist in early detection of infestation to native forests and actions to treat pest areas will decrease risk of degradation of native forests.

- *Issue 5. Urban Forest Sustainability*: Education, monitoring and detection will increase the body of knowledge about hazards of activities that will promote invasive species spread and will increase probabilities of success for eradication, containment and control. Working with contract laborers and companies positioned to serve the Military buildup to practice Best Management Practices (e.g. washing equipment to ensure spread does not occur to other areas of Guam, nursery quarantine and native species-driven landscaping) will improve sustainability outcomes with the impending development. Tree ordinances with accountability for tree survival and routine monitoring will increase likelihood of success for meeting UCF objectives as well as for improving overall forest health to minimize vectors originating from infected zones.

Description: Guam Forestry's in-house capacity in technical leadership is severely limited in its ability to perform day-to-day operations of Forest Health related activities of prevention (including education and outreach), early detection, or means of wide-spread eradication, containment or control. As such, Guam Forestry has partnered with UOG for conducting monitoring and/or biocontrol projects for CRB, cycad scale, Casuarina decline, and some invasive plant species (see *Biotic Disturbances Affecting Forest Health* section, on page 33). UOG has received pass-through funding from S&PF programs via Guam Forestry to conduct assessments, monitoring and biocontrol efforts in partnership with Guam Forestry.

Despite these efforts, there are serious shortcomings in the Guam-based capacity to manage forest health concerns as a lead agency. Guam Forestry is a participant in the Guam Invasive Species Advisory Committee (GISAC), which is an interagency group with focus on invasive species prevention, detection and control, and has emergency response plans in place (dated 2005). Like Guam Forestry, GISAC has limited capacity to fully manage an island-scale invasive species program that includes prevention (education, outreach, port-of-entry inspection, etc.), early detection (survey and manage), eradication (complete removal), containment and control for species-based strategies, or to fully respond to serious emergency situations. Regionally, the Micronesian Regional Invasive Species Committee (RISC) has been developing a biosecurity plan to address prevention with the military buildup. Guam Forestry has not been an active participant with RISC to

this point; the purpose and hopeful outcome of this strategy is to fortify relationships with local and regional partners to apply what capacity Guam Forestry has to the invasive species issues, and to build local, technically-trained capacity to assist in local and regional efforts.

Next Steps and Actions

- Build capacity within Guam Forestry to participate and lead an invasive species program, seek funding, and implement the strategy.
- Review significant information available, gather additional information on distribution and local impacts (survey and map key species), and develop or participate in a unified plan with APHIS, DoD, marine and wildlife resources, USFWS, GISAC and participate in RISC.
- Focus on incoming pests to urban areas, in particular the points of entry (airports, harbors). Urban areas have been the first detection areas and diligence in these areas will likely increase early detection of new pests.
- Create outreach and informational fliers about potential pests ("look out" lists of potential pests incoming from Asia-Pacific region) and distribute to hotels and groundskeepers for increasing awareness and detection through the tourism and professional grounds maintenance staff (see Strategy 5).
- Coordinate with APHIS CAPS and Guam Department of Agriculture to include potential forest pests in biosecurity risk assessments.
- Coordinate with nursery trade to develop codes of conduct regarding the introduction, sale (nurseries) and use (landscapers) invasive plant species to minimize importation risks and spread through the impending development avenues.
- For ongoing cycad scale and CRB efforts: continue the emphasis on IPM programs, including continued monitoring, evaluation, biocontrol and pesticide control in urban areas. Continue supporting cycad breeding in CNMI including conservation and incorporation of germplasm native to Guam.
- Continue CRB cooperative efforts with UOG and Emergency Incident Command System to support ongoing efforts of IPM programs to eradicate CRB. A cooperative

effort with Guam Department of Agriculture, APHIS and UOG for sanitation, trapping and biocontrol.

- Determine causes and solutions to Casuarina decline
- Continue and expand ongoing biocontrol programs for *Chronolaena*, *Mimosa*, *Coccinia* and *Lantana* and initiate regional program (Micronesia) for *Mikania* - in cooperation with UOG scientists for invasive plants with wide distribution.
- Use existing information and evaluate the list of potential invasive species identified by PIER (Pacific Island Ecosystems at Risk). Gather new information (including survey data) for high risk species and evaluate the condition and species- or site-based strategies to eradicate, contain or control.
- Establish monitor points of entry throughout the island (Andersen AFB, AB Won Pat Airport, Port Authority of Guam). Collect and compile field data.
- Develop an island wide insect and disease survey and detection and tree health survey program in coordination with APHIS and UOG.
- Conduct public education efforts, including local business (developers, nurseries, landscapers) to help expand awareness and identify "top ten" invaders on Guam, demonstrating their effects to Guam's forests and cultural resources.
- Implement use of GIS forest canopy layer for use as database on forest health and to map the outbreak and spread of diseases and pests
- Conduct island-wide inventories on a 5 year cycle (including PIER and RISC identified species)
- Continue with conversion efforts on restoration sites in *Acacia* to native species
- Coordinate with other stakeholders and determine best strategy for accomplishing the "Next Steps", including staff, technical capability, funding sources, responsibilities, and trainings. Work with community leaders, landowners, volunteers and other stakeholders to develop and implement treatments.
- Seek support from the cross-agency full-time Invasive Species Coordinator, funded by UNDP – GEF.

