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COLLEGE OF NATURAL
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Forestry on Guam

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Introduction

The most distinguishing environmental feature of Guam is its greenery. The first impression of visitors is of the many vibrant shades of green. The lush island vegetation can be a tangle of trees, shrubs, and vines, but by looking closely at the individual trees that make up the tropical jungle, it is possible to trace the island's history through the verdant flora. The first trees developed in isolation on the uninhabited island. Then there were successive waves of trees

arriving by natural means, on board voyaging canoes, on Spanish sailing ships, on American war vessels, and, most recently on airplanes and container ships. At present there are 74 million trees on Guam representing 64 species (Lazaro *et al.*, 2020; Micronesian Challenge, 2019). Over half of the island (53%) is covered in forests (Figure 1). These trees have profound cultural, economic, and ecological importance to the island's inhabitants.

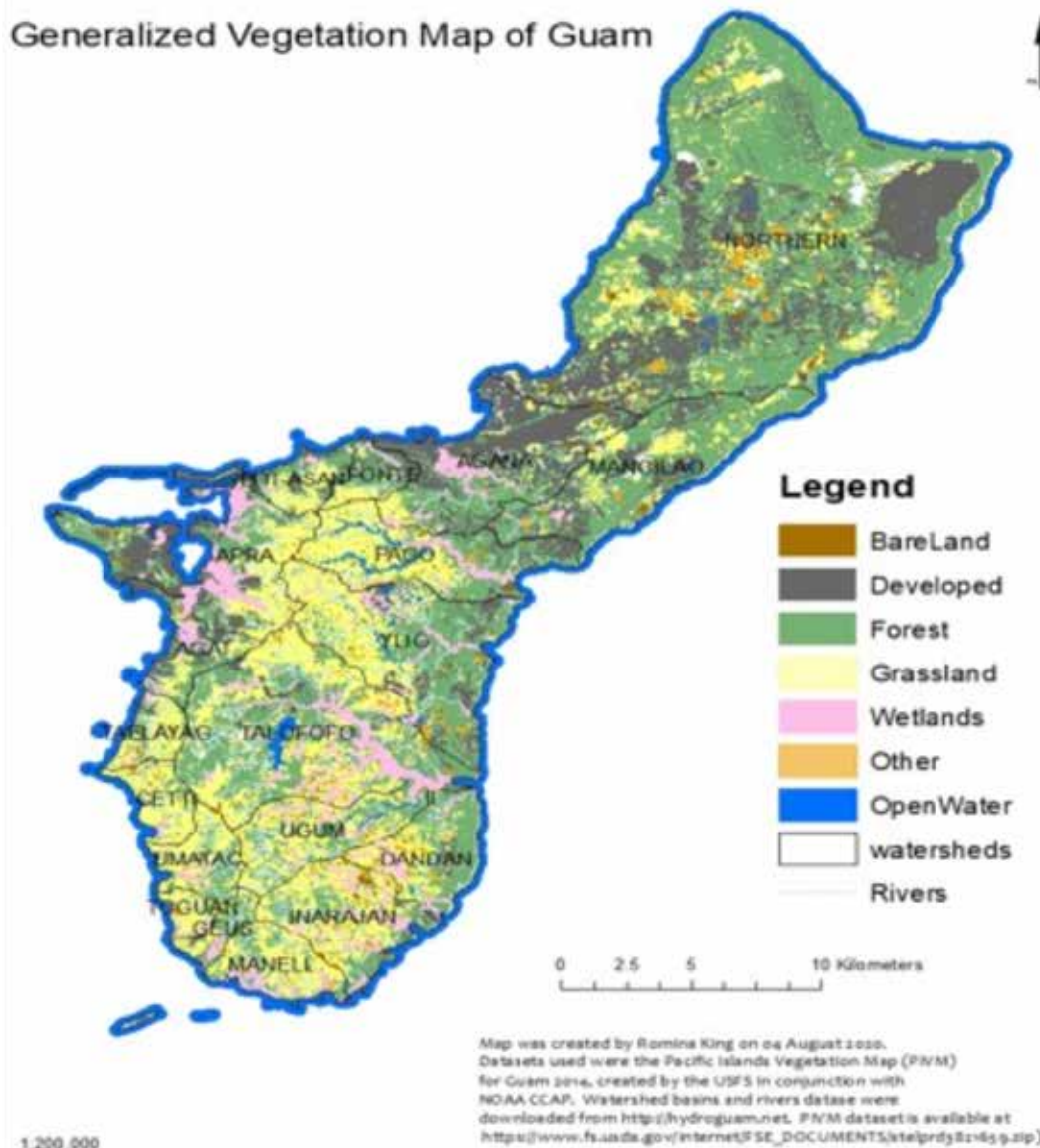


Figure 1. Forests cover 53% of Guam's land area.



