

**The 2021-2030 Republic of Palau
Statewide Assessment of Forest Resources and Resource Strategy (SWARS)
(Palau Forest Action Plan)**

Situation Analysis

*A comprehensive analysis of forest-related conditions, trends, threats, opportunities, priority areas
and strategies with descriptions of the resources necessary*



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Republic of Palau
Ministry of Agriculture, Fisheries and Environment
Bureau of Environment, Division of Forest, Land & Water Management
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Cover Caption

Ngerikiil Watershed, Airai State tree planting after fire. Photo credit: Lynna Thomas (Upper Left), *Ongedechuul* System of Conservation Areas tree planting, Ngardmau State Photo credit: Ebiil Society (Upper Right); Melekeok breadfruit tree planting. Photo credit: Palau Red Cross Society (Lower Left); Kayangel, post Super Typhoon Haiyan November 2013. Photo credit: Ann Kitalong (Lower Right)



Ongedechuul System of Conservation Areas tree planting, Ngardmau State
Photo credit: Ebiil Society

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ACRONYMS

| | |
|----------|--|
| ASCA | Aimeliik System of Conservation Areas |
| AYA | Aimeliik Youth Association |
| BDPA | Beijing Declaration and Platform for Action |
| BOE | Bureau of Environment |
| BoA | Bureau of Agriculture |
| BoASP | Bureau of Agriculture Strategic Plan |
| BMS | Belau Modekngai School |
| BNM | Belau National Museum |
| BWA | Babeldaob Watershed Alliance |
| CE | Conservation Education (Combination of multiple USFS funding programs) |
| CFP/CFOS | Community Forest & Open Space Program (USFS funding) |
| CRB | Coconut Rhinoceros Beetle |
| CTFS | Center for Tropical Forest Science |
| CWPP | Community Wildfire Protection Plan |
| DFLW | Division of Forest, Land, & Water Management |
| DFR | Division of Fire and Rescue |
| DFW | |
| MTS& | |
| FWP | Division of Maritime Security and Fish and Wildlife Protection |
| DPS | Division of Public Safety |
| EEZ | Economic Exclusive Zone |
| ENSO | El Niño Southern Oscillation |
| EQPB | Environmental Quality Protection Board |
| F&WS | US Dept. Interior Fish & Wildlife Service |
| FAM | Fire & Aviation Management (USFS funding) |
| FAP | Forest Action Plan |
| FH | Forest Health programs (USFS funding) |
| FIA | Forest Inventory & Analysis (USFS research) |
| FLP | Forest Legacy Program (USFS funding) |
| FAC | Forest Advisory Council |
| FSC | Forest Stewardship Council (“State” Forest Stewardship Council) |
| FSP | Forest Stewardship Program (USFS funding) |
| GEF | Global Environment Facility |
| IBA | Important Bird Area |
| IPIF | USFS Institute of Pacific Islands Forestry |
| IUCN | International Union for Conservation of Nature |
| LSR | Landscape Scale Restoration (competitive USFS funding) |
| MAFE | Ministry of Agriculture Fisheries and Environment |
| MCN | Melekeok Conservation Network |
| MCT | Micronesian Challenge Trust |
| MNRET | Ministry of Natural Resources, Environment, and Tourism |
| MOE | Ministry of Education |

| | |
|---------|--|
| MOJ | Ministry of Justice |
| MOS | Ministry of State |
| MOU | Memorandum of Understanding |
| NASF | National Association of State Foresters |
| NBAKA | Ngarchelong Bngal A Klikm Association |
| NBSAP | National Biodiversity Strategy and Action Plan |
| NISSAP | National Invasive Species Strategic Action Plan |
| NMDP | National Master Development Plan |
| NEMO | National Emergency Management Office |
| NEC | National Emergency Committee |
| NEPC | National Environment Protection Council |
| NRCS | USDA Natural Resource and Conservation Service |
| NNR | Ngardok Nature Reserve |
| NSWRP | Ngiwal State Watershed Restoration Plan |
| OERC | Office of Environmental Response and Coordination |
| OSCA | Ongedechuul System of Conservation Areas |
| PALARIS | Palau Automated Land and Resources Information Systems |
| PAN | Protected Areas Network |
| PCAA | Palau Community Action Agency |
| PCC | Palau Community College |
| PCCP | Palau Climate Change Policy |
| PCS | Palau Conservation Society |
| PEP | People Empowerment Project |
| PFLA | Palau Forest Land Assessment |
| PIPPNET | Pacific Island Permanent Plot Network |
| PNRC | Palau Natural Resource Council |
| PRCS | Palau Red Cross Society |
| PWRA | Palau Wildfire Risk Assessment |
| ROP | Republic of Palau |
| S& PF | State and Private Forestry |
| SFM | Sustainable Forest Management |
| SFMP | Sustainable Forest Management Policy |
| SGP | Small Grants Program GEF |
| SOE | State of the Environment |
| SPC | Secretariat of Pacific Communities |
| SWARS | Statewide Assessment of Forest Resources and Resource Strategy |
| TEI | The Environment, Inc. |
| TNC | The Nature Conservancy |
| UCFC | Urban and Community Forestry Council |
| USDA | United States Department of Agriculture |
| WAP | Wildfire Action Plan |

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“State”-Wide Forest Resource Strategy

Forest Action Plan 2021-2030: "State"-wide (Palau) Forest Resource Strategy

National Sustainable Forestry Management Vision:

A Palau enriched by healthy forests that sustain our culture and livelihoods, expand our economy, and strengthen the resilience of our island ecosystems, and communities

Three "National" Priorities (Themes): 1. Conserve Local Forest Landscapes 2. Protect Forests From Harm 3. Enhance Public Benefits from Trees and Forests

FOCAL AREA 1. Conserve Local Forest Landscapes.

Objective 1. Increased participation in sustainable forest management by communities

| Outcome | Policy Directive | Indicators (Performance measures) | Actions | Priority | Starting Date | Fund Source (USFS & other programs that contribute) | Lead Agency /Organization | Partners | Issue |
|---|---|---|--|-----------------|----------------------|--|----------------------------------|------------------------------|--------------|
| State Governments and local communities know and appreciate the value of their forest ecosystems and have sustainable management measures in place to ensure their continued health | Forest ecosystems provide social, economic, and ecological benefits to Palau and therefore, high conservation value forests must be identified and prioritized for sustainable management measures. | Sustainable Forest Database System & usage of USFS "Stewardship Mapping and Reporting Tool" (SMART) | A Sustainable Forest Database system will be established, and staff trained to track landowners assisted, number of species propagated and planted, and survival rates, number, and size of demonstration agroforest plots, acres of important forest resources areas and acres of sustainably managed forest resource areas on public and private lands, develop and implement FSP and UCF Plans. Use & supplement existing SMART system. | Highest | 2021 | MAFE/USFS-FSP | MAFE | MAFE/PAN/PALARIS/State/NGOs | All |
| | | Areal extent of forests as PAN sites (post 2015) | Spatial analysis of PAN sites | High | 2021 | MAFE/USFS-FSP | PALARS | | 5 |
| | | State Regulations or legislation designating sustainable management measures for forests | Develop Model Law and regulations for States to Adopt | High | 2022 | MAFE/WFLC advice | MAFE | MAFE/Attorney General Office | 6 |
| | | Social Marketing Campaign for Palau's Forests | Design /implement social marketing campaign around forests to improve attitudes/behavior and valuing forests (including mangroves) | High | 2022 | MAFE/USFS-CE | NGO | MAFE/PAN/USFS/PCS | All |

| | | | | | | | | | |
|--|--|---|---|--------|------|--|------|-------------------------------|-----|
| | | Project to increase community participation in SFM activities | Design Project and Conduct Stakeholder Analysis | High | 2022 | MAFE/ USFS-UCF | MAFE | MAFE/ USFS | All |
| | | State of Palau's Forests Report | Develop reporting format aligned with State of Environment Report | Medium | 2022 | MAFE/ USFS | MAFE | MAFE/ USFS | All |
| | | Scholarship, internships in field of sustainable forestry established | Develop scholarships, internships for sustainable forestry educational programs | High | 2022 | MAFE/ Palau Scholarship USFS-CE | MAFE | State/NGOs /community | All |
| | | Educational Materials | Research available materials | Medium | 2025 | MAFE/ USFS-CE | MAFE | NGOs/PCC/ State | All |
| | | Collaborations established, education materials and curriculum module for forests developed and integrated in school programs | Collaborate with NGO's PCC and MOE to develop and disseminate educational materials and a curriculum module for forests | Medium | 2025 | MAFE/ USFS-CE | MAFE | NGOs/PCC/ State | All |
| | | Annual Forest Forum | Forest Stewardship and Urban and Community Forest Councils and partners host an Annual Forest Forum for members and project leaders | High | 2022 | MAFE/ USFS-FSP- UCF | MAFE | State/ NGOs / community | All |
| | | Nekken Station Land Use Plan updated and implemented | The Nekken Station Land Use Plan will be updated and implemented including demonstration plots for sustainable agroforestry using best management practices | High | 2022 | MAFE/ USFS-FSP | MAFE | State/ NGOs/ community | 6,7 |
| | | Programmatic Agreement | Establish a programmatic agreement with the military for large military projects on forest habitats. | High | 2022 | ROP/USA | MAFE | ROP/USA | 2,5 |

Objective 2. Improved Conservation status of forest related biodiversity

| Outcome | Policy Directive | Indicators | Actions | Priority | Starting Year | Fund Source (USFS & other programs that contribute) | Lead Agency/ Organization | Partners | Issue |
|--|--|---|--|----------|---------------|---|---------------------------|---|-------|
| Under represented forest ecosystems and other High Conservation Value (HCV) forests* are identified and protected in the PAN sites and terrestrial conservation areas outside of PAN or have management measures in place to protect their conservation value <i>*High Conservation Value forests (HCVs) are natural habitats, which are of outstanding significance or critical importance</i> | Palau's unique forests are part of our natural heritage, and every effort must be made to ensure that this collective legacy is able to thrive today and into the long term. | Progress towards Sustainable Forest management (SDG Indicator 15.2.1) | Conduct spatial analysis to inventory and assess underrepresented forest ecosystems and other HCV forests (PAN sites, habitats of endangered species). | High | 2021 | MAFE/ USFS-FSP or IPIF | MAFE PALARIS | State, BNM, NGOs, community | 5 |
| | | Areal extent of under-represented forests or other HCV identified, surveyed, and mapped | Assist States to Identify HCV Forests (including cultural sites, endangered species, and their habitat) | High | 2024 | MAFE/ USFS-FSP or IPIF | MAFE PALARIS | State, BNM, NGOs, community, historians, Private sector | 5 |
| | | Areal extent of priority areas for reforestation efforts surveyed and mapped | Collaborate with state governments to identify priority areas for reforestation efforts (produce maps) | Medium | 2025 | MAFE/ USFS-F or IPIF | MAFE PALARIS | State, BNM, NGOs, community | All |
| | | Student and Community volunteer program established | Cooperate with NGOs on a student and community volunteer program | High | 2025 | MAFE/ USFS-UCF /PAN/State | MAFE | State NGOs community | All |
| | | State Regulations or legislation mandating sustainable forest management (SFM) measures for forests | State Regulations and legislation developed, adopted, and enforced to protect forests and restore degraded forests | High | 2025 | MAFE/ WFLC/ PAN/ State | State | MOJ, NGOs community | All |
| | | Forest health indicators (extent and change, diversity, endangered species, degraded land, tree damage, invasive species, fire) show improving trend of HCV forests (reflected in the Palau's State of Environment (SOE) report | Conduct comprehensive State inventories of HCV forests including habitats for endangered species | High | 2022 | MAFE/ USFS-FSP& FH/PAN/ State | PALARIS | Palau Forestry Service, PAN, State, USFS | 5 |

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|--|---|--|---|---------|------|----------------------------------|---------------|--|-------|
| <i>due to their high biological, ecological, social or cultural values.</i> | | Rapid Forest Assessments for HCV forests post typhoons, post severe droughts, and other natural or human induced impacts | Design and implement Rapid Forest Assessment for HCV forests post typhoons, post severe droughts, and other natural or human induced impacts and recovery plan (reforestation, green waste recycling) | High | 2022 | MAFE/ USFS-FSP& FH/MOF | MAFE | Palau Forestry Service, PAN, State, USFS | 1,2,5 |
| Forest Protected Area Sites that are PAN members and partners demonstrate improved biodiversity conservation and ecosystem health scores | Sustainable Forest Management (SFM) requires an understanding of the condition and trends of forest resources. Palau must invest in the collection, analysis and appropriate dissemination of findings of forest information to forest owners, managers, and users to strengthen SFM in the PAN | PAN Forest and Terrestrial Conservation Sites outside of Pan are Assessed and Reports Completed | Conduct assessments of all Terrestrial PAN sites and other Terrestrial Conservation Sites Assessments of HCV and underrepresented forest habitats (e.g. swamp forests) | Highest | 2021 | PAN/USFS FSP&FH | PAN/ STATE | Palau Forestry, BNM | 5 |
| | | Report on Updated vegetation maps and hydrological models | PALARIS and other partners update vegetation maps and hydrological models from 2015 | High | 2022 | MAFE/ USFS-IPIF | PALARIS | Palau Forestry Service, PPUC, USFS | All |
| | | Standardized Forest Survey methodology for PAN sites implemented and data analyzed | Standardized PAN Forest Survey methodology developed and implemented by PAN sites | High | 2022 | MAFE/ USFS- FSP&FH& FIA | MAFE | State, BNM, | 5 |
| | | Forest Health Indices for PAN sites and Terrestrial Conservation Sites outside of PAN sites | Forest Health indices are developed and used by PAN | Medium | 2022 | MAFE/ USFS-FH | MAFE | | 5,4 |
| Resource managers use information derived from monitoring | Forest Ecosystems including the biodiversity that depend on them provide a | The national legislature provides funding support to the National Bird Program which monitors forest health using birds as an indicator species. | Continue and enhance forest monitoring program to get forest health indicator (birds) baseline for each state | High | 2021 | MAFE/ USF&WS /PAN/ State | BNM/ MAFE | State, BNM, NGOs, community | 5 |

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|---|---|---|--|---------|------|---|------------------------------|--------------------------------------|-------------|
| programs and other research activities to guide their conservation and Natural Resource Management (NRM) implementation efforts. | number of services upon which our communities depend. Palau must invest in developing and implementing mechanisms (forest inventories, comprehensive mapping of invasive species) that facilitate their conservation and management. | Number of management actions documented in annual work plans informed by monitoring data | Integrate biodiversity conservation and ecosystem health indicators such as birds and water | High | 2021 | MAFE/ F&WS, USGS/ PAN / State | MAFE | State, NGOs, community | 3,5 |
| Agencies and organizations mandated to manage forests utilize best practices that include standard operating procedures, agreed upon forest monitoring protocols in the implementation of SFM | Effective SFM requires strong competent institutions to support the development and implementation of natural resource management and biodiversity conservation measures. Palau must invest in forestry institution building in state governments and the Forestry Division of MAFE | Development of forestry monitoring protocols (e.g. The Montreal Process Criteria and Indicators of SFM (MPC&I) or its modified version) | Develop State of Palau's Forest Report | Highest | 2021 | MAFE/ USFS | MAFE | MAFE/ USFS/ NGOs/ community | All |
| | | Forestry monitoring protocols integrated into standard operations at PAN and the Forestry Unit of MAFE | Gather and develop useful forest related information to disseminate to states and other resources users | Medium | 2023 | MAFE/ USFS- CE/PAN/ State | PAN/ STATE | NGOs/ community | All |
| | | Palau SFM Plan & Best Practices are developed and implemented | Develop and implement Palau SFM Plan and Best Practices | High | 2021 | MAFE/ USFS-FSP | MAFE | NGOs / community | 1,2, 6,7 |
| | | Forest Resource Management (FRM) competency requirements integrated into human resource development processes at PAN and MAFE | FRM Requirements established and integrated | High | 2022 | MAFE /USFS- FSP/ PCC-CRE | | State/NGOs/ community | All |
| | | Comprehensive State Forest Management Plans for 16 states | Work with the States and partners to develop Comprehensive State Forest Management Plans addressing watershed protection, conservation, rehabilitation, and sustainable use of forests | High | 2021 | MAFE/ USFS- FSP&UCF | State/ NGOs/ community | All | |
| | | | State consultations and visits detailed planning in each state for overall forest management | | | | | | All |

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| | | | Request Governors to designate a lead person from each state to work with MAFE team | | | | | | All |
| | | | MAFE- Forest Stewardship Council Support PAN Technical Committee and PAN coordinator to designate forests protected areas to be included in PAN | | | | | | 5 |

FOCAL AREA 2. Protect Forests from Harm

Objective 1. Strengthened sustainable forest management across local and national governance levels

| Outcome | Policy Directive | Indicators | Actions | Priority | Time | Fund Source (USFS & other programs that contribute) | Lead Agency/ Organization | Partners | Issue |
|---|---|---|--|----------|------|---|---------------------------|--|-------|
| Technicians, managers, and local communities engaged in forest resource management have the competency (can demonstrate the skills and use the tools needed) to implement their agency or site management plans. Data management system | The Sustainability of Palau's Forest Resources (PFR) is directly correlated to our ability to manage these resources. Palau most invest in building and sustaining a local workforce skilled in all areas of SFM from technicians to managers to scientists | Memorandum of Agreement (MOA) or Memorandum of Understanding (MoU) or Letter of Commitment between Palau Forest Services, State, Community, Private Sector, NGOs, and Landowners are established that includes a program plan | Establish either a Memorandum of Agreement (MOA), or Memorandum of Understanding (MoU) or a Letter of Commitment between Palau Forest services, State, Community, Private Sector, NGOs, and Landowners on Roles and responsibilities and level of commitment | Highest | 2021 | MAFE/ States/ USFS | MAFE | MAFE/States community-cheldebechel, landowners, private sector | All |
| | | An Integrated Reporting Permit & Assessment System between EQPB, DFR & BPS as part of the National Sustainable Forest Data Management System; | Develop a protocol for data collection, analysis and management of permits, monitoring, and mapping fires in Palau. | Highest | | MAFE/ MOJ-BPS- DFR/ USFS- FAM | | EQPB, BPS, STATE, PAN, Communities NGOs | 4 |
| | | Dedicated budget from National Congress with regular funding source | MAFE justify and secure Congressional funds | Highest | | Palau Congress | | State, NGO's | All |
| | | Number of Forest Resource Management (FRM) training modules and trainees | Develop, test, and implement training modules that include guidelines for SFM, SFM data management and | High | | PAN USFS-all MAFE | | State, NGO's PCC-CRE, community-cheldebechel | All |

| | | | | | | | | |
|-------------|---|--|--------|------|---------------------|------|----------------------------|--------|
| established | Number of FRM personnel trained in an aspect of FRM: species identification, monitoring, geospatial and data analysis, report writing | analysis and reporting, species identification, monitoring, geospatial and data analysis, report writing, field demonstrations, best practices, erosion, and sediment control, BMPs for littoral and mangrove forests. | | | | | | All |
| | Number of local communities (cheldebechel) involved | | | | | | | All |
| | Number of programs and successful completions of participates | Create professional development programs to increase terrestrial resource management expertise and competencies in Palau. | High | | MAFE /USFS-all | | | All |
| | Active Wildfire Network with Community Wildfire Protection Plans | Establish and support a core group to engage in Wildfire Network and identify communities for CWPP development | | | PAN/ USFS-FAM/ MAFE | | | 4 |
| | Study on human impact to mangrove forests | Conduct socio economic and Environmental impact study of mangrove forests | | 2022 | MAFE/ USFS-FSP&IPIF | | MAFE/ States/ community | 2 |
| | Study of forest health and seawater intrusion | Conduct socio economic and environmental impact study of seawater intrusion and forests | Medium | 2022 | MAFE/ USFS-FH | | | 1,2 |
| | Area of clearance for fire prevention 10 -15 ft wide | Implement fire prevention clearance strips | High | 2021 | National, MOJ, PPUC | | State, NGOs | 4 |
| | Fire breaks at priority sites (areas of repeated fires) in Babeldaob | Establish fire breaks and green belts in priority areas in Babeldaob | | | MAFE/ USFS-FAM | | DFR/State/ NGOs/ community | 4,7 |
| | Educational material | Develop, print, and disseminate Educational material on invasive species and fire prevention, climate change, the value of mangrove forests and existing forest-related regulations. | | | MAFE/ USFS-CE | | MAFE/PCC-CRE, MOE, NGOs | 1,4, 5 |
| | Fire Suppression Plot | Set up a fire suppression demonstration plot for fire breaks and green belts | High | 2021 | MAFE/ USFS-FAM | MAFE | DFR/State/ NGOs/ community | 4 |

| | | | | | | | | | |
|---|---|--|---|---------|------------------|--|--|--|---------|
| | | Forest health indicators (degraded land, tree damage, invasive species-CRB, fire) show improving trend of HCV forests (reflected in the Palau's State of Environment (SOE) Report | Conduct comprehensive State inventories using forest health indicators of HCV forests including habitats for endangered species | | 2022 | MAFE/ USFS- FSP&FH /PAN/ State | | Palau Forestry Service, PAN, State, USFS | 4,5,6 |
| States, Forestry Unit, NGOs, and other Sectors (Public and Private) consistently collaborate on activities that ensure forest ecosystem health with resulting social/economic benefits | Healthy Forest Ecosystems provide services that benefit society. Addressing threats (such as invasive species) to the health of forests requires a coordinated and collaborative response. Palau must develop mechanism such as biosecurity task force to facilitate implementation of collaborative forest solutions. | Existence and # of mechanisms such as Forest Stewardship Council, Bio-security task force, an open forum, and others to facilitate collaborative engagements in support of forests | Develop a program to enhance collaboration and institutional strengthening for SFM Partners through a bio-security task force focused on forest health | | 2021 | MAFE/ PCC-CRE/ USFS- FH&FAM /PAN/ State | | State, NGO community | 4,5,6,7 |
| | | # of forest projects implemented by partnerships or coalitions | Forest Advisory Council with Partners, such as GEF Small Grants Program, support sustainable forest projects | | | | | | All |
| | | area extent of invasive species showing a decreasing trend | Invasive species identified, removed And area measured and mapped with focus on top 20 worst species (e.g. Macaque monkey, CRB, <i>Mikania</i> , Cycad scale, fruit flies etc. as determined by NISC) | Highest | MAFE/ PCC-CRE | 4,5,6,7 | | | |
| | | | Identify and test virulence of OrNV of CRB in Palau | | PCC-CRE | 4,5,6,7 | | | |
| | | areal extent of forest and savanna fires show decreasing trend | Burnt areas measured and mapped | High | MAFE | 4 | | | |
| | | number and area of fire breaks and green belts established | Plant fire breaks and green belts along fire prone areas | | | 4,7 | | | |

| | | An official terrestrial information management system is developed | Terrestrial information management system developed and utilized | | | | | | All |
|---|--|--|---|--|------|---|--|--|-------|
| FOCAL AREA 3. Enhance Public Benefits from Trees and Forests | | | | | | | | | |
| Objective 1. Increase climate change adaptation benefits from forests | | | | | | | | | |
| Outcome | Policy Directive | Indicators | Actions | Priority | Time | Fund Source (USFS & other programs that contribute) | Lead Agency Organization | Partners | Issue |
| Communities experience minimum impact and less instances of flooding events during periods of persistent rain and other natural and manmade events impacting the forest | Degraded lands exacerbate the negative impacts of climate change. Reforesting bare slopes, eroded stream banks and coastal zones strengthen the water regulating services that healthy forests provide | % Increase in forest cover: area number of native trees propagated, planted and survival rates | Propagate, collect and plant at least 20,000 saplings/year for rehabilitation programs with emphasis on native and fruit bearing trees; map and monitor sites | Highest | 2021 | MAFE/USFS-FSP-FH | MAFE/PALARIS | State, NGOs landowners community | All |
| | | % reduction in area of degraded land | | All | | | | | |
| | | map of rehabilitated areas | | All | | | | | |
| | | number of urban agroforest garden plans | Develop and implement urban agroforest plans | Highest | 2023 | MAFE/USFS-UCF | MAFE | State, Palau Housing Authority, NGOs, PCC-CRE, PCAA, communities | 7 |
| number of urban agroforest gardens | Develop maps and monitor urban agroforest gardens | Medium | MAFE/USFS-UCF- FH | State, Palau Housing Authority, NGOs, PCAA, PCC-CRE, communities | | 7 | | | |
| Palau reduced or mitigated its development footprint | Implement a "No Net Loss" Policy for development that impacts forests. Forest ecosystem services that would otherwise have been | amount of carbon stock stored in forests (including mangroves) | Develop and implement training module for estimated carbon stocks/ carbon trading and ecosystem services of forests (e.g. i-tree) | Highest | 2021 | MAFE/USFS-all | PCC-CRE, State, PAN, NGOs, Ministry of Finance community, landowners, private sector | 1,5, 6 | |
| | | Potential ecosystem services value for forests | PES Value for impacted forests is estimated | High | | MAFE/USFS | | 1, 2, 5 | |

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| | lost are replicated elsewhere. Such that, development results in the removal of a tract of forest, the developer must replant the same amount or greater of forest in another area to maintain carbon mitigation capacity | Greenhouses and Greenhouse Network established | Establish a greenhouse network between states and partners to collaborate on increased inventory of native trees and plants, expand greenhouses, establish greenhouses where needed | High | | MAFE/ USFS-FSP | | State, Communities landowners, private sector, NGOs | All |
| | | number and area covered of forest trees lost | Native trees propagated, planted, and survival rates quantified | High | | MAFE/ USFS-FSP | | | All |
| | | number & area covered of forest trees replaced for no net loss | | | | | | | All |

Objective 2. Increase the contribution of forest to the economy and household livelihoods

| Outcome | Policy Directive | Indicators | Actions | Priority | Time | Fund Source (USFS & other programs that contribute) | Lead Agency /Organization | Partners | Issue |
|---|---|--|---|----------|------|---|---------------------------|----------------------------------|-------|
| Small scale forest plantations are consistently providing wood for building materials, arts, and crafts, for Palau's growing home construction and tourism market | Sustainably using local wood resources to reduce market dependence on imported building materials strengthens our economy. Fostering the development of agroforestry operations (agriculture varieties and tree species) and small scale forest plantations build | number and area extend of small scale forest plantations | Conduct annual inventory/profile of small scale forest plantations (including fruit trees) | Medium | 2022 | MAFE/ STATE / USFS-FSP | MAFE | State/USFS /PCC-CRE | 6 |
| | | number of enterprises selling local wood products | Conduct annual inventory/profile of enterprises selling local wood products | | | MAFE/ State | | State/ Private Business Owners | |
| | | number of enterprises other than local wood products | Conduct annual inventory/profile of enterprises selling products other than local wood products | | | MAFE | | State/ landowners/ PCC-CRE | |
| | | % increase of small scale plantations and local wood businesses as part of GDP | Provide incentives and opportunities for forest related businesses. | | | MAFE | | | |
| | | #of economically valuable species providing economic benefits | Review literature and interview local experts to determine number of species of economic and cultural value | High | 2021 | MAFE/ PAN/ USFS- IPIF- FSP | State Historians, BNM | 6 | |

| | | | | | | | | | | | | |
|---|---|---|---|---------|------|---------------------------|--------------|--|-------------------------------|------|---------------------|-----|
| | resiliency into these livelihood options. | | | | | | | | | | | |
| Visitors and residents to Palau participate in tourism activities in forests of Palau including terrestrial PAN sites | Diversifying Palau's tourism to include forest based recreational activities grow Palau's tourism portfolio and increases tourism revenue streams. The Bureau of Tourism (BOT) must actively facilitate partnerships between the tourism sector, and state and PAN and forestry sector in support of forest tourism product development | Trained Forestry Staff | Forestry staff trained to develop, implement, and report on FS and UCF projects with landowners and community | Highest | 2022 | MAFE/ USFS-FSP- UCF | MAFE/ PAN | Palau Forestry, State, community, landowners, private sector | 6,7 | | | |
| | | Number of PAN sites and other sites with viable forest related tourism products (bird watching tours, reforestation activities | Develop ecotours and reforestation activities | Highest | | PAN/ USFS-FSP | | | 5, 6,7 | | | |
| | | number of recreational public areas landscaped with native trees and plants | Public areas (State and National Parks) are landscaped with native trees and plants | Highest | | MAFE/ USFS-UCF | | | 7 | | | |
| | | Increase in production economically valuable trees for timber, food, and medicine | Effective management & marketing training for landowners of economically valuable trees for timber, food, and medicine | High | | MAFE/ USFS-FSP | | | 6 | | | |
| | | Economically valuable trees are mapped nationwide and landowners identified for potential technical or financial support | Conduct nationwide spatial analysis of <i>Casuarina</i> , coconut, mahogany, and other important trees and land ownership other using Aerials & IKONOS, LIDAR & SAR, and ground truth information | | | MAFE/ USFS | | | 2,6,7 | | | |
| | | number of forest recreational tourism products available for visitors and residents (food tasting, bird watching, botanical gardens, historical/cultural) | Interview State officials and entrepreneurs to determine forest products available. | Medium | | PAN | | | State, BNM, community leaders | 6 | | |
| | | amount of revenue generated from these activities | Interview State officials & entrepreneurs to determine revenues generated | | | 2025 | | | MAFE | MAFE | State/ community | 6 |
| | | Ecotour trail at Nekken Station | Design, develop, implement an Demonstration ecotour at Nekken State | | | | | | MAFE/ GEF5/ | | USFS | 6,7 |

| | | | | | | | | | |
|--|--|--|---|------|------|---------------|--|---------------------------|-----|
| | | promotional material for two non-timber products | Collaborate with NGOs/partners to develop/ disseminate promotional materials for at least 2 non-timber products (cultural or medicinal use) | | | MAFE/USFS- CE | | BNM, PCC-CRE, NGOs | 6,7 |
| | | List of projects developed | Create a list of projects that can be done related to sustainable forestry | | | MAFE/USFS | | State/ community | All |
| | | Educational materials | Educational and awareness materials are developed (posters, radio shows, videos | High | 2022 | MAFE/USFS-CE | | PAN/State/ PVA/ community | All |

Objective 3. Improve the quality of fresh water supply via forests

| Outcome | Policy Directive | Indicators | Actions | Priority | Time | Fund Source (USFS& other programs that contribute) | Lead Agency/ Organization | Partners | Issue |
|--|--|---|--|----------|------|--|---------------------------|--------------------------------------|-------|
| Drinking water source watersheds are formally protected through special management or other land use designation and are under active management | Health forests are a part of Palau's water supply infrastructure. State and national governments must take action to maintain or rehabilitate drinking water source watersheds to ensure water access for all. | Decreasing levels of turbidity & bacteria, and areas of obstructed water flow by fallen trees, or overgrowth of herbaceous plants | Design and implement a monitoring program in upper watersheds that are drinking water source (Ngerikiil Watershed is a top priority) | Highest | 2021 | National Congress | MAFE/ EQPB | PPUC/State/ Belau Watershed Alliance | 3 |
| | | Areal extent of rehabilitated bare soil/slopes in drinking water source catchments | Propagate, plant, and monitor survival rates of rehabilitated bare soils | Highest | | National Congress | MAFE/ State | EQPB/PPUC Belau Watershed Alliance | All |
| | | Educational materials | Develop, produce, and disseminate educational materials on fresh water sources and their importance linked with potential ecosystem services of forests. | Highest | | MAFE/ EQPB/ PPUC | MAFE/ EQPB | PPUC/State /NGOs/ Communities | All |
| | | Number of community activities & areas that reduced obstruction of waterflow from natural or man-made causes | Communities identify and remove obstructions to waterflow. | Highest | | State | State | Communities PPUC/State | All |
| | | State Land Use Plan integrated with Fresh Water supplies | Develop and/or implement State Land Use Plans | High | 2022 | National Congress | State/ MAFE | State/ Belau Watershed Alliance | All |

| | | | | | | | | | |
|--|--|---|---|--------|------|--------------------------------|---------------|---|------------|
| | | Comprehensive State Forest Management Plans integrated with Freshwater supplies | Integrate water supply into State Forest Management Plan | | | MAFE/ USFS-FSP | State | State/PPUC/ EQPB/ communities | 1,2, 3, |
| | | Increase in storage capacity and distribution of drinking water | Assess and conduct a feasibility study of watersheds to identify, design and construct water storage and distribution lines | Medium | 2025 | National Congress /PPUC/CIP | | PPUC/State/ | 1,2 |
| | | Number of point sources of pollution identified and eliminated | State and EQPB identify and eliminate or mitigate point sources of pollution | | | State | MAFE/ EQPB | PPUC/State/ NGOs/ Communities | 2 |
| | | Zones surveyed and mapped, areal extent, areal extent of removed invasives | Establish Zone 1 and Zone 2 buffer zones and remove invasive species from these zones | High | 2022 | State/ MAFE | MAFE | State/ Communities NGOs | 2,4, 5, |
| | | Location, number, and aerial extent and plant composition of fire breaks | Install fire breaks at areas of repeated fires | | | State/ MAFE/ BPS | | | 4 |
| | | Assessment of Need Completed | Conduct an "Assessment of Need" for Forest Legacy Program and other funding for easements from private landowners for permanent buffer areas of high priority upper watershed areas | Medium | 2026 | MAFE/ STATE /USFS-FLP | | MAFE/ STATE /EQPB/ PPUC /USFS /NGOs /Landowners | 3,5 |
| | | Location, number, and aerial extent and plant composition of reforested areas | Reforest areas of Point & non-point sources of pollution identified in Ngerikiil Watershed | | 2025 | | | State/ NGOs/ community | 3 |
| | | water quality results pre and post reforestation | Water monitoring of pre and post reforestation areas | | | MAFE/ EQPB | | | 3 |
| | | Watershed management plan | Develop one watershed management plan for a terrestrial PAN site each year | | | PAN/ USFS-FSP | MAFE/ PAN | | 3,5 |
| | | Education Materials on Watershed Value | Develop educational modules for curriculum, video, poster on value of watershed forests | High | 2021 | MAFE/ EQPB/ USFS-CE | MAFE | NGO's community | All |

Introduction

The Republic of Palau is a small yet diverse island nation similar in size to its neighboring islands in the region. The relatively small size and isolation of island nations linked by large bodies of water directly relates to the issues, challenges and opportunities island nations share. The rapidly increasing population is placing high demand and threats on Palau's forests, whether for wood products, wildlife habitat, clean water, or large farms. Infrastructure to support an increasing population is expanding into forests and savanna causing the loss of these resources and services they provide as watersheds and for traditional uses. Forests serve as carbon sinks that mitigate the impacts of climate change and need to be safeguarded by all nations.