- Engage in cross-training of current staff to identify invasive species while implementing other projects (see other strategies)

State and Private Forest Programs that Contribute: Forest Health Program, Urban & Community Forestry, Forest Stewardship

Key Stakeholders : University of Guam, US Fish & Wildlife Service, Guam Invasive Species Advisory Council (GISAC), APHIS, NRCS, RISC, Guam Wildlife Division, Off-Island Collaborators & NGO, Guam Tourism Bureau, Nursery industry, hotel association

Resources Needed Including Staff and Project Funding: Training for identification of forest health concerns for nursery industry, landscapers, and forestry staff. Liaison with full time coordinator (GEF funded) to help define the role for Guam Forestry in invasive species management, including how capacity can be built internally. Public outreach staff and training to develop and distribute a "watch list" and engage businesses and the public.

Performance Measures: Coordination meetings with other agencies, participation in RISC, number of meetings with businesses, development of a "watch list" and number of businesses and entities to where it is distributed, number of surveys, number of trained staff, number of acres treated for invasive species, number of acres converted from Acacia to native species, number of successful introductions of biocontrol.

Step-Down Approach for Landscape Management

A general approach for resource management involves the staging of management strategies in a "vision-to-outcome" approach. Completion of a management strategy can be gauged from a "1 %" (or, the "vision") to a 100% (completed "outcome") stage. The approach is designed to be nested so that individual actions are targeted to meet desired goals beyond the project site scale. This approach has been successful with other large scale efforts and builds in efficiencies in assuring that invested time and funds meet desired outcomes. The following description provides the linkage between each planning stage, starting with the SWARS strategy, and the subsequent stage ending with project implementation.

Island Assessment & Resource Strategy (1-10% Design). This represents the initial scoping of questions at broad scales to identify the stakeholders, major issues affecting forestry resources, and how forestry is tied to other natural resource management and conservation objectives. This begins with the SWARS planning process and document. G***eographic Scale****: Island and Neighboring Islands (largest scales, 100,000s of Acres).*

Watershed Assessment (10 – 30% Design). This is the synthesis of connecting resources within a single watershed or a small group of watersheds. The assessment involves a multidisciplinary approach to resource management, involving vegetation, hydrology, soils, wildlife, marine resources, agriculture, recreation, and other cultural resources. Typically this involves an assessment of the *current conditions,* an estimate of the *potential future conditions*, and a framework for developing and attaining the *desired future conditions* through planning, design, and implementation. The purpose is to investigate, identify, and synthesize what limiting factors are affecting watershed-level processes. The watershed assessment leads into an Action Plan for restoration and resource enhancement. ***Geographic Scale****: Watershed Scale (1,000s of Acres).*

Watershed Action Plan (30 – 40% Design): This is a concise listing of the limiting factors affecting natural and cultural resources by geographic area (e.g. watershed) and provides an adaptive management approach for restoration and enhancement projects. Projects are prioritized on the basis of resource needs and stakeholder criteria. The Plan identifies the range of needs (staff, funding, outreach, partners) for full design and implementation, and in effect serves as the 'to do' list for restoration/ enhancement projects in the watershed as a whole. ***Geographic Scale****: Watershed Scale or Smaller (1,000's of acres).*

Site Design & Implementation Strategy (40 – 70% Design). This piece focuses on one or more of the identified projects/ action items from the Action Plan and provides the technical and cost basis for implementation, the completed restoration plan with "typical" prescriptions, establishes project costs and staff commitments, and begins the "project rollout". In this phase, specific standards for meeting regulatory and stakeholder issues are described, a public outreach campaign is conducted (with appropriate feedback and modifications), funding for materials for implementation are secured (e.g. nursery stock, tools, chemicals, etc.), and a monitoring plan is assembled to meet project-level guidelines. ***Geographic Scale****: Project Scale (single or multiple, 10-100 acres).*

Implementation (70 – 100% Design). At this stage the project design and specifications are completed with sufficient detail to specify staff requirements, issue Request for Proposals to contractors and implement the project with Forestry staff oversight. The 70 - 80% design is the preferred design scale for implementation to allow for *ad hoc* decisions that are inevitable when implementing the plan. Crews, volunteers and contractors are organized and the project is completed (100%). The monitoring plan is also initiated where appropriate. **G*eographic Scale****: Approved and Vetted Project Areas within Watershed (site-specific, 10's of acres).*

Monitoring (Feedback Loop). The technical monitoring study is implemented by collecting field data as identified in the Monitoring Plan. In addition, benchmarks are established that can readily be tracked by managers and communicated to decision makers and grantors. Adaptive management is used to ensure project implementation success, evaluate if benchmarks are realistic and attainable, and account for unforeseen challenges through time. A Technical Advisory Committee (TAC) involving specialists and citizen stakeholders should be established for this long-term phase to assist in project evaluation. ***Geographic scope****: Specific to process monitored.*