Figure 2. The lead agency for the protection and management of island forests is the Forestry and Soil Resources Division within Guam’s Department of Agriculture. The division has four programs relating to urban and community trees, forest health, stewardship, and fire protection.

The lead organization for the protection and management of island forests is the Forestry and Soil Resources Division (Figure 2) within Guam’s Department of Agriculture. The division has four program that relate to urban and community trees, forest health, stewardship, and fire protection.

Goals

The goals of this publication are to describe:

1. The history, nature, and extent of Guam’s forests,
2. The value of the forests,
3. The factors that threaten Guam’s forests,
4. Forestry Division programs designed to respond to these threats by protecting and enhancing the forests,
5. The challenges that confront the future of trees on Guam, and the strategies being

employed by the Forestry Division to overcome these challenges to ensure the sustainability and health of Guam’s forests.

The information presented in this publication is primarily drawn from three sources. (1) The Guam Forest Action Plan (GFAP) 2020-2030 is a road map for the management of the territory’s forest resources (Fejeran, 2020). (2) An island-wide forest inventory analysis that was conducted by the U.S. Forest Service in 2013 (Lazaro *et al.*, 2020). (3) The Micronesia Challenge conducted a similar inventory in 2013, but with a focus on protected conservation areas in northern Guam and ravine forests in southwestern Guam (Micronesia Challenge, 2019). All photographs are the work of the authors: R. Bevacqua and C. Fejeran.

Terminology

Three terms must be defined. A tree is a woody perennial plant, usually with a single well-defined stem or trunk carrying a leafy crown, with a minimum height of 15 ft at maturity (Lazaro et al., 2020). A forest is an area dominated by trees. Forestry is the science or practice of planting, managing, and caring for forests.

Four additional terms: endemic, indigenous, introduced, and invasive, that are important in appreciating the origins of island trees.

Endemic trees are those that evolved in the Mariana Islands and are found nowhere else in the world. *Fadang* or cycad (*Cycas micronesica*) (Figure 3) and *paipai* (*Guamia mariannae*) (Figure 4) are examples of endemic plants – ones that are unique to Guam and the Mariana Islands.



Figure 3. *Fadang* or cycad (*Cycas micronesica*), was once the most prevalent endemic tree on Guam, but invasive insects have reduced its numbers and it is now considered threatened.

Indigenous trees are those that are naturally distributed in the region. Their seeds were transported by birds or floated on the sea to the island. They became established before the arrival of humans.



Figure 4. Patrick Quenga checks on seedlings of *paipai* (*Guamia mariannae*) the most numerous endemic tree on Guam, which is being propagated by the Forest Health Program.

Pagu or sea hibiscus (*Hibiscus tiliaceus*) (Figure 5), *lemon China* or limeberry (*Triphasia trifolia*) (Figure 6), and *gagu* or ironwood (*Casuarina equisetifolia*) are examples of indigenous trees that were naturally distributed among the islands of the Pacific without human intervention.



Figure 5. *Pagu* or sea hibiscus (*Hibiscus tiliaceus*) is the second most common tree on Guam. It is indigenous and sprawls to form dense thickets.

Endemic and indigenous plants, together, are often referred as native plants.



Figure 6. *Lemon China* or lime berry (*Triphasia trifolia*), is the third most common tree on Guam. It is indigenous and forms thorny brambles that are difficult to penetrate.



Figure 7. *Lemmai* or breadfruit (*Artocarpus altilis*) was brought to the island 4,000 years ago by CHamoru navigators. It continues to be culturally and economically important as a source of food, forage, and wood.