Due to Palau's small population, many people in the environmental field collaborate on the same projects and initiatives. Therefore, members of the Urban and Community Forest Council also serve as members of the Forest Stewardship Coordinating Committee for the 2021 FAP along with additional technical experts and community leaders. These members, also commonly known as the Forest Advisory Council were the main technical contributor to this report. The council has members who work within the communities and brought their concerns and issues forward during meetings.

The impact of climate change related incidents (super typhoons etc.) coupled with population shifts (different rates of growth or loss in each state of Palau) with a trend toward migration to urban areas pose increasing threats as a result of storms, flooding and landslides, droughts, fire, deforestation for timber, invasive flora, and fauna, and increasing reclamation for development and crop production. Managers are increasingly challenged to address these threats in an effective and efficient way that will ensure that available funds result in positive outcomes that mitigate impacts and that enable islands to adapt with a focus on their most vulnerable forests habitats.

This assessment analyzes Palau's current forest conditions and trends and delineates priority rural and urban forest landscapes from which the 2021 nation-wide strategy was developed. The focus of this assessment is based upon three "priorities" eligible for USDA Forest Service assistance: conserve working forests; protect forests from harm; and enhance the benefits from trees and forests. This geospatial based assessment used the best available data to describe forest conditions on all ownerships in the Republic and to identify forest related benefits, services, and threats to forest resources. This assessment highlights issues and trends of concern and opportunities for action and delineates high priority forest landscapes.

Spatial data gaps existed for the States of Angaur, Peleliu, Kayangel, Sonsorol and Hatohebei and parts of Koror. Spatial data gaps existed for sizes of tree plantations and sizes of forest habitats of endangered species. Many infrastructure projects have not yet been mapped. There are also contour data gaps for sea level rise issues for climate change which require contour of 0.5 meter along the coastlines of the Republic. These spatial gaps existed for the 2010 SWARS.

The 2021-2030 Republic of Palau Statewide Forest Action Plan was developed around the issues facing the Republic's forest and tree resources rather than based on the forest resources themselves. With input from the community at all levels, the Division of Forest, Land, and Water Management (DFLW) program managers identified seven primary issues of rural and urban forests in the Republic:

- 1) Climate Change
- 2) Population Growth and Urbanization
- 3) Water Quality and Quantity
- 4) Wildfire Prevention

- 5) Conservation and Protection
- 6) Sustainable Use of Forest Resources
- 7) Urban Forest Sustainability

For each issue, areas of priority were determined using existing geospatial data and the outcome of discussions during the two workshops and with members of the Forest Advisory Council. The following paragraphs summarize each of the seven issues:

Issue 1: Climate Change

In the past decade, the impacts of climate change have been affecting all forests of Palau. Two super typhoons (Super Typhoon Bopha in 2012 and Super Typhoon Haiyan in 2013), a typhoon (Typhoon Surigae in April 2021), and severe droughts, storm surge and sea level rise have impacted Palau's forests. Coastal forests are being lost due to shoreline erosion. Lowland forests along steep slope are being lost to massive landslides after extreme rains. Sea level rise is causing seawater intrusion in taro gardens. Heavy rains and winds are toppling large trees. These extreme weather conditions are leading to the spread of invasive species into areas where forests are opened up or taro patches or agroforest are abandoned due to crop loss caused by super typhoons, extreme droughts, and subsequent fires after extended periods without rain. Climate Change is a cross cutting issue that will be discussed in each issue. This section will focus on urgent problems related to climate change: drought, heavy rainfall, typhoons, landslides, sea level rise and coastal erosion. Rapid site-specific assessments of the impact of climate change on our forests after a major event like a typhoon, drought and heavy rainfall is needed.

Issue 2: Population Growth and Urbanization (Mitigating Effects on Natural Environment)

The Republic of Palau's communities are growing at different rates. The population of Palau is estimated 17,661 in 2015. A total of 12,538 were Palauans, 307 were dual citizens, 299 were US citizens, 295 were Chinese, 522 were Bangladeshi, 181 were Japanese, and 315 were from the Federated State of Micronesia (FSM) and 3,204 were others. In 2015, 2,337 people had legal residence in the Philippines. (Bureau of Planning and Statistics. 2016; 2015 Census of Population, Housing and Agriculture for the Republic of Palau). An estimated 78.7% of the population lived in urban areas and 21.3% lived in rural areas. The population density was 109 people per square mile in 2015. The largest population (66%) and density (202/km²) is in Koror State. Changes in population distribution between 2012 and 2015 shows increased populations in Hatothobei (150%), Ngiwal (24.8%), Aimeliik (18.9%), Ngeremlengui (13.3%), Ngerchelong (12.5%), and Ngatpang (9.7%). There was low population growth in Ngchesar (1.4%) and Koror (0.8%). The increase in Ngiwal and Aimeliik may be the result of new housing projects in these states. A decrease in population size was found in Kayangel (-28.9%), Ngaraard (-8.8%), Angaur (-8.5%), Melekeok (-7.4%), Ngardmau (-5.1%), Airai (-3.2%) and Peleliu (-1.0%). The decrease in Kayangel may be result of the impact of Super typhoon Haiyan in 2013. The decrease in Angaur and Ngaraard may be the result of Super typhoon Bopha. The local population growth rate between 2012 and 2015 dropped to 0.9%. The tourism industry dropped drastically since the spring of 2021 due to the COVID-19 pandemic.

Housing developments within critical watersheds have led to concern because of the potential impact to water quality. Community leaders need proactive management tools and technical support systems to help prepare for the impacts this growth will have on the forests. Geospatial analysis in 2010 revealed that areas of high priority for reforestation were the city of Koror, Koror State, the Ngerikiil Watershed in Airai State, the National Capitol in Melekeok, and Ngarchelong State. These locations continue to be priority areas for reforestation as well as new housing developments in the states of Aimeliik, Ngiwal, Ngeremlengui, and Melekeok State. Population growth and urbanization is a cross cutting issue related to all other issues.

Issue 3: Water Quality and Quantity

In the Republic of Palau, freshwater quality and quantity is overall good and plentiful; the challenge has been in storage and distribution, especially during periods of drought. The main source of drinking water for Palau's population is the Ngerikiil Watershed. In 2010, the estimated total demand for water in Koror was 1,460,000,000 gal/y including waste and inefficiencies (Kitalong 2012). From 2014 to 2017, PPUC reported sales ranging from 730,000 to 800,000 gal/y. This decrease may infer that the system is more efficient with less leakage and lower consumption. Each State in Babeldaob has a source of water. The outer states have ground water and wells. It is critical that these sources of water be protected and upstream of pumping stations be protected. Ensuring that the newly established buffer zone (2020 EQPB Marine and Freshwater Quality Regulations) for rivers is implemented through reforestation activities of bare areas upstream of drinking water intake areas and upper watersheds supports natural filtration and improved water quality within each watershed.

Issue 4: Wildfire and Public Safety

The Division of Public Safety (DPS) is tasked with the responsibility to prevent and suppress wildfires. At the peak of the spring 1998 drought during the ENSO Event, there were daily fires throughout Babeldaob. The main challenge during the 2016 drought was the lack of access roads and sources of accessible water to suppress these fires. This continues to be a challenge. During 2012 to 2019, the reasons for burning were hunters (33%), arson (31%), farming (22%), government activities (8%), clearing of vegetation (3%), brush piles (2%), and buildings (1%) (Dendy et al. 2019). Primary factors that relate to high incidences and intensity of fires are population growth, changing land use, and an increase in drought frequency. There is a need for more enforcement officers and trained firefighters, equipment, and community education and awareness. Vulnerable areas are those near infrastructure with limited access for fire trucks and lack of sufficient supply of water. These areas are either far from fire stations or fire hydrants and mainly in savanna areas. Often these areas have easy access via the national highway yet relatively far or remote from village centers.

Issue 5: Conservation and Protection

Forest protection and conservation is critical to preserve terrestrial biodiversity, and protect watersheds which are a source of timber, medicine, food, and a habitat for wildlife. The forests are threatened by population growth, land fragmentation, fire, and invasive species. Geospatial analysis revealed that areas of high priority were the upper watershed areas, and main water sources in Palau (Refer to Issue 3). Palau has about 146 endemic plant species confined to an area of 453km². About 15% of these are only known from type collections. In 2009, 61% of these endemics were considered Data Deficient (by IUCN standards), By 2013, 16 of these species were assessed with sufficient data for establishing a red-list category, reducing Data Deficiency by 20% (Costion 2013). The International Union for Conservation of Nature (IUCN) Red Listing of endemic plants is important because of threats of habitat loss, development, and climate change. Knowing which plants are most threatened will enable effective biodiversity conservation in Palau. Approximately 51 species of Palau's endemic plants species have been given a preliminary IUCN red-listing category.

Issue 6: Sustainable Forest Resource Use

The 2018 Sustainable Forest Management Policy (SFMP) provides a roadmap for sustainable forest resource use. The forests of Palau provide food, timber, medicine, materials for arts and crafts and recreation for the community. Population growth, ownership shifts, and new residential development have impacted the forest landscape. There is more demand for native trees that are good timber trees such as *Gmelina palawensis* for building homes. However sustainable harvest of local wood with an active replacement with local propagules has existed for many generations. Promotion of sustainable harvest of

top timber trees for local use through proper site management has been ongoing with private landowners. Historically, Nekken has planted two species of mahogany (*Swietenia macrophylla* and *Swietenia mahagoni*) because of their fast growth rates. The coconut tree, *Cocos nucifera*, is a cultural key stone species with over 45 uses that is an invaluable resource to Palau (Balick and Kitalong 2020). Old coconut plantations have existed in Palau since the German Administration over 100 years ago that can be replanted with younger trees and sustainably managed for an increase in production. A comparative analysis of the forest inventory between 2005 and 2015 show a decline in coconut plantations that is attributed to the impacts of typhoons (Dendy et al 2021 in prep.)

A small-scale coconut oil processing plant in Ngchesar State demonstrated that coconut oil production as a village industry has potential. The Ngchesar State plant was operational and then closed down. Super typhoon Haiyan destroyed the newly constructed coconut oil processing plant in Kayangel in 2013. This plant had not become operational when the typhoon impacted the entire island. However small home industries are still in operation. It is important to provide ongoing support for small scale coconut oil processing.

Over 404 plant species are used for local medicine, construction, weaving, decoration, food, and customary practices (Balick and Kitalong 2020). Visitors curious about traditional forest resource use support eco-tourism programs that sustain forests throughout the world. The unique craft of storyboard carving, as well as the construction of the bai, tools, baskets and traditional clothing are reliant on forest resources and play an integral role in sustainable tourism. Agro tourism continues to be promoted throughout the region. As visitors and the local community enjoy demonstrations of local food preparation and tasting unique foods of Palau.

Issue 7: Urban Forest Sustainability

With the national highway completed, residents are slowly building and relocating to their private lands in Babeldaob. The urban center of Koror and Airai were expanding at a slower rate compared to other states into Babeldaob, and more distant forested areas are being converted to urban areas. More and more impervious surface exists in Koror and Airai. Widening the main road of Koror and the construction of more secondary roads in Babeldaob has resulted in the loss of many large shade trees including large mango trees. Trees provide health and environmental benefits that are important for good quality of life for Palauan communities. It is critical to plant, care for and conserve trees in the communities where Palauans live, work and play. Koror and Airai are very high or high priority for focusing future programs of urban forests. As housing developments are growing in Babeldaob, there is a priority to develop urban forests within these new housing communities. Public parks and recreational areas have expanded in the states of Palau that serve as learning centers about forest trees and their uses. The landscapes around the schools provide shade and outdoor learning about native trees and plants. The PAN sites have begun to establish visitor centers with agroforests and small botanical gardens for residents and visitors.

Purpose of this Document

USDA Forest Service State and Private Forestry (S& PF) financial assistance can support Palau's forestry program to shape and influence use of forest land to optimize benefits from trees and forests for both present and future generations. The USDA Forest Service (USFS) worked closely with the National Association of State Foresters (NASF) to empower each "state" forestry program, including Palau, to write a Forest Action Plan (this document) in 2010 and again in 2021 to:

- Examine current conditions and trends affecting forest lands.
- Review existing S&PF programs to determine how best to address threats to forests.

- Develop a strategy for delivering a relevant and meaningful set of S&PF programs and opportunities.

State and Private Forestry “National” (US) Priorities and Objectives

1. Conserve working forest landscapes

- 1.1. Identify and conserve high priority forest ecosystems and landscapes
- 1.2. Actively and sustainably manage forests

2. Protect forests from harm

- 2.1. Restore fire-adapted lands and reduce risk of wildfire impacts
- 2.2. Identify, manage, and reduce threats to forest and ecosystem health

3. Enhance public benefits from trees and forests

- 3.1. Protect and enhance water quality and quantity
- 3.2. Improve air quality and conserve energy
- 3.3. Assist communities in planning for and reducing wildfire risks
- 3.4. Maintain and enhance the economic benefits and values of trees and forests
- 3.5. Protect, conserve, and enhance wildlife and fish habitat
- 3.6. Connect people to trees and forests, and engage them in environmental stewardship activities
- 3.7. Manage and restore trees and forest to mitigate and adapt to global climate change

Methods for SWARS

Overlay spatial analysis of up to 10 input data layers were identified by the technical team to produce maps for each of the 7 issues. Criteria for each layer were set primarily by PALARIS with input from the Forest Advisory Council technical team. Meaningful spatial analysis required 3-5 layers: vegetation, soil, rivers & streams, and infrastructure. Specific layers were only used for a given issue as follows: Issue 1 Climate Change: low elevation areas and areas of slope failure: Issue 3 Water Quality and Quantity: priority watershed layer; Issue 4 Wildfire Prevention: point locations for areas of chronic wildfires; Issue 5 Conservation and Protection: important forest areas and habitats for endangered species; Issue 6 Sustainable Use: plantations for coconut, mahogany, and Issue 7 Urban Forests: other trees and urban forest projects.

The Republic of Palau Forest Land Assessment (PFLA) is a cooperative project of the Republic of Palau forest to identify important lands across the landscape where future efforts in rural forestry assistance should be focused. A national project implemented by MAFE entitled Integrating Biodiversity Safeguards and Conservation into Development funded through the Global Environment Facility is working with the States of Ngiwal, Ngeremlengui, Ngaraard, Ngardmau, Ngarchelong, and Melekeok through a Babeldaob Island Joint Coordinating Body (JCB) to develop State Master Plans and State Planning Commissions that is conducting spatial analysis for Babeldaob Island that includes forests. This project is conducting a more in-depth spatial analysis in Palau for Babeldaob. The land use guides for Babeldaob include a series of base maps developed in coordination between MAFE, PALARIS, and the States through a series of consultations and ground truthing exercises. One of these maps is used under Issue #2. These maps are still under development with the States.

Data Gaps

Spatial data gaps exist for the States of Angaur, Peleliu, Kayangel, Sonsorol and Hatohobei, and parts of Koror. Therefore, spatial analysis was done primarily for Babeldaob; and aerial and satellite imagery was used for other states with data gaps. Spatial data gaps existed for the size and locations and frequency of fires, sizes of tree plantations, sizes of forest habitats of endangered species. Infrastructure data gaps existed as new development was not yet mapped. Contour data gaps for the sea level rise issue of climate change require 0.5-meter contours along the coastlines to better prioritize areas of the Republic.

Physical Features

The Republic of Palau became an independent nation on October 1, 1994, in part with the implementation of the Compact of Free Association between Palau and the United States of America.

Palau stretches from about 2 to 8 degrees north latitude and 131 to 135 degrees east longitude. It is about 500 miles equidistant from the Philippines to the west and from Papua New Guinea to the south. It consists of more than 340 islands, of which only 9 are inhabited. These are, from Northeast to Southwest: Kayangel, Babeldaob including the southeastern rock islands, Koror including the rock islands, Peleliu, Angaur, Sonsorol, Pulo Anna, Hatohobei, and Helen Reef. Most of the islands are of volcanic origin, and others are of raised limestone (Figure 0.1). Babeldaob is the largest island, making up 80 percent of the total land area. Babeldaob Island consists of ten states: Airai, Aimeliik, Ngeremlengui, Ngarchelong, Ngchesar, Melekeok, Ngiwal, Ngaraard, Ngardmau, and Ngatpang. There are 16 States in Palau.

Palau covers 415 km² (160 sq mi) of land area including rock islands. The surrounding sea area is very large, including an exclusive economic zone extending over 237,850 sq mi. Koror with a land area of 7.1 sq mi is the most densely populated state: two thirds of the population reside in Koror. Koror lies just south of Micronesia's second largest island, Babeldaob, which contains 153 square miles of undulating forests, grasslands, rivers, waterfalls, wetlands, mangroves, and some of the most beautiful stretches of beaches. The Capitol of Palau is in Melekeok along the east coast of Babeldaob.

Palau's distance to major cities in nautical miles: Palau's distance to major cities in nautical miles (mi): Guam (722 mi), Hong Kong (1,739 mi), Honolulu (4,449 mi), Manila (528 mi), San Francisco (5,751 mi), Shanghai (1,679 mi), Sydney (3,319 mi), and Tokyo (1,890 mi). The Palau Island is 9 hours ahead of Greenwich Mean Time. Palau is in the same time zone as Japan.

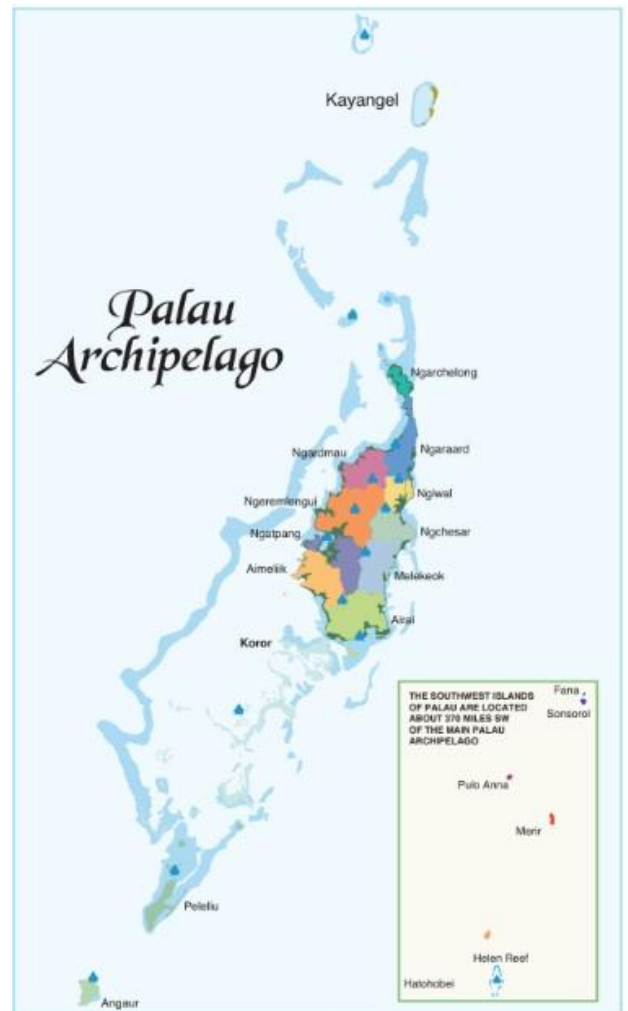


Figure 0.1. Map of Palau Archipelago showing the 16 States. Source: Imagineering Palau.

Forest habitats

The Republic of Palau is relatively small yet diverse with several habitats. The flora of Palau shares many common species with the Philippines and Indo-Malaysia, the source of biodiversity for this part of the world. Each of the forest types are best described as a complete habitat with unique soils, vegetation, landscape location and associated biological communities. Forest species composition in Palau is related to the soil type among other factors. Volcanic soils are found on Babeldaob, Ngerkebesang, Malakal and Koror. Coral limestone soils are found on Peleliu, Angaur, the Rock Islands, Kayangel and the Southwest Islands. All forests in Palau are classified generally as “lowland tropical rainforests”. Lowland because they are below 300 meters in elevation and rain forests because Palau receives about 380 cm of rain distributed throughout the year. The volcanic islands support a primary vegetation type which is a mixed species lowland tropical rain forest we call volcanic forest (previously referred to as upland forest in Cole et al., 1987). Also on volcanic islands are swamp forests which are found on soils that are inundated with fresh-water. Mangrove forests are found along most of the coast of the volcanic islands and sparsely on limestone islands in salt or brackish water. Savanna grasslands are found where the forest has been removed, typically along the ridges. The coral islands support vegetation types which are species rich and variable; these include the limestone forests, atoll forests and strand vegetation along the coasts. Limestone islands also have limited areas of mangrove forests along the coastal flats mostly on Peleliu and on certain Rock Islands (Cole et al., 1987). There is some amount of overlap of species between the different forest types or habitats. Many species have adapted to both extremes of limestone soils and volcanic soils that have highly varying pH regimes.

Freshwater swamp forests

Freshwater swamp forests tend to occur slightly inland of mangrove forest in areas of fresh or slightly brackish water and in wet lowland areas or along the riparian zone. This sensitive forest habitat represents the least amount of area of all forest types and requires protection. The dominant canopy species in swamp forest vary with their proximity to salt water and other topographic considerations, such as riparian sites versus lowland sites near the coast versus inland sites. The other layers of this forest vary less. Typically, the forest floor growth is predominantly the seedlings of the dominant trees. Species commonly found in freshwater swamp forests are *Barringtonia racemosa*, *Calophyllum pelewense*, *Camptosperma brevipetiolata*, *Cynometra ramiflora*, *Horsfieldia irya*, *Pandanus kanehirae*, and *Stemonurus ammui*. In disturbed areas or open areas *Hibiscus tiliaceus* and *Macaranga carolinensis* are found extensively. In the moist ravines and riparian areas, dense and diverse forest vegetation occurs including *Barringtonia racemosa*, *Colona scabra* and the poison tree, *Semecarpus venenosa*. A common, but not universal, trend of the zones of large swamp forests from upland to mangrove has been described by Canfield et al. (1992) as *Calophyllum*, *Stemonurus*, *Pandanus* association as transitional between inland mangroves and the *Horsfieldia* forest.

Volcanic forests

Volcanic forests are on basalt soils; these lowland forests are dense, multi-layered, and structurally complex encompassing distinct subtypes of forest in undisturbed ecosystems. The volcanic lowland forests are considered the most species rich in Micronesia (Stemmermann, 1981) and have the highest rate of endemism. It has also been previously noted that the species composition varies with topographic richness (Canfield et al., 1992). Forests on ridges have higher species diversity with *Maranthes corymbosa* often dominant, whereas forests on the slopes and in valleys are less diverse and dominant with *Camptosperma brevipetiolata* and the understory palm, *Pinanga insignis*. Forests of Palau are heterogeneous, with no distinctly dominant species. There are landscapes where dominant climax species prevail. Tree species also include *Alphitonia carolinensis*, *Calophyllum inophyllum*, *Calophyllum inophyllum* L. var. *wakamatsui*, *Elaeocarpus joga*, *Gmelina palawensis*, *Maranthes corymbosa*,

Pterocarpus indicus, *Rhus taitensis*, *Semecarpus venenosus*, *Serianthes kanehirae* Fosberg var. *kanehirae*, *Atuna racemosa* Raf. subsp. *racemosa*, *Cerbera* spp., *Fagraea ksid*, *Horsfieldia palauensis*, *Manilkara udoido*, and *Myristica insularis*. Understory tree species also include *Osmoxylon truncatum* and *Pandanus aimiriikensis*.

Mangrove forests

Mangrove forests comprise a dense forest which grows in brackish to salty water along a narrow strip of the tidal zone near the shore. Mangrove forests are widespread around Babeldaob and found in the low lying, coastal, muddy seashores, bays, and estuaries. Mangrove forests are found in the Rock Islands, along the coasts and the edge of marine lakes. Mangroves provide potential ecosystem services as follows: a buffer that reduces the impacts from storms and surge waves along coastal areas, a nursery habitat for marine and terrestrial life, and filter for runoff exiting terrestrial ecosystems. The filtration that mangroves provide helps to sustain coral reef and fish habitat by reducing siltation. The mangrove forests include over 24 different species. The species found in mangroves include *Avicennia marina* subsp. *marina*, *Bruguiera gymnorhiza*, *Ceriops tagal*, *Dolichandrone spathacea*, *Excoecaria agallocha*, *Lumnitzera littorea*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Scyphiphora hydrophyllacea*, *Shirakiopsis indicus*, *Sonneratia alba*, and *Xylocarpus granatum* and the palm *Nypa fruticans*. Smaller plants include *Dalbergia candenatensis*, *Derris trifoliata*; and the ferns *Acrostichum aureum* and *Nephrolepis acutifolia*. Mangrove trees adapt to a muddy saltwater environment by producing specialized prop roots for structural support, knee shaped pneumatophores or conical roots for gaseous exchange, and buttress roots for both structural support and gas exchange.

Limestone forest

Limestone forest vegetation types are found on limestone islands and outcrops mainly on Peleliu, Angaur, the Rock Islands and Airai. On the Rock Island limestone substrate of the coral rock, the organic matter from the vegetation forms a thin layer of soil in places in which the vegetation grows. The karstic substrate is steep, porous, and rugged. The species-rich forest includes *Aidia racemosa*, *Badusa palauensis*, *Barringtonia racemosa*, *Bikkia palauensis*, *Clerodendrum inerme*, *Cordia subcordata*, *Cycas micronesica*, *Cyrtandra todaiensis*, *Eugenia reinwardtiana*, *Flacourtia rukam* Zoll. & Mor. var. *micronesica*, *Garcinia matsudai*, *Garcinia rumiyo* Kaneh. var. *calicola*, *Geniostoma sessile*, *Guettarda speciosa*, *Hydriastele palauensis*, *Intsia bijuga*, *Ixora casei*, *Meryta senffiana*, *Morinda latibractea*, *Pandanus dubius*, *Pemphis acidula*, *Pleomele multiflora*, *Polyscias grandifolia*, *Pouteria calcarea*, *Pouteria obovata*, *Premna serratifolia*, *Psychotria* spp., *Rinorea bengalensis*, *Scaevola taccada*, *Semecarpus venenosa*, *Soulamea amara*, and *Tarenna sambucina* (Forst.) var. *oweniana*.

Atoll and Coastal forests

Atoll forests are usually found in the interior of larger and wetter atolls along sandy or rocky coasts and generally behind strand forest but can be mixed with strand species. The transition from strand to atoll forest is often gradual and indefinite. Species commonly found include an outer fringe of the shrubby *Scaevola taccada* (korrai or kirrai), *Heliotropium foertherianum* (rirs) and *Sophora tomentosa* (dudurs). Along the rocky limestone coastlines the tree *Pemphis acidula* is common. *Casuarina equisetifolia* (ngas) is common at areas of human settlement and expand into adjacent areas. Other atoll and coastal plant species include *Calophyllum inophyllum* (btaches), *Cordia subcordata* (badirt), *Hernandia sonora* (doko), *Guettarda speciosa* (belau), *Pandanus* spp. *Pisonia grandis*, *Terminalia catappa* (miich), *Morinda citrifolia* (ngel), *Ochrosia oppositifolia* (uaoch), *Hibiscus tiliaceus* (chermall), *Ficus* spp. and *Premna serratifolia* (chosm). Coastal forests along Babeldaob include a similar flora.

Agroforest

Agroforests are forests consisting of areas under cultivation for fruit and food crops and trees and wood products. Agroforests are often a mosaic of manmade landscapes that are integrated into the natural landscape. Traditional agroforests of Palau have complex irrigation systems with organic fertilization. The depth of soil for taro production within these systems can be more than one meter.

Coconut plantations

Coconut plantations are agroforests dominated by *Cocos nucifera* (lius) that were cultivated in large plantations during the German, Japanese and American administration. Copra, a product of coconut was a major industry during the German period. Today many of these plantations still can be found throughout Palau.

Casuarina forests

Casuarina forests are dominated by *Casuarina equisetifolia* (ngas) which is a coastal tree common in sand and coral rubble that is often near the high water mark but can be found in both limestone and volcanic soils and as part of the coastal strand vegetation. The southern states of Angaur, Peleliu, and the Ngemelis Complex are dominated by large *Casuarina* trees. Some of the rock islands are now dominated by this species. This tree can also be found in Babeldaob in areas where coral fill was used to either reclaim reef or build roads. The wood of *Casuarina* is used for posts, handicrafts, and fuel. This native tree is a highly adaptable species and can grow in poor soils and marginal habitats. The needles can inhibit growth of other native trees.

Mahogany plantations

Mahogany plantations consist of two species of tall trees: *Swietenia macrophylla* and *Swietenia mahogani*. Since the Japanese administration, mahogany has been actively planted as a source of timber with many small plantations and larger plantations of over 100 acres found in Palau.

Urban Forest

Urban forests are near homes and infrastructure in highly populated areas such as Koror and Airai State and areas with higher densities than the mean for a given state. Native and introduced trees in urban areas included 64 species and 37 families (Kitalong, 2001). The most common trees include *Mangifera indica*, *Areca catechu*, *Cocos nucifera*, *Terminalia catappa*, *Swietenia macrophylla*, *Spondias pinnata* (titimel), *Plumeria obtuse* (chelilai) and *Artocarpus altilis* (meduu). Other important trees and shrubs were *Musa* spp., *Persea americana*, *Syzygium aqueum*, and *Nephelium lappaceum*. Less common trees included *Carica papaya*, *Citrus* spp., *Psidium guajava*, *Annona muricata*, *Premna serratifolia*, *Averrhoa carambola*, *Muntingia calabura* and *Bambusa vulgaris*. Decorative bushes and plants included *Gardenia jasminoides*, *Hibiscus rosa-sinensis* and *Cordyline fruticosa*. Large trees observed included *Serianthes kanehirae* Fosb. var. *kanehirae*, *Falcataria moluccana*, *Cananga odorata*, *Samanea* sp. and *Camptosperma brevipetiolata*. *Rhizophora mucronata* and *Calophyllum inophyllum* were found near homes adjacent to the mangroves and coasts.

Volcanic steep slope palm forests

High basaltic outcrop ridges represent 1% of Babeldaob forests and are dominated by the palm *Heterospatha elata* var. *palauensis* (demailei or beokl) and also dominates steep cliffs in limestone forests (Costion and Kitalong 2006).

Savanna grasslands

Savanna grasslands with associated trees occur on volcanic soil substrates where the primary forest has been removed and some are naturally occurring. There are over a dozen endemic savanna species suggesting that there may have been some isolated pockets of native savanna. The loss of native forest resulted in soil erosion and degradation decreasing the probability of forest regeneration. The savanna systems persist due to repeated periodic fire caused by humans. Savanna is found throughout the island of Babeldaob and in areas of Koror. The vegetation consists of grass, sedges, ferns, shrubs, and a few scattered tree species including some endemic species. Trees and shrub species that grow in the harsh savanna ecosystem are potential reforestation species. These species included *Commersonia bartramia*, *Morinda citrifolia*, *Morinda pedunculata*, *Mussaenda philippica*, *Pandanus tectorius*, *Dracaena multiflora*, *Symplocos racemosa* var. *palauensis*, *Timonius subauritus*, and *Trichospermum ledermannii* and *Calophyllum inophyllum* var. *wakamatsui*. Shrubs often found include *Decaspermum parviflorum*, *Dianella carolinensis*, *Eurya japonica* Thun. var. *nitida*, *Hedyotis korrorensis*, *Melastoma malabathricum*, *Phyllanthus palauensis*, *Dracaena multiflora*, *Spathoglottis* spp., and *Wikstroemia elliptica*. Forest-savanna edge species are exposed to more light than the surrounding forest and included *Alphitonia carolinensis*, *Calophyllum inophyllum* L. var. *wakamatsui*, *Fagraea ksid*, *Garcinia matudai*, *Dracaena multiflora*, *Pouteria obovata* and *Rhus taitensis*.

Status and Trends of Forest Resources

MAFE Bureau of Environment (BOE) Division of Forest, Land, and Water Management (DFLW) in cooperation with the US Forest Service conducts forest inventories to measure the status of all the forest resources in the state. The goal of the Forest Inventory and Analysis (FIA) program is to determine the extent, growth, composition, mortality, and health of forests as well as land use changes and potential for wildfire in the Republic. The inventory consists of a series of 56 permanent survey plots established in a grid pattern across the Republic that are surveyed every 10 years.

Forest Surveys

Cole et al. (1987) estimated a forest cover of 80% including agroforest and secondary forest vegetation and 20% non-forest vegetation. Donnegan et al. (2007) estimated a forest cover of 82% including agroforest and secondary forest vegetation and 18% non-forest. Cole et al. (1987) mapped 412 km² with a canopy threshold equal to or greater than 30% using 1976 aerial photography. Donnegan et al. (2007) covered 445 km² with a canopy threshold of equal to or greater than 10% using 2003 IKONOS (GeoEye Corp.) and 2005 QuickBird satellite imagery. Given the difference in canopy cover thresholds between 1987 and 2007 surveys, it is not possible to make a direct comparison between studies. Trends indicate that there may be some areas in Babeldaob where non-forest vegetation reverted to forest. Comparisons of the 1987 and 2007 surveys suggest that forested land in Babeldaob was maturing and may be encroaching slightly on non-forest vegetation. In contrast, Peleliu, Koror and Angaur were losing forested land to urban and non-forest vegetation land uses. Donnegan et al. (2007) estimated that 16% of the forest was limestone and 66% was volcanic.

MacLean et al. (1988) conducted a timber inventory using forty-nine plots of which three plots were in swamp forest, five plots were in mangrove forest and 41 plots were in either limestone or volcanic forests of Babeldaob. Donnegan et al. (2007) delineated land cover using 54 permanent plots of which 11 plots were in limestone forest and 43 plots were in volcanic forest in Babeldaob and Koror. Donnegan et al. (2007) estimated 2,115 trees ha⁻¹ (SE=68) compared to 3,168 trees ha⁻¹ (SE=102) in 1988. The estimated basal area was 33.5 m² ha⁻¹ in the 2007 survey compared to 31.2 m² ha⁻¹ in the 1988. The estimated tree volume per hectare was 192 m³ (SE=296) in the 2007 survey compared to 122 m³ (SE=188) in the 1988 survey. Donnegan et al. (2007) suggested that some trees were increasing in size while others died during a thinning phase. The 2007 inventory data further suggested there was a higher net wood volume in limestone than volcanic forests with fewer species per plot in limestone (10 species) compared to volcanic forests (12 species).