Program Capacity

Introduction

The Assessment identified the resource issues, their geographic location and magnitude. The Strategies describe an approach and the actions to be taken to conserve, protect and restore forest resources in Guam. Guam Forestry currently does not have the program capacity to implement these strategies and actions in full. It is critical in meeting the purpose and objectives of the SWARS planning process to identify current and future

needed capacity. Program capacity is further compounded by the planned increase in population and stress on resources that is envisioned with military expansion and development that will occur throughout the island. This section addresses the following objectives:

1. Identify the current program capacity and limitations.
2. Identify the capacity needed to implement the strategies and meet the challenges on an increasing population.
3. Identify potential funding sources from a diversity of sources – GovGuam, US Forest Service, the DoD, NOAA, EPA, NRCS, NGO's etc. and devise an approach to putting these funding sources together to meet the overall program needs.

Current and Needed Program Capacity

The current allocation of S&PF funds are predominately applied to Cooperative Forest Health Management, Forest Stewardship, Cooperative Fire Protection and Urban and Community Forestry Programs.

Elements of the Assessment of Need (AON) required for the Forest Legacy Program were completed during the SWARS assessment. Guam Forestry is the Lead Agency for the Forest Legacy Program and will complete the planning requirements needed to participate in the Forest Legacy Program in the future (elect in favor of the "state option" for Forest Legacy).

The total current staff in the Guam Forestry program in FY2010 includes 10 people, consisting of two administrative staff and eight foresters at different professional levels. The current program staff is heavily weighted to Forestry Aides with few staff in the professional forestry positions. More professional positions are needed to provide the planning, leadership, and communication skills and knowledge necessary to implement the future programs envisioned by the strategies described above.

Guam Forestry has been working within the Guam Department of Agriculture to identify future staffing needs to fill current capacity requirements as well as to implement the strategies identified in this document. The future visioning process anticipates that the Cooperative Forest Health and Stewardship programs will require a total of 9 staff, comprised of 3 professional foresters (Forester I, II, III positions) and 6 Forester Aides. Cooperative Fire Protection will need similar increase in staff support to 3 professional

foresters and 6 Forester Aides. Urban and Community programs will need 2 professional foresters and 4 forestry aides.

The current program in Guam Forestry is severely underhanded. The lack of professional staff translates into an inability to complete the planning, prescriptions, and on-the-ground leadership visualized in the Strategy section, and therefore is a major obstacle to addressing the issues identified in the Assessment and the actions identified in the Strategy Section.

In addition to the current staff situation, the military build-up looms as the single largest threat to natural resources in Guam. Without an increase in program capacity, Guam Forestry will not in a position to prevent further deforestation, erosion, sedimentation and decline of the reef habitat.

Matrix of Strategies and Program Needs

The matrix (Table 18) below provides a summary of the strategies and program needs. For more complete information, the reader is directed to the detailed strategy descriptions provided in the section above. The matrix lists the 1) Strategy, 2) State and Private Forestry Programs that contribute to implementing the strategy, 3) the Resources Required by Guam Forestry, 4) the National Themes and Objectives addressed by the Strategy, 4) Performance Measures, 5) Priority Areas and 6) the expected Partners and Stakeholders.

Note on Priority Areas: It is important to note that Priority Areas have been identified spatially in the assessment, but, are not listed specifically in the table. Areas have been prioritized for forest conservation, watershed restoration, fire risk reduction in wildlands and urban areas, water quality improvement, and avoidance of impacts associated with military build-up developments. The priority areas are identified in GIS layers and this information will be used to develop implementation actions described in the strategies.

Table 18. Matrix of Strategies and State and Private Forestry Programs. Full narrative descriptions are found beginning on page 99.

Strategy Title	Issues Addressed	Program that contributes or May Contribute	Primary Activity, Acres to be Treated Priority Area References	Resources Required	National Theme/ Objective	Performance Measures	Partners/ Stakeholders
Strategy 1: Implement Highest Priority Plantings that Meet Multiple Objectives.	**All Issues Addressed** Issue 1. Wildfire and Public Safety Issue 2. Water Quality and Water Supply Issue 3. Population Growth and Urbanization Issue 4. Deforestation of Native Forests Issue 5. Urban Forest Sustainability Issue 6. Degraded Lands	Cooperative Fire, Forest Stewardship, Urban and Community Forestry	Strategic Planting Projects to reduce fire risk to forests and expand forest fragments and to reduce sediment delivery to streams 13,098 Acres (8,920 acres on forest edges, 4,178 acres in urban zones) Forest lands: Figure 30 & Table 17. Urban zones: Figure 29 & Table 16	Professional Foresters, GIS and Spatial Analysis Technical Support, Nursery operational funds and staff, Funding and staffing to support community meetings, Education & outreach coordination with existing programs, Fire assistance (prevention, protection, control).	**1. Conserve Working Forest Lands** a. Identify and conserve high priority forest ecosystems and landscapes **2. Protect Forests from Harm** a. Restore fire-adapted lands and reduce risk of wildlife impacts b. Identify, manage and reduce threats to forest and ecosystem health **3. Protect and Enhance Public Benefits from Trees** a. Protect and enhance water quality and quantity	Number of meetings held with communities, Number of meetings with SWARS Advisory Council and UCF Committee, Number of acres treated included in the Highest Priority Areas, Number of fire outbreaks, Number of acres burned, Number of surviving trees, Number of firebreaks established/maintained, Number of Smokey Bear presentations, Number of Public Outreach events, number of S&PF competitive grants submitted per year (target 1 per year for treating Highest Priority Areas), number of acres restored.	Bureau of Statistics & Plans, Guam Fire Department, Guam Environmental Protection, Guam Aquatic and Wildlife Division, Soil and Water Conservation Districts, US Fish and Wildlife Service, National Park Service (Agat and Asan Watersheds), Community Councils and Mayors, UCF Committee, SWARS Advisory Committee, Key Private Landowners