Introduced plants are those transported to the island by humans. These introductions can be categorized into three historical eras: CHamoru, Spanish, and American. *Lemmai* or breadfruit (*Artocarpus altilis*) (Figure 7) and *niyok* or coconut palm (*Cocos nucifera*) were brought to the island by ancient CHamorus. Spanish colonists brought *kadena de amor* or chain of love (*Antigonon leptopus*) (Figure 8) and Americans after WWII seeded large areas of the island with *tangantangan* (*Leucaena leucocephala*) (Figure 9).



Figure 8. The most widespread invasive plant is *kadena de amor* or chain of love (*Antigonon leptopus*), a vine that can smother trees.

Invasive is a general term for pest plants that are characterized by fast growth, rapid reproduction, an ability to spread easily, an absence of natural enemies, an association with humans, and a high cost to remove or control (Virginia Department of Conservation and Recreation, n.d.). Invasive plants are typically introduced by humans, though they can be endemic or indigenous. False rattan (*Flagellaria indica*), for example, has the aggressive characteristics of an invasive vine, but is considered to be indigenous by botanists (Yoshioka, 2008). Guam's most numerous invasive plants are *tangantangan* (Figure 9) and *kadena de amor* (Figure 8).



Figure 9. *Tangantangan* (*Leucaena leucocephala*) is the most common tree on Guam. It is introduced and is considered an invasive threat.

Environmental Setting

Guam has a tropical climate and is the southernmost island in the Mariana chain. The northern half of the island is a flat plateau composed of uplifted coral reefs. Northern soils are typically a thin clay with high pH and high permeability. Beneath the plateau is the island's principle aquifer or fresh water lens. The southern half of the island is volcanic in origin and is drained by many streams and rivers. Southern soils are characteristically deep, acidic clays with poor drainage.

The island of Guam is surrounded by coral reefs that provide habitats for large numbers of diverse marine species.

Historical Setting

Guam was a primarily forested environment before human contact (Peterson and Wescom, 2019). The dominant tree was the endemic *fadang* (Figure 2). Change to the forests began when CHamoru voyagers arrived 4,000 years ago (Athens and Ward, 2004). Fire was introduced as a land-clearing tool and native trees began to be replaced by introduced ones, such as *lemmai* (Figure 7). This transition from native to introduced species accelerated through the Spanish, Japanese, and American colonial periods. WWII had an especially pronounced impact on the island's natural environment. Large tracts of forest were destroyed by bombardment, battles, and the construction of military facilities such as airfields. A salient trend throughout the recorded history of Guam's forests is a decrease in endemic and indigenous trees and an increase in introduced trees.

Nature and Extent of Guam's Forests

At present, the five most prevalent tree species on Guam (Table 1) are *tangantangan* (Figure 9),

pagu (Figure 5), *lemon China* (Figure 6), *paipai* (Figure 4), and *vitex* (*Vitex parviflora*) (Fejeran, 2020). Of these five, only *paipai* is endemic. The domination of island forests by invasive introduced trees is illustrated with an aerial look at forest cover or canopy. Forest cover is clearly dominated by invasive species. Three introduced trees comprise over 26% of the island's forest cover. These three trees are *vitex* (13% cover), *tangantangan* (9% cover) and *palma brava* (*Heterospathe elata*) (4% cover) (Lazaro et al., 2020).

The island's history of colonization, occupation, and war, coupled with the effects of fire, typhoons, and droughts, has left little endemic or undisturbed primary forest on the island (Mafnas, 2010). Forests of endemic trees are now fragmented and restricted to scattered patches on cliffs and to other relatively inaccessible areas on military installations in northern Guam. In southern Guam, pockets of endemic trees can be found in ravines, valley bottoms, and on steep hillsides. The few endemic trees that can still be commonly observed are *paipai* (Figure 3), *mapunao* (*Aglaia mariannensis*) (Figure 10), and *langiti* (*Ochrosia mariannensis*).



Figure 10. Kulan Salil of the Urban and Community Forestry Program prepares a native *mapunao* tree (*Aglaia mariannensis*) for use in a school beautification project.