Endress & China (2001) studied landscape change in the Ngeremeduu Bay Drainage Area, an 84 km² area located along the west central coast of Babeldaob. They overlaid 1947 maps over 1992 maps and set plots with the study site. Their results showed that the forest increased by 10.9% and the grasslands decreased by 11.2% between 1947 and 1992. Therefore, the rate of forest growth over this 45-year period was 0.22% yr⁻¹ or 3 times greater than the rate of growth estimated throughout Palau derived from the Donnegan et al. (2007) study. The majority of this transition occurred between 1947 and 1976 when 41.6% of the grassland cover was converted to forest. This conversion slowed substantially after 1976 as only 3.6% of the grassland areas were further converted to forest by 1992. Forest expansion was significantly associated with the location of abandoned agricultural communities. Over 92% of the forest expansion occurred within 100 m of established forests suggesting that nearby forests facilitate recovery following human disturbance. This may also suggest that agricultural lands originally within forested areas became reforested after abandonment because the soils were less degraded than open savanna areas.

Over a 13-year period (1992-2005), analysis of aerial images indicated that there was differential forest growth for 46 forest patches within a watershed area in Airai, southeastern Babeldaob, with an overall increase in forest size of 2.28 hectares or 0.5% (462.26 ha in 1992 to 464.54 ha in 2005) or a rate of 0.04% yr⁻¹ which is slightly lower but within a similar range as the rate derived by Donnegan et al. (2007). Further analysis showed that the mean rate of expansion (± 1 SD) was 38 ± 525 m² yr⁻¹. Nine of the forest patches increased in size at a rate of 608 ± 461 m² yr⁻¹ with a maximum expansion of 1,725 m² yr⁻¹. Three forest patches decreased in size at a rate of $1,267 \pm 1,150$ m² yr⁻¹ with a maximum rate of loss of 2,594 m² yr⁻¹. A total of 35 forest patches remained unchanged. This preliminary study showed relatively slow forest growth in recent years in southeastern Babeldaob. More field investigations are needed to determine the composition of these forest patches and possible causes for these differential growth rates. Tree species commonly found along forest edges include the endemic *Trichospermum ledermannii*, *Macaranga carolinensis*, *Cerbera manghas*, *Rhus taitensis*, and *Maranthes corymbosa*; they have been observed to gradually expand into grasslands. These species are typically more stunted in growth in open edge areas than in the interior of the forest. More research using similar methodologies at finer spatial and temporal scales would provide a better understanding of changes in vegetation landscape of Palau.

During 2004 and 2005, a semi-quantitative survey was conducted to determine important forest areas of Babeldaob (Costion & Kitalong 2006). A total of 51 transects and 398 stations were covered in this study. At each station, an area within a 20 m radius was assessed covering 1256 m² per station and a total area of 50 ha. An average of 5 transects and 40 stations were visited at each state. The stations were mainly in lowland forest (60%), followed by savanna (15%), riparian forests (11%), swamp forests (11%), limestone forests (4%), marshes (4%), mangroves (4%) and coastal forests (3%). The southern state of Airai has the only limestone forests in Babeldaob. Coastal forests were surveyed along the northeastern coast of Babeldaob. During this survey over 342 plant species were recorded including 249 native plants, 31 introduced species; 47 species determined to genus and 21 undetermined plant species. The most frequently encountered tree species found in the 1988, 2003 and 2005 surveys were ranked according to

relative abundance. The most common species were *Pinanga insignis*, *Maranthes corymbosa*, *Alphitonia carolinensis*, *Semecarpus venenosus*, *Camptosperma brevipetiolata*, *Horsfieldia palauensis*, *Horsfieldia irya*, *Gmelina palawensis*, *Rhus taitensis* and *Pouteria obovata*. The largest trees by volume were *Camptosperma brevipetiolata*, *Maranthes corymbosa*, *Horsfieldia irya*, *Pinanga insignis*, *Sonneratia alba*, *Rhizophora apiculata* and *Intsia bijuga*. The dominant Families included Anacardiaceae, Clusiaceae, Fabaceae, Myristicaceae, Myrtaceae, Sapotaceae and Tiliaceae. Relative rankings differed between surveys as each survey was conducted in different habitats and locations in Palau. These findings corroborate with an earlier botanical reconnaissance study (Raulerson et al. 1997) and an earlier forest habitat study (Kitalong & Holm 2004).

Stunted mangrove trees of *Sonneratia alba*, *Rhizophora mucronata*, *Bruguiera gymnorrhiza*, *Scyphiphora hydrophyllacea* and *Ceriops tagal* grow on marginal elevated areas such as raised man-made beams composed of coral fill from abandoned dredge sites. Inner zones of mangroves along southeastern Babeldaob have extensive stands of *Rhizophora apiculata* with stunted growth compared to larger forms of the same species along the seaward edge and adjacent to *R. mucronata*. Dwarfism may enable specific mangrove species to grow and reproduce in elevated, less optimum conditions and enable them to retreat to higher ground as the sea level rises in the next century.

Mangroves are the second largest forest type in Palau covering 48.5 km² or 12% of all vegetation. The mangrove-associated plants are adapted to soft, muddy substrate, oxygen poor soils and saltwater with modified roots, leaves, flowers, and fruits. The mangrove holly, *Acanthus ebracteatus* and the mangrove tree, *Avicennia alba* had more restricted distributions. An estimated 1.43 km² of forests, 0.28 km² of wetlands and 0.6 km² of mangroves were lost or reclaimed for the construction of national highway (TEI 2003). Using 2005 Quickbird imagery, an estimated 0.4 km² of mangrove forest was reclaimed for landfills, development, and aquaculture. The 2007 National Highway reclaimed an estimated 1.3 km² of mangrove forest. An estimated 1.7 km² of mangroves was reclaimed over 40 years (1970 to 2010 at an estimated rate of 0.04 km² yr⁻¹). Margoes et al. (1994) estimated mangrove cover at 45 km² compared to the 2010 estimate of 48 km² or an estimated increase of 3 km² in 15 years (0.2 km² yr⁻¹). In 2014, the estimated area of mangroves was 48.5 km² or 0.5 km² in a 4-year period or (0.12 km² yr⁻¹).

A comparison of aerial photographs between 1968 and 2005 showed that mangroves forests within Airai Bay nearly doubled in size (from 4.2 to 7.9 km²) in a 37-year period at a rate of 0.1 km² yr⁻¹. These rough estimates indicate that the rate of increase in mangrove forests is 2.5 to 5 times greater than the rate of loss from reclamation for development. Airai Bay became a mud bank and was silting at a rate of 150 tons km⁻²yr⁻¹ (Golbuu et al. 2003). If siltation continues at its current rate, it was estimated that the bay will be above sea level in 15 years (Victor 2007). The rate of gain of mangrove in Airai was measured at 0.1km²/year (Neville 2014). Elsewhere in Palau, the rate of mangrove reclaimed or lost due to development is 0.04 km²/year (Neville 2014).

This increase has been attributed to natural and accelerated growth due to increased sedimentation into the bay. Increasing populations, unplanned development, and more frequent and intense rainfall result in accelerated rates of sedimentation which provides additional substrate for mangrove propagules to grow. Accelerated sedimentation from soil erosion and mangrove expansion may not be a new phenomenon. This process may have been initiated thousands of years ago when the first immense terrace systems were created (Masse et al. 2006). Sediment cores with pollen grain analysis of agricultural and native plants would enable scientists to reconstruct more accurate timelines and to better determine relationships between human activities, sedimentation, and forest dynamics for a given location over a longer time frame.

The 2014 Palau Forest Inventory and Analysis (FIA) collected forest and tree measurements from 56 forest plots among three forest communities across Babeldaob, Koror, Peleliu, Angaur, and the Rock Islands. A total of 125 tree species and 196 dominant vascular plants were recorded, most in lowland

rainforest. Strand forest on Ngemelis and Ngedebus islands had the lowest stem density and highest basal area and volume per acre among forest communities. The Rock Islands had the highest basal area, volume per acre, and percentage of trees greater than 10 inches DBH, and the highest stem density among island groups (Babeldaob, Rock Islands, or Peleliu/Angaur). Palau had high forest canopy cover in 2014 with some missing canopy cover associated with wind or fire disturbance. There was very little damage to forests from wild pigs, no specifically human disturbance observed except for fire, and very little cutting of trees recorded, but approximately 40 % of coconut trees were infested with coconut rhinoceros beetles. Less than 1 % of total forest area was covered with nonnative invasive plants. The number of dead coconut trees was not given. The mean percent cover of the native/invasive vine *Merremia peltata* decreased by 17 % compared to 2003. Between 2003 and 2014, the average height of all trees in Palau increased by 2 ft. The forest grew an estimated 100,000 tons of tree biomass per year (50,000 tons of carbon). The estimates for average diameter, basal area, and volume per acre of forest overall did not change significantly. The percentage of disturbed forest area increased from 1 to 25 percent, tree damage increased by 10 percent, and trees with moderate to heavy epiphyte loads decreased from 45 to 15 percent, all likely due to major typhoon impacts prior to the inventory in 2012 and 2013 (Dendy et al. 2021 in prep.).

Vegetation Type Maps

The most updated vegetation map for Palau is for Babeldaob with land cover for 2014 (Greenberg et al. 2020). Refer to Figure 0.2. The data indicates that forests covered 73% of Babeldaob followed by grassland and savanna (14%) mangrove forests (11%), marsh (2 %) and the built-up community (1%). Land and vegetation change in Babeldaob between 1976 and 2014 showed an increase in forests (5.5%), and a decrease in savanna and grasslands (-5%), a decrease in mangroves (-0.3%), an increase in marsh (0.2%), and a decrease in urban areas (-0.5%). Refer to Table 0.1. Vegetation maps in 1987 and 2007 provide information for different vegetation types for more locations in Palau. Refer to Figure 0.3.

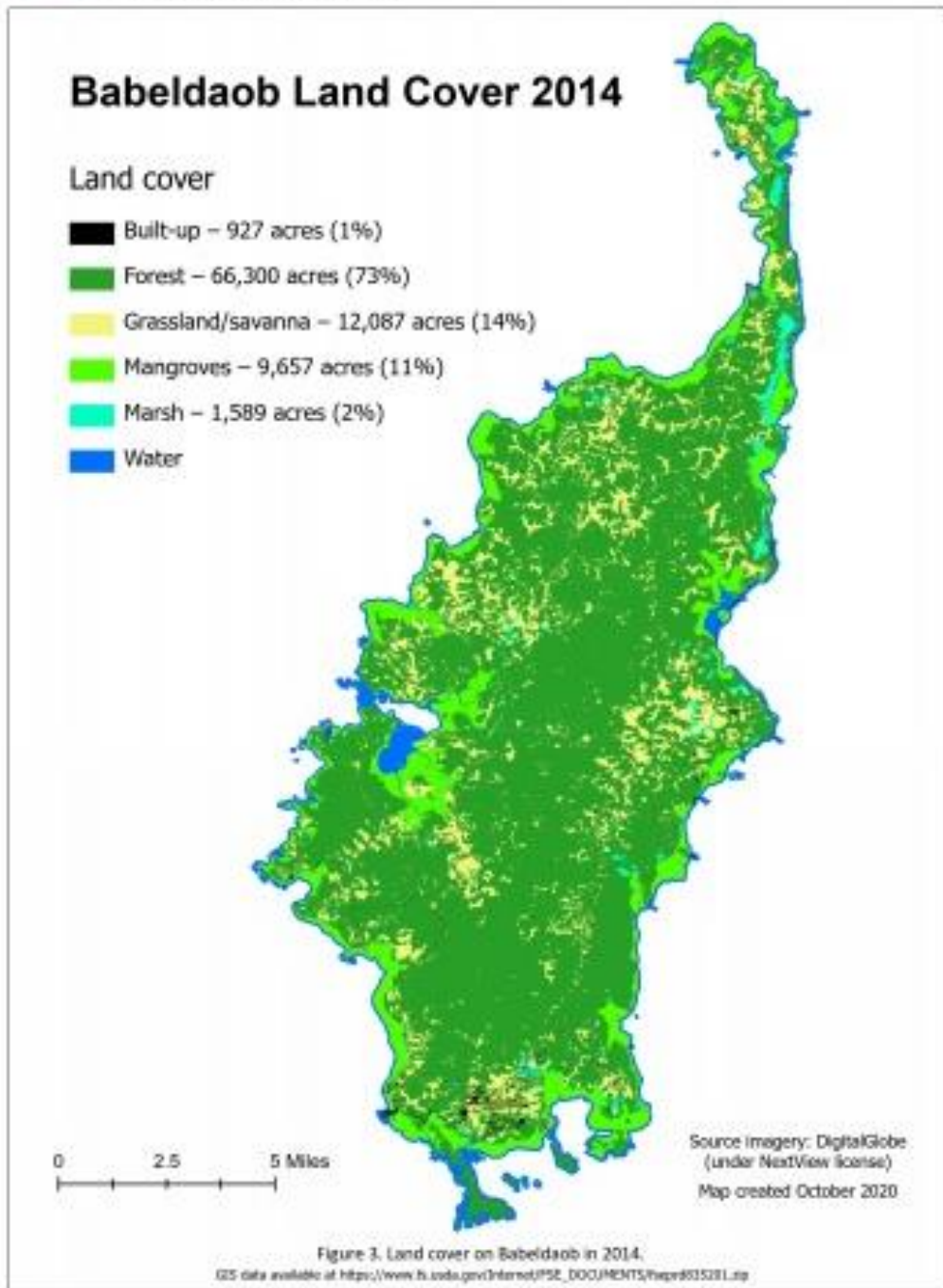


Figure 0.2 Babeldaob Land Cover 2014 Greenberg et al. 2020.

Table 0.1. Land Use Change between 1976 and 2014 for Babeldaob Island Palau.
(Cole 2021 pers. comm.).

| Land Class | 2014 | 1976 | Change | 1976 Pct | 2014 Pct. | % Chg |
|-----------------|-------|-------|--------|----------|-----------|-------|
| | ac | ac | ac | | | |
| Urban | 927 | 1362 | -435 | 1.5 | 1.0 | -0.5 |
| Urban | | 348 | | | | |
| Crop | | 608 | | | | |
| Barren | | 368 | | | | |
| Water | | 37 | | | | |
| Mangrove Forest | 9657 | 9946 | -289 | 11.0 | 10.7 | -0.3 |
| Upland Forest | 66300 | 61465 | 4835 | 67.7 | 73.2 | 5.5 |
| Upland | | 53597 | | | | |
| Swamp | | 3996 | | | | |
| Agroforest | | 2283 | | | | |
| Other | | 316 | | | | |
| SV | | 1273 | | | | |
| Grassland | 12087 | 16625 | -4538 | 18.3 | 13.3 | -5.0 |
| Marsh | 1589 | 1371 | 218 | 1.5 | 1.8 | 0.2 |
| Total | 90560 | 90769 | -209 | 100.0 | 100.0 | |

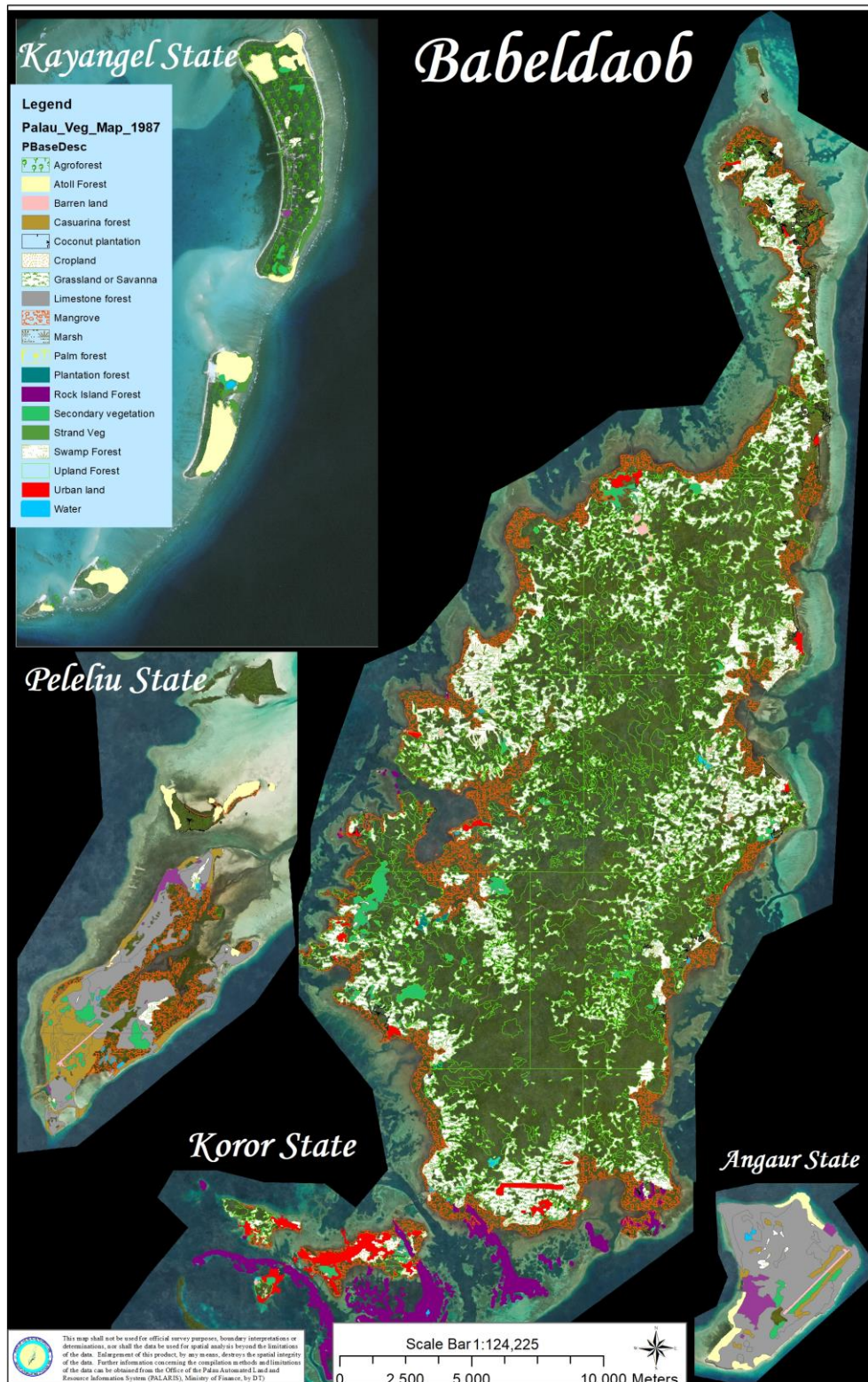


Figure 0.3 Vegetation map from 1987. Source: PALARIS

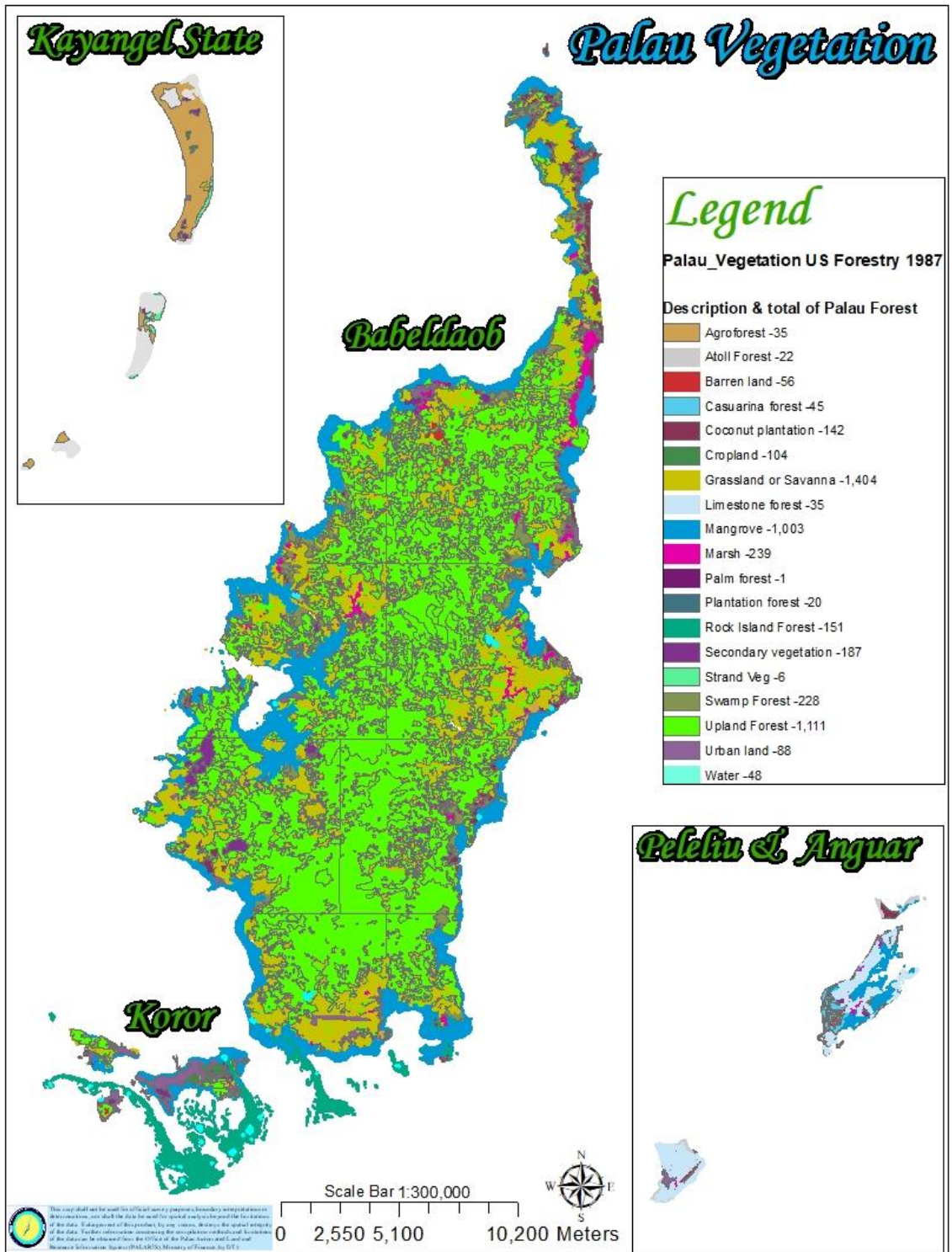


Figure 0.4 Vegetation Map produced from data Cole et al 1987. PALARIS

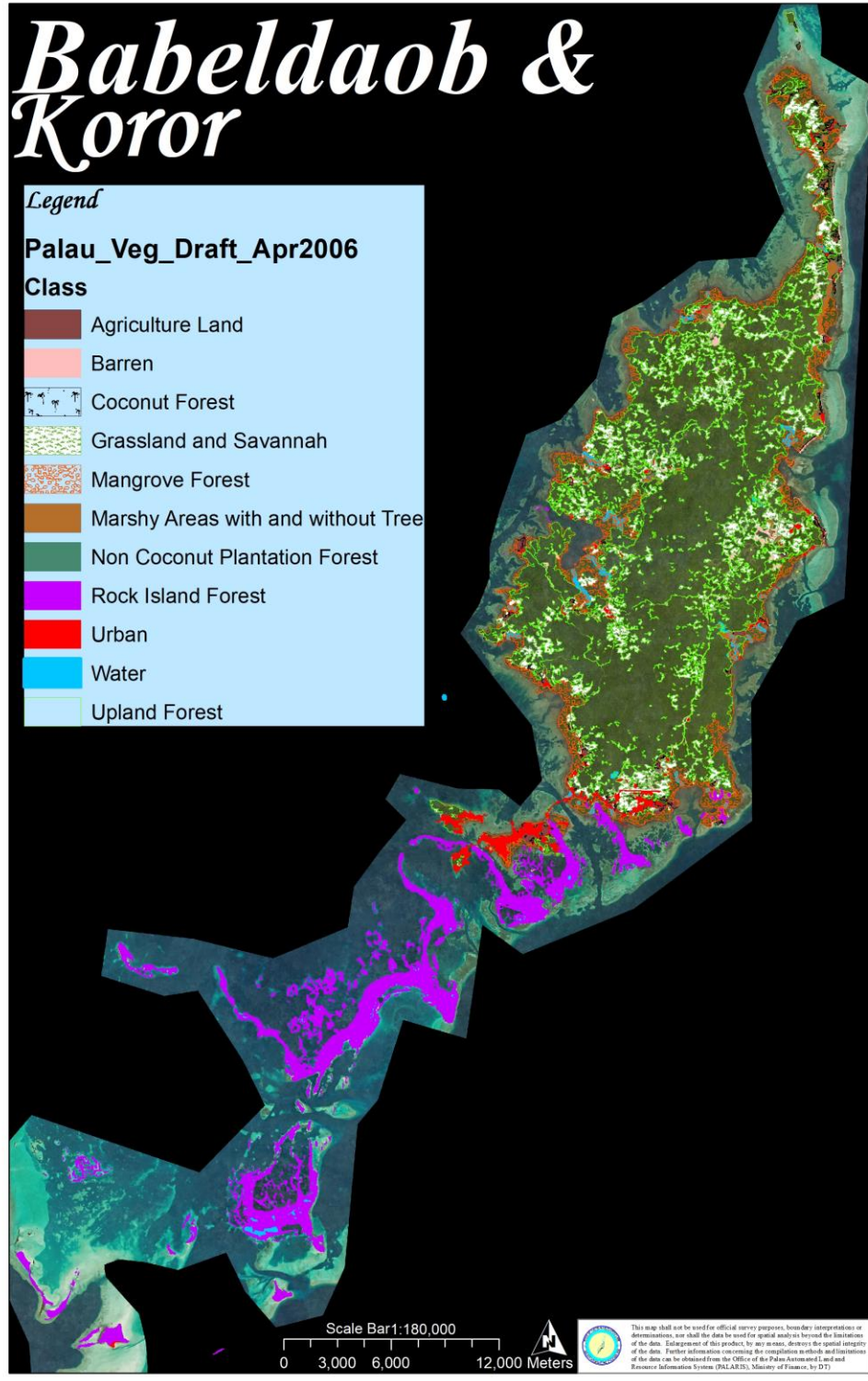


Figure 0.5 Vegetation map from 2006 from Donnegan et al. (2007) PALARIS

Land Ownership

An example of land ownership and forest coverage is given for Aimeliik State. Refer to Figure 0.6. The cadastral lots shown for Aimeliik State can be either private or public lands. The map of Aimeliik State shows the large extent of forested land that has yet to be surveyed that can be either private or public lands. The map shows that there are several large parcels of private land that are forested. Most of the private land is along the coast. Figure 0.7 is a map of Palau that shows the cadastral lots, public lands, and lands not surveyed for 14 States, it does not include Hatohobei and Sonsorol. Therefore, based on discussions with a surveyor at Lands and Surveys and the Land Registration Office, most land has not yet been determined as either private or public lands, as it has not been surveyed and the court documentation of ownership is yet to be determined (Lands and Survey pers. comm. August 30, 2021). A total of 17,654 ha of forest in Babeldaob have not yet been surveyed. Refer to Figure 0.8.

In 2010, individuals, partners, corporations, and traditional clans were estimated to own approximately 29% of the land. Most of the land in Palau (71%) was considered yet to be determined and under the jurisdiction of the individual States' Public Land Authorities. Refer to Table 0.2. In the states of Kayangel, Angaur, Peleliu and Ngarchelong, the key stakeholders are the private landowners. In most of Babeldaob designated "public" lands range from 50% in Ngiwal to 94% in Ngeremlengui. However as stated above these "public" lands have yet to be surveyed and to be determined as public or private. Therefore, the State Public land authorities play a critical role in land use. Of Palau's forested land, approximately 91% was "public" and 9% was private, based on USFS FIA plot data in 2014 (Kuegler, 2021). However, the FIA estimates of "public" land included land under the jurisdiction of states' Public Land Authorities and did not consider the distinctions explained above for unsurveyed land. The 2015 Agricultural Census indicated that the number of agroforests and farms were predominately private land (85% or 202 agroforests and farms), some farms were on leased land (12%), and 1% of the farms were on clan land. Refer to Table 0.3. PALARIS provided data in September 2021 indicating that 17,850 ha of surveyed land was privately owned, and 2,200 ha of surveyed land is public land. Most of Palau's land is unsurveyed and ownership has not been determined (PALARIS 2021).

Land Tenure

Land in Palau can be either privately owned as a result of direct purchase, an inheritance from family, or given to an individual from a clan or individual as a payment for a service or in exchange for goods. Taro gardens or mesei are traditionally passed on through the women to a daughter or relative. Land can be used by individuals under a lease agreement from the landowner, or a clan member can use to farm by a written or verbal agreement. A clan member can use a plot of land within a larger parcel owned by the whole clan. Land that is farmed is not necessarily owned by the individual farming and may have to be returned to an owner or clan once it is no longer in active use. State lease agreements (State land leased to private individuals or families) often have a condition that the land must be put to use within a certain period of time to either build or farm. If not, the lease will be canceled, and the land will be returned to the State. Lease holders can sublease land to a second party in some States. Clan properties are usually under the jurisdiction of a chief of the clan and elders of the clan who act as a trustee for the land. Decisions on land exchanges are traditionally done through consensus of the clan members. When there are disagreements on land exchange, the decision often rests within the land court through a trial or through a mediation process.

Table 0.2. Estimated area of public and private land by state with total area and percent of public Lands in the Republic of Palau. Units in hectares Ha (10,000 m²)

| STATES | PUBLIC LANDS (Ha) | PRIVATE LANDS (Ha) | TOTAL (Ha) | Percent Public Lands |
|------------------|-------------------|--------------------|------------|----------------------|
| NGEREMLENGUI | 4713.54 | 303.81 | 5,017.35 | 93.94% |
| NGARDMAU | 4339.55 | 957.01 | 5,296.55 | 81.93% |
| NGCHESAR | 3407.92 | 807.3 | 4,215.23 | 80.85% |
| AIRAI | 4936.02 | 1569.02 | 6,505.04 | 75.88% |
| AIMELIIK | 4282.05 | 1394.72 | 5,676.76 | 75.43% |
| NGARAARD | 2224.81 | 863.77 | 3,088.58 | 72.03% |
| NGATPANG | 2120.17 | 928 | 3,048.17 | 69.56% |
| MELEKEOK | 1554.26 | 818.44 | 2,372.7 | 65.51% |
| NGIWAL | 1867.91 | 1853.15 | 3,721.05 | 50.20% |
| KOROR MAIN. IS. | 309.25 | 487.18 | 796.43 | 38.83% |
| PELELIU | 296.56 | 941.21 | 1,237.76 | 23.96% |
| NGARCHELONG | 163.17 | 609.43 | 772.6 | 21.12% |
| ANGAUR | 51.02 | 803.68 | 854.7 | 5.97% |
| KAYANGEL | 0 | 170.94 | 170.94 | 0.00% |
| HATOHOBEL | | | 70.0 | |
| SONSOROL | | | 300.0 | |
| Total | 30266.23 | 12507.66 | 42,773.86 | |
| Percent of Total | 70.76% | 29.24% | | |

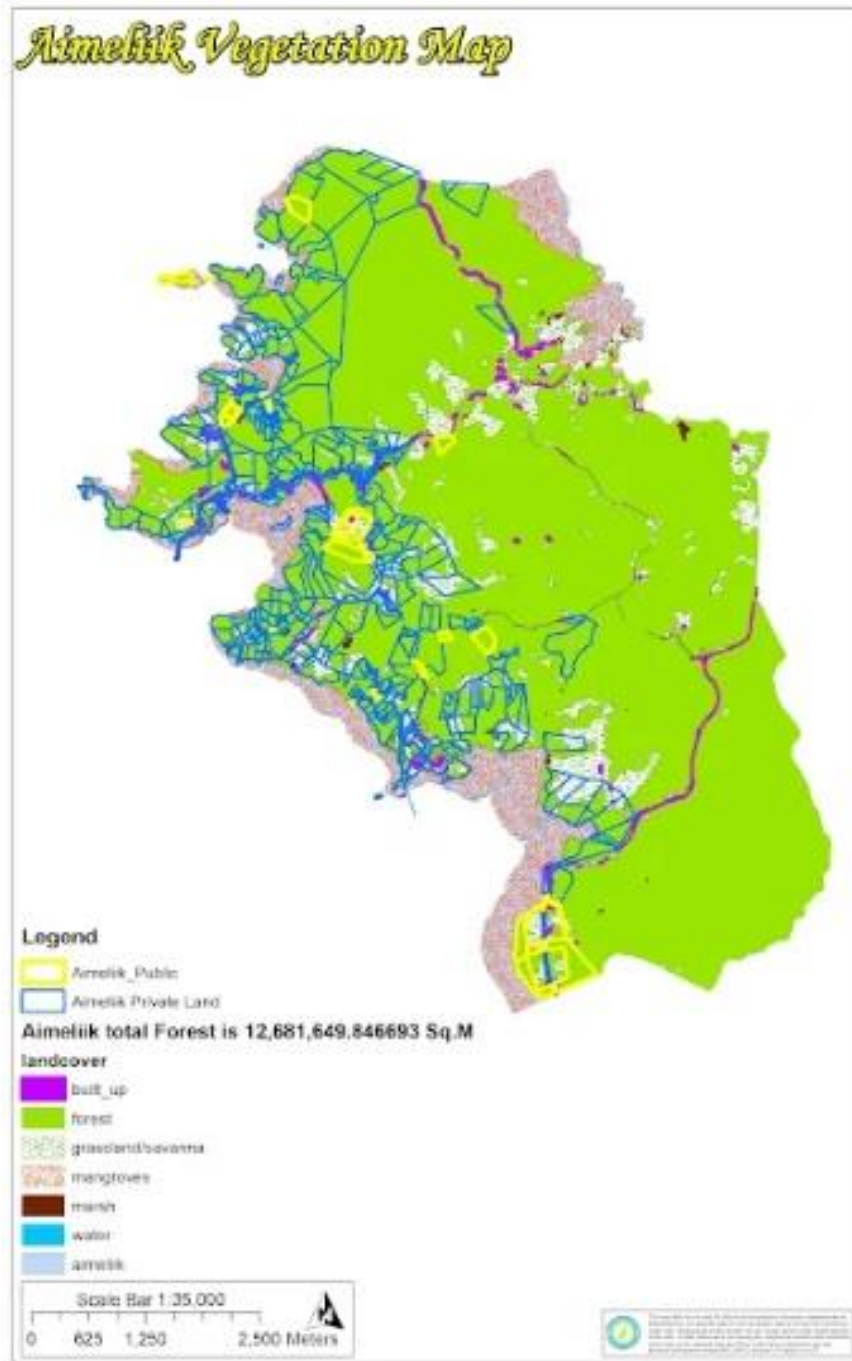


Figure 0.6. Aimeliik Vegetation Map showing large portion of forests that have not been surveyed and are assumed to be public land.