Strategy Title	Issues Addressed	Program that contributes or May Contribute	Primary Activity, Acres to be Treated Priority Area References	Resources Required	National Theme/ Objective	Performance Measures	Partners/ Stakeholders
Strategy 2: Protect, Conserve and Restore Forests On State, Private, And Other Non-Military Lands	Issue 1. Wildfire and Public Safety Issue 3. Population Growth and Urbanization Issue 4. Deforestation of Native Forests Issue 5. Urban Forest Sustainability	Urban and Community Forestry, Forest Stewardship, Forest Legacy, Forest Health	Active restoration (planting); passive restoration (protection) on non-military lands Fire Priorities: 20,284 acres Native Forest Conservation: 25,000 acres Urban zones: ~35,000 potential planting area in non-forest and ~30,000 acres for conservation in forest Ownerships: (Figure 24), Threat to Fire Priorities (Figure 16 & Figure 17), Native Forest Conservation and Expansion Priorities (Figure 23), Urban Forest Planting and Conservation Priorities (Figure 27). Linked to Strategy #1	Multiple: Professional Foresters GIS resources, training and staff Funding to support meetings and coordinator Staff to complete Forest Legacy AON outreach Outreach support for building relationships with landowners Fire program support for new plantings: protection, control, suppression and prescribed fire as well as capacity and apparatus for organizing, training and equipping additional fire watch crews.	**1. Conserve Working Forest Lands** a. Identify and conserve high priority forest ecosystems and landscapes **2. Protect Forests from Harm** a. Restore fire-adapted lands and reduce risk of wildlife impacts **3. Protect and Enhance Public Benefits from Trees** a. Protect and enhance water quality and quantity e. Protect, conserve, and enhance wildlife and fish Habitat g. Manage and restore trees and forests to mitigate and adapt to global climate change	Number of inventories (or acres surveyed) to confirm forest conditions (forest health, potential prescriptions, and identify native forest), number of candidate sites evaluated, Assessment of Need for Forest Legacy completed, priorities of willing landowners established for purchase/conservation easements, number of landowners in the program for purchase/easements, meetings held with or MOU's secured with funding partners, number of acres planted, number of acres of forest monitored..	Private landowners, Soil and Water Conservation Districts, Community Councils and Mayors, DoD, EPA, NOAA Fisheries, GovGuam Interagency Partners, UOG

Strategy Title	Issues Addressed	Program that contributes or May Contribute	Primary Activity, Acres to be Treated Priority Area References	Resources Required	National Theme/ Objective	Performance Measures	Partners/ Stakeholders
Strategy 3: Work with Military to Avoid Deforestation and Develop Tree Ordinance Laws for New and Old Development Zones	Issue 1. Wildfire and Public Safety Issue 2. Water Quality and Water Supply Issue 3. Population Growth and Urbanization Issue 4. Deforestation of Native Forests Issue 5. Urban Forest Sustainability	Urban and Community Forestry, Forest Stewardship, Forest Health, Forest Legacy (private lands).	Develop Tree Ordinances, development codes, and work with military to incorporate native forest in development design 5,432 acres of forest, mostly suspected of being native (10% of Guam's total forest immediately at risk) Priority areas for military buildup (Figure 22), Native forest distribution priorities to not deforest (Figure 23), Priority communities and villages and urban buffer areas (Figure 26), Reference ownership of current trees (Figure 24)	Urban/ landscape forester that is dedicated to liaison during the military expansion period, GIS technician, policy support from other GovGuam resources for developing tree ordinance criteria.	**1. Conserve Working Forest Lands** a. Identify and conserve high priority forest ecosystems and landscapes **2. Protect Forests from Harm** b. Identify, manage and reduce threats to forest and ecosystem health **1. Protect and Enhance Public Benefits from Trees** a. Protect and enhance water quality and quantity c. Assist communities in planning for and reducing wildfire risks e. Protect, conserve, and enhance wildlife and fish Habitat	MOU developed and signed by all parties, Number of operational activities completed with the military, Tree Ordinance developed and transmitted to military, implement planning partnership with DOD, Number of acres protected from deforestation within the military development zones, number of private developers that are willing participants during the Ordinance development process.	DoD, GovGuam interagency urban planning departments, Attorney General Guam, Guam Aquatic and Wildlife Division, US Fish and Wildlife Service, Community Councils and Mayors, private developers.