Table 1. The names of the 15 most numerous trees, in descending order of abundance, on Guam.

| CHamoru ¹ | English ² | Scientific ³ |
|----------------------|----------------------|----------------------------------|
| <i>tangantangan</i> | n/a | <i>Leucaena leucocephala</i> |
| <i>pagu</i> | sea hibiscus | <i>Hibiscus tiliaceus</i> |
| <i>lemon China</i> | lime berry | <i>Triphasia trifolia</i> |
| <i>paipai</i> | n/a | <i>Guamia mariannae</i> |
| n/a | <i>vitex</i> | <i>Vitex parviflora</i> |
| <i>ladda</i> | noni | <i>Morinda citrifolia</i> |
| <i>fagot</i> | n/a | <i>Neisosperma oppositifolia</i> |
| <i>ahgao</i> | n/a | <i>Premna obtusifolia</i> |
| <i>palma brava</i> | n/a | <i>Heterospathe elata</i> |
| <i>mapunao</i> | n/a | <i>Aglaiia mariannensis</i> |
| <i>pikue</i> | pickle tree | <i>Averrhoa bilimbi</i> |
| <i>gagu</i> | ironwood | <i>Casuarina equisetifolia</i> |
| <i>niyok</i> | coconut palm | <i>Cocos nucifera</i> |
| <i>ylang-ylang</i> | n/a | <i>Cananga odorata</i> |
| <i>kafo'</i> | pandanus | <i>Pandanus tectorius</i> |

¹(Topping et al., 1975) ²(Raulerson & Rinehart, 2018) ³(Lazaro et al., 2020)

The island of Guam has an area of 132,183 acres. Forests comprise 69,703 acres or 53% of this. Furthermore, 17,890 acres or 26% of forests are in reserved or protected areas, such as refuges or conservation areas (Lazaro et al., 2020).

Land ownership of Guam's forests is divided between private (53%) and public management (47%). Public lands are managed by the Department of Defense, National Park Service, National Wildlife Refuge, and the Government of Guam which manages 27,376 acres or 20% of the land area (Mafnas, 2010).

Value of Forests

Guam's forests provide island residents with cultural, ecological, and economic benefits.

Forests have played an integral part in the shaping of CHamoru identity and culture. For four thousand years CHamorus have depended on the resources forests provide for sustaining life and livelihood. Even today, forests provide food, clothing, medicine, fishing gear, and building materials, and exemplify the integral role forests play in the daily life of islanders. Trees and forests also play important roles in legends, chants, and cultural attitudes toward the environment (Perez, 2019). There is a legend, for example, of a beautiful CHamoru maiden who died at the age of 18. From her grave the first *niyok* or coconut palm sprouted, which has provided her people with sustenance ever since. Two other culturally important trees are the *lemmai* (Figure 6) which provides food, forage, and lumber and *ifit* (*Intsia bijuga*) (Figure 11).



Figure 11. Patrick Quenga of the Urban and Community Forestry Program inspects an *ifit* (*Intsia bijuga*) seedling. *Ifit* wood is highly valued for wood carvings and has figured prominently in CHamoru history.

Once widely used as a building material, but now uncommon, *ifit* is still prized for wood carving and furniture.

Ecologically, Guam's forests are of value in several ways. They provide food and habitat for native plants and animals. In northern Guam, forests help in recharging the aquifers beneath the limestone plateau. In southern Guam, forests decrease flooding and erosion. If left uncontrolled, these factors result in the movement of soil into streams and coastal waters where the soil settles on the reefs and smothers the coral (Figure 12).

The greatest economic value of island forests is their contributions to Guam's developing tourist industry. The natural beauty of Guam's trees and forests are an important attraction to visitors (Figure 13). The greenery enhances visitors experiences on the island, and they leave with an appreciation for Guam's tropical diversity.



Figure 12. One of the ecological benefits of healthy forests is the protection of coral reefs from soil sedimentation.

Secondly, forests are harvested by residents as sources of food, firewood, poles, handicrafts, forage, and medicine. Many residents have rural properties where they practice agroforestry – the cultivation of trees for wood and food. Some of the more popular agroforestry trees are *niyok* (Figure 13), *manga* or mango (*Mangifera indica*) and *alageta* or avocado (*Persea americana*).



Figure 13. Guam's trees are of great economic importance because they enhance the visitor's experience. The coconut grove at Asan Beach, for example, attracts thousands of people each year.