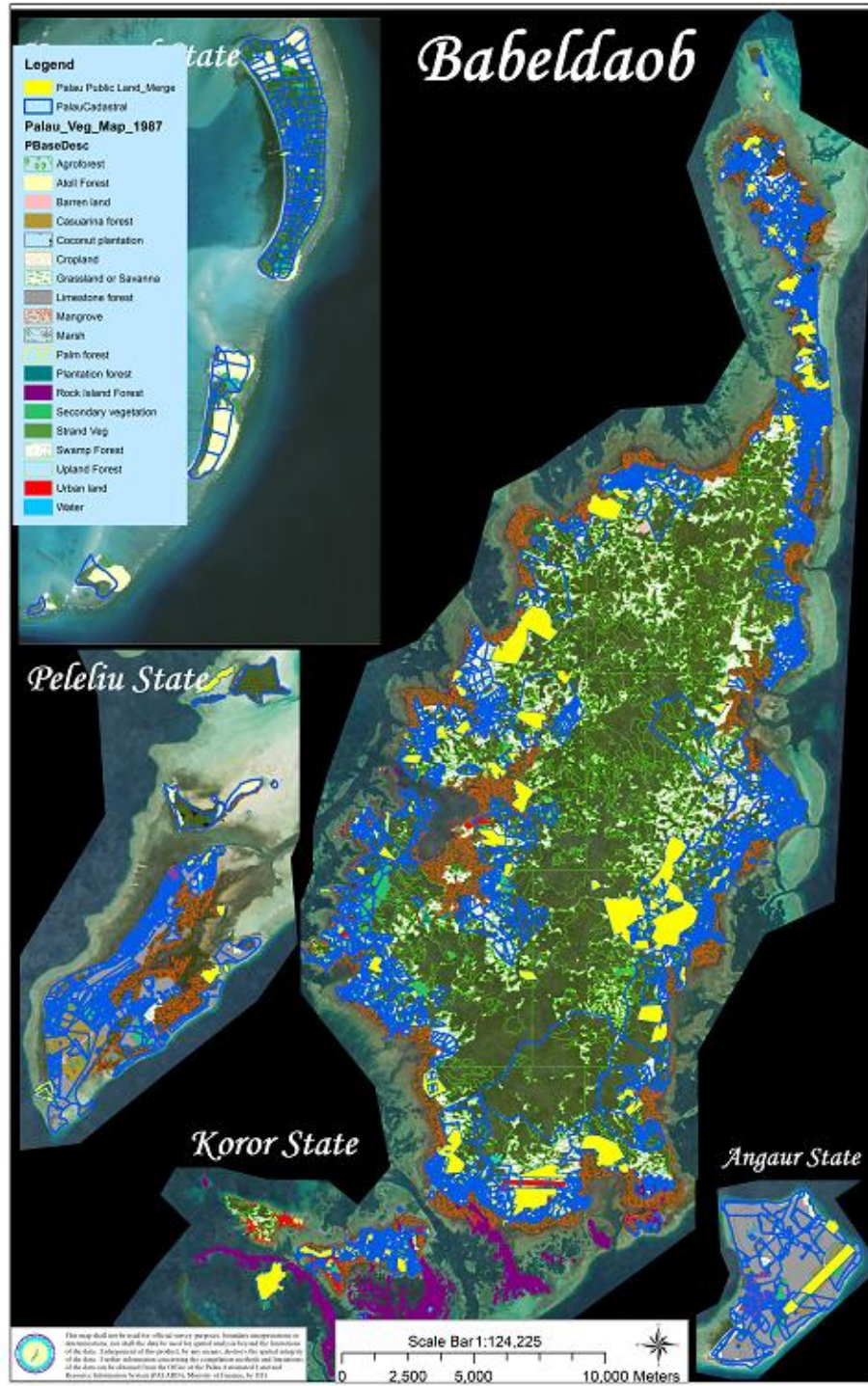


Figure 0.7 Cadastral Lots (outlined in blue), public lands (solid yellow), remainder is unsurveyed land, not outlined, and remains to be determined as either private or public lands. PALARIS.

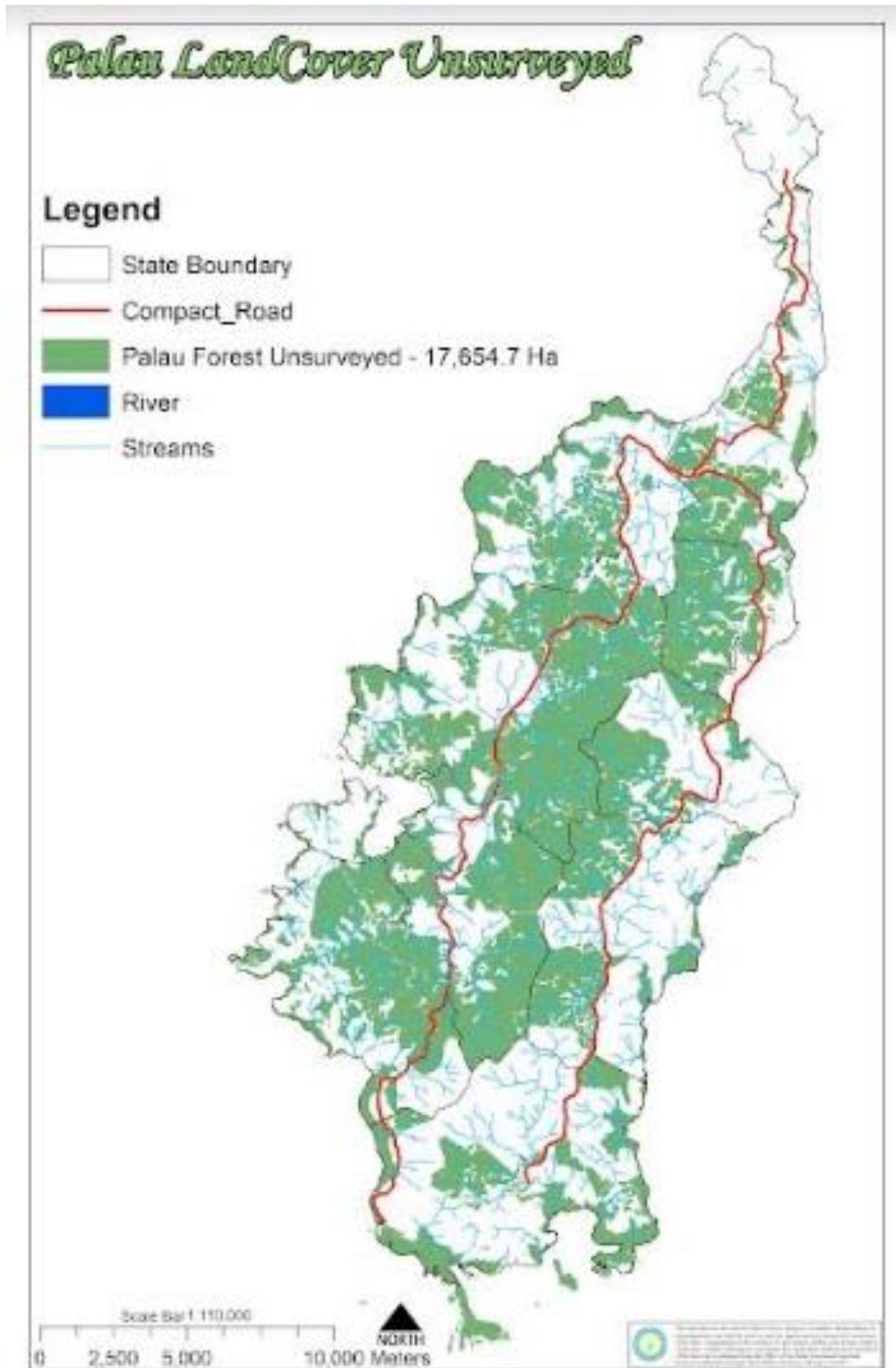


Figure 0.8 Map of Babeldaob showing the forest not yet surveyed or determined as either private or public land.

Table 0.3. Land ownership for agroforests and farms based upon the 2015 Agricultural Census

| State | LAND OWNERSHIP TYPE | | | |
|-----------------------|---------------------|-------|---------|-----|
| | CLAN | LEASE | PRIVATE | N/A |
| Kayangel | 0 | 0 | 9 | 0 |
| Ngerchelong | 0 | 0 | 42 | 0 |
| Ngaraard | 0 | 4 | 29 | 0 |
| Ngiwal | 0 | 0 | 11 | 3 |
| Melekeok | 0 | 1 | 6 | 1 |
| Ngesarch/ Ngchesar | 0 | 0 | 11 | 0 |
| Airai | 0 | 3 | 15 | 0 |
| Ngardmau | 2 | 2 | 6 | 0 |
| Ngeremlengui | 1 | 9 | 20 | 0 |
| Ngatpang | 0 | 4 | 17 | 0 |
| Aimeliik | 0 | 4 | 16 | 0 |
| Koror | 0 | 1 | 9 | 1 |
| Peleliu | 0 | 0 | 2 | 0 |
| Angaur | 0 | 0 | 4 | 0 |
| Sonsorol | 0 | 0 | 0 | 0 |
| Hatohobei | 0 | 0 | 5 | 0 |
| Total | 3 | 28 | 202 | 5 |

Populations and Demographics

The population of Palau is estimated at 17,661 in 2015 with a 0.9% increase compared to 2012. Refer to Table 0.4. An estimated 78.7% of the population lives in urban areas and 21.3% live in rural areas. There was a small increase in the population living in the rural areas compared to the urban areas between 2012 and 2015. Refer to Table 0.5. The population density was 109 people/mile² (42 people/km²) in 2015. Refer to Table 0.6. The largest population (66%) and density (202/km²) is in Koror State. Changes in population distribution shows increased populations in Hatohobei (150%), Ngiwal (24.8%), Aimeliik (18.9%), Ngeremlengui (13.3%), Ngerchelong (12.5%), Ngatpang (9.7%), Ngchesar (1.4%), Koror (0.8%). The increase in Ngiwal and Aimeliik may be the result of new housing projects in these states. A decrease in population size was found in Kayangel (-28.9%), Ngaraard (-8.8%), Angaur (-8.5%), Melekeok (-7.4%), Ngardmau (-5.1%), Airai (-3.2%) and Peleliu (-1.0%). The decrease in Kayangel may be the result of the impact of Super typhoon Haiyan in 2013. The decrease in Angaur and Ngaraard may be the result of Super typhoon Bopha.

Table 0.4. Population by State: 1995, 2000, 2005, 2012 Mini Census and 2015 Census

| State of Residence | Population | | | | | Change 2015/2012 |
|--------------------|---------------|---------------|---------------|---------------|---------------|---------------------|
| | 1995 | 2000 | 2005 | 2012 | 2015 | |
| Total | 17,225 | 19,129 | 19,907 | 17,501 | 17,661 | 0.9% |
| Aimeliik | 419 | 272 | 270 | 281 | 334 | 18.9% |
| Airai | 1,481 | 2,104 | 2,723 | 2,537 | 2,455 | -3.2% |
| Angaur | 193 | 188 | 320 | 130 | 119 | -8.5% |
| Hatohobei | 51 | 23 | 44 | 10 | 25 | 150.0% |
| Kayangel | 124 | 138 | 188 | 76 | 54 | -28.9% |
| Koror | 12,299 | 13,303 | 12,676 | 11,665 | 11,754 | 0.8% |
| Melekeok | 261 | 239 | 391 | 299 | 277 | -7.4% |
| Ngaraard | 421 | 638 | 581 | 453 | 413 | -8.8% |
| Ngardmau | 162 | 221 | 166 | 195 | 185 | -5.1% |
| Ngaremlengui | 281 | 367 | 317 | 309 | 350 | 13.3% |
| Ngatpang | 221 | 280 | 464 | 257 | 282 | 9.7% |
| Ngchesar | 228 | 267 | 254 | 287 | 291 | 1.4% |
| Ngerchelong | 253 | 286 | 488 | 281 | 316 | 12.5% |
| Ngiwal | 176 | 193 | 223 | 226 | 282 | 24.8% |
| Peleliu | 575 | 571 | 702 | 489 | 484 | -1.0% |
| Sonsorol | 80 | 39 | 100 | 6 | 40 | 566.7% |

Source: 1995, 2000, 2005 Census, 2012 Mini Census & 2015 Census

Table 0.5. Population and Growth Rate: 1995, 2000, 2005 Census; 2012 Mini Census and 2015 Census

| Census/ Survey Year | Population | Average Annual Growth Rate (%) | Urban Population | | Rural Population | |
|------------------------|------------|--------------------------------------|------------------|---------|------------------|---------|
| | | | Number | Percent | Number | Percent |
| 1995 | 17,225 | 2.60 | 12,299 | 71.4 | 4,926 | 28.6 |
| 2000 | 19,129 | 2.10 | 13,303 | 69.5 | 5,826 | 30.5 |
| 2005 | 19,907 | 0.80 | 15,399 | 77.4 | 4,508 | 22.6 |
| 2012 | 17,501 | -0.41 | 14,202 | 81.1 | 3,299 | 18.9 |
| 2015 | 17,661 | 0.03 | 13,899 | 78.7 | 3,762 | 21.3 |

Sources: Census Reports: 1995, 2000, 2005, 2012 Mini Census & 2015 Census, Republic of Palau

Table 0.6. Land Area and Population Density by State of Residence: 2015

| State of Residence | Land Area* | | Population Density | | |
|--------------------|---------------|------------|--------------------|--------------|-------------|
| | Sq. Mi. | Sq. Km. | Population | Per Sq. Mi. | Per Sq. Km |
| Total | 161.94 | 416 | 17,661 | 109.1 | 42.5 |
| Aimeliik | 14 | 37 | 334 | 23.9 | 9.0 |
| Airai | 19 | 49 | 2,455 | 129.2 | 50.1 |
| Angaur | 3 | 8 | 119 | 39.7 | 14.9 |
| Hatohobei | 0.3 | 0.7 | 25 | 25.0 | 25.0 |
| Kayangel | 0.7 | 1.7 | 54 | 54.0 | 31.0 |
| Koror* | 22 | 58 | 11,754 | 534.3 | 202.7 |
| Melekeok | 10 | 25 | 277 | 27.7 | 11.1 |
| Ngaraard | 11 | 29 | 413 | 37.5 | 14.2 |
| Ngardmau | 12 | 30 | 185 | 15.4 | 6.2 |
| Ngaremlengui | 24 | 61 | 350 | 14.6 | 5.7 |
| Ngatpang | 14 | 35 | 282 | 20.1 | 8.1 |
| Ngchesar | 15 | 38 | 291 | 19.4 | 7.7 |
| Ngarchelong | 3 | 8 | 316 | 105.3 | 39.5 |
| Ngiwal | 6 | 16 | 282 | 47.0 | 17.6 |
| Peleliu | 7 | 17 | 484 | 69.1 | 28.5 |
| Sonsorol | 1 | 3 | 40 | 40.0 | 13.3 |

Source: 2015 Census, Republic of Palau

The trend towards a decrease in population in both urban and rural areas for both males and females. Refer to Table 0.7. This decreasing trend is found in population density and the average population growth rate. The median age increased, and the average household size decreased. The number of females and males increased from 1980 to 2015, with more males than females in the population. Refer to Table 0.8.

Table 0.7. Population Statistics from 1986-2015. Source: Office of Planning and Statistics

| Census Years | 1986 | 1990 | 1995 | 2000 | 2005 | 2015 |
|--------------------------------|--------|--------|--------|--------|--------|--------|
| Total Population ^a | 13,873 | 15,122 | 17,225 | 19,129 | 19,907 | 17,930 |
| Urban | 9,442 | 10,501 | 12,299 | 13,303 | 15,399 | 14,209 |
| Rural | 4,431 | 4,621 | 4,926 | 5,826 | 4,508 | 3,452 |
| Male | 7,398 | 8,139 | 9,213 | 10,450 | 10,699 | 9,433 |
| Female | 6,475 | 6,983 | 8,012 | 8,679 | 9,208 | 8,228 |
| Population Density (per sq mi) | n/a | n/a | n/a | 112 | 116 | 109 |
| Average Growth Rate | 2.3 | 2.2 | 2.6 | 2.1 | 0.8 | 0.03 |
| Median Age | 22.0 | 25.6 | 28.1 | 30.8 | 32.3 | 35.9 |
| Average Household size | n/a | 5.01 | 4.86 | 4.63 | 3.86 | 3.4 |

Table 0.8 Census years of population: Total population by sex: 1980-2005. Source: Office of Planning and Statistics

| Year | Total | Male | Female |
|------|--------|--------|--------|
| 1980 | 12,116 | 6,279 | 5,837 |
| 1986 | 13,873 | 7,398 | 6,475 |
| 1990 | 15,122 | 8,139 | 6,983 |
| 1995 | 17,225 | 9,213 | 8,012 |
| 2000 | 19,129 | 10,229 | 9,028 |
| 2005 | 19,907 | 10,699 | 9,208 |
| 2015 | 17,661 | 9,433 | 8,228 |

Palau Visitors

The number of visitors peaked at 168,770 in 2015 and dropped in 2020 due to global COVID-19 pandemic (<https://www.palau.gov.pw/visitor-arrivals/>). Refer to Table 0.9 and Figure 0.9. Palau began implementing border controls early. The President issued an executive order suspending all charter flights from China, Macau, and Hong Kong in February 2020. By March 2020, the country's borders were

closed. In April 2020, schools were closed, and travel suspended to Palau. An executive order quarantined all non-citizens who recently entered Palau for fourteen days. In April 2021, Palau and Taiwan established a "travel bubble", allowing people to travel between the two countries, with restrictions. Palau registered its first case of COVID-19 on 31 May 2021. The majority of the population were vaccinated against SARS-CoV-2. The visitors were mainly from Japan and China. Refer to Table 0.10 and Figure 0.10.

Table 0.9 Visitor arrivals 2008-2020. Source: Palau Visitors Authority

| Month | Calendar Year | | | | | | |
|--------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Total | 108,250 | 140,450 | 163,905 | 138,426 | 122,566 | 106,309 | 94,051 |
| January | 10,161 | 10,933 | 14,881 | 14,182 | 11,654 | 10,465 | 7,359 |
| February | 10,931 | 11,125 | 17,742 | 14,137 | 10,025 | 12,418 | 9,776 |
| March | 10,621 | 10,959 | 14,961 | 12,248 | 8,886 | 11,024 | 9,067 |
| April | 7,394 | 8,875 | 12,844 | 10,665 | 9,882 | 10,337 | 8,439 |
| May | 6,204 | 8,690 | 12,704 | 9,603 | 9,016 | 7,651 | 7,502 |
| June | 7,018 | 10,488 | 12,840 | 11,381 | 10,105 | 8,176 | 6,107 |
| July | 9,384 | 12,331 | 12,838 | 12,494 | 12,291 | 9,009 | 7,084 |
| August | 10,506 | 13,880 | 15,576 | 13,285 | 13,153 | 11,091 | 8,544 |
| September | 9,501 | 11,863 | 13,072 | 12,187 | 8,794 | 7,033 | 6,733 |
| October | 8,493 | 11,843 | 12,445 | 8,988 | 9,622 | 6,217 | 6,196 |
| November | 8,057 | 14,020 | 11,423 | 9,384 | 9,377 | 5,905 | 7,983 |
| December | 9,980 | 15,443 | 12,579 | 9,872 | 9,761 | 6,983 | 9,261 |

Source: Palau Visitors Authority and Bureau of Immigration and Labor, Ministry of Justice, ROP

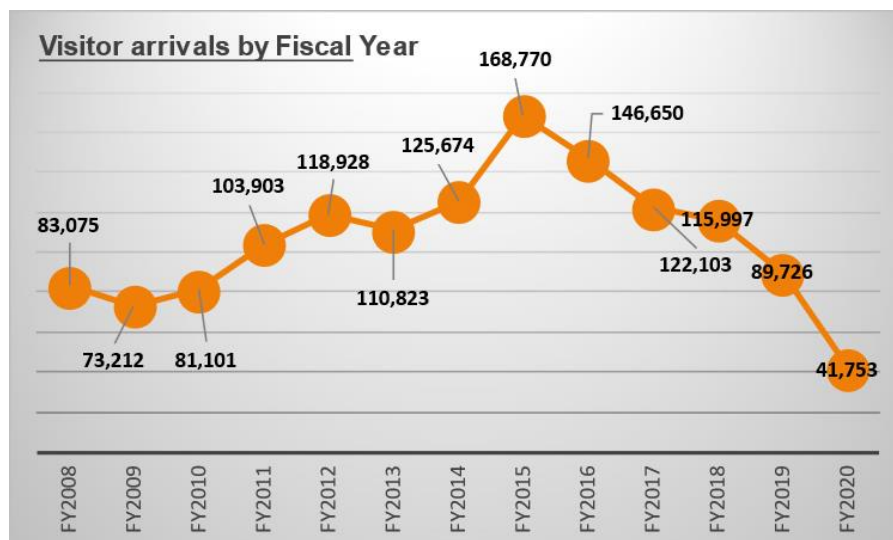


Figure 9. Visitor arrivals 2008-2020. Source: Palau Visitors Authority

Table 0.10. Visitor arrivals by Country Group FY2008 to FY2020

| Country Group | FY2008 | FY2009 | FY2010 | FY2011 | FY2012 | FY2013 | FY2014 | FY2015 | FY2016 | FY2017 | FY2018 | FY2019 | FY2020 |
|---------------|---------------|---------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------|---------------|
| JAPAN | 29,586 | 29,350 | 28,046 | 37,759 | 38,428 | 36,474 | 38,200 | 31,786 | 30,585 | 25,829 | 24,437 | 19,637 | 10,647 |
| SOUTH KOREA | 14,534 | 14,556 | 14,104 | 14,826 | 18,675 | 18,501 | 15,834 | 12,453 | 12,529 | 13,472 | 12,872 | 11,569 | 6,227 |
| TAIWAN | 22,785 | 14,569 | 22,209 | 32,682 | 40,645 | 28,171 | 31,175 | 15,258 | 15,501 | 9,493 | 11,354 | 14,065 | 6,279 |
| CHINA | 634 | 651 | 956 | 1,656 | 3,715 | 9,357 | 21,706 | 91,174 | 70,741 | 55,491 | 50,211 | 28,504 | 9,761 |
| USA/CANADA | 7,800 | 7,001 | 7,560 | 8,439 | 8,308 | 8,432 | 8,630 | 8,856 | 8,499 | 8,532 | 8,426 | 7,832 | 4,015 |
| EUROPE | 3,946 | 3,519 | 3,819 | 4,297 | 5,092 | 5,507 | 5,390 | 4,653 | 4,293 | 5,005 | 4,486 | 3,786 | 2,541 |
| OTHERS | 3,790 | 3,566 | 4,407 | 4,244 | 4,065 | 4,381 | 4,739 | 4,589 | 4,502 | 4,281 | 4,211 | 4,333 | 2,283 |
| Total | 83,075 | 73,212 | 81,101 | 103,903 | 118,928 | 110,823 | 125,674 | 168,770 | 146,650 | 122,103 | 115,997 | 89,726 | 41,753 |

Source: Bureau of Immigration, MOJ, Palau Visitors Authority, and Bureau of Budget and Planning, MOF

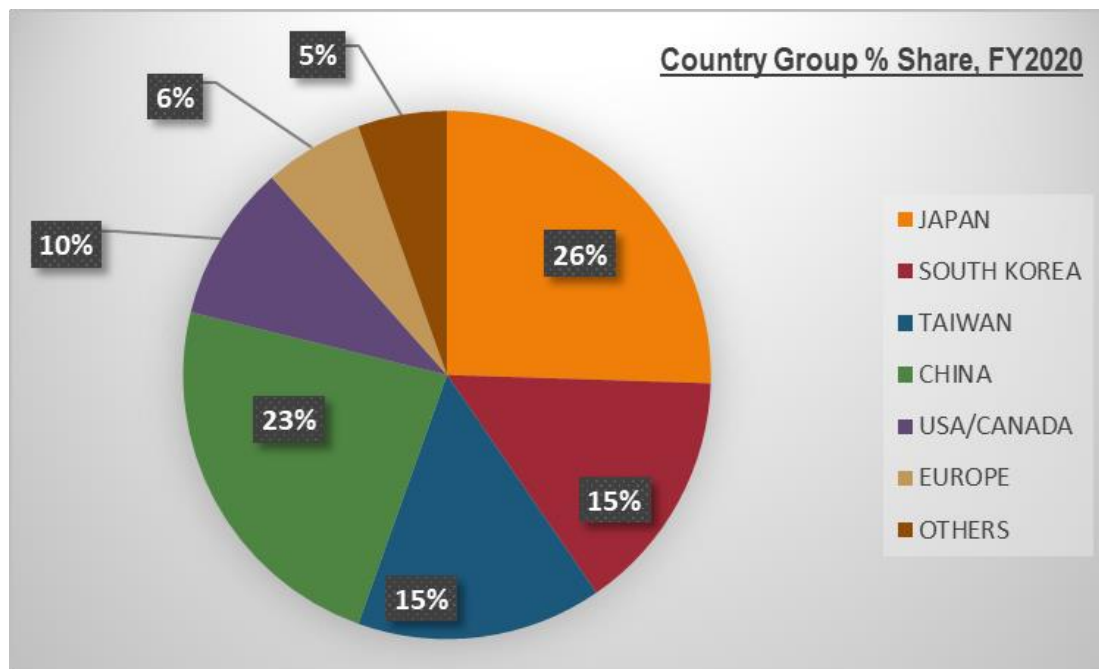


Figure 0.10 Visitors Entries by Country of Residence CY 2013 to 2019

Climate

Palau has a tropical wet climate. It has a complex pattern of monthly rainfall with the highest average rainfall in the months of June and July and the lowest average rainfall in the months of February, March, and April. A secondary rainfall minimum occurs in August and September when the monsoon trough and typhoon tracks move north causing a lowering of rainfall. The average annual rainfall ranges from 3 to 4 m with a mean of 3.7 m per year. The dry period occurs from January to April and a wet period is from June to August. The humidity ranges between 75 to 85%. Aimeliik State is considered the wettest State in Palau. The mean air temperature is 27°C and the maximum diurnal and seasonal variation is 5.5°C. Refer to Figures 0.11-0.14 and Table 0.11.

The large-scale near-surface water circulation is a westward-flowing North Equatorial to the North of Palau and an eastward flowing Equatorial Countercurrent to the South of Palau. Palau is located in a recirculation zone. Palau has prevailing northeast trade winds from November to May and a southwest wind from June to October. The wind field around Palau varies with the topography of the land. Weak east trade winds prevail from December to April changing to southwest trade winds from May to October (Wolanski & Furukawa 2007).

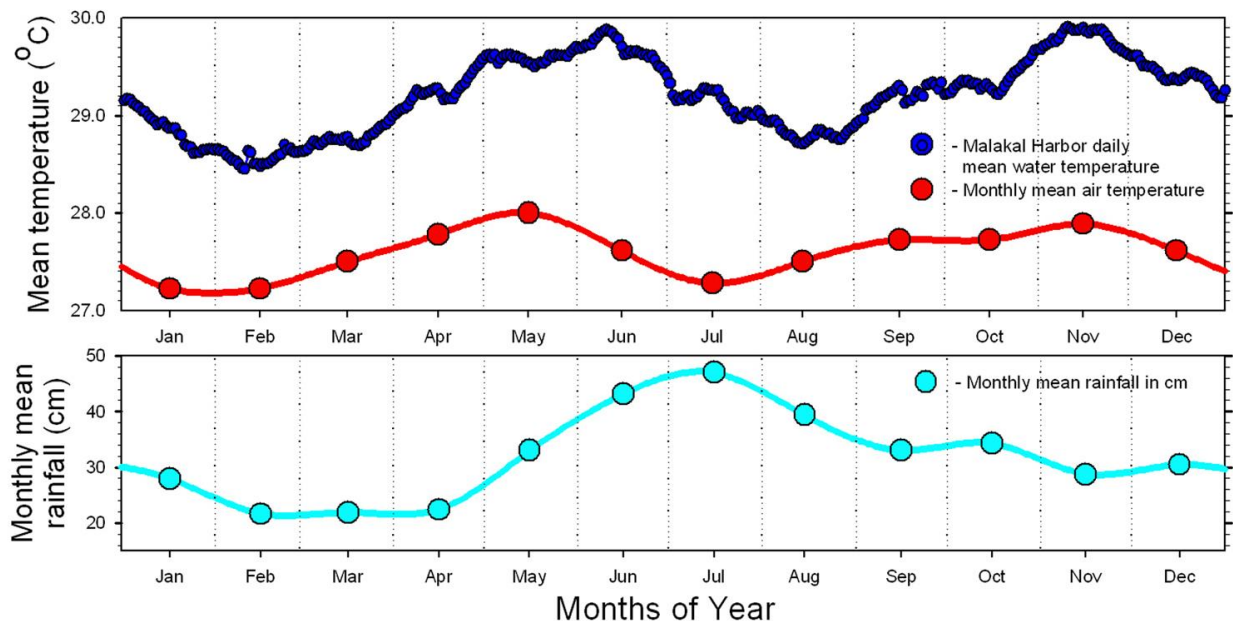


Figure 0.11 Upper graph: The annual mean air (red) and lagoon water (blue) temperatures for the island of Koror follow the same pattern. The air temperature varies only about 1°C over the course of the year while the water temperature varies about 1.5°C. Both values show decreases in the middle of summer, probably due to higher cloud cover and westerly winds during the summer monsoon. The highest temperatures occur during the late spring (May–June) and late fall (November). Lower graph: The average monthly rainfall for Koror, based on records from 1926 to 1988, is lowest during February–April and highest during July (modified from Lundgren 2002). Figure from Marine Environments of Palau, courtesy Coral Reef Research Foundation (CRRF).