Strategy Title	Issues Addressed	Program that contributes or May Contribute	Primary Activity, Acres to be Treated Priority Area References	Resources Required	National Theme/ Objective	Performance Measures	Partners/ Stakeholders
Strategy 4: Improve Fire Prevention, Control, Suppression and Prescribed Fire Activities through Organizing, Training and Equipping Staff and Resources.	Issue 1. Wildfire and Public Safety Issue 2. Water Quality and Water Supply Issue 5. Urban Forest Sustainability Issue 6. Degraded Lands	Cooperative Fire Program, Forest Stewardship, Urban and Community Forestry	Fire Prevention, Control, Suppression, Prescribed Burning, increasing capacity to protect forest and new planting projects Approximately 20,000 acres bordering forest edges with high fire risk (prevention through prescribed burns, mechanical treatment, protection of newly planted trees from Strategy 1 and 2); Island-wide responses to fires to protect 56,000 acres of standing forestland on Guam with interagency partners. Priority fire risks to forests and urban areas (treatment areas and also attack zones (Figure 16 and Figure 17), standing forests on Guam, by ownership type (Figure 24).	Fire Management Officer (or operational equivalent) is needed to lead efforts to improve prevention, control, suppression, and prescribed fire, Organize, train and equip additional crew resources to improve prevention, control, suppression and prescribed fire activities, Build crew capacity to respond to multiple fire incidents and improve fire watch coverage, Additional patrol units to detect and enforce anti-arson laws, especially during hunting season (Law Enforcement), Additional public outreach staff, or coordination of outreach fire training needed to implement other Strategies, Additional fire vehicles, equipment, and personal protective equipment (PPE) to outfit additional crews, patrols, etc., Fire and safety training for additional personnel.	**2. Protect Forests from Harm** a. Restore fire-adapted lands and reduce risk of wildlife impacts b. Identify, manage and reduce threats to forest and ecosystem health	Fire Fighter Certification Program developed, number of communities/acres addressed by a Community Wildfire Prevention Plan, Number of fire outbreaks, Number of acres burned, Number of firebreaks established/maintained, Number of Smoky Bear presentations, Number of public outreach events, number of certified fire fighters, number of outreach meetings involving fire that are incorporated with other Strategies (cross-over involvement).	Guam Fire Department, Federal Fire Department (Navy), Anderson Air Force Base Fire Department, Guam Coastal Management Program, Community Councils and Mayors where arson predominates, Guam Aquatic and Wildlife Division, Soil and Water Conservation Districts

Strategy Title	Issues Addressed	Program that contributes or May Contribute	Primary Activity, Acres to be Treated Priority Area References	Resources Required	National Theme/ Objective	Performance Measures	Partners/ Stakeholders
Strategy 5: Implement Tree Planting and Monitoring Projects in Developed Areas, Open Space, and Parks In Communities (Urban Forestry)	Issue 2. Water Quality and Water Supply Issue 3. Population Growth and Urbanization Issue 5. Urban Forest Sustainability	Urban and Community Forestry, Forest Health, Forest Stewardship, Cooperative Fire	Planting projects in Urban Zones; monitoring forest health of current trees 88,400 total acres 52,000 non-forest for planting priorities 36,400 forested for monitoring forest health Urban planting priorities for all ownerships, including current forest (Figure 26) and for private lands only (Figure 27)	Professional foresters, certified arborists, forestry aides, public involvement and extension specialists, increased nursery capacity, legal liaison for discussing ordinance procedure for creating legal responsibilities.	**3. Protect and Enhance Public Benefits from Trees** a. Protect and enhance water quality and quantity b. Improve air quality and conserve energy c. Assist communities in planning for and reducing wildfire risks f. Connect people to trees and forests, and engage them in environmental stewardship activities	Number of community groups recruited as cooperators, Number of community Tree Ordinances developed, State-wide implementation plan for tree ordinances and development, Number of trained personnel added to the program to deliver services to communities, Number of acres of open space, parks and regional park area planned or developed (as set asides or after the fact), Number of Landowners receiving technical assistance, Number of Landowners participating in educational programs, Number of acres covered by new or revised Forest Stewardship Plans, Number of acres in Important Forest Resource Areas, Number of acres that are confirmed as being managed sustainably, number of educational material releases and agreements targeting professional cross-over positions (e.g. hotel, school and business groundskeepers to assist in monitoring as part of their job).	UCF Committee, Community Councils and Mayors, Community Volunteer Organizations and Schools, Guam Fire Department, Private Landowners and Developers, Guam Visitor's Bureau, Hotel Associations, private landscape businesses, private businesses in urban zones