No timber industry exists on Guam at present. Island trees do not lend themselves to commercial logging. The dominant trees are short, thin in diameter, and crooked in growth habit. Also, a high percentage of forest trees exhibit damage from storms, pests, decay, or other factors (Mafnas, 2010). There is no commercial harvesting of trees for lumber and no sawmills on Guam, but this could change in the future. Trial plantings of introduced hardwoods, such as mahogany (*Swietenia macrophylla*) (Figure 14), teak (*Tectona grandis*), and eucalyptus (*Eucalyptus* spp.), have had great success. These hardwoods could replace the declining *ifit* (Figure 11) and provide an opportunity for a small-scale industry.



Figure 15. Wildfires are a major threat to island forests.

Wildfires (Figure 15) can have the direct effect of destroying forests and the indirect effects of damaging watersheds. Wildfires accelerate erosion and the movement of soil pollutants into surface waters and domestic water supplies. Fires also contribute to the decline of the coral reef systems by hastening the delivery of soil sediment into the coastal waters. On Guam, all wildfires are started by humans and are considered a crime – arson (Figure 16). On average, 4.8% of the island’s total land area was burned each year between 2015 and 2020 (Figure 17).



Figure 14. The success of trial plantings of introduced hardwoods, such as mahogany (*Swietenia macrophylla*), may offer an opportunity for economic diversification.

Forest Threats

There are five major threats to Guam’s forests: wildfires, typhoons, drought, population growth/urbanization, and invasive species.



Figure 16. In 2018 there were 468 wildfires on Guam that destroyed 6,251 acres.

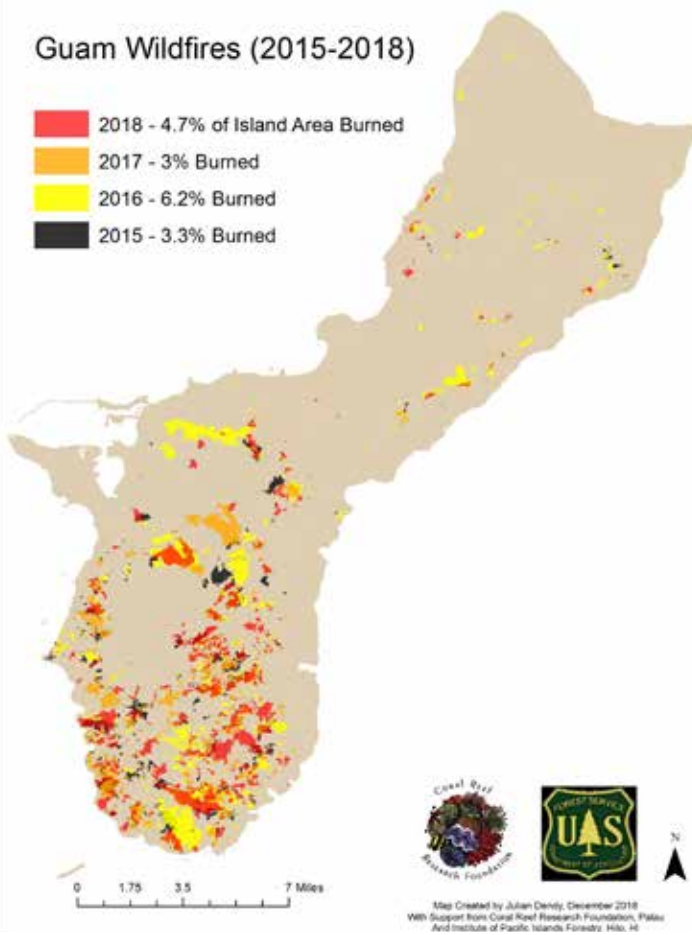


Figure 17. Each year almost 5% of Guam’s outdoor environment is destroyed by fires.

Typhoons and tropical storms can have devastating impacts on the island’s natural environment (Figure 18) (NOAA, 2020b). Trees, in particular, are vulnerable to wind damage. They can be defoliated, toppled, or have branches broken. The storms may weaken a forest and make it susceptible to attacks by invasive species.