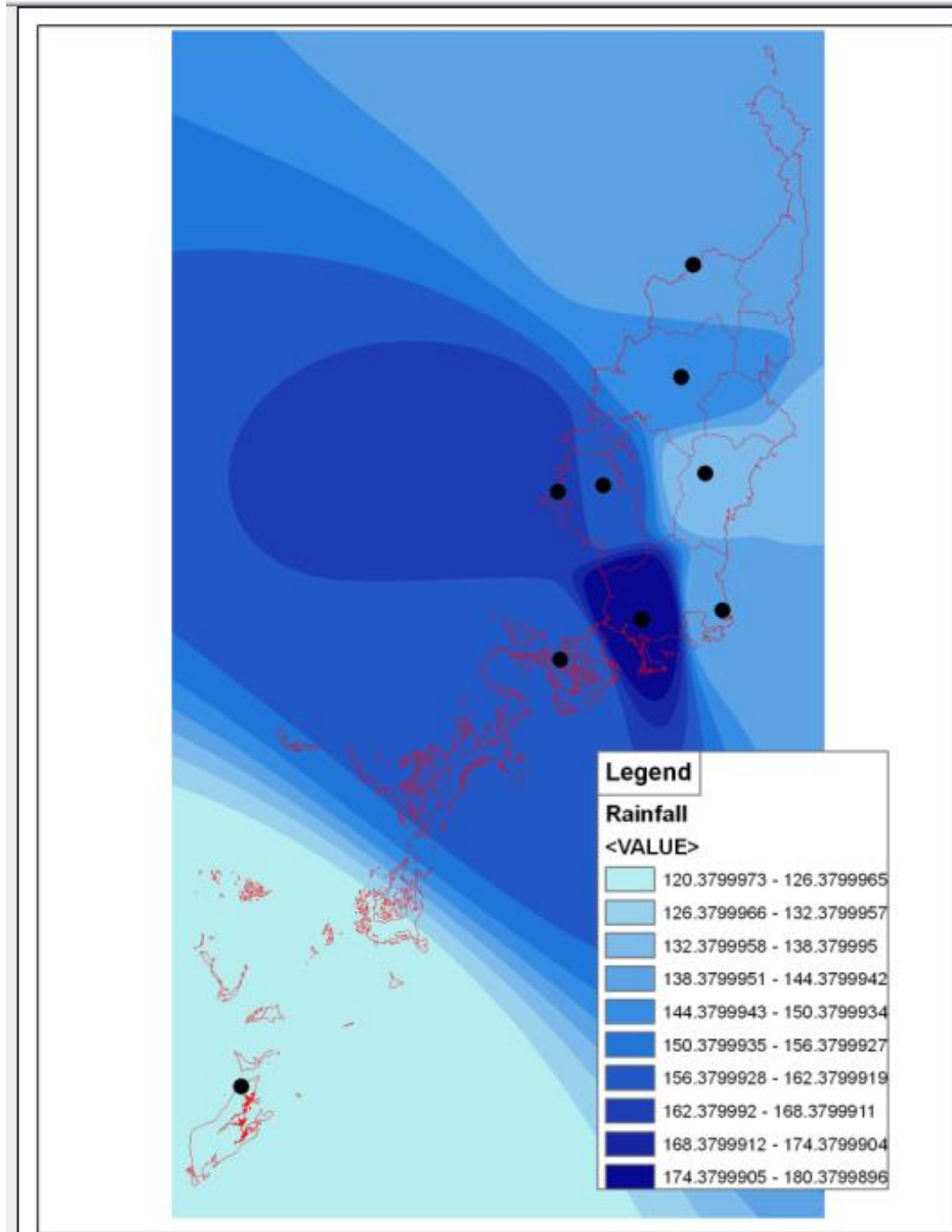


Figure 0.12 Annual Precipitation Map for Palau (inches/year) showing location of rain gages as black dots. Source: Palau Automated Land & Resources Information Systems (PALARIS) 2009

Table 0.11. Yearly average temperature, total rainfall & mean monthly rainfall . Source: Palau National Weather Service

| Climatic Conditions | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|-----------------------------------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|------|--------|--------|
| Mean Temperature | 82.1 | 82.6 | 82.1 | 82.1 | 82.8 | 83.2 | 82.7 | 83.2 | 82.6 | 82.9 | | | |
| Total Rainfall (inches) | 150.5 | 114.4 | 171.9 | 161.4 | 168.5 | 130.8 | 177.25 | 125.05 | 166.75 | 157.03 | n/a | 172.14 | 107.82 |
| Average monthly Rainfall (inches) | 12.5 | 9.5 | 14.3 | 13.5 | 14.0 | 10.9 | 14.8 | 10.42 | 13.90 | 13.09 | 8.66 | 10.55 | 10.43 |

Table 0.11. Yearly average temperature, total rainfall & mean monthly rainfall continued

| Climatic Conditions | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|-----------------------------------|--------|-------|-------|-------|-------|------|-------|-------|-------|-------|------|
| Mean Temperature | | | 82.2 | 82.4 | 82.5 | 83.2 | 82.9 | 83.0 | 82.8 | 81.0 | |
| Total Rainfall (inches) | 107.82 | 209.4 | 134.8 | 114.8 | 139.3 | 96.5 | 109.0 | 176.8 | 121.4 | 127.2 | |
| Average monthly Rainfall (inches) | 10.75 | 11.38 | 11.23 | 9.57 | 11.61 | 8.05 | 9.08 | 14.73 | 10.11 | 10.6 | |

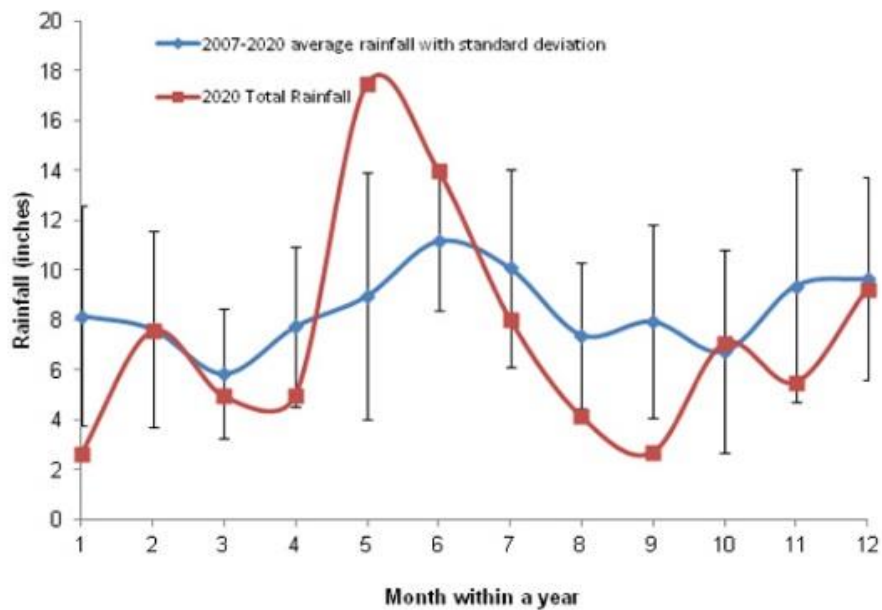


Figure 0.13 The average rainfall data between 2007 and 2020 and the total rainfall for 2020. This weather data was collected by Coral Reef Research Foundation (CRRF) at Ngeanges Island, Koror.

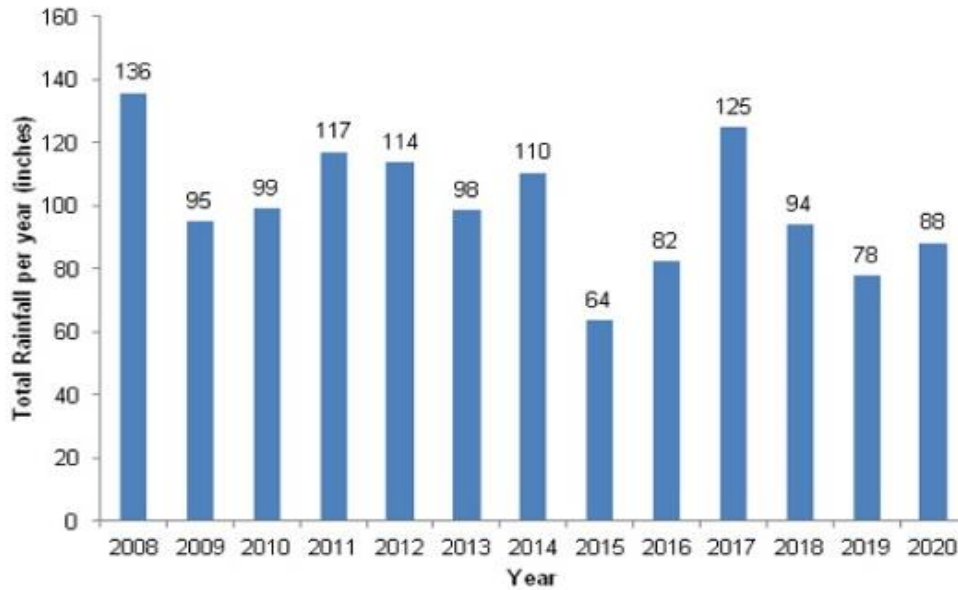


Figure 0.14. Total Annual Rainfall Data for 2008 to 2020 collected by CRRF

Sea Level Rise

The University of Hawaii Level Center has a tidal gauge at Malakal Harbor. The Coral Reef Research Foundation website (<https://coralreefpalau.org/research/oceanographyweather/ocean-observations>) shows a map depicting the trend in Palau’s mean sea level (MSL) variation between 1969 and 2016. The greatest variation was associated with El Niño and La Niña events. During this 46-year period, the mean sea level increased 2.3 mm/year. During short term periods (1-2 years) the mean sea level is more variable. During 1992 to 2010, Palau’s sea level rose at a rate of 9 mm/yr, based on satellite sea surface less than 3 mm/year which was consistent with worldwide sea level rise rates.

Review of Republic of Palau Natural Resource Policies and Plans

Plans and Publications Incorporated in the 2021-2030 Statewide Assessment and Strategy

- 1997 Division of Fish and Wildlife (DFW) National Wildlife Action Plan
Issue 7: Urban Forest Sustainability is addressed in the (DFW) Plan for capacity building in sustainable economic activities. The DFW Plan stated how the laws and policies affecting wildlife conservation and management need to be coordinated with the activities undertaken by EQPB: to protect Palau's fresh and marine waters related to Issue 3: Water Quality and Supplies. The DFW Plan addressed information gaps related to the life history of endangered species, botanical and florist research, forest ecology, and the role of fruit bats and frugivorous birds in the pollination and dispersal of fruiting trees. The DFW Strategic Plan had similar goals, objectives, proposed activities, and driving issues as Forest Health, Urban and Community Forest, Forest Stewardship, Conservation and Education Program and Forest Legacy Programs. The work plans were related to Issue 5 Conservation and Protected Areas and overlapped with the strategies of the Bureau of Agriculture (BOA), the Belau National Museum (BNM), the Palau Conservation Society (PCS), and The Nature Conservancy (TNC).
- The BoA Palau's National Invasive Species and Biosecurity Strategic Action Plan (NISSAP) 2018-2022 were incorporated into Issue 5: Conservation and Protected Areas and Issue 4 on Wildfire Prevention. The Bureau of Agriculture Nekken Agriculture Station Plan was the key document used for Issue 6: Sustainable Use of Forests Resources.
- The Five Year Urban and Community Forestry Plan 2009-2014 was the key document used for Issue 7: Urban Forest Sustainability.
- The Republic of Palau 2020 Wildfire Action Plan and 2020 Network for Wildfire Prevention Dry Season Response Action Plan was the key documents used for Issue 4: Wildfire Prevention.
- The EQPB Ngerikiil Integrated Watershed Management Demonstration Project and Babeldaob Watershed Alliance Plan 2018-2022 were key documents used for the Issue 3: Water Quality and Quantity and Issue 2: Population Growth and Urbanization.
- The Republic of Palau Revised National Biodiversity Strategy and Action Plan (NBSAP) 2015-2025 was incorporated into Issue 5: Conservation and Protection
- The Ngardok Nature Reserve Management Plan 2010-2014, was incorporated into Issue 2: Population Growth and Issue 5: Conservation and Protection
- The 2015 Palau Climate Change Policy (PCCP) was a key document used for Issue 1: Climate Change.
- The Belau National Museum Natural History Section Program was incorporated into Issue 5 Conservation and Protection, Issue 3 Water Quality, and Issue 7 Urban Forest Sustainability.
- The Rock Island Southern Lagoon Management Plan 2012 to 2016 was incorporated into Issue 5: Conservation and Protection
- 2020 National Master Development Plan (NMDP) 1996 was incorporated into all issues.

Visions and Goals of National Policies

The 2012 Sustainable Land Management Policy (SLM), the 2018 Sustainable Forest Management Policy (SFMP), the Bureau of Agriculture Strategic Plan (BASP) 2019 to 2025, and the 2019 State of the Environment Report were incorporated for all 7 issues. The 2019 Beijing Declaration and Platform for Action, the 2018 Gender Mainstreaming Policy, The Republic of Palau Non-communicable Disease Prevention and Control Strategic Plan of Action 2015-2020 were reviewed.

Ministry of Agriculture, Fisheries and Environment (MAFE)

Ministry of Agriculture, Fisheries Strategic Plan 2021-2024

Vision: The Ministry envisions a Palau where sustainable food production and wise stewardship of our marine and terrestrial resources enhances the wellbeing and economic livelihoods of all.

Mission: Provide clear direction and leadership in natural resource management that optimizes benefits to people, economy, and environment.

Bureau of Agriculture Strategic Plan (BoASP) 2019-2025

Vision: “A healthy and productive Nation in Harmony with the environment where all families have the skills, resources, and opportunity to ensure wise stewardship of natural resources and systems and sustained food production.”

Forestry Division Goal: To Develop a National Forest Monitoring Program with the collaboration of the national government, state government and NGOs.

Sustainable Forest Management Policy (SFMP) 2018

Vision: “A Palau enriched by healthy forests that sustain our culture & livelihoods, expand our economy & strengthen the resilience of our island ecosystems & communities.”

Goal: To support forest resource management & forest related biodiversity conservation, so that forest ecosystem services contribute towards the country’s sustainable development. It aims to inform the development & implementation of strategies that reduce pressures on forest resources & enhance forest ecosystem provisioning capacities.

Guiding Principles

- Palau’s forest ecosystems play a vital role in maintaining island ecological processes is recognized & valued
- Owners of forest resources have the right to use, manage & develop these resources and ensure that their activities do not cause harm to the environments & downstream ecosystems
- Forest resources are important to our environmental, social & economic wellbeing & need protection from the harmful effects of pollution, fires, invasive species, and unsustainable development
- State governments maintain & increase forest cover with national, technical, and financial support (Palau PAN & other funding mechanisms)
- Effective Sustainable Forest Management requires timely, reliable & accurate information. The Forestry Unit assists States to conduct baseline assessments & regular monitoring to determine forest trends to aid in management
- Generate sustainable economic benefits from forest landscapes, species & related products, through tourism, timber production, and cultural uses.

Forestry Section 2010 Republic of Palau Statewide Assessment of Forest Resources and Resource Strategy (SWARS)

The 2010 SWARS was a comprehensive analysis of forest-related conditions, trends, threats, and opportunities. The 2010 SWARS was the foundation from which the 2021-2030 FAP is built upon. The priority goals for the 2021-2030 Forest Stewardship program are the same as the 2010 goals such as (1) enhance & organize planting of trees, (2) foster self-reliant communities, and (3) develop forest-based sources of livelihood among others.

The Republic of Palau Revised National Biodiversity Strategy and Action Plan (NBSAP) 2015-2025

Policy Statement: Biodiversity is a key component of the natural history, culture, and economy of Palau. Loss of biodiversity threatens ecosystems and the services they provide, the underpinnings of Palauan culture, and the future food security and economic stability in Palau. The aim of this Revised National Biodiversity Strategy and Action Plan is to encourage, guide and coordinate an integrated national process that will engage stakeholders across sectors to achieve the holistic conservation and sustainable use of biodiversity while protecting and enhancing economic opportunity, sustainability of livelihoods, food security, culture, and the environment for present and future generations.

Vision: By 2020 all implementing partners will have in place the requisite human resources and institutional capacities to ensure at least a minimum level of NBSAP policy implementation in support of the conservation and sustainable use of biological diversity, while also taking into account the necessity of sustainable socioeconomic development. The NBSAP Goal and objectives related to forestry and agriculture are as follows: **Goal:** To conserve and sustainably manage Palau's agro-biodiversity for the benefit of present and future generations **Objective:** (1) Develop a comprehensive inventory of Palau's agro-biodiversity to identify and prioritize species and varietal importance; (2) Sustainably manage and conserve Palau's agro-biodiversity. **Goal:** Establish an enabling framework to support sustainable biodiversity use and biodiversity-based livelihoods. **Impact Objectives:** Establish guidelines and standards (1) to ensure sustainable tourism actions at the national and state levels (2) to ensure sustainable agriculture and forestry development and management and (3) for the sustainable utilization of terrestrial wildlife and plants.

Ministry of Finance

Climate Change Policy 2015

Vision: Happy, healthy sustainable and resilient Palauan communities in a changing world. The objectives for the policy are as follows: Enhance adaptation and resilience to the expected impacts of global climate change across all sectors, • Improve Palau's ability to manage unexpected disasters and minimize disaster risk, and • Mitigate global climate change by working towards low carbon emission development, maximizing energy efficiency, protecting carbon sinks, and minimizing greenhouse gas emissions.

The Guiding Principles for the Palau Climate Change Policy: • Establish a "No Regrets" approach to national development priorities. "No Regrets" is defined as an approach that achieves benefits under all possible future climate change and disaster scenarios, including both low emission and high emission (e.g. low impact and high impact) cases and worst case disaster scenarios; • Subscribes to the IPCC definition of climate change, which refers to any change in climate over time, whether due to natural variability or as a result of human activity; • Clarifies and links the roles, powers, duties, functions, and responsibilities of stakeholders within national and state governments, the private sector, civil society, communities, and Traditional Leadership; • Guides national budgeting and fiscal year spending, informs sector (including private stakeholder) spending priorities, and facilitates domestic and international fundraising.

Sustainable Land Management (SLM) Policy 2012

Vision: Sustainable Land Management (SLM) is the wise management of natural and cultural resources to meet changing human needs and benefit the people of Palau while protecting the long-term productive potential and cultural value of these resources for future generations.

Top priorities: (1) Nationwide Coordination; (2) Development Guidelines; and (3) Sustainably Financed Agencies.

Key issues identified by the States were as follows: (1) Prioritization of good agricultural lands for local food production; (2) Protection of water sources; (3) Development and maintenance of wastewater and solid waste management systems; (4) Protection and maintenance of historic and cultural sites; (5) Access to adequate housing, local community commercial centers, parks & recreation, infrastructure, public services, and facilities; (6) Strategic planning and zoning for adaption to and mitigation of the impacts of Climate Change; and (7) Implementation of existing Best Management Practices for National and State Land Use and Master Planning

Ministry of Justice Division of Maritime Security & Fish and Wildlife Protection

The Division of Fish and Wildlife (Division MTS & FWP) 2019 -2022 Work Plan

Vision: To maintain the continuation of our marine and terrestrial species.

Mission: Enforce law and protect our marine and terrestrial species, which includes Endangered and Invasive Species.

Functions:

- Enforcing laws relating to the protection of identified plants and animals including those listed in the Endangered Species Act;
- Resources intelligence gathering;
- Close off shore SAR;
- Disaster Management;
- Implement Title 24 of the PNC relating to protection of sea and land life, illegal method of capture, and wildlife and natural heritage preserves;
- Enforce Title 27 of the PNC within the internal waters and near shore water; and
- Coordinate its activities with Marine Law, Bureau of Public Safety and other national and state government and non-government agencies and entities involved in the protection and preservation of all protected life form within Palau

2020 Wildfire Action Plan (WAP)

Vision: To extinguish fires safely and effectively when needed, use fire hoses where allowable, and manage our natural resources.

Goals: 1. Restore and maintain landscapes: Palau forest covers 75% of the land area which covers mangrove, volcanic, swamp, limestone, coastal, plantations, urban and agro forests. Landscapes across all jurisdictions are resilient to fire related disturbances only if actions and management objectives and plans are implemented. 2. Community Outreach Programs: Human population and infrastructure is growing fast; Firefighters are reaching out to the community and schools doing fire drills and raising awareness on how to suppress and/or what to do in case of fire emergencies. 3. Establish a community-based map: for the purpose of identifying wildfires that are happening at the moment for future research and reports. 4. Convene Decision Makers: To create a memorandum of

understanding between the Division of Fire and Rescue and the 16 states of Palau to allow state rangers and conservation officers to help suppress wildfire

The DFR implements its WAP through partnerships. The DFR partners with Ministry of Education (MOE) to educate the public about fire safety. The DFR partners with Environmental Quality Protection Board (EQPB) to educate and inform the public to apply for a burning permit before burning. The DFR partners with the Bureau of Agriculture (BoA) to save landscapes and vegetations. It organizes brief fire prevention & awareness workshops for the private sector with a 30-min PowerPoint presentation. The DFR's aim is to develop fire adapted communities – communities that suppress and reduce threats from fire. The DFR aims to develop and implement standards and protocols that strengthen mobilization capabilities for rapid and effective wildfire response. The DFR's success depends on the commitment of all firefighters, land managers, and our partners at all levels to take action toward meaningful reductions in risk in short and long term. Meaningful reduction in wildfire risk is difficult and requires everyone to prioritize and use available resources, apply for burning permits and always be cautious when burning, and raise awareness by informing other family and or community members about wildfires. With everyone taking precautionary measures, DFR believes that significant progress will be made to improve wildfire management.

Community Wildfire Protection Plans (CWPPs)

(Required to be considered in FAP if they exist) At this time, no CWPP has been completed by the USDA Forest Service definition, but several of the documents listed here are good steps towards developing them. The Ebiil Society has worked in partnership with the Division of Fire and Rescue (DFR) to conduct several community wildfire protection trainings (Chief Jeffery Erich, pers. comm. August 30, 2021). The Network for Wildfire Prevention Dry Season Response Action Plan was developed. The DFR works closely with the PAN officers from each state, as fire is considered a major threat to homes and agroforests and cropland and addressed in the management plans for the PAN terrestrial sites. The Network has successfully reduced the number of wildfires from 112 to 13 and the overall burnt areas from 500 acres to 34 acres (Ann Singeo, pers. comm. August 26, 2021).

2020 Network for Wildfire Prevention Dry Season Response Action Plan

On November 16-17, 2020, a wildfire prevention planning workshop was held to develop a coordinated action plan between Protected Areas Network (PAN) office and site managers/ rangers in Babeldaob, (10 states), Bureau of Agriculture (BoA), Fire Department, Ebiil Society, Palau Environmental Quality Protection Board, and US Forest Service (USFS) providing technical assistance and training. The workshop is primarily intended to assist in preparedness planning that will improve collaborations for wildfire prevention during the upcoming dry season from December to April 2021. Thus, **Network for Wildfire Prevention Dry Season Response Action Plan** successfully implemented to increase education and outreach, public information and advisory on wildfire level of risks, increased targeted monitoring and surveillance, and support during fire suppression to ensure safety of people and animal lives, properties, and effectiveness of fire fighters. The NWPDSRAP Goal is to protect our natural resource and communities from threats of wildfire. The **objectives** were (1) Increase knowledge of wildfire threat to our natural resources; (2) Improve monitoring/ surveillance on Babeldaob during dry season; and (3) Improve coordination for wildfire response. A communication strategy was developed.

The Republic of Palau Wildfire Risk Assessment

The Division of Fire and Rescue (DFR) developed the Republic of Palau Wildfire Risk Assessment (PWRA) to quantify and document the wildfire problem in Palau (Dendy et al. 2020). This assessment

focused on Babeldaob Island. The PWRA was a semi-quantitative assessment that provides baseline information that will allow Palau's fire managers to implement proactive fire management planning.

The objectives were to provide the information necessary to support the following key priorities:

- Identify those areas that are currently most prone to fire
- Identify areas that may require additional tactical planning, specifically related to mitigation projects and community wildfire protection planning
- Provide information needed to support resources, budget & funding request in response to wildfire risk
- Allow agencies to work together to define priorities and improve emergency response, particularly across jurisdictions
- Increase communication between local residents & the public to address community priorities and needs
- Plan and prioritize hazardous fuel treatment programs
- Establish a data repository and a series of software tools to support continued analysis and monitoring of wildfire risk throughout the Republic of Palau

The results of PWRA allow the Republic to identify areas of wildfire risk in a relative manner from low to high, for each community fire response zone and State. This will allow fire managers to prioritize and focus resources and funding efforts in those areas that need it the most. The assessment is currently underway with the development of a database and mapping system and community outreach.

State Wildlife Action Plan (required)

Palau is a sovereign nation in a Compact of Free Association with the U.S. Palau was not required to complete the same Wildlife Action Plan as U.S. domestic states and territories. Other Palau policies and plans relevant to wildlife were considered including the 1997 DFW National Wildlife Action Plan.

1997 Division of Fish and Wildlife (DFW) National Wildlife Action Plan

The 1997 Division of Fish and Wildlife (DFW) National Wildlife Action Plan recommended enforcement, training 4 officers, and a study on ways that traditional and western laws could be more compatible. The DFW Plan recommended better coordination to develop and implement a consistent strategy for the enforcement of regulations regarding the import and export of species to and from Palau. The plan recommended education and outreach, training for officers, educators, and naturalist guides for eco-tourism and sustainable economic activities. Issue 5 on Conservation and Protected Areas assesses commonalities for endangered species of flora and fauna that the Division of Fish and Wildlife monitor and protect and regulations regarding import and export of species. The DFW currently does not have an updated DFW Action Plan and refers to the 1997 DFW plan. The DFW continues to work in partnership with the PAN rangers to build their capacity in enforcement and monitoring, logging information, evidence procedures, report writing, and arrest and monitoring tactics (Lieutenant Brenda Santos, pers. comm. August 31, 2021.)

Ministry of State Gender Office Bureau of Domestic Affairs

The 2019 Beijing Declaration and Platform for Action (BDPA)

The 2019 Beijing Declaration and Platform for Action (BDPA) 2015-2019) review set priorities related to agriculture and forestry as follows: (1) Promotion of local food production to combat noncommunicable diseases (NCDs). (2) Focus on life skills (farming), technical skills, traditional values, and practices. (3) Increase after school and summer programs that teach language, cultural values and practices and value of “Palauan-ness”. (4) Enable entrepreneurs to access finance based on merit and qualification and mobile assets.; (5) Entrepreneurs provided training in accounting and business management; (6) Minimum wage applied to employees in farming; (7) Tax incentives for local food production; (8) Implement Environmental Policies, and land use plans; (9) GIS mapping of natural and cultural resources; (10) Monitor post recovery after disasters; and (11) Interagency disaggregated data harmonization and mapping.

The 2018 Gender Mainstreaming Policy

Policy Statement: Our National government commits to create all necessary conditions to ensure that our polices and services benefit all women and men. The government is taking additional measures to remove barriers to the equality of women and men where they exist and to safeguard their human rights. To achieve our objectives of social economic, and cultural development, well-being, peace, and social justices, we support measures to guarantee that all girls and boys, and women and men have equal rights, equal opportunities, and equal access to services so that they reach their full potential in all areas of life. Palau is committed to promote the equality of women and men through national, regional, and international conventions and instruments, which include Palau’s Constitution, the Revises Pacific Platform for Action on the advancement of Women and Gender Equality Declaration, the Beijing Platform of Action, the Universal Declaration of Human Rights, the Convention on the Rights of the Child, the Millennium Development Goals, and the 2030 Agenda for Sustainable Development.

Ministry of Health and Human Services

Vision: “Healthy communities with access to high quality healthcare services.”

The Republic of Palau Non-communicable Disease Prevention and Control Strategic Plan of Action 2015-2020

Goal: to improve overall nutrition. **Objectives:** Establish a multi-sectoral working group to address overall nutrition improvement by 2015; and increasing fruits and vegetable intake by 50% by 2020
Overnutrition: Overweight and obesity is a serious problem among both children and adults. With almost 38 percent of the adults obese, Palau now ranks #3 on the list of the “world’s most obese countries” behind Nauru and the Cook Islands (World Population Review, 2019).

2020 National Master Development Plan (NMDP) 1996

Vision: To substantially enhance the quality of life of Palauans and future generations of Palauans. **Goals:** (1) Increase real economic growth per capita on a sustained basis; (2) Share the benefits of economic growth on an equitable basis, but in ways that still reward enterprise, risk taking and hard work, and allow foreign workers and investors a genuine stake in development and (3) Enrich and enhance confidence in the Palau culture, raise national consciousness, and protect the national environment of Palau.

Belau National Museum (BNM)

Mission: BNM is a dynamic institution for the preservation and promotion of the national heritage, exhibition of natural, cultural, social, and historical values, and the development of arts at all levels. The Belau National Museum is an institution of learning established to collect, curate, preserve and display objects of scientific, cultural, historical, and aesthetic value. The Museum's purpose is to preserve and protect the nation's cultural heritage through collection, identification, documentation, preservation, interpretation and exhibition of specimens, artifacts, and other Palauan cultural property. The BNM **Objectives** are to Preserve and Promote, Educate and Manage Palau's Cultural and Natural Heritage. The BNM Natural History Section manages the collections of terrestrial plants and insects and serves as a depository for Palau's terrestrial biodiversity. The BNM-NH completed a study on the ethnobotany of important plants in Palau. The Herbarium and Living Collection (Botanical Garden) aim to collect and preserve all of Palau's native plants. Currently the NH Section is working with Ngeremlengui and Koror states to survey two endangered tree species and support the development of management plans for these species. <http://www.belaunationalmuseum.net/>

Koror State

Koror State Rock Island Southern Lagoon Management Plan 2012-2016

Vision: "To maintain the spectacular beauty and the abundant and diverse natural, cultural and historical resources of the Rock Islands Southern Lagoon, so that it can continue to be used and enjoyed by current and future generations of the people of Koror and Palau and remain a central part of our culture and lifestyle, and for the current and future enjoyment of the world."

Five goals to achieve this overarching goal are: (1) Maintain the full range and richness of biological diversity, species habitats, ecological processes, and high environmental quality of the RISL; (2) Subsistence and commercial fishing and other extractive activities in the RISL are environmentally and economically sustainable and culturally compatible, and provide continued benefits to the people of Koror and Palau ; (3) Nurture and sustain Palauan culture by preserving and maintaining the landscapes, artifacts and oral traditions associated with the stonework village sites in the RISL, and preserve Koror's historical sites; (4) High quality tourism and recreational activities in the RISL are environmentally and economically sustainable, culturally compatible and provide benefits to the people of Koror and Palau; and (5) Improve the institutional capacity of Koror State Government to effectively manage the RISL, focusing on strengthening regulatory frameworks, enforcement, and surveillance, and building relationships and communication with key organizations and stakeholders relevant to the implementation of activities

Melekeok State

Ngardok Nature Reserve Management Plan 2010-2014.

Research objectives are:(1) To monitor trends. (2) To assess the status of ecosystem targets. (3) Encourage research in the Reserve. The Plan states that park rangers will test monitoring techniques and conduct ongoing monitoring in partnership with other agencies in Palau and the United States. The **Goal** is to maintain the ecological integrity of these habitats. Threats to the Reserve include human disturbances (permitted and overuse), poaching, fire, unsustainable water usage, erosion, invasive species, and climate change. Management activities are designed to minimize or reverse threats. One of the plan objectives is that Agricultural pest infestations, including weeds, insects, and diseases are managed to reduce adverse effects on plant growth, crop production, and

environmental resources. An action is to monitor for introduction or spread of invasive species with the nursery supervisor as the responsible personnel. <https://www.palaupanfund.org/ngardok.html>

Palau Conservation Society Strategic Plan 2016 - 2021

Vision: “Healthy Ecosystems for a Healthy Palau”

Programmatic Goals: By 2021, there is increased compliance of conservation laws and Protected Area (PA) rules and regulations in Babeldaob 2. By 2021, tourism impacts on the health of the environment have been reduced 3. By 2021, people are taking action to manage invasive species 4. By 2021, green solutions are available to enhance resiliency to climate change 5. By 2021, policies, practices, support structures, and training are in place to encourage reduced reef fishing.

Conservation Goals: By 2030, negative trends in mangroves and estuarine species extent or population have reversed, and conditions are all “Good.” Thematic Area- Forested ecosystems/Forests: By 2030, negative trends in forest health have reversed and conditions are all “Fair” or better. Freshwater Systems: By 2030, Freshwater Systems (marshes, rivers, streams, and lakes) are healthy. Seed Dispersers: By 2030, negative trends in Seed Disperser populations have reversed. <https://www.palauconservation.org/>

The agency documents reviewed and incorporated into the 2021-2030 FAP narratives and strategies are listed below:

| | |
|--|---|
| Ministry of Agriculture, Fisheries, & The Environment (MAFE) | MAFE Strategic Plan 2021-2024 |
| Bureau of Agriculture | Nekken Agriculture Station Plan Strategic Action Plan 2005-2007 Five Year Urban and Community Forestry Plan For the Republic of Palau 2009-2014 Palau's National Invasive Species and Biosecurity Strategic Action Plan (NISSAP) 2018-2022 |
| Ministry of Natural Resources, Environment, and Tourism (MNRET) now MAFE | Belau Watershed Alliance Action Plan 2018-2022 |
| Palau Public Safety Fire and Rescue Division | 2020 Wildfire Action Plan 2020 Network for Wildfire Prevention Dry Season Response Action |
| Division of Fish and Wildlife | 1997 Division of Fish and Wildlife (DFW) National Wildlife Action Plan |
| Ministry of Finance Bureau of Planning and Statistics | 2019 Statistical Yearbook |
| Climate Change Office | 2013 Republic of Palau 2 nd National Communication Framework for the Convention on 2015 Palau Climate Change Policy |
| Ministry of Natural Resources, Environment, & Tourism (MNRET) Now MAFE | 2019 Republic of Palau’s 6th National Report to the Convention on Biological Diversity |

Republic of Palau Revised National Biodiversity Strategy and Action Plan (NBSAP) 2015-2025

| | |
|---|--|
| Palau Conservation Society | Palau Conservation Society Strategic Plan 2016-2021. |
| Melekeok State | Ngardok Nature Reserve Management Plan 2010-2014. |
| Koror State | 2012-2016 Rock Islands-Southern Lagoon Area Management Plan |
| Belau National Museum | Natural History Section Strategic Plan |
| Environmental Quality Protection Board | 2013 Ngerikiil Watershed Restoration for Improved Water Quality GEF Pacific IWRM Demonstration Project |
| National Environmental Protection Council | 2019 State of the Environment Report Republic of Palau |

Stakeholder Groups Coordinated with for the Statewide Assessment and Strategy

The Palau “State” Forest Stewardship Coordinating Committee (required, locally called “Forest Advisory Council”) were consulted by phone, in person, site visits, and during two workshops (July 29, 2021, and August 26, 2021). During the workshops, which were also attended by partners that were not part of the actual council, a presentation on the current situation was presented and then 2 groups were facilitated to discuss the strategic action plan and amend or include items where gaps were perceived. Actions were prioritized within both groups. Groups were asked to discuss specific sites for activities to be implemented and challenges to implementation of the FAP. During the workshop we had 5 recorders who were PCC students (Marinca Faimau, Deureng Camacho, Britney Isaac, Kesiil Thomas, and Bhilanna Temol); and two facilitators, Tarita Holm and Ann Kitalong. Refer to Table 0.12 below. USDA Forest Service does not have staff in Palau and thus it is not feasible to include them as Forest Stewardship Committee members. Instead, in addition to the local meetings and discussions, a series of zoom meetings during May-August 2021 were conducted with Katie Friday and the USFS program management team to ensure that the FAP met the necessary requirements for USFS funding. These meetings included Wendy Yun, River Thomas, Ann Kitalong, and Kathleen Friday (June 28, 2021); Sheri Smith, Phil Cannon, Stacey Clark, Fred Sengebau, River Thomas, and Ann Kitalong (July 13, 2021); Miranda Hutten, Ann Kitalong, Kathleen Friday, Fred Sengebau, and River Thomas (July 26, 2021); Kathleen Friday, Ann Kitalong and River Thomas (August 4, 2021). Note that the USDA Farm Services Agency was not included because the FSA and its programs do not serve Palau; likewise, Palau does not have a USDA-recognized Soil and Water Conservation District. The Forest Stewardship Council plans to set up an annual meeting to advise the Forest Stewardship Program.