Strategy Title	Issues Addressed	Program that contributes or May Contribute	Primary Activity, Acres to be Treated Priority Area References	Resources Required	National Theme/ Objective	Performance Measures	Partners/ Stakeholders
Strategy 6: Implement a Forest Health Program: Unify Interagency Efforts to Prepare for Buildup	Issue 1. Wildfire and Public Safety Issue 2. Water Quality and Water Supply Issue 3. Population Growth and Urbanization Issue 4. Deforestation of Native Forests Issue 5. Urban Forest Sustainability	Forest Health Program, Urban & Community Forestry, Forest Stewardship	Unifying strategies with other stakeholders, monitoring forest health with emphasis on invasive species, <u>many specific activities</u> (see narrative) Island-wide. Focus on 56,000 acres of current forest for monitoring. Urban areas and ports of entry monitoring. Map of all forests and ownerships identifies forested environments and stakeholders for forest health (Figure 24). Current trends for Coconut Rhinoceros Beetle (CRB, Figure 12). Few spatial data exist on the distribution of invasive species.	Training for identification of forest health concerns for nursery industry, landscapers, and forestry staff. Liaison with full time coordinator (GEF funded) to help define the role for Guam Forestry in invasive species management, including how capacity can be built internally. Public outreach staff and training to develop and distribute a "watch list" and engage businesses and the public.	**2. Protect Forests from Harm** a. Restore fire-adapted lands and reduce risk of wildlife impacts b. Identify, manage and reduce threats to forest and ecosystem health	Coordination meetings with other agencies, participation in RISC, number of meetings with businesses, development of a "watch list" and number of businesses and entities to where it is distributed, number of surveys, number of trained staff, number of acres treated for invasive species, number of acres converted from Acacia to native species, number of successful introductions of biocontrol.	University of Guam US Fish & Wildlife Service Guam Invasive Species Advisory Council (GISAC) Natural Resources Conservation Service Off-Island Collaborators & NGO

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Appendices

Appendix 1: SWARS Coordination

The Chief of Forestry is part of the NRCS Local Working Group. Once the SWARS document is completed the Local Working Group will have an opportunity to review the document. Since Guam is a small community Guam Forestry decided to have the same members on each stakeholder group. This makes for a more efficient way of deciding issues related to each board. The SWARS Advisory Council consisted of the both FSP board and UCF council that contributed to identification of threats and conditions.

The Forest Service Checklist for the SWARS report requires coordination of Stakeholder Groups with the Statewide Assessment and Strategy. Because Guam is a small island in comparison to mainland states many of these required coordinating group members participated on the SWARS Advisory Council. The required Stakeholder Groups on the checklist are listed below with an indication of their participation in development of the SWARS document. The table below shows the crosswalk of committee members that also are on the Stewardship Coordinating Committee and the Urban Forestry Council.

1. **State Forest Stewardship Coordinating Committee**:- Members of Stewardship Committee were included on the SWARS Advisory Council

2. **State Wildlife Agency:** The State Wildlife Agency (Guam Dept. of Agriculture, Aquatic and Wildlife Division) was included on the SWARS Advisory Council**.**

3. **State Technical Committee**: The SWARS Advisory Council functions as the State Technical Committee.

4. **Forest Legacy Lead Agency**: Guam Forestry is the lead agency for the Forest Legacy Program.

5. **Applicable Federal land management agencies.** U.S. FWS, Navy, NRCS were included on the SWARS Advisory Council, National Park Service was consulted. The NAVFAC Naval Facilities Engineering Command is the lead agency for the relocation EIS and therefore provide representation for the U.S. Marine Corps, U.S. Army, and U.S. Air Force.

SWARS Advisory Council

Name/Position	Agency
Joseph D. Torres, Director	Dept. of Agriculture, 163 Dairy Rd., Mangilao, 96913
Justin Santos, Forestetr I	Dept. of Agriculture, Forestry & Soil Resources Div.
Bel I. Soliva, Forester I	Dept. of Agriculture, Forestry & Soil Resources Div.
Joseph Mafnas, Chief Forester	Dept. of Agriculture, Forestry & Soil Resources Div.
Dave Burdick, Biologist	Bureau of Planning
Antonette Cruz	Soil & Water Conservation District
Christian Eggleston, Biologist	Guam National Wildlife Refuge, U.S. Fish & Wildlife
Kennedy Tolenoa	University of Guam
	WERI (Water & Energy Research Institute of Western Pacific
Roland Quitugua, Director	(Northern) Soil & Water Conservation District
C. Donato (GFD)	Guam Fire Department
Nora Camacho	Deputy Director, Guam Military Build-up, Office of the Gov.
Benny San Nicolas, Director	(Southern) Soil & Water Conservation District
John H. " Bart " Lawrence	Natural Resources Conservation Service
Assistant Director	Jackie Flores, Resource Conservationist,
Trina Leberer	Nature Conservancy
Jay Gutierrez, Asst. Chief	Department of Agriculture, Aquatic & Wildlife Div.
Joanne Brown, Assistant Director	Soil & Water Conservation District
Ray Calvo, Planner IV	Guan Environmental Protection
Brent Tibatts, Biologist	Department of Agriculture, Aquatic & Wildlife Div.
David Peredo, GFD Chief	Guam Fire Department
Dr. Leonard Olive, Gen. Manager	Guam Waterworks
Jesse Bamba, Extension Agent	University of Guam
Marvin Aguilar, Planner	Land Management
Jessie Garcia, Director	Chamorro Land Trust
Mike Gawel, Chief Planner	Guam Environmental Protection Agency
Anne Brooke, Ph.D.	NAVFAC Naval Facilities Engineering Command
Dan Guerrero	

Appendix 2: Technical Supporting Information

Appendix 2 is provided in a separate document.