Droughts are extended periods of no or little rain. They generally occur during the dry season (Figure 19) (NOAA, 2020a), especially during March and April. Droughts can reduce tree growth and increase tree mortality. They can increase a tree’s susceptibility to disease and insect attack (Szizepaniec and Finke, 2019). Droughts also increase the risk of wildfires through the build-up of very combustible dry fuels.

Guam’s urban environment can be characterized by steady population growth and increasing urbanization (Figure 20). In 1960 the population was 66,742 and in 2019 it was 167,294 (World Bank, 2020). This is an increase of over 100,000 people in 59 years. The trend for urbanization is similarly upward. In 1960 50% of the population lived in urban areas. In 2019 this figure increased to 95% (World Bank, 2020). These trends lead to the destruction and further fragmentation of forests.

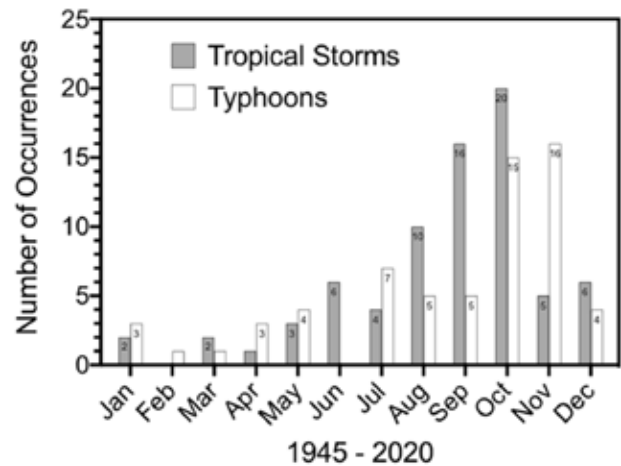


Figure 18. Throughout history tropical storms and typhoons have had devastating impacts on island forests.

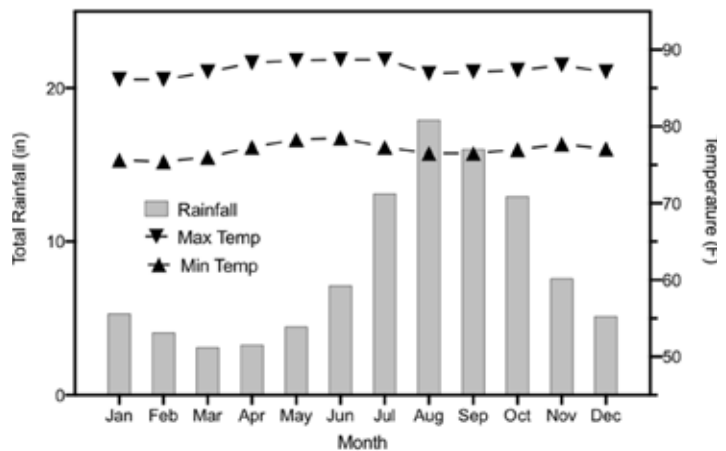


Figure 19. Droughts can occur in the dry season. They can stunt or prevent tree growth and favor wildfires.

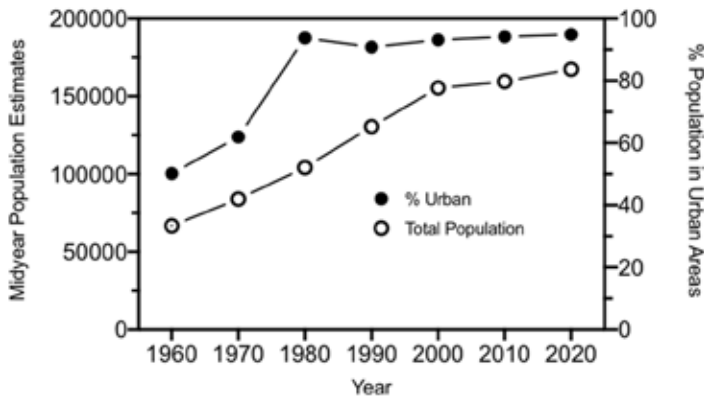


Figure 20. Important factors in the future management of Guam’s forests are the steadily rising rates of population growth and urbanization.