Table 0.12. FAP Workshop Participants

| Workshop Participants | | | |
|-----------------------|-------------------------------|--------|---|
| | Name | Office | Consultations |
| 1 | Fred Sengebau Former Director | BOA | Meeting 8/24/20, Participant 1 st Workshop |
| | Gwen Sisor Acting Director | | Meeting:8/24/21, Participant 2 nd Workshop |
| | Joe Tiobech, retired | | Meeting 6/25/21 |

| | | | |
|----|-------------------------------------|--|--|
| | Leah T Ngiratchu | | Participant 1 st Workshop |
| | Ngeyaol Polycarp | | Participant 1 st Workshop |
| | Edwin Polloi | | Participant 1 st Workshop |
| | Trebkul Tellei | | Participant 1 st Workshop, Phone Interview |
| | Micky Towai | | Participant in 1 st Workshop |
| | Ray Wasisang | | Participant in 1 st Workshop |
| 2 | Pua Michael Head Forester | DFLW | Participant 2 nd Workshop |
| | River Thomas | | Meetings 6/25/21, 8/9/21, August 2021, Participant at 1 st and 2 nd workshops |
| | Beverly Subris UCF Coordinator | | Meeting August 2021 Participant 1 st and 2 nd Workshops |
| | Larry Mamis Acting Head Forester | | Meeting 6/25/21 Participant 1 st and 2 nd Workshops |
| | Omerkael Sadang Forester | | |
| 3 | Adelle (Lukes) Isechal | MAFE/PAN Office (representing Palauan state/local government management of forest lands) | Meeting:6/25/21, Participant 1 st Workshop Meeting: 8/24/21 |
| | Joyce Beouch | | Participant 1 st and 2 nd Workshops |
| | Vicky Riungel | MAFE | Participant 1 st and 2 nd Workshop |
| 4 | David Idip Director | PALARIS | Participant 1 st Workshop, Meeting August 2021 |
| | Jacque | | Participant 1 st Workshop, |
| | Daryleen Takeo | | Participant 2 nd workshop |
| | Ophelia OJ | | Participant 2 nd workshop |
| 5 | Derrick David, Fire Lieutenant | Bureau of Public Safety Division of Fire and Rescue (DFR) | Meeting 6/25/21 Participant 1 st Workshop |
| 6 | Lieutenant Brenda Santos | Division of Fish and Wildlife Protection | 8/30/21 & 8/31/21 Phone calls and email exchange on updates for DFW; September 30 th draft FAP sent for DFWP review and comment |
| 7 | Mike Aulerio | The Nature Conservancy | Participant 1 st Workshop |
| 8 | Mike Blesam | EQPB Acting CEO | Sent invitations for Workshops, will review |
| | Bernie Ngiralmu | EQPB | Sent invitations for workshops, Reviewed and commented on August 9 draft FAP Strategies |
| 9 | Charlene Mersai | National Environment Protection Counsel (NEPC) | Participant 1 st and 2 nd Workshops |
| 10 | Christopher Kitalong Vice President | Palau Community College, College or Research and Extension (PCC-CRE) | Participant 1 st Workshop Meeting 7/28/21 |
| | Felix Sengebau | | Participant 1 st Workshop |
| 11 | Ann Singeo | Ebiil Society | Participant for 1 st and 2 nd Workshops |
| | Ilima Kloulechad | | Participant 1 st and 2 nd Workshops |
| | Ives Rdialul | | Participant for 2 nd Workshops |
| | Margie Olsudong | | , Site Visit to Ebiil Nursery 8/20/21 |
| 12 | Umai Basilius | Palau Conservation Society | Sent invitations for 1 st and 2 nd Workshops |
| 13 | Leonard (Gork) Basilius | Palau Community Action | Participant in 2 nd Workshop |

| | | | |
|----|---|---|---|
| | Chairman for Small Grants Program (SGP-GEF); Community Agriculture Agent | Agency (PCAA) | |
| 14 | Ann Kitalong- Manager Natural History Section | Belau National Museum | Participant for 1 st and 2 nd Workshops |
| | Milang Eberdong | | Participant for 1 st and 2 nd Workshops |
| | Naito Soaladaob | | Participant for 2 nd Workshop |
| | Niro Nobel | | Participant for 1 st Workshop |
| 15 | Nels Liljedahl | Palau office, USDA Natural Resource Conservation Service | Participant 1 st Workshop |
| 16 | Leilani Reklai Philip Reklai | Media/Mahogany Farm, Former Governor Aimeliik State- Private Sector | Participant 1 st Workshop Phone Interview |
| 17 | Dr. Joel Miles | Bureau of Agriculture Former Researcher | Email correspondence Sept 2021 |
| 18 | Ephram Polycarp | Blue Moon Exotic Wood Company | Phone Interview 9/13/21 |
| 19 | Sherry Koshiba | Aimeliik State | Phone Interview 9/13/21 |
| 20 | Jefferson Thomas | President Ngerubesang Men's Club | Phone Interview 9/13/21 |
| 21 | Joe Reklai | Chief, Public Works | Phone Interview 9/27/21 |

Table 0.13. Forest Advisory Council Members

| Members | | | |
|---------|------------------|----|------------------|
| 1 | Derrick David | 8 | David Idip |
| 2 | Bernie Ngiralmou | 9 | Ann Kitalong |
| 3 | Nels Liljedahl | 10 | Chris Kitalong |
| 4 | Ann Singeo | 11 | Ngeyaol Polycarp |
| 5 | Mike Aulerio | 12 | Milang Eberdong |
| 6 | Joyce Beouch | 13 | Leilani Reklai |
| 7 | Lukes Isechal | 14 | Charlene Mersai |

State Technical Committee and other stakeholders “required” for Forest Action Plan consultation

The USDA NRCS has the responsibility to convene the “State” Technical Committee, and for the Pacific, only sometimes, does so by inviting Palau to remotely attend meetings conducted in Honolulu including six other island jurisdictions. Furthermore, if the STC were formed in Palau, it would have most of the same members as the SFSCC above. Therefore, this requirement is considered met by the participation of NRCS staff in Palau (Nels Liljedahl) and review of this document requested 9/8/2021 by email from the NRCS “state forester” for the Pacific region (Mathew Cocking, based in Honolulu).

Lead agency for the Forest Legacy Program (if not the state forestry agency) (required) N/A because Palau has not yet completed an Assessment of Need for the Forest Legacy Program

Applicable Federal land management agencies (required) N/A because the U.S. government does not own or manage federal (U.S.) forest land in Palau

The US Military does not own or have a long-term lease in Palau. It is planning to construct a radar system in Ngaraard and Angaur States. Military exercises and training are being conducted in Angaur, Peleliu, Ngeremlengui and Ngaraard. The land used for both are private lands. It is recommended to establish a programmatic agreement with the military for large military projects on forest habitats.

Stakeholder Input

During meetings and the workshops, the main issue was coordination and communication between partners to better collaborate and update each other on program needs and support during periods of intensive activities. Information management, storage, analysis, and user-friendly guides to navigate information for specific needs was a common concern (David Idip 2020). Landownership was raised as projects are started on land with clear knowledge of ownership once a project has begun (Leonard Basilius, 2020). Working with communities directly and consistently was raised as project follow up in communities is critical (Ilima Kloulechad). Data gaps on under representative forest habitats (e.g., swamp forests) was raised, much work focused in Babeldaob and not for other islands and areas outside PAN (Tarita Holm).

Overview of Spatial Analysis

The 2021-2030 analysis used only certain layers that were available for spatial analysis. Babeldaob Island has the most comprehensive vegetation information. For most cases there was only data available for Babeldaob and Koror. Priority areas for reforestation in 2010 remained priority areas in 2021 including critical waters sources and watersheds, bare areas in upper watersheds and repeatedly burned areas; with additional information on areas of repeated fires, areas impacted from super typhoons, and mapping of invasive species, and the expansion of housing developments in Babeldaob by the stakeholders and technical groups. There was more spatial data for fire, endangered species, drinking water sources, and invasive species. There was no contour data for 1m for Palau to determine priority areas for sea level rise.

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<https://www.palauconservation.org/>

<https://www.palaupanfund.org/ngardok.html>

<https://www.palau.gov.pw/visitor-arrivals/>

Issue 1 Climate Change

Global warming is a major threat and issue for coastal forests and communities. Forests act as important carbon sinks that absorb carbon dioxide, a major greenhouse gas and mitigate the impacts of climate change. Global warming is causing extreme weather events including severe droughts and water shortages during the 1997-1998 ENSO event (OERC 2002), super typhoons and typhoons. Climate change was considered one of the top challenges to Palau's environment during a national meeting of conservation and environmental professionals in 2016 (NES2016). These climate changes affect the health of the trees, causing stressed conditions that make trees vulnerable to pathogens and insects. Loss of coral reef barriers and storms cause coastal erosion and loss of beaches in Palau. The top tourism destinations are the Rock Islands and several of the designated picnic areas along the east coast are losing their beaches and trees as shown above for the island of Ngermeaus. Refer to Figure 1.1. This beach and others are not only important for the tourism industry but as important hawksbill turtle nesting grounds. Hawksbills are critically endangered species that depend upon vegetation to camouflage their nests (Kitalong A. and J. Eberdong. 2005).



Figure 1.1 Coastal Erosion
Ngermeaus Beach with exposed
Casuarina equisetifolia roots Ann Kitalong

Drought

On March 22, 2016, the National Emergency Committee (NEC) recommended that the President declared a State of Emergency. The NOAA weather report that placed the Republic of Palau (RoP) in Extreme Drought Level 3 of 4 with cumulative rainfall over past months was the lowest recorded since 1951 at 17.65 inches. The PPUC shut down the Ngerimel Dam; and the Ngerikiil River was at 19% of its normal water production. A State of Emergency was approved by Congress and further extended until April 11, 2016, that resulted in water hours in Koror and Airai. On May 9, 2016, water levels were back to normal and 24-hour water service was resumed. Mitigation actions included exploring alternative water sources and expanding distribution systems (NEC 2016). On March 30, 2018, the water level at Ngerimel Dam was at 9.3 feet or 40% of its normal capacity. The Ngerikiil Dam was at 8 feet or still at 100% capacity bringing a combined capacity of the two water sources to 70%, triggering Stage 2 Drought Management Action. A comparison of Ngerimel Dam between March 30, 2018, and March 14, 2016, shows that there was more water in 2018 than during the height of the 2016 drought but the difference was small. Normally the dam is at 23 feet but as National Emergency Committee (NEC) reported, as of March 30, 2018, it was at 9 feet, 40% of its normal capacity (Island Times 2018).



Figure 1.2 Ngerimel Reservoir prior to drought



Ngerimel Dam - Mar 2016 (Photo by: OTV production).

Ngerimel Dam - Mar 2018 (Photo by: Lightning Strikes Production).

Figure 1.3 The Ngerimel Dam during March 2016 OTV (left) and March 2018 during severe drought. Lightning Strikes Productions (right)

Typhoons

Palau was struck by two super typhoons within a 12-mo period – Super Typhoon Bopha in December 2012 and Super typhoon Haiyan in November 2013. These typhoons destroyed homes, critical infrastructure, and crop production in eastern Babeldaob, Peleliu, Angaur and Kayangel. Taro gardens were contaminated with sea water and water supplies were limited. Displaced families relocated to homes of relatives after Haiyan struck Kayangel in 2013; residents were temporarily housed at the Ngarachamayong Cultural Center under the request of Bilung Gloria Salii. In 2020, some farms have yet to recover from these typhoons and in some cases taro crops were substituted for other more resilient crops. In April 2021, Typhoon Surigae struck and lingered over Palau destroying infrastructure and forests. Kayangel was under water from Typhoon Surigae.



Figure 1.4 Super typhoon Haiyan November 2013 compared to two months earlier. Coral Reef Research Foundation <https://coralreefpalau.org/research/oceanographyweather/>



Figure 1.5 Super typhoon Haiyan Kayangel November 2013 NEMO (Left); Super Typhoon Bopha impact in Angaur December 2012 Ann Kitalong (Right)



Figure 1.6 Typhoon Surigae April 2021 Bernadette Carreon

During 2018 to 2020, the Centre for Women’s Empowerment Belau (C-WEB) and Palau Red Cross Society (PRCS) conducted a Gender Responsive disaster risk reduction and resilience building program in Babeldaob that supported over 250 women with the skills to cope with disasters. The ‘Women’s Empowerment through Emergency Preparedness, Crisis Response and Recovery’ project or People Empowerment Project (PEP), funded by The Women’s Peace & Humanitarian Fund (WPHF) *partnered* with eight locally based organizations to train community women in disaster preparedness, response, and recovery, to be first responders and community leaders in humanitarian response. The Palau Red Cross Society and the Centre for Women’s Empowerment Belau (C-WEB) worked with local women’s organizations to organize trainings across eight of the most vulnerable of Palau’s 16 states due to the major impact to these states from Super typhoons Haiyan and Bopha

(Kayangel, Ngerchelongs, Ngaraard, Ngiwal, Melekeok, Ngchesar, Peleliu, and Angaur). These are **eight priority areas** due to the impact of storm surge from past Super typhoons and sea level rise. These 2012 and 2013 super typhoons had less impact on Koror. A total of 253 women and 12 men received 270 climate resilient breadfruit saplings. These communities received water test kits, family disaster toolkits and overall training on disaster management, food, and water security (PRCS 2019 Annual Report).

| STATE | Female | Male | Total Distributed |
|-------------|--------|------|-------------------|
| Kayangel | 25 | | 25 |
| Ngarchelong | 23 | 7 | 30 |
| Peleliu | 35 | | 35 |
| Angaur | 30 | 5 | 35 |
| Ngaraard | 35 | | 35 |
| Ngiwal | 35 | | 35 |
| Melekeok | 35 | | 35 |
| Ngchesar | 35 | | 35 |
| Total F/M | 253 | 12 | 265 |



Figure 1.7 Distribution of Breadfruit Plants by state (left) and breadfruit tree planting in Melekeok (right) through the Palau Red Cross Society.

Sea Level Rise and Coastal Erosion

Seawater and freshwater inundation of coastal agroforests is impacting food production in lowland agroforests. The less drastic and gradual rise in sea level is predicted to be from 0.2 to 0.9m by 2100. The state of Kayangel will be completely underwater by 2100 if sea levels rise is close to 1m. In Koror all of its coastal infrastructure will be underwater shown in red for the map of Koror (Figure 0.3). This is critical for Koror which has the largest populations with many homes along the lowland areas. A 6% loss in annual taro productions was due to saltwater intrusion (Del Rosario et al., 2015). The Office of Environmental Response and Coordination (OERC) reported a 50% drop in food production during the severe drought in 1997-1998 (OERC 2008). Climate change is a threat to food security with ongoing interventions to rehabilitate taro gardens with salt tolerant taro varieties and drought resilient crops (SOE 2019).

A geospatial model developed for the 2010 SWARS to determine the highest priority areas to protect forests from flooding and saltwater intrusion and landslides were also priority areas for the 2021-30 FAP. Refer to Figure 1. 8. Forestry worked with homeowners and business in agroforestry and conservation on their land. Six data layers (infrastructure, soil, contour elevation, coastal erosion hazard, forests, and endangered species) were identified by the technical team to be used in the model analysis. Each layer was weighted based upon its perceived relative importance to this issue of landslides, coastal erosion, and flooding as a result of increased extreme weather events. Although a layer for contour elevation at 1m is highly weighted there was no data available.

Coastal erosion hazard areas were highly weighted however these areas have not been surveyed and no geospatial data is available. Endangered species such as nesting turtles and nesting shorebirds are known from areas, but their habitats have not yet been mapped. The 2010 GIS spatial analysis showed low coastal areas in Figure 1.8. The analysis for coastal erosion and slope failure was based on two layers that were weighted equally: infrastructure (weight=50%) and contour (weight =50%). For coastal flooding contours 0-1m were priority areas for stabilization and reforestation. For slope failure, contours 50 to 100m were priority areas for stabilization and reforestation for the 2021 FAP. The 2021 FAP results from the overlay analysis are shown in Figure 1.8. High priority areas for flooding were coastlines 0 to 1m above sea level. Koror has one of the highest priorities because it is the most densely populated State. Other vulnerable States with lower population densities include the low-lying States of Kayangel, Peleliu and Southwest Islands of Hatohobei and Sonsorol.

Key tourist beaches of the southeastern lagoon are eroding away due to several factors including sea level rise, storms, loss of reefs from prolonged elevated sea temperatures, loss of leaf litter and strand vegetation due to much raking and removal for tourist to experience “sandy white beaches” and the impact of tourists. More studies are needed to determine best management practices for the tourist beaches. The highest priority areas are low lying areas in Koror, the urban center, in which forestry efforts will be directed to mitigate or prevent coastal erosion caused by sea level rise and storms based upon frequency and magnitude of use, density of infrastructure, elevation of 1m or less above sea level. Top priority areas are the east coasts of Babeldaob, and the Rock Islands of Koror and Airai States; the islands of Kayangel State, and the Southwest Island of Hatohobei and Sonsorol States. These islands had elevations of a few meters and it is critical to get the needed data for this analysis.

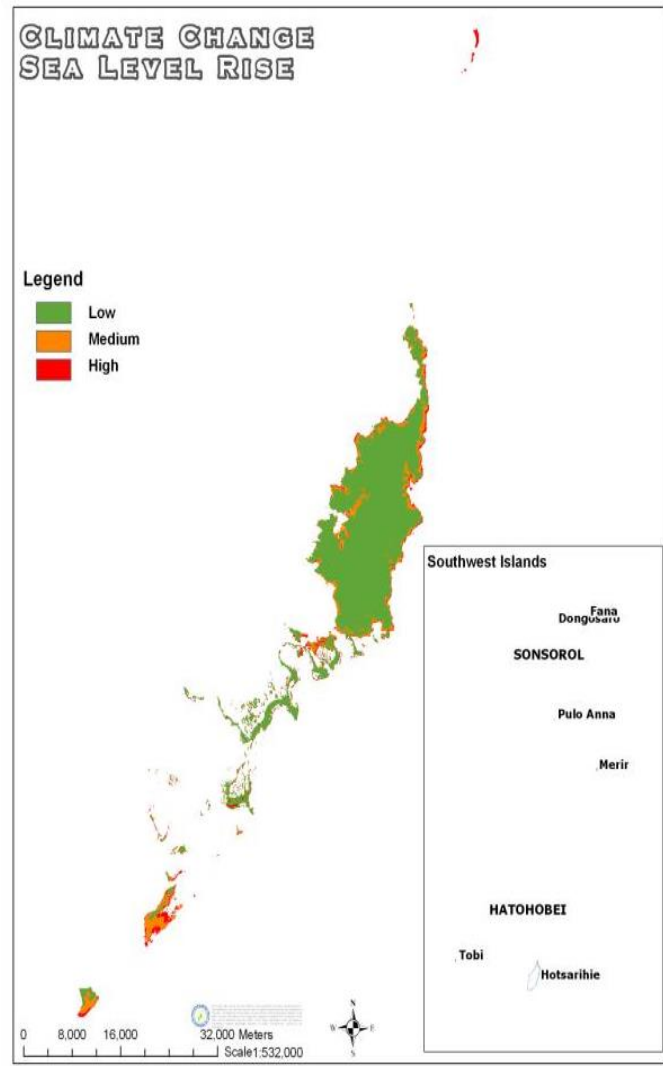


Figure 1.8 Sea level showing **high priority areas** (0-1 m) in red and include Hatohobei and Sonsorol States PALARIS

Landslides

The 2021-2030 **priority sites** for mitigation efforts for landslides through reforestation and civil engineering as follows: Malakal Quarry (Figure 1.11), the Ngerikiil Road Tmetuchl National Airport in Airai State southernmost state in Babeldaob; Ngchesar on SE coast of Babeldaob in (Figure 1.12) and the upper NE coast of Ngkeklau, Ngaraard. Refer to Figure 1.9. These sites were ranked based upon past discussions with partners and a recent discussion with the Chief of Public Works, Joe Reklai, who has been maintaining slope failures along the National Highway for the last decade (Joe Reklai pers. comm. 9/27/21). The main justification for these priority sites was population density and road traffic and

repeated slope failure in Koror and Airai. The repeated slope failure along the east coast of Babeldaob was justification for Ngchesar and Ngkeklau sites. Since 2010, the landslide area in Ngermid, Koror has been stabilized and part of the road alignment by the Airport. However, there are continual stabilization problems on this alignment that require revegetation and engineering. The slopes along the western alignment have been less of a concern. The western alignment and steep slope areas are ongoing problems but less of a concern than in 2010.



Figure 1.9 The four Priority sites for stabilization for 2021-2030 are Malakal Quarry in Koror, Airai Airport Road and the eastern alignment along Ngchesar and Ngaraard in Ngkeklau (Chief Reklai, P Public Works)

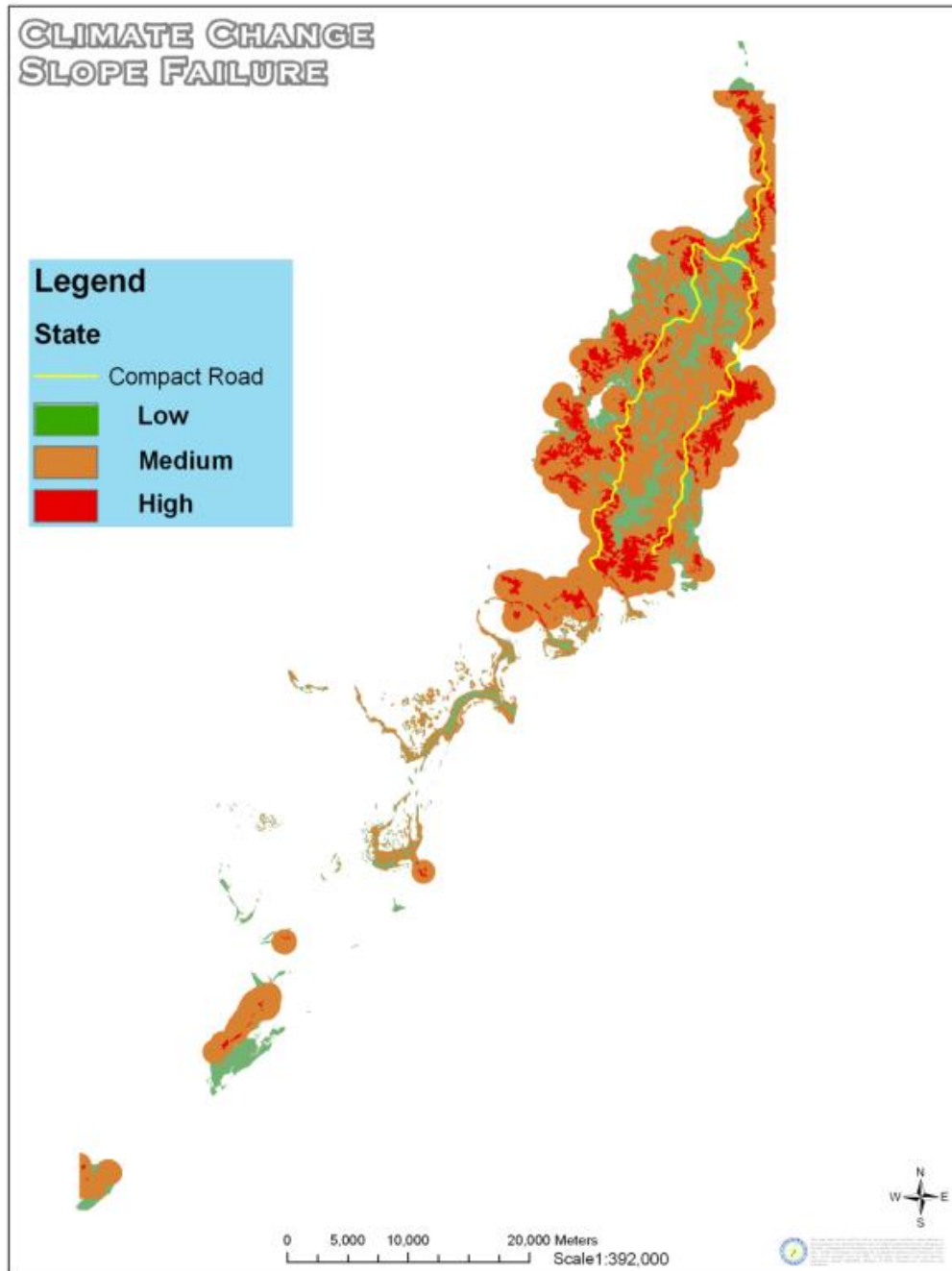


Figure 1.10. 2010 Spatial analysis of contour and infrastructure shown areas of **high priority** to stabilize slopes and reforest that are also top priority areas for 2021-2031 and consistent with repeated landslides in the similar locations. PALARIS.



Figure 1.11 Malakal Island showing basalt quarry area (66,282 m²) marked in a red circle which was once forest. An area of chronic landslides is circled in yellow that crushed an adjacent warehouse downslope after heavy rains in 2009. The area of slope failure has 70% slopes. Quarry activity has left a thin and unstable rim of steep sloped forests that has caused several landslides after heavy rains. This is a **priority site** for stabilization and reforestation. Source: PALARIS 2006 Ikonos Satellite Imagery.

The number of landslides and road damage (Figure 1.12) increased in the last two decades. Forests are sliding down the slopes. The increased intensity and duration of rainfall attributed to climate change is a major contributing factor. Palau’s high rainfall and highly erodible soil make infrastructure design and construction a constant challenge. Forestry directed their efforts to stabilize sites to either protect existing forests or restore lost forests. Currently there is work being done on one section of the Ngerikiil Road. However, it remains unstable along other sections. The Malakal Quarry remains unstable and requires stabilization and reforestation and is a **priority site** for stabilization and reforestation.



Figure 1.12 Slope failure in Ngeremlengui (left) and Ngchesar (center), and road damage in Ngardmau (right) after Super Typhoon Surigae April 2021. Slope failure sites are **priority sites** for stabilization of slopes to prevent forest loss.

The forestry staff currently assists homeowners and businesses to apply best practices in agroforestry to conserve their soils and forests especially in areas vulnerable to landslides. Standard Operating Procedures to address erosion and sediment controls for roads were to identify practical, daily activities that will make an impact in reducing and/or eliminating erosion and sediment sources in the watersheds of the States of Melekeok, Ngarchelong, and Ngeremlengui in the Republic of Palau (York 2021).

Measures of Success Issue 1 Climate Change

The measures of success for the past decade were as follows: best management guidelines for slope stabilization for EQPB were developed; at least 2 slopes were restored and stabilized using best management practices. The Smithsonian Institution's Forest Global Earth Observatory (ForestGEO) was established in the Ngerdorch Reserve for long term monitoring of global climate change. Vulnerable areas were reforested in Ngeremlengui, Ngardmau and Ngiwal and Airai. The Centre for Women's Empowerment Belau (C-WEB) and Palau Red Cross Society (PRCS) conducted a Gender Responsive disaster risk reduction and resilience building program that supported over 250 women trainings across eight of the most vulnerable of Palau's 16 states (Kayangel, Ngerchelung, Ngaraard, Ngiwal, Melekeok, Ngchesar, Peleliu, and Angaur). A total of 253 women and 12 men received 270 climate resilient breadfruit saplings. These communities received water test kits, family disaster toolkits and overall training on disaster management, food, and water security (PRCS 2019 Annual Report). Community outreach training and awareness was conducted in Babeldaob. Two sites of major landslides near the Tmetuchl National Airport and in Ngermid Hamlet have undergone stabilization through engineering efforts.

The 2021-2030 Forest Action Plan will address Issue 1 Climate Change through the implementation of the following actions in the next decade:

- (1) A Sustainable Forest Database system will be established, and staff trained to track landowners assisted, number of species propagated and planted, and survival rates, number, and size of demonstration agroforest plots, acres of important forest resources areas and acres of sustainably managed forest resource areas on public and private lands, develop and implement FSP and UCF Plans. Use and supplement existing SMART system;
- (2) Program for Rapid Forest Assessments for site specific areas post typhoon, drought, or heavy rain event;
- (3) Study of erosion rates in vulnerable coastal areas;
- (4) Report on best management practices and guidelines for littoral forests and mangroves with 1-2 trainings;
- (5) One study on human impact to mangroves;
- (6) Report of forest health (regrowth, recruitment, lack of invasive species, survivorship of saplings) and impact of seawater intrusion;
- (7) Design /implement social marketing campaign around forests to improve attitudes/behavior and valuing forests (including mangroves);
- (8) Design Project and Conduct Stakeholder Analysis on Climate Change and Forests;
- (9) Develop report format aligned with the State of the Environment Report;
- (10) Develop scholarships, internships for sustainable forestry educational programs;
- (11) Research available materials on Forests and Climate Change;
- (12) Collaborate with NGOs, PCC, and MOE to develop and disseminated educational materials and a curriculum module for forests and climate change;
- (13) Hold an Annual Forum for members of the Forest Advisory Council as well as other partners partners interested in Forest Stewardship and Urban and Community Forestry.
- (14) Collaborate with state governments to identify priority areas for reforestation efforts (produce maps);
- (15) Cooperate with NGOs on a student and community volunteer program;
- (16) State Regulations and legislation developed, adopted, and enforced to protect forests and restore degraded forests from impacts of Climate Change;
- (17) Design and implement Rapid Forest Assessment for HCV forests post typhoons, post severe; droughts, and other natural or human induced impacts and recovery plan (reforestation, green waste recycling);
- (18) PALARIS and other partners update vegetation maps and hydrological models;

- (19) Gather and develop useful forest related information to disseminate to states and other resources users;
- (20) Develop and implement Palau SFM Plan and Best Practices;
- (21) Forest Resource Management Requirements established and integrated;
- (22) Work with the States and partners to develop Comprehensive State Forest Management Plans addressing climate change, watershed protection, conservation, rehabilitation, and sustainable use of forests;
- (23) Consultations and visits detailed planning in each state for overall forest management;
- (24) Request Governors to designate a lead person from each state to work with MAFE team;
- (25) Establish either a Memorandum of Agreement (MoA), or Memorandum of Understanding (MoU) or a Letter of Commitment between Palau Forest Service, State, Community, Private Sector, NGOs, and Landowners on roles, responsibilities, and commitments of each party;
- (26) MAFE justify and secure Congressional funds for forestry programs;
- (27) Develop, test, and implement training modules that include guidelines for SFM;
- (28) Create professional development programs;
- (29) Conduct socio economic and environmental impact study of seawater intrusion and forests;
- (30) Develop, print, and disseminate educational material on invasive species and fire prevention, climate change, the value of mangrove forests and existing forest-related regulations;
- (31) Forest Advisory Council with partners such as GEF Small Grants Program will support sustainable forest projects;
- (32) Propagate, collect, and plant at least 20,000 saplings/year for rehabilitation programs using native and fruit bearing trees; map and monitor sites;
- (33) Develop and implement training module for estimated carbon stocks/carbon trading and ecosystem services of forests (e.g., i-tree training);
- (34) Estimate Potential Ecosystem Services (PES) value for impacted forests;
- (35) Establish greenhouse network, expand existing greenhouses, and establish greenhouses where needed;
- (36) Native trees propagated, planted, and monitor survival rates quantified at priority sites;
- (37) Create a list of projects that can be done related to sustainable forestry and climate change;
- (38) Develop educational and awareness materials (posters, radio shows, videos) related to forestry and climate change;
- (39) Develop, produce, and disseminate educational materials on freshwater sources and the potential ecosystem services of forests.
- (40) Communities identify and remove obstructions to waterflow caused by debris and fallen trees from storms.
- (42) Develop and implement State Land Use Plans that address SFM and water management
- (43) Assess and conduct a feasibility study of watersheds to design, and construct water storage and distribution lines.

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Issue 2 Population Growth and Urbanization (Mitigating Effects on Natural Environment)

Over the past nearly three decades (1986 to 2015) the mean annual population growth rate has been 1.4% with a range from 2.3% in 1986 to -0.41 in 2012. Refer to Table 2.1. The urban population (Koror and Airai) represented a mean of 73.7% of the population with 26.3% of the population in 14 rural areas (States other than Koror and Airai). The trend over the past three decades was a migration from rural to urban areas. However, between 2012 and 2015, there was a slightly higher migration from the urban to rural areas. Refer to Table 2.1. The total land area is reported at 416 km² in the 2015 Census with a mean density of 42.5 people/km². Refer to Table 6. The highest population growth rates between 2012 and 2015 occurred in the rural States of Ngiwal (26%), Aimeliik (18%) and Ngchesar (14%), Ngardmau (11%) and Ngeremlengui (10%). Refer to Table 2.2. During the 2005 Census, the Rock Islands were separated out from the total area of Koror and Airai State. During the 2015 Census the Rock Islands were not separated out from the States. However, the slight decrease in population from these urban states did occur.