NATIONAL PRIORITIES SECTION
(New section or addendum to Forest Action Plan)
Actions taken 2010-2015 toward U.S. national priorities
Island of Guam

Background: The 2010 Statewide Assessment and Resource Strategy (SWARS) document was completed to meet the requirements of the 2008 Farm Bill and the redesign objectives of the USDA Forest Service State and Private Forestry (S&PF) programs. This State-wide Assessment and Resource Strategy (SWARS) provided the Guam Department of Agriculture, Forestry and Soil Resources Division (Guam Forestry) an opportunity to identify the highest priorities for forest resource management and a vision for the future of our forestry program in line with the three national priorities

- Conserve and Manage Working Forest Landscapes for Multiple Values and Uses
- Protect Forests from Threats
- Enhance Public Benefits from Trees and Forests

This document was developed with input from members of the Forest Stewardship and Urban & Community Forestry advisory council, Soil and Water Conservation districts, Natural Resource Conservation Service, and other pertinent local Government utility agencies addressing issues of concern in their respective area of responsibilities.

This 2015 "National Priorities" addendum serves as a record of activities taken by all Guam partners to address strategic actions taken as part of the Guam Forest Action Plan (FAP) (2010-2015), and will be updated annually as appropriate.

1. Conserve and Manage Working Forest Landscapes for Multiple Values and Uses

Issue(s) Addressed:

a. Wildfire and Public Safety
b. Water Quality and Water Supply
c. Population Growth and Urbanization
d. Deforestation of Native Forest
e. Urban Forest Sustainability
f. Degraded Lands

Long-term strategy 1 (FAP): Implement Highest Priority Plantings that meet multiple objectives

Actions taken 2010-2015:

a. Conducted numerous tree planting events in rural and urban areas identified as high priorities in FAP.

b. Conducted Education and Outreach events in public and private schools, provided service learning opportunities, and community events on tree care, fire prevention, and Smokey Bear presentations.

c. Wildland fire suppression, pre-suppression work including fuel load reduction projects and firebreak maintenance.

d. Reforestation on high priority landscapes known to contribute to wildland fires, soil erosion and forest fragmentation.

e. Conducted re-measure of FIA plots in 2013.

f. Maintained nursery operations which included collection, propagation and maintenance of seeds and saplings for private and public lands. Plants were utilized to support reforestation efforts.

g. Collaborated with the University of Guam on implementing a Plant Extinction Prevention Program funded via the SPF Western Competitive grant process.

Long-term Strategy 2 (FAP): Protect, Conserve and Restore Forests on State, Private and other Non-Military Lands

Actions taken 2010-2015:

a. Provided technical assistance to private landowners on Forest Stewardship program benefits.
b. Provided native tree saplings to cooperators to address conservation issues such as soil erosion/enrichment, windbreaks, fire breaks, agroforestry operations, and wildlife habitat.
c. Worked in existing forest landscapes to reintroduce native plants.
d. Reforested previously burned sites.
e. Initiated the Guam Plant Extinction Prevention Program via a Western States Competitive Grant.
f. Legislation to set aside state lands for conservation.
g. Continue efforts to monitor native cycads in response to the Asian Cycad Scale invasion and also implemented genetic conservation efforts for cycads.
h. Participated in efforts to eradicate coconut rhinoceros beetle and little fire ant.
i. Developed several integrated pest management tools for coconut rhinoceros beetle and little fire ant.
j. Initiated studies to determine the decline off casuarina trees on Guam.
k. Initiated studies to determine what forest pathogens exist on Guam.

Long-term Strategy 3 (FAP) Work with Military to avoid Deforestation and Develop Tree Ordinance laws for new and old development zones

Action taken 2010-2015:

a. Met with stakeholders and created a Tree Ordinance working group comprised of utility agencies, Guam Visitors Bureau, Parks and Recreation, Senator's office, University of Guam, Military officials, and Land Management agency and Soil Water Conservation District.
b. Drafted Tree Ordinance for review.
c. Met with Senators during a round table discussion to provide an update on the status of draft ordinance.
d. Arborist certification (5 certified arborists).

e. Tree worker training.

f. Issued tree trimming permits to various Government utility companies.