Invasive species are a serious and continuing threat to Guam’s forests. This includes invasive plants, insects, and diseases. Three invasive trees dominate the rural landscape: *vitex*, *tangantangan* (Figure 9) and *palma brava* (Lazaro et al., 2020). *Kadena de amor* (Figure 8) is a wide-spread, invasive vine capable of smothering trees.

The coconut rhinoceros beetle (*Oryctes rhinoceros*) (Figure 21) was first detected on Guam in Tumon in 2007 (Moore, 2018). Its distribution is now island wide. All coconut palms are at risk (Figure 22). The best hope for the future is to identify a biocontrol agent – a disease that is specific to the beetle.



Figure 21. The single greatest threat to island forests is the introduction of invasive species, such as coconut rhinoceros beetle.



Figure 22. Coconut rhinoceros beetle is an invasive insect that threatens coconut palms. At present, there are no reliable control methods for it.

Little fire ant (*Wasmannia auropunctata*) was detected in 2011 (Raymundo and Miller, 2012). It has quickly spread by humans transporting green waste and is now an island-wide pest. It upsets island ecology and the sting is very painful for humans. Current research on control methods centers on killing reproductive queenants.

Asian cycad scale (*Aulacaspis yasumatui*) was detected in 2003 (Marler and Cruz, 2019). It infests the *fadang* (Figure 3) and has reduced its numbers to the point when this endemic tree is now considered a threatened species (IUCN, 2020). There are no control methods at present.

Ironwood decline (Figure 23) is a bacterial wilt disease that attacks *gagu* (Schlub, 2018). The decline was first noted in 2002. At present different genetic strains of *gagu* are being evaluated for resistance to the disease.



Figure 23. Ironwood decline is an invasive disease that attacks *gagu* or ironwood (*Casuarina equisetifolia*), trees. The tree on the left suffers from ironwood decline. The tree on the right is a healthy ironwood tree.

Forestry Programs

The Forestry & Soil Resources Division (Figure 2) in the Department of Agriculture is located on Dairy Road in Mangilao. The division is comprised of four programs:

- Urban and Community Forestry (UCF) conducts tree plantings in schools, parks, and government agencies: and hosts Arbor Day planting activities (Figures 10 & 11).
- Cooperative Forest Health Management (CFH) is a program that protects and improves native forests that have been damaged by typhoons, droughts, and invasive species (Figure 4).
- Forest Stewardship Program (FSP) provides technical assistance and seedlings to private landowners for establishing and managing forests. It can include windbreaks and erosion control projects (Figure 25).
- Cooperative Fire Protection Program (CFP) is responsible for the prevention and control of wildfires (Figures 15, 16, and 17) on

Government of Guam and private lands. Other activities include outreach efforts to schools, landowners, and the general public.



Figure 24. Ruddy Estoy of the Forest Stewardship Program prepares an endemic *ahgao* (*Premna obtusifolia*) for outplanting in southern Guam.

Looking to the Future

The island's past has been traced through its trees whether they are endemic, indigenous, or introduced. Now the future is considered and how forests can survive for the benefit of future generations. The challenges that confront the Division of Forestry are related to wildfires, water quality, invasive species, population growth, deforestation, and sustaining urban trees.

The division's strategies for addressing these challenges are to (1) prioritize tree planting (Figure 25), (2) protect existing forests, (3) improve fire prevention and control, (4) continue urban tree planting, and (5) cooperate with other agencies in controlling invasive species.



Figure 25. The planting of endemic trees, such as these *fagot* (*Neisosperma oppositifolia*) at Asan Beach is a priority in the Forestry Division's strategy for the future.



Figure 26. The ultimate success of forestry programs on Guam requires the support and participation of citizens, such as these students (above & below) conducting a survey of forest trees in Piti.

The future success of forestry programs on Guam, especially those involving the planting and care of trees, requires the support and involvement of the public (Figure 26). This support, in turn, will ensure the availability of the benefits forests can provide, such as clean drinking water. Forests are instrumental in recharging the aquifer in the north and capturing stream and spring water in the south. Forests also provide recreational opportunities and protect our coral reefs from soil erosion and sedimentation. Probably the best reason for Guamanians to be involved in conserving their forests is to preserve the cultural, economic, and ecological benefits for future generations of islanders.



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