Table 2.1 Population growth between 1986 and 2015 in Urban and Rural Areas.

| Census Year | Population | %Annual Growth Rate | Urban Population (Koror & Airai) | | Rural Population Other States | |
|-------------|---------------|---------------------|----------------------------------|-------------|-------------------------------|-------------|
| | | | Number | Percent | Number | Percent |
| 1986 | 13,873 | 2.3 | 9,442 | 68.1 | 4,431 | 31.9 |
| 1990 | 15,122 | 2.2 | 10,501 | 69.4 | 4,621 | 30.6 |
| 1995 | 17,225 | 2.6 | 12,299 | 71.4 | 4,926 | 28.6 |
| 2000 | 19,129 | 2.1 | 13,303 | 69.5 | 5,826 | 30.5 |
| 2005 | 19,907 | 0.8 | 15,399 | 77.4 | 4,508 | 22.6 |
| 2012 | 17,501 | -.41 | 14,202 | 81.1 | 3,299 | 18.9 |
| 2015 | 17,661 | 0.03 | 13,899 | 78.7 | 3,762 | 21.3 |
| | | | | | | |
| mean | 17,418 | 1.4 | 12,721 | 73.7 | 4,482 | 26.3 |
| std | 1,699 | 1.2 | 2,119 | 5.3 | 811 | 5.3 |

Source: Census Reports and Census of Population and Housing, Republic of Palau

Table 2.2. Population growth for each State in the Republic of Palau from 1980 to 2005
 Sources: 2005 Census Monograph and 2000 and 2005 Census of Population and Housing. Office of Planning and Statistics. Office of Planning and Statistics. 2020. 2019 Statistical Yearbook. Republic of Palau Bureau of Budget and Planning Ministry of Finance.

| State | Total area (km ²) (2005) | Population 2005 | Population per km ² 2005 | % of total population 2005 | 25 yr (1980-2005) population growth (%) | Total Area (km ²) 2015 | Population 2015 | Population per km ² 2015 | % of total population 2015 | 10 yr (2005 - 2015) % Population growth |
|--------------|--------------------------------------|-----------------|-------------------------------------|----------------------------|---|------------------------------------|-----------------|-------------------------------------|----------------------------|---|
| Total: | 491 | 19,905 | | | | 416 | 17,661 | | | |
| Aimeliik | 52 | 272 | 5.2 | 1.3 | 0 | 37 | 334 | 9 | 1.9 | 18 |
| Airai | 44 | 2,723 | 61.9 | 13.7 | 75 | 49 * | 2,455 | 50.1 | 13.9 | -10 |
| Angaur | 8 | 320 | 40.0 | 1.6 | 24 | 8 | 119 | 14.9 | 0.7 | -63 |
| Hatohobei | 3 | 44 | 14.7 | 0.2 | -40 | 0.7 | 25 | 25.0 | 0.1 | -43 |
| Kayangel | 3 | 188 | 62.7 | 0.9 | 34 | 1.7 | 54 | 31.7 | 0.3 | -71 |
| Koror | 18 | 12,676 | 704.2 | 63.7 | 40 | 58* | 11,754 | 202 (653) | 66.6 | -7 |
| Melekeok | 28 | 391 | 14.0 | 1.9 | -9 | 25 | 277 | 11.1 | 1.5 | -29 |
| Ngaraard | 36 | 581 | 16.1 | 2.9 | 21 | 29 | 413 | 14.2 | 2.3 | -29 |
| Ngarchelong | 10 | 488 | 48.8 | 2.4 | -32 | 8 | 316 | 39.5 | 1.8 | -35 |
| Ngardmau | 47 | 166 | 3.5 | 0.8 | 3 | 30 | 185 | 6.2 | 1.0 | 11 |
| Ngeremlengui | 65 | 317 | 4.9 | 1.6 | -13 | 61 | 350 | 5.7 | 2.0 | 10 |
| Ngatpang | 47 | 464 | 9.9 | 2.3 | 64 | 35 | 282 | 8.1 | 1.6 | -39 |
| Ngchesar | 41 | 254 | 6.2 | 1.3 | -43 | 38 | 291 | 7.7 | 1.6 | 14 |
| Ngiwal | 26 | 223 | 8.6 | 1.1 | -20 | 16 | 282 | 17.6 | 1.6 | 26 |
| Peleliu | 13 | 702 | 54.0 | 3.5 | 13 | 17 | 484 | 28.5 | 2.7 | -31 |
| Sonsorol | 3 | 100 | 33.3 | 0.5 | 21 | 3 | 40 | 13.3 | 0.2 | -60 |
| Rock Islands | 47 | | | | | | 0 | | | |

The urban development within the Ngerikiil Watershed in Airai is the top priority as this watershed is a source of drinking water for Koror and Airai with 80.5% of the population in 2015. Refer to Table 2.3 and Figure 2.1. The population growth in Airai was 75% 1980 and -10% in 2005, however between 2005 and 2015, the population growth declined by 10%. Due to saturated soils, the housing developments have had problems with septic overflow, increased solid waste, loss of vegetation and an increase in impervious surfaces. In 2021, the national landfill opened to serve all of the States. The national plan to build a separate sewage system in Airai was not implemented.



Figure 2.1 View showing urban growth in the Ngerikiil Watershed in Airai State

The forests play a critical role in filtering runoff and the placement of **buffers along the rivers near development areas is critical and a priority area for reforestation**. Land use planning is critical to ensure that watersheds are protected from potential pollutants such as solid waste. The PCS 2010-2015 strategy was to integrate protected areas into land use planning. The Republic is required under the Convention on Climate Change to submit a Green House Gas Inventory that requires quantification of land use change which is primarily due to infrastructure development from population growth. Through a well-documented planning process land use change can be followed over time and incorporated into the GHG inventory. Palau's forests remove 98.57 Gg-CO₂ from the atmosphere, serving as Palau's carbon sink (2013 2nd National Communication on Climate Change). Loss and degradation of habitats due to urban and commercial development are top threats to Palau's terrestrial and marine resources

The 2018-2024 GEF6 National Project entitled Integrating Biodiversity Safeguards and Conservation into Development is working with the States of Ngiwal, Ngeremlengui, Ngaraard, Ngardmau, Ngarchelong, and Melekeok through a Babeldaob Island Joint Coordinating Body (JCB) to develop State Master Plans and State Planning Commissions. The land use guides for Babeldaob include a series of base maps developed in coordination between MAFE, PALARIS, and the States through a series of consultations and ground truthing exercises. One of these maps identified areas suitable for agroforestry and tree plantations and housing projects. Refer to Figures 2.2a and 2.2b. These maps are still under development with the States. The GEF6 project has produced a report entitled Climate Smart Resilient Development in Melekeok State that includes a listing of species of trees to use as street trees for Melekeok. The GEF6 developed Standard Operating Procedures to address erosion and sediment controls for roads to address landslides. Subdivision Housing Suitability Criteria were approved in 2020.

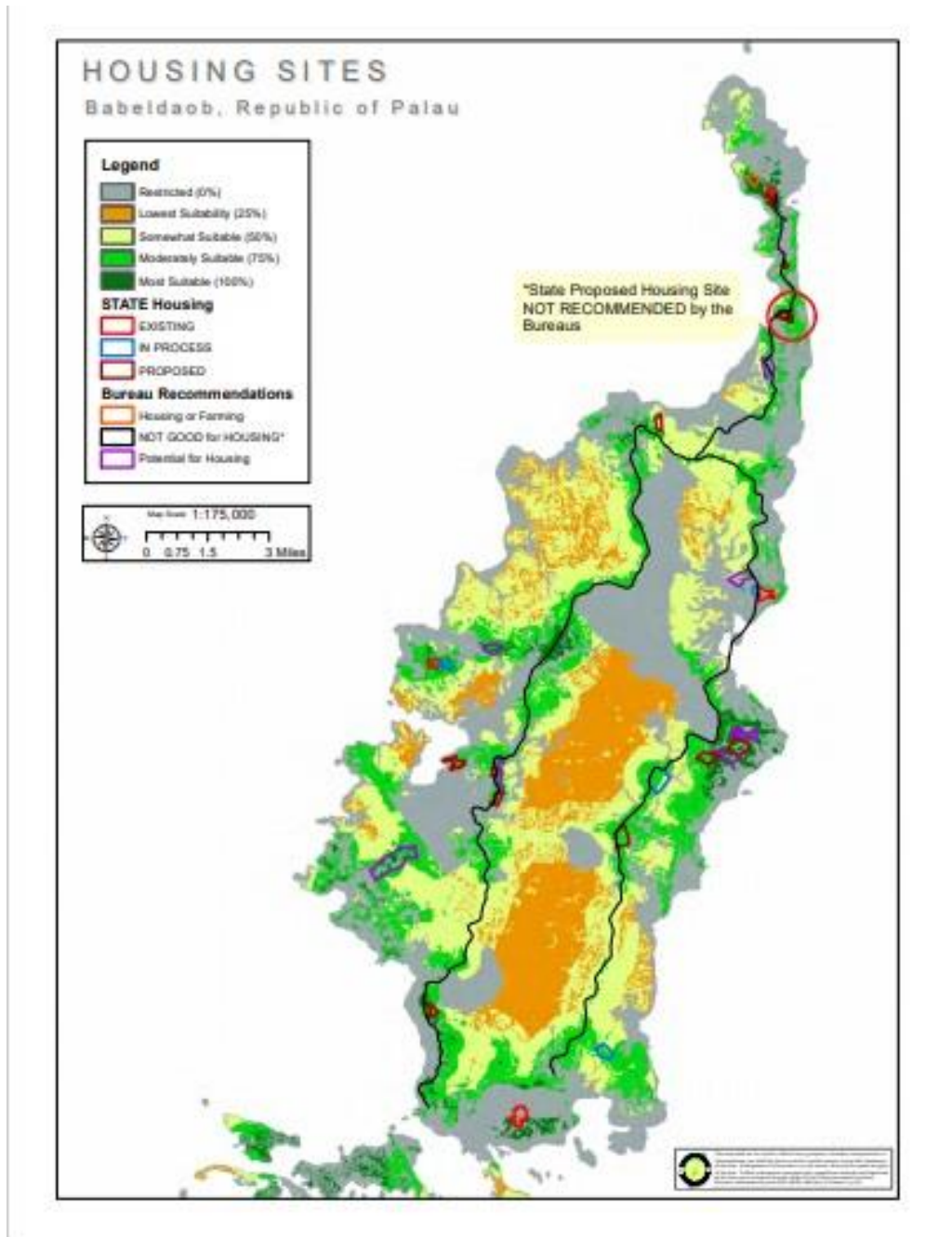


Figure 2.2a Planning Maps for Housing for Babeldaob Island. MAFE and PALARIS

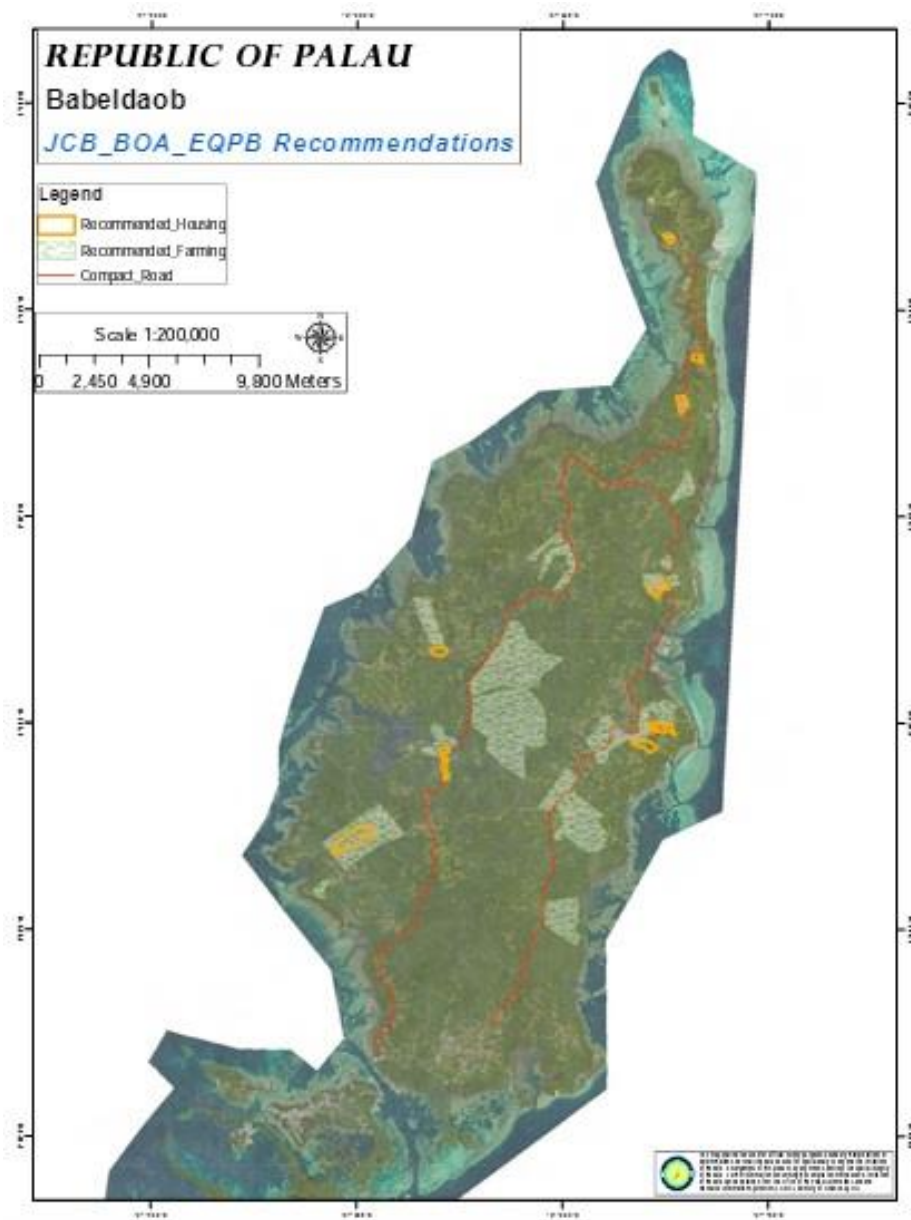


Figure 2.2b Planning Maps for Housing and Farming for Babeldaob Island and MAFE and PALARIS

The 2010 SWARS identified Koror State and Airai State Ngerikiil Watershed as the highest priority areas for mitigation of the impacts of urban growth on the environment. The Ngerikiil Watershed is a critical watershed for drinking water and highly vulnerable to fire and invasive plants and its upper watershed was an important bird area. Koror State was a top priority area because it is the most populated State with gradual long-term conversion of forests to infrastructure. Koror is home for several endangered species and had recurrent landslides. A small population of the critically endangered palm *Ponapea* was found at the Ngermid Rock Island Complex near the urban center. It is unknown if this palm is susceptible to attack by CRB. There is no field evidence to suggest this is the case. Malakal Island in Koror is the only known location of the nearly extinct *Timonius salsedoi* and only known from a type specimen (Costion et al. 2009). It is critical to locate this species and protect them from encroaching development. The Ngerikiil Watershed of Airai (Babeldaob) and Malakal Island of Koror are two **priority areas** to implement reforestation projects to protect the existing forests and provide healthy forests to the urban

communities of these two most densely populated States of Palau. MAFE has identified existing and proposed housing development areas in Babeldaob (Figures 2.2a and 2.2b) as well as degraded lands from past mining activities in watersheds in Ngardmau for reforestation projects. The mining areas are in areas adjacent to land leased for housing development. Currently, BOA and partners are working on a Ngermetengel and Imeong Forest Restoration Project in Ngeremlengui for an existing housing development, not a proposed housing site. The bare areas have been mapped, and sediment ponds, sediment traps and restoration areas have been mapped. Refer to Figures 2.3.



Figure 2. 3 Ngermetengel Forest Restoration Project in Ngeremlengui

Measures of Success Issue 2 Population Growth and Urbanization (Mitigating Effects on Natural Environment)

During the past decade, measures of success for Issue 2 Population growth and urbanization were as follows: Land Use Plan for Airai State was developed. Land Use Planning Training was conducted in Airai State and an Airai State Planning Commission was established. The 2018-2024 GEF6 National Project entitled Integrating Biodiversity Safeguards and Conservation into Development is working with the States of Ngiwal, Ngeremlengui, Ngaraard, Ngardmau, Ngarchelong, and Melekeok through a Babeldaob Island Joint Coordinating Body (JCB) to develop State Master Plans and State Planning Commissions. The land use guides are being developed. Over 1,000 native trees have been propagated in Nekken Station, the Ngardmau greenhouse, the Melekeok green house, the Ebiil Society greenhouse, and the Belau National Museum greenhouse annually with a minimum survival of 50%. Reforestation projects have been initiated in housing developments in Ngiwal and Ngeremlengui States. The next decade will build upon these successes by expanding greenhouse production and working with partners to develop urban forests in areas where urbanization and population growth is showing an increasing trend.

The 2021-2030 Forest Action Plan will address Issue 2: Population Growth and Urbanization (Mitigating Effects on Natural Environment) through the implementation of the following actions in the next decade:

- (1) A Sustainable Forest Database system will be established, and staff trained to track landowners assisted, number of species propagated and planted, and survival rates, number, and size of demonstration agroforest plots, acres of important forest resources areas and acres of sustainably managed forest resource areas on public and private lands, develop and implement FSP and UCF Plans. Use & supplement existing SMART system;
- (2) Design /implement social marketing campaign around forests to improve attitudes/behavior and valuing forests (including mangroves);
- (3) Develop report format aligned with the State of the Environment Report;
- (4) Establish scholarships and internships for sustainable forestry educational programs;
- (5) Research available materials on Forests and Sustainable Development for educational materials;
- (6) Collaborate with NGOs, PCC, and MOE to develop and disseminate educational materials and a curriculum module for forests and sustainable development;
- (7)) Hold an Annual Forum for members of the Forest Advisory Council as well as other partners partners interested in Forest Stewardship and Urban and Community Forestry;
- (8) Collaborate with state governments to identify priority areas for reforestation efforts (produce maps);
- (9) Cooperate with NGOs on a student and community volunteer program;
- (10) State Regulations and legislation developed, adopted, and enforced to protect forests and restore degraded forests from impacts of population growth and infrastructure expansion;
- (11) Design and implement Rapid Forest Assessment for HCV forests post typhoons, post severe droughts, and other natural or human induced impacts and recovery plan (reforestation, green waste recycling);
- (12) PALARIS and other partners update vegetation maps and hydrological models;
- (13) Develop an annual State of Palau's Forest Report;
- (14) Gather and develop useful forest related information to disseminate to states and other resources users;
- (15) Establish and integrate Forest Resource Management Requirements with national and state plans;
- (16) Work with the states and partners to develop Comprehensive State Forest Management Plans addressing climate change, watershed protection, conservation, rehabilitation, and sustainable use of forests;
- (17) Consult and visit each state for detailed SFM planning;
- (18) Request Governors to designate a lead person from each state to work the MAFE team;
- (19) Establish either a Memorandum of Agreement (MOA), or Memorandum of Understanding (MoU) or a Letter of Commitment between Palau Forest Service, State, Community, Private Sector, NGOs, and Landowners on roles, responsibilities, and commitments of each party;
- (20) Justify and secure congressional funds for forestry programs;
- (21) Create professional development programs;
- (22) Conduct socio economic and environmental impact study of mangrove forests;
- (23) Conduct socio economic and environmental impact study of seawater intrusion and forests;
- (24) Forest Advisory Council with partners such as GEF Small Grants Program support sustainable forest projects;
- (25) Propagate, collect, and plant at least 20,000 saplings/year for rehabilitation programs using native and fruit bearing trees; map and monitor sites;
- (26) Estimate Potential Ecosystem Services (PES) values for impacted forests
- (27) Establish greenhouse network, expand existing greenhouses, and establish new greenhouses where needed;
- (28) Native trees propagated, planted, and survival rates quantified for priority sites;
- (29) Conduct national spatial analysis of Casuarina, coconut, mahogany and other important trees and landownership using aeriels, IKONOS, LIDAR & SAR, and ground truth information;

- (30) Create a list of projects that can be done related to sustainable forest management and sustainable development;
- (31) Develop educational and awareness materials (posters, radio shows, videos) related to sustainable forest management, freshwater sources, and the potential ecosystem services of forests;
- (32) Communities identify and remove obstructions to waterflow caused by debris and fallen trees.
- (33) Develop and implement State Land Use Plans and integrate water supply;
- (34) Establish buffer zones and remove invasive species along the rivers and streams.
- (35) Establish a programmatic agreement with the military for large military projects on forest habitats.

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Issue 3 Water Quality and Quantity

Forests produce the cleanest waters as they absorb rainfall, reduce flooding, recharge aquifers, and provide habitat to wildlife and act as buffers along streams and rivers to retard flows of sediment laden runoff into streams. Riparian forests can trap over 80 % of sediment and nutrients and reduce peak flooding by 50% (Cooper et al. 1987). Water storage, distribution and protection are critical for extreme drought periods associated with ENSO events and Climate Change. Twenty upper watersheds provide public drinking water to Babeldaob and Koror. These **priority** upper watersheds are indicated in blue in Figure 3.1. Priority water quality and quantity areas for Babeldaob were identified. Refer to Figure 3.2.

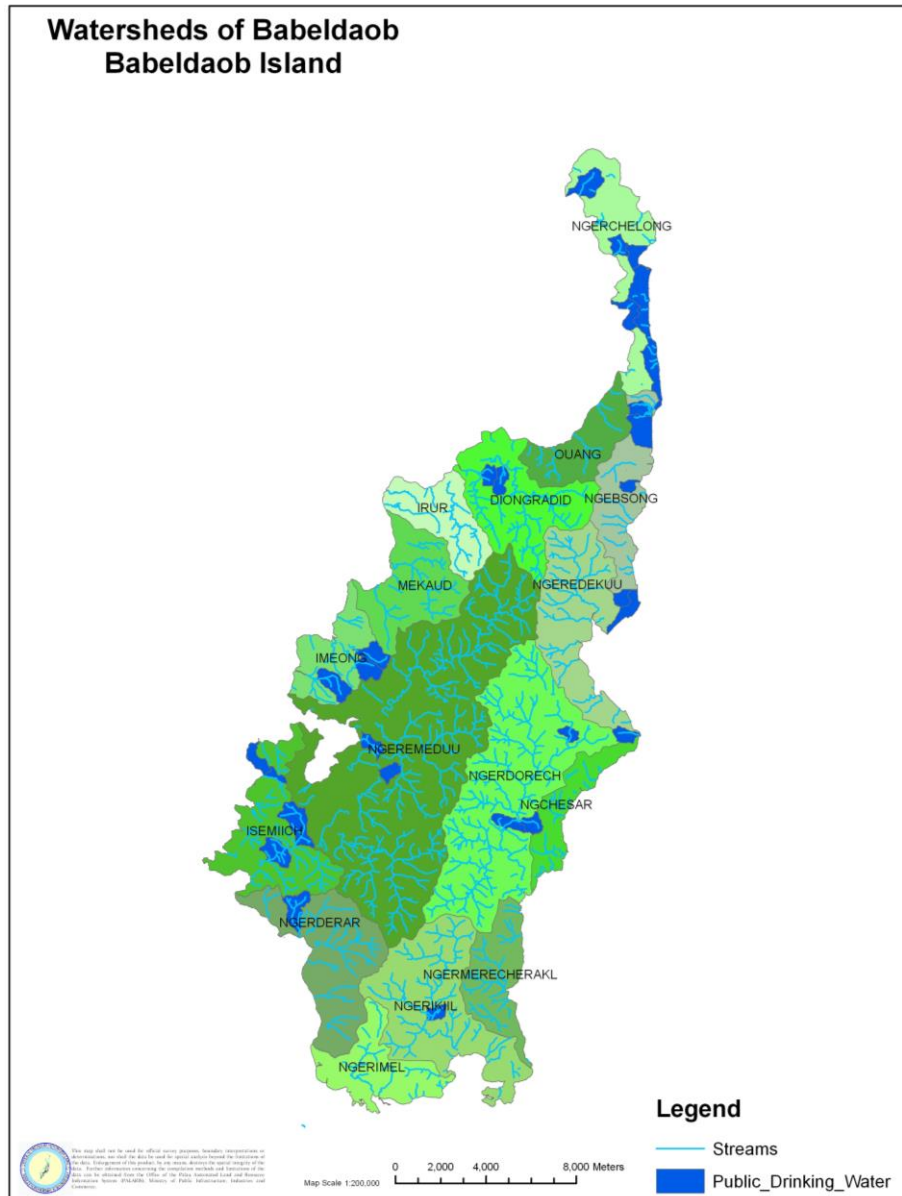


Figure 3.1 Map showing the upper watershed areas for public drinking waters sources of Babeldaob. The upper Ngerikiil watershed in Airai State, the southernmost State in Babeldaob provides the largest supply of public drinking water in Palau These are **priority areas** for reforestation.

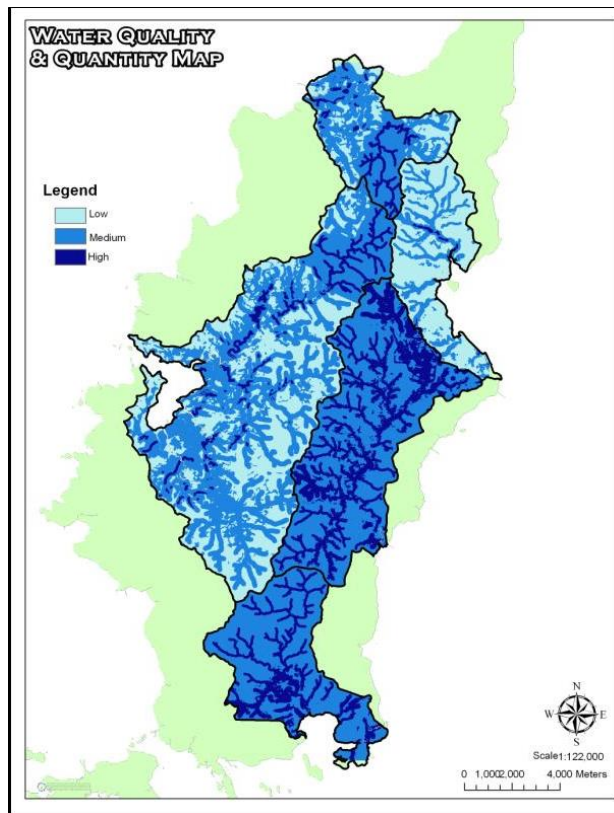


Figure 3.2 The 2021-2030 **priority areas** in darkest blue, medium areas in lighter blue and lower priority areas in sky blue are similar to the SWARS 2010 priority areas.

In 2006, the Babeldaob Watershed Alliance was formed to help states sharing the same watershed coordination efforts through Conservation Action Plans to better protect and manage their forests and water supplies. Most States of Babeldaob have become involved in this process. The vision of the Babeldaob Watershed Alliance is to become a model for ensuring states have continued access to clean water and healthy environments and promote environmentally sustainable economic development through collaborative efforts of a diverse array of stakeholders (TNC 2007). Forestry is assisting in this process and addressing the technical needs of each State. In Palau, there are five main watersheds based upon their size and as potential sources of water.

The 2021-2030 FAP also prioritizes the **priority watersheds** that were identified in the 2010 SWARS as follows: Ngerikiil, Ngerdorch, Ngeremeduu, Diongradid, and Ngerbekuu. Ngerikiil is the most important watershed for the people in Palau as the main source of drinking water for Koror and Airai serving 80.5% of the population in 2015. The Airai-Koror waters supply system derives its water from the Ngerikiil river diversion dam and the Ngerimel Dam with a storage capacity of 75, 700 m³ (20 million gallons). The Ngerikiil has an average daily flow of 20 million gallons of surface water. Sustainable agroforestry and buffers were planned in the lower watershed of Ngerikiil with mangrove conservation and sustainable management. Ngerikiil had the fastest growing population with major earthmoving activities. The bare areas that are **priority areas for reforestation** in 2016 are found along the south and southeastern areas of the watershed. Refer to Figure 3.3.

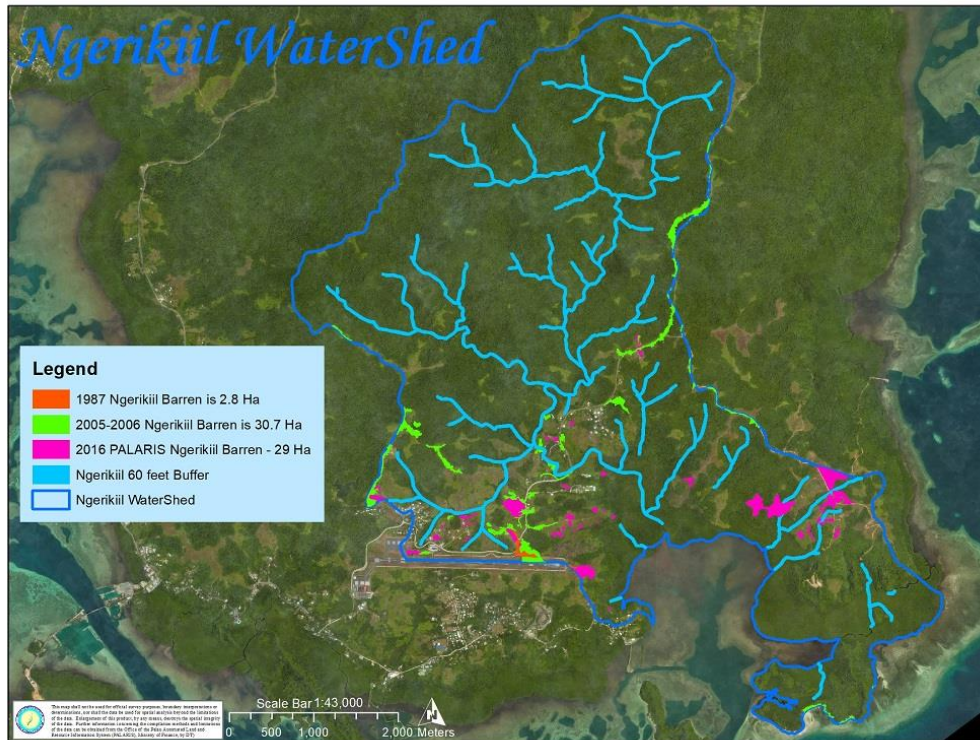


Figure 3.3 Ngerikiil Watershed showing barren areas along the streams by the airstrip and **top priority areas** for reforestation

During 2009 to 2010, the threat to water quality from pollution in the Ngerikiil Watershed was a top concern during stakeholder meetings and consultations. The community was primarily concerned about water quality and pollution and the impact of soil erosion and sedimentation, nutrient fertilizers, pesticide, septic systems, and solid waste disposal on water quality. Approximately 72% of the Ngerikiil watershed has slopes greater than 12% and 44% of the watershed has slopes greater than 30% accounting for 44% of the watershed (Gavenda et al. 2005). In 2010, a major earthmoving project for the expansion of the airport cut and filled tons of soil into this watershed. Available data show that the barren areas in the Ngerikiil watershed increased from 2.8 ha in 1987 to 30.7 ha in 2005 to 2006. This is more than a 10-fold increase in barren area.

Ngerikiil Watershed Restoration for Improvement of Water Quality 2009 to 2013

The Environmental Quality Protection Board (EQPB) implemented the Ngerikiil Watershed Restoration for Improvement of Water Quality to promote proper watershed and integrated management practices during 2009 to 2013. This project promoted proper watershed and integrated management practices. Proper watershed practices reduce land degradation while preserving ecosystem stability, functions, and services such as soil and watershed protection, water purification and nutrient retention. The project increased political awareness and support for IWRM; President Johnson Toribiong participated in Palau’s 1st National Water Summit (2011) and endorsed the Palau National Water Policy and national coordination mechanism (2012). The protection and rehabilitation of the Ngerikiil Watershed included an increase in land area rehabilitated, the establishment of buffer zones, mitigation of pollution sources, and leveraging of financing for ongoing watershed conservation. The IWRM project increased collaboration between



Figure 3.4 Palau High School Students replanting trees in Ngerikiil Watershed.

agencies that manage water which is driving strengthened coordination of investments in water and sanitation activities at National and State levels (Thomas 2013). Refer to Figure 3.4.

Ngerdorch Watershed

Ngerdorch Watershed includes Ngardok Lake, the largest freshwater lake in Micronesia and a center of biodiversity. Ngerdorch Watershed Reserve had restricted activities and poor soils. Reforestation activities are ongoing within the Reserve. The location of bare areas in 2016 and **priority areas** for reforestation are concentrated in the northern area of the watershed. Refer to Figure 3.5

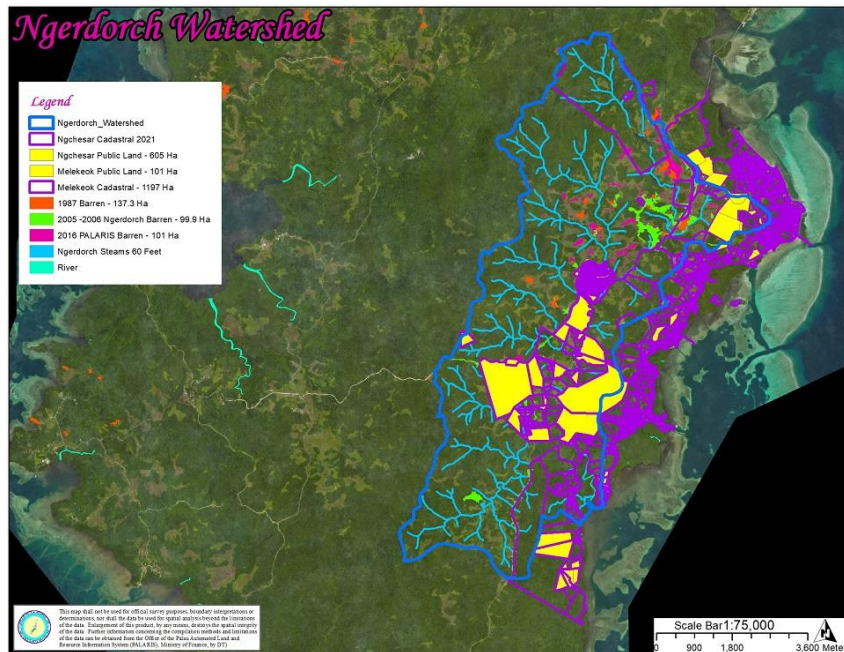


Figure 3.5 Ngerdorch Watershed showing barren areas that need revegetation. A forest restoration project is being conducted in the along the northern boundary of the watershed. An insert of a barren canyon just north of an ongoing reforestation project is also shown and a **priority area** for reforestation.

The role of remnant forest patches for habitat restoration in degraded areas in Ngerdorch Watershed

Dendy et al. (2015) monitored native forest patches (4–275 m²) within the Ngerdorch Watershed over 3 years to assess the influence of low-cost restoration methods on patch expansion, growth of naturally established tree saplings, density of naturally establishing tree seedlings, growth of planted tree seedlings, flower and fruit production, and bird and flying fox visitations. Treatments included fertilization, trimming of surrounding herbaceous vegetation, mulching of patch perimeters, and planting native tree seedlings. Fertilized patches expanded faster and were associated with higher growth rates of perimeter saplings, higher fruit and flower production and growth of adjacent planted *Acacia auriculiformis* trees. Trimming perimeter vegetation led to higher tree seedling densities and species diversity. Trimming and fertilizer effects on patch perimeter measures decreased over time. *Pterocarpus indicus* (las) a high value native legume, was the fastest growing planted tree species. The most common visitors were small, omnivorous, predominately endemic bird species. Visitations to fertilized patches were more frequent than to non-fertilized patches. The strongest predictors of visitation frequency were patch area, mean number of total fruits, and mean height of nearest neighboring trees. We conclude that forest succession can be accelerated by applying small amounts of fertilizer (approximately 22.5 g/m² per application) to enhance tree growth and increase visitation rates of native pollinators and dispersers.

Melekeok Lake Ngardok *Hanguana malayana* (cheuais) Clean-up

During December 10, 2020, Melekeok Conservation Network – Melekeok PAN, Ongedechuul Systems of Conservation Areas – Ngardmau PAN, Ngeremlengui Protected Areas – Ngeremlengui PAN, and Ngchesar State Protected Areas – Ngchesar PAN joined forces to help remove and control the cheuais (*Hanguana malayana*) from covering the center of Lake Ngardok. The PAN States and the network worked effortlessly to remove a big chunk of cheuais to ensure the natural flow of the water is restored. Field expedient tools and methods were efficient, and 26 personnel from the PAN states contributed to the effectiveness of the project. About 30 percent of the cheuais was removed to allow the natural flow of the lake. Melekeok Conservation Network (MCN) staff are assigned to monitor the trends and status of the water resources within Ngardok Nature Reserve. The encroachment of the “cheuais” had some effects in the monitoring activities (<https://islandtimes.org/cheuais-control-project-in-lake-ngardok>).