2. Protect Forest from Threats

Issue(s) Addressed:

a. Wild fire and Public Safety
b. Water quality and Water supply
c. Urban Forest sustainability
d. Degraded Lands

Long-term strategy 4 (FAP): Improve Fire Prevention, control, suppression and Prescribed fire activities through organizing, training and equipping staff and Resources

Actions taken 2010-2015:

e. Fuel load reduction projects.

f. Fire break maintenance.

g. Fire suppression efforts.

h. Acquired firefighting equipment via the Federal Excess Personal Property program and provided to the local fire department on loan to support our wild land fire suppression operations.

i. Planted greenbelts in existing conservation areas to protect trees.

j. Provided standby services for burning permit requests.

k. Collaborated with partners on fire prevention workshops.

l. Produced outreach PSA, "Munnga Ma Sonnge Guahan" which was recently revised to read, "Munga masongge Guåhan, Don't burn Guam!" Which was a collaborative effort between the Bureau of Statistics and Plans, Guam Coastal Management Program.

m. Conducted fire patrols during fire season.

n. Purchased and maintained fire equipment.

o. Hired a Cooperative Fire Program Manager to oversee the Fire Program. In addition, eight Forestry Aides were hired to support all four Forestry Programs.

p. Cooperative Fire Program Manager has begun drafting the "Fire Management Plan for Guam," a five year plan, which will coincide with the priorities detailed in the State Action Plan.

Long-term strategy 6 (FAP): Implement a Forest Health Program to unify interagency efforts to prepare for military buildup

Actions taken 2010-2015:

a. Worked collaboratively with the University of Guam on staff development.

b. Participated in local meetings addressing invasive species issues.

c. Installed monitoring/detection traps throughout the island.

d. Collected specimens were identified and reporting system is being develop.

e. Trapping site/lures and collection dates were reported in the US Forest Service National EDRR database.

f. Conducted invasive plant removal in conservation areas.

g. Collaborated with partners including the University of Guam (UOG) in forest and green waste management efforts to prevent the spread of invasive species throughout the island.

3. <u>Enhance Public Benefits from Trees and Forests</u>

Issue(s) Addressed:

a. Water Quality and Water supply
b. Population Growth and Urbanization
c. Urban Forest Sustainability

<u>Long-term strategy 5 (FAP):</u> Implement Tree Planting and Monitoring projects in developed areas, open spaces, and park in communities (Urban Forestry)

Actions taken 2010-2015:

d. Worked with local and federal government agencies to implement tree planting projects within their landscapes.

e. Worked with public and private schools on tree planting events.

f. Provided tree trimming permits and provided guidance on proper pruning techniques.

g. Assisted Island-wide Beautification Task Force (IBTF) on landscaping iconic urban site.

h. Coordinated with federal counterpart to train local resource agencies on Tree Worker workshop, and Arborist Certification workshop.

i. Lead numerous education and outreach events.

j. Spearheaded all Arbor Day events supported by local politicians, students, agency partners and various members of the community. The entire month of October was celebrated as Arbor Month, and included numerous planting events and service learning opportunities (more than 2100 trees were planted). This event has grown to celebrating Arbor Day to now Arbor Month

k. Assisted partners in establishing rain gardens in parks and commercial buildings

l. Propagation incorporated the use of a variety of native and non-native tree species to support agroforestry related projects.

m. Approximately 3000 trees were grown in the nursery for outplanting activities.

4. <u>Challenges:</u>

a. Funding – Increase funded needed to effectively implement action plan.

b. Reporting – Online reporting constantly change/upgraded, it would be beneficial to have one standardize reporting system to address all programmatic requirement(s).

c. Technical assistance – More onsite assistance from technical specialists and grant program managers would be beneficial to keep up-to-date with policies, procedures, technology transfer and program development and implementation.

5. <u>Focus next 5 years:</u>

a. Continue to work with partners to leverage resources that meet multi-agency objectives.

b. Work with partners on developing Landscape Scale Restoration (LSR) proposals to assist in the implementation of the FAP.

c. Invasive species: Trapping, collecting, reporting and identifying also implementing surveys for plant injury.

d. Development of an invasive plants strategic plan.

e. Increase data collection for forest and urban tree pest to include baseline data for future comparisons.

f. Decrease forest fragments, conversion of grassland to forest.

g. Maintain Forestry's Nursery operations.

h. Education and outreach on natural resource management, wild land fire, soil erosion, invasive species, proper tree care and maintenance, Implement Tree ordinance, Develop rules and regulations and management plan for Guam Forest System law.

i. Succession planning and increased training opportunities for recently hired personnel

j. Recruitment of additional personnel.

k. Work collaboratively with newly established Biosecurity Division within the Guam Department of Agriculture.

6. **Data Needs or New issues:**
    a. Update maps
        i. Vegetation Maps
        ii. Fire Prone Sites / Historical Mapping of Burned Areas
        iii. Invasive Species Mapping (hotspots)
        iv. Priority Site Map
        v. Include Cocos Island as part of priority sites
    b. Build an Agroforestry program
    c. Include Historic preservation section 106 requirements into FAP
7. Append attached “Important Forest Resource Areas” (IFRA) map.

Site preparations in a High Priority Area.

Outplanting of *Acacia auriculiformis* with Service Learning students.

Arbor planting with partners: Sen. Rory Respicio, Natural Resource Committee Chair; Director Of Agriculture; Director of Parks and Recreation

Outreach and education during Fire Prevention Week

Fire suppression activities.

Funnel trap installed to monitor for insects and test early detection tools.

Production of plants in the Guam Forestry Nursery

Appendix: Important Forest Resource Areas map for Guam.