Figure 3.6 Ngardok Reserve *Hanguana* (cheuais) 2020 clean up. Island Times

The 2020 Ngiwal State Watershed Restoration Plan

The Ngiwal State Watershed Restoration Plan (NSWRP) includes 5 watersheds including the Ngerbekuu Watershed. Refer to Figure 3.7. The Plan calls for the clean-up & restoration-to maintain the Taiyo River Channel, enlarge access point to Ngerbekuu Nature Reserve, clean and clear Ngerbekuu River to unclog and increase water flow, reinforce erosion, and run off controls, build bridges, and restructure trail to Orsoulkesol Waterfall. This Plan put together the collective efforts and values placed on Ngiwal State natural water resources through community restoration and maintenance projects.

The NSWRP includes a Ngiwal Dam Restoration Project that aims to improve and provide access to clean and drinkable water sources and to mitigate the effects of droughts and resulting water shortage. Ngiwal is a growing community due to public leasehold areas being improved by new homeowners. The increase in number of homes and new water lines is taking a toll on the existing public water system. Prolonged dry season cause for low levels of water, resulting

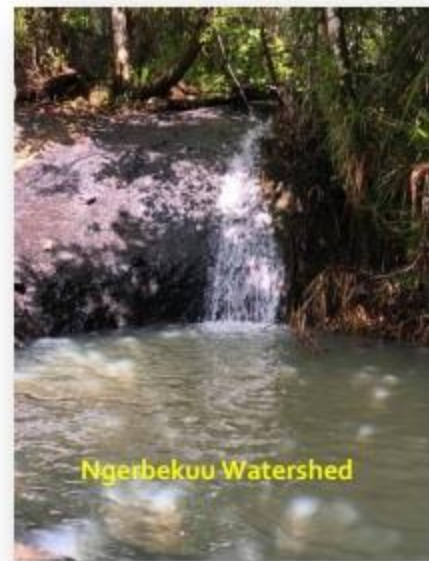


Figure 3.7 Ngerbekuu Watershed

in water hours and or muddy water flow from public water line. Most of drinking water comes from water catchment tanks, which will eventually run out during dry seasons forcing people to drive into Koror to fill up water containers for drinking and cooking use at home.

Six actions to be taken to provide access to clean drinking water and serve as a backup water source in the event of prolonged dry season or a drought are as follows:(1) Drain and clean water reservoir. (2) Clean and enlarge water line to improve flow of water into the water reservoir/dam. (3) Route all streams and spring water sources within the area into the water line feeding the dam. (4) Procure water purifying equipment along with electrical poles and lines to the dam area. (5) Construct a purifying station with packaging and or holding area for clean water distribution. (6) Package, distribute, and or sell purified drinking water to provide sustainable financing for dam operation.

Povak A. et al (2020) developed a decision support tool for the conservation of tropical forest and nearshore environments on Babeldaob Island, Palau. The **highest priority for reforestation catchments**

were located near the coast while all the high priority areas for protection of existing forest were further inland. The maps in Figure 3.8 are the underlying data, and conclusions about priority areas. These areas included the Ngerikiil, Ngerdorch, and Ngeremeduu Watersheds. The **Ngerikiil Watershed is the top priority as the main source of water for Airai and Koror**. The Ngerdorch and Ngeremeduu are the largest watersheds in Babeldaob and are top priority, with Ngerdorch second to Airai due to the high biodiversity and as a water source to the nation's capital. The **upper watersheds for each state's public drinking water remain top priorities** as shown in Figure 3.1.

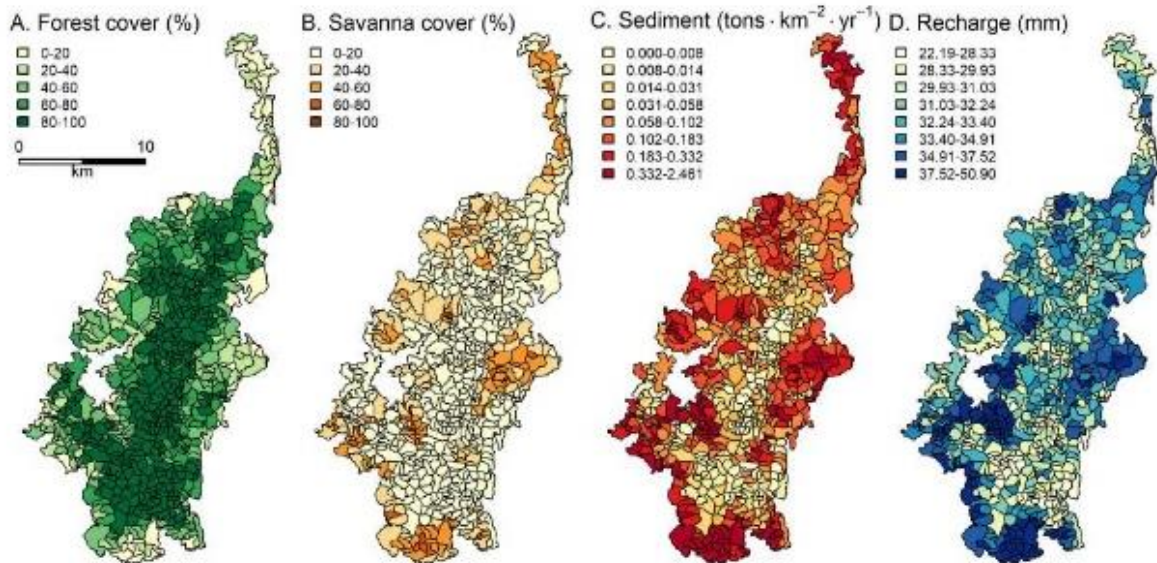


Figure 3.8 Maps of current (A) forest coverage and (B) Savanna coverage (B) sediment load production and (D) ground water recharge. Povak A. et al (2020).

EQPB Establish Buffer Zones

In 2020, EQPB adopted amendments of the marine and freshwater quality regulations to include riparian and wetland buffers in Chapter 2401-11 Marine and Fresh Water Quality Regulations. The minimum buffer zones for all freshwater lakes, streams, swamp forests and marine Outstanding National Resource Waters shall be sixty (60) feet. (2) The minimum buffer zones for Class AA and Class A marine waters shall be thirty (30) feet. Development is not permitted in these **buffers zones that are a priority for forest management**.

Belau Watershed Alliance

The Belau Watershed Alliance (formally the Babeldaob Watershed Alliance) developed a Belau Watershed Alliance Action Plan 2018 to 2022. The BWA vision is as follows: “The Belau Watershed Alliance will become a national model for ensuring that states have continued access to clean water and healthy habitats and promote environmentally sustainable economic development through collaborative efforts of a diverse array of stakeholders.”

The mission of the Belau Watershed Alliance is to protect, conserve and restore the waters resources of Belau through collaborative outreach, education, networking, science, information sharing and technical assistance by and for the communities of the island. All Babeldaob states are members of BWA and are at various stages of awareness raising, assessment and strategic planning for the watersheds under the Alliance. The four goals of BWA are as follows: (1) Communicate up-to-date best watershed management practices and water resource information through education outreach and materials and events. (2) Achieve Sustainable financial support to carry out its vision and mission. (3) Help build

resiliency to changes in climate and weather patterns by protecting biodiversity, maintaining ecosystem functions, sustaining water and food resources to ensure health, safety, and security for the community.
(4) Improve capacity to reach BWA's vision and mission

Measures of Success Issue 3 Water quality and quantity

Measures of success over the past decade are as follows: (1) The 2015 Agriculture Census inventoried agroforests and farms in the watersheds of Babeldaob. The National EQPB regulations established national buffers for all States in Palau. The Airai State Watershed Management Plan was produced and the 2018-2022 Belau Watershed Action Plan profiles each State and its land cover including agricultural land, house sources of water and soils. Decision making conservation tool for reforestation. Fire breaks were set in prone areas. Invasive species such as Rattan were removed from prone areas. Point sources of pollution were identified in Ngerikiil Watershed. Water testing was conducted in collaboration with EQPB for the Ngerikiil and Ngerdorch Watersheds. Reforestation programs were initiated in Ngerikiil Watershed and Ngiwal's watersheds. At Ngerdorch Watershed, a permanent dynamics plot was established to monitor change in forest health, research on the role of forest patches and restoration options were explored, and recently there is a community effort to clear *Hanguana* plants to restore water flow in the lake.

The 2021-2030 Forest Action Plan will address the Issue 3 Water Quality and Quantity through the implementation of the following actions in the next decade:

- (1) A Sustainable Forest Database system will be established, and staff trained to track landowners assisted, number of species propagated and planted, and survival rates, number, and size of demonstration agroforest plots, acres of important forest resources areas and acres of sustainably managed forest resource areas on public and private lands, develop and implement FSP and UCF Plans. Use & supplement existing SMART system;
- (2) Establish buffer zones according to EQPB regulations;
- (3) Fire breaks will be installed, and invasive species removed from buffer zones;
- (4) Assess the need for easements from private landowners of permanent buffer areas of high priority upper watershed areas;
- (5) Reforestation of areas of point & non-point sources of pollution identified in Ngerikiil an upper watersheds of drinking water sources;
- (6) Collaborate with EQPB in water testing before & after reforestation;
- (7) Secure funds from PAN for at least 1 watershed;
- (8) Design /implement social marketing campaign around forests to improve attitudes/behavior and valuing forests (including mangroves) and the PES regarding water quality and quantity;
- (9) Design project and conduct stakeholder analysis on watersheds and forests;
- (10) Develop a report format aligned with the State of the Environment Report;
- (11) Establish scholarships, and internships for sustainable forestry educational programs;
- (12) Research available materials on forests and watersheds for development of educational materials;
- (13) Collaborate with NGOs, PCC, and MOE to develop and disseminate educational materials and a curriculum module for watersheds and forests
- (14)) Hold an Annual Forum for members of the Forest Advisory Council as well as other partners partners interested in Forest Stewardship and Urban and Community Forestry;
- (15) Collaborate with state governments to identify priority areas for reforestation efforts (produce maps);
- (16) Cooperate with NGOs on a student and community volunteer program;
- (17) Developed, adopt, and enforce state regulations and legislation to protect watersheds and restore degraded forests from impacts of population growth and infrastructure expansion;
- (18) PALARIS and other partners update vegetation maps and hydrological models;
- (19) Integrate biodiversity conservation and ecosystem health indicators such as birds and water;

- (20) Develop an annual State of Palau's Forest Report;
- (21) Gather and develop useful forest related information to disseminate to states and other resources users.
- (22) Develop and implement Palau SFM Plan and Best Practices;
- (23) Forest Resource Management Requirements established and integrated;
- (24) Work with the states and partners to develop Comprehensive State Forest Management Plans addressing climate change, watershed protection, conservation, rehabilitation, and sustainable use of forests;
- (25) Conduct State consultations and visits to support detailed planning in each state for overall forest management.
- (26) Request Governors to designate a lead person from each state to work with MAFE team
- (27) Establish either a Memorandum of Agreement (MOA), or Memorandum of Understanding (MoU) or a Letter of Commitment between Palau Forest Service, State, Community, Private Sector, NGOs, and Landowners on roles, responsibilities, and commitments of each party.
- (28) MAFE justify and secure Congressional funds for forestry programs.
- (29) Develop, test, and implement training modules that include guidelines for SFM.
- (30) Create professional development programs
- (31) Forest Advisory Council with partners such as GEF Small Grants Program support sustainable forest projects;
- (32) Propagate, collect, and plant at least 20,000 saplings/year for rehabilitation programs using native and fruit bearing trees; map and monitor sites;
- (33) Establish greenhouse network, expand existing greenhouses, and establish greenhouses where needed;
- (34) Native trees propagated, planted, and survival rates quantified;
- (35) Create a list of projects that can be done related to sustainable forest management and watersheds.
- (36) Develop Educational and awareness materials (posters, radio shows, videos) related to sustainable forest management and watersheds, freshwater sources, and the potential ecosystem services of forests.
- (37) Design and implement a water monitoring program in the upper watersheds that are drinking water sources.
- (38) Propagate, plant, and monitor survival rates of rehabilitated bare soils.
- (39) Communities identify and remove obstructions to waterflow caused by debris and fallen trees.
- (40) Develop and implement State Land Use Plans and integrate water supply.
- (41) Assess and conduct a feasibility study of watersheds to identify, design, and construct water storage and distribution lines.
- (42) State and EQPB identify and eliminate or mitigate point sources of pollution.
- (43) Conduct an "Assessment of Need" for Forest Legacy Program and other funding for easements from private landowners for permanent buffer areas of high priority watershed areas and HCV forests;
- (44) Reforest areas of point and non-point sources of pollution identified in the Ngerikiil Watershed;
- (45) Monitor water quality pre and post reforestation of bare areas along rivers and streams;
- (46) Develop at least one watershed management plan for either a upper watershed that provides drinking water or a PAN site;

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Issue 4 Wildfire and Public Safety

Wildfires are a major threat to Palau's infrastructure and terrestrial landscape. During ENSO related drought years, the danger of wildfire increases and the impact of wildfires during these critical periods can be catastrophic. During severe droughts, the savannas burn uncontrollably in remote areas. Fire burns through buffer zones of major rivers. Kitalong observed fires burning to the edge of the Ngarmeskang River in 1997-1998 ENSO events. The Republic of Palau National Biodiversity Strategy and Action Plan (2004) lists uncontrolled fires with repeated fires as one of the major threats to terrestrial biodiversity. Grasslands originating from abandoned agricultural land fail to reforest and often vegetation is lost, and soil erosion occurs. The Fire and Rescue Division of the Bureau of Public Safety is mandated to suppress both urban and rural fires but is understaffed and has limited equipment. The Division of Forest, Land, and Water Management of the Bureau of Environment has very limited fire management or suppression capacity (ROP NBSAP).

Most wildfires are initiated by people during drier periods and periods of higher wind contributing to the incidence of uncontrolled fire. There are two main types of burning in Palau: burning for traditional agricultural purposes or to claim land and simply setting fires for sport which is arson. Fire has long been a tool used by traditional gardeners to clear areas for gardening. Today abandoned gardens are overtaken by invasive plants of which some are more flammable than others. These invasive plants inhibit reforestation and cause areas to be more vulnerable to fire. Recreational burning (arson) and burning to clear hunting trails or paths are believed to be the main cause of wildfire. To better manage and control fire related activities, burning permits are administered through the Environmental Quality Protection Board (EQPB). The permit is aimed at preventing air pollution and prohibits the burning of tires. The permit regulates the size of fire and requires fires to be contained. When a burning permit is issued the Division of Fire and Rescue is notified. A citation is issued for cases of non-compliance with the permit process. Currently there is poor compliance, especially in less accessible areas in Babeldaob and the outer states of Angaur, Peleliu, Kayangel, Hatohobei and Sonsorol.

The Republic of Palau Wildfire Plan 2008-2013 described the Division of Fire and Rescue (DFR) as a branch of the Bureau of Public Safety (BPS) under the National Emergency Management Office (NEMO) within the Ministry of Justice (MOJ). A bill was pending to change the Division into a Bureau. The Plan stated that the staff included a Chief, an Assistant Chief, 11 full time officers, and a secretary. The six Officers were located in Koror and 4 officers were located at the Melekeok substation. It is estimated that an additional 39 firefighters were needed. The DFR has a central fire station and two to three 800-gallon crash trucks (forestry trucks) and a substation in Melekeok State

In 2010, firefighting equipment was provided by US Forest Service Region 5 Cooperative Fire Program included flappers, backpack sprayers, and Pulaski's shovels. It was estimated that two new 1,500-gallon fire engines and 2-3 smaller 500-800 gallon engines with hoses and pumps were needed. Given the size of Babeldaob, at least one additional substation at the West Coast was recommended. In 2011, a new substation was built for Ngardmau State. In 2016, the DFR opened 16 firefighter positions. The DFR and Police Officers did Community Awareness Program where everyone participated by presenting prevention messages to the public with a roadside campaign. The DFR partnered with the Forestry Division (FD), now known as the Division of Forest, Land, and Water Management (DFLW) on the state inventory and needs assessment to ensure full integration of the fire protection program. School visits were conducted jointly with the DFLW. Invitations were extended to the Division of Fish and Wildlife Protection (DFWP) to join this effort. Billboards were placed on the side of the roads in Babeldaob. Five new firefighters joined DFR. We had 5 elementary school visits in Babeldaob and Koror with the Ministry of Education (MOE) and conducted a Fire Evacuation Drill for fire emergencies. During 2016, the DFR collaborated with EQPB on the permitting system and continued outreach with Palau Community Action Agency (PCCA) and outlying states and continued producing billboards. In 2018,

DFR conducted 10 school visits on fire prevention awareness, hired two new firefighters, conducted in-house training, and continued their ongoing partnership with DFLW on inventory. In 2020, the DFR partnered with Palau Red Cross Society (PRCS), MOE, FD, and Ebiil Society for community awareness and training on fire prevention. They have an ongoing partnership with EQPB for the permit process and PPUC for water access in outlying states. As well as, developing a Memorandum of Agreement (MOA) between DFR and DFLW to enable state officers to assist firefighters in emergencies. They also conducted training with Ebiil Society on tree planting in burned areas. In 2021, DFR collaborated with NEMO, MOH, PRCS in training for fire prevention and suppression.

The 2021 “**priority wildfire areas**” (high risk fire locations, where fires occur repeatedly) are where Palau will concentrate efforts to prevent, pre-suppress, control, and suppress the frequency and sizes of wildfires. These areas were chosen based upon consultations with the DFLW and the Division of Fire and Rescue (DFR) in 2021 and are similar to the 2010 priority areas. **The priority areas are Ngerikiil Watershed, Airai the barren hills in Ngetkib Airai, the road intersection by Ngatpang, the road between Ngardmau and Ngkeklau, Ngaraard, and the road between Choll, Ngaraard and Ngarchelong.** Refer to Figure 4.1 and 4.3. These five high risk wildfire areas were priority areas for reforestation and fire prevention and comprised 2.75 km² of savanna. Most reported fires occur along the National Highway which provided easy access to these vulnerable areas.

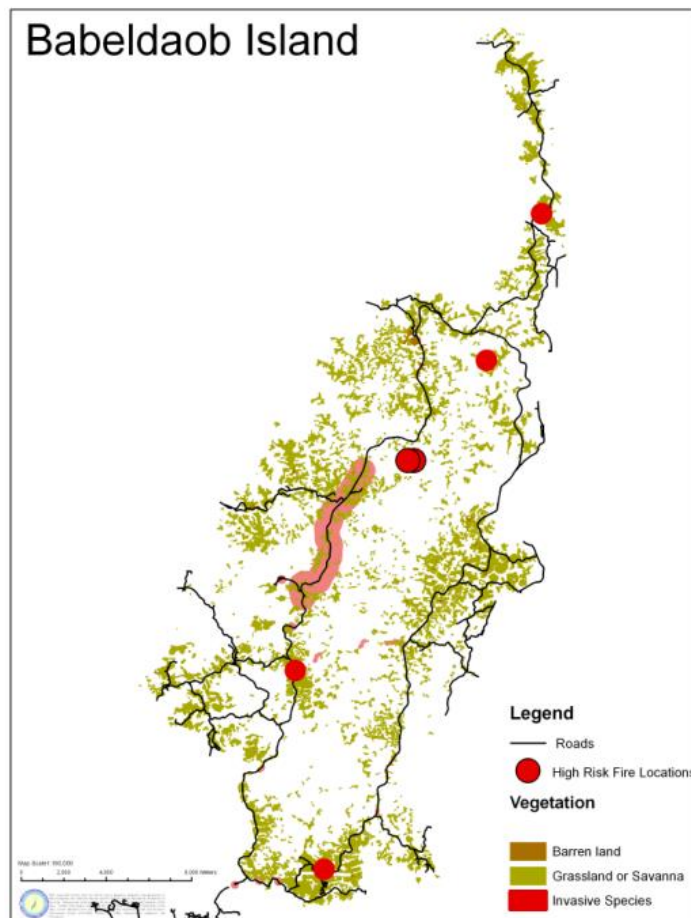


Figure 4.1 2010 SWARS High Priority sites - High Risk Fire Locations -that are **high priority** areas for 2021-2030 and represent similar areas as shown in Figure 4.3

A partnership between CRRF, DFLW and USDA Forest Service mapped the extent and impact of fire on Babeldaob over an eight -year period during 2012 to 2019. The number of fires were highest during the dry months of February and March. Refer to Figure 4.3. The percent of Babeldaob that burned between 2012 and 2020 ranged between 0.3 to 1.8% with an average of 0.8% a year. Babeldaob had an average of 173 fires/y and burned 3km² or 3,000,000 m²/yr or 0.8% of the island. There was an average of 122 fires per state, which burned an average of 5.7% of each Babeldaob State’s total area (including mangroves). Airai had the most fires (33% of all fires) followed by Aimeliik and Ngeremlengui. Ngeremlengui, Airai and Aimeliik had the most area burned. Ngarchelong, Airai, and Aimeliik had the greatest percentage of their total state area burned. Refer to Table 4.1

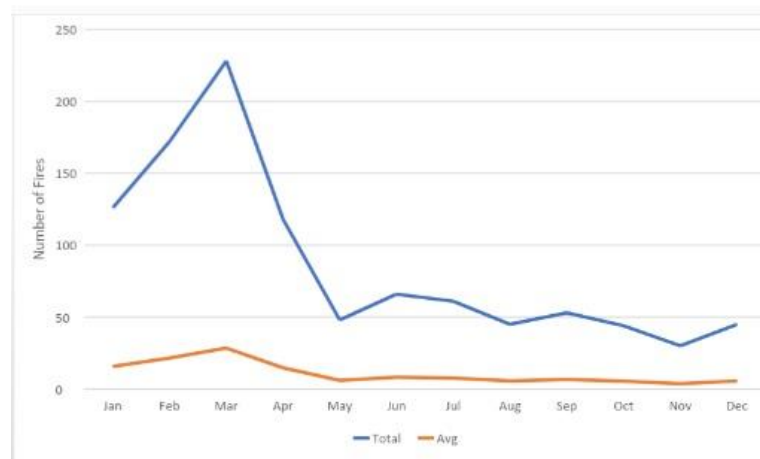


Figure 4.2 The total number and mean number of fires each month between 2012 to 2019 (Dendy et al. 2020).

Table 4.1 Fires by State (2012-2019) reported in square meters (Dendy et al. 2020)

| State | # of fires | % of all fires | Size Range of Burned Area (m ²) | | Mean Area Burned (m ²) | Total Area Burned (m ²) | % of State Area |
|--------------|------------|----------------|---|----------------|------------------------------------|-------------------------------------|-----------------|
| | | | Smallest | Largest | | | |
| Aimeliik | 174 | 13.2 | 59 | 284,521 | 18,417 | 3,204,595 | 7.7 |
| Airai | 443 | 33.7 | 137 | 126,816 | 9,621 | 4,262,008 | 7.8 |
| Ngchesar | 100 | 7.6 | 240 | 192,495 | 17,697 | 1,769,732 | 4.3 |
| Ngatpang | 67 | 5.1 | 90 | 101,936 | 14,702 | 985,021 | 2.5 |
| Melekeok | 43 | 3.3 | 410 | 151,233 | 20,566 | 884,357 | 3.4 |
| Ngiwal | 47 | 3.6 | 356 | 118,247 | 16,157 | 759,388 | 4.7 |
| Ngeremlengui | 164 | 12.5 | 157 | 328,084 | 29,467 | 4,832,553 | 7.4 |
| Ngardmau | 70 | 5.3 | 170 | 161,550 | 32,594 | 2,281,594 | 6.8 |
| Ngaraard | 129 | 9.8 | 228 | 326,084 | 19,734 | 2,545,648 | 7.8 |
| Ngarchelong | 77 | 5.9 | 125 | 188,588 | 15,360 | 1,182,737 | 10.6 |
| Total | 1314 | | | | | 22,707,633 | |
| Mean | 131.4 | | 197.2 | 197,955 | 19,432 | | 6.3 |

The characteristics of the fires were as follows: 43% of the fires burned some forest edge; 0.1% of the Babeldaob forests burned at mean rate of 0.1%/year; and a total of 0.9% of the forests burned between 2012 and 2020. The savanna burned at a rate of 4%/year; and a total of 30% of the savanna burned between 2012 and 2020. About 28% of the fires indicated the presence of invasive species.

Approximately 1.4% of Babeldaob burned at least twice in the 8-year period. Refer to Figure 4.3. These repeated fires occurred mainly in the savanna (89.9%), followed by forest (7.8%), marsh (1.6%) and urban areas (0.7%). These repeat fire areas are potential indicators of invasive species, arson, hunting and erosion. Over twice the total area of vegetation burned in 2015 during a drought/El Nino year, compared to an average year. On March 31, 2020, Ngatpang had a fire that burned for 4 days, destroying 182acres (72 hectares) of savanna and forest.

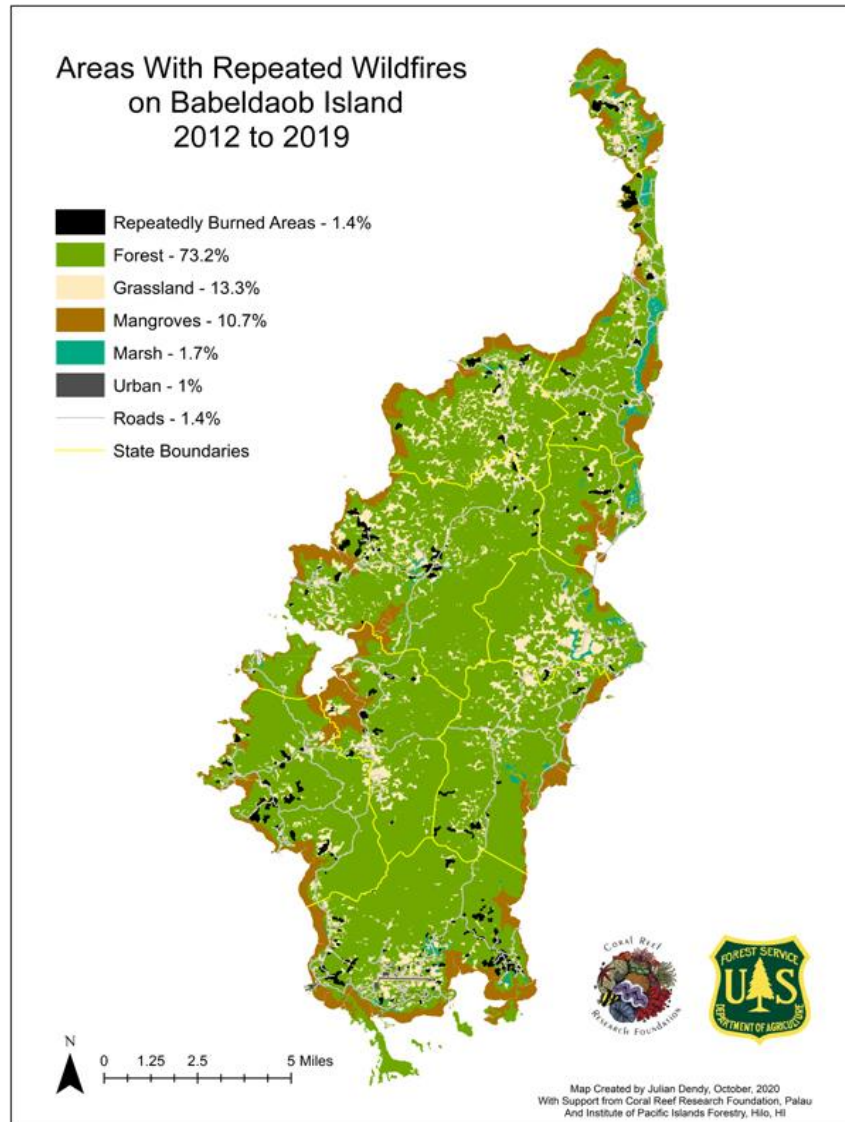


Figure 4.3 Repeated wildfires are **priority areas** for reforestation on Babeldaob 2012-2019



Figure 4.4. Ngatpang wildfire destroyed 182acres (72 ha) of savanna and forest on March 31, 2020

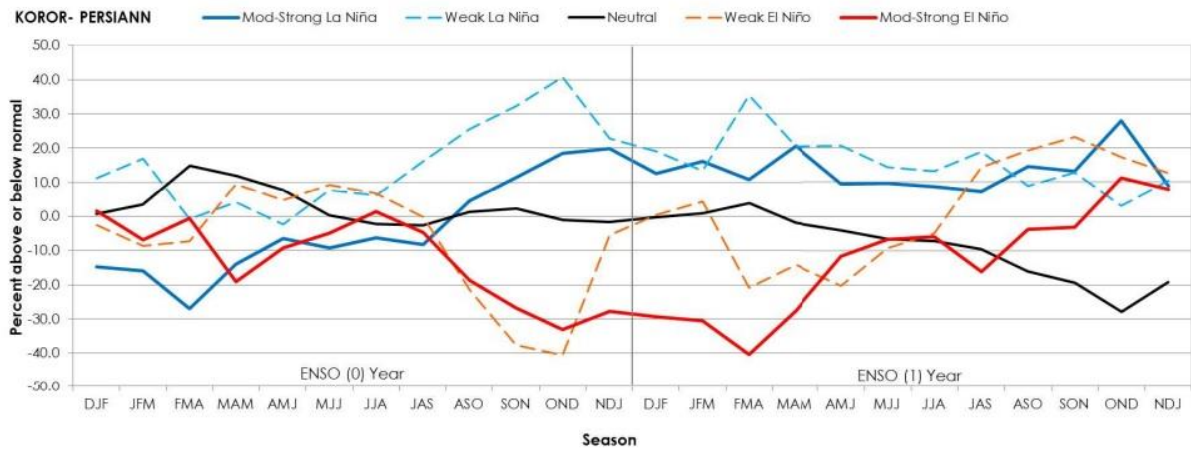
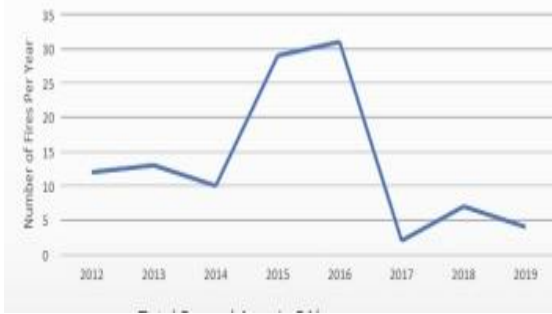


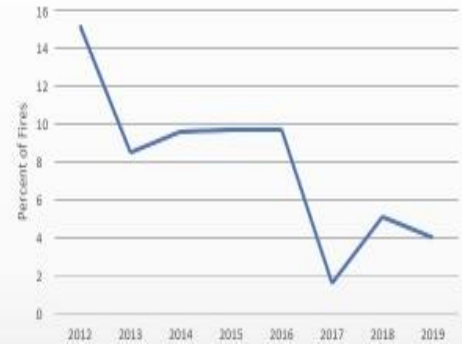
Figure 4.5. The ENSO phenomena showing neutral, weak, and moderately strong oscillations during La Nina and El Nino years (Sutton et al 2015) that are linked to droughts and fire.

ENSO events are linked with more severe droughts and areas burnt by wildfires in Guam based on a 20-year record: a dry spring follows an El Nino year. Figure 4.5 depicts the ENSO during normal, week and moderately strong annual events. There was an average of 15 fires/yr inside Protected Areas. There was a trend of decrease in fires in the protected areas. It is critical that Palau quantify and document the extent and frequency of fires through field work linked with annual aerial photography. The 2010 SWARS reported 68 fires between 2007 and 2009 covering a total of 0.07 km², which was far less than 3.0 km² between 2012 and 2019; indicating that fires were more frequent than previously reported (SOE 2019). Between 2012 to 2019, there was a peak in total numbers of fires and total areas of fire in Protected areas during 2015 and 2016. The percent of burned areas in Protected Areas showed a drop between 2012 and 2014 with a slight rise between 2015 and 2016 and 2018. Refer to Figure 4.6.

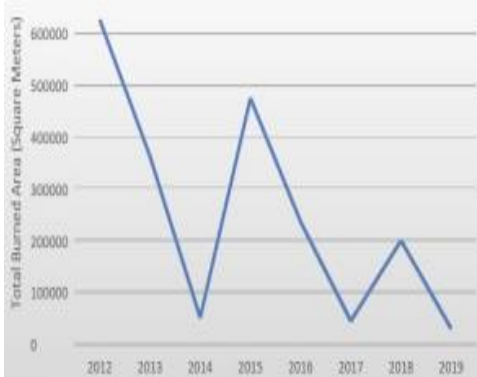
Number of Fires in the Protected Areas (PA's)



Percent of Fires in PA's



Total Burned Area in PA's



% of Burned Area in PA's

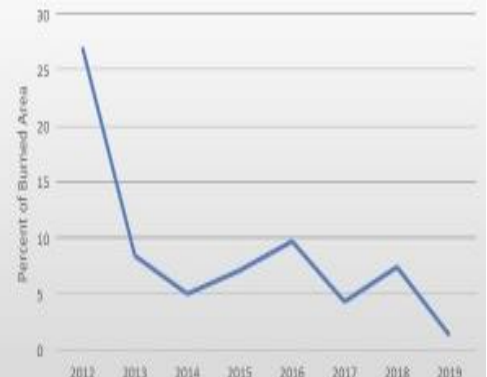


Figure 4.6 Wildfires in Palau Protected Area Network (PA'S) between 2012 and 2019.

Cooperative Fire Protection

The Forest Service and Ebiil Society have co-hosted a quarterly webinar series for members of the NWP that began in November 2020. The NWP is comprised of members (Ministry of Agriculture, Fisheries, and Environment, Bureau of Environment, DFLW, Protected Areas Network, Ministry of Justice, Bureau of Public Safety, Division of Fire and Rescue, and the Environmental Quality and Protection Board), state governments, state protected area managers, and the Ebiil Society. NWP has held 3 webinars to date that focused on wildfire prevention, wildfire suppression, and the development of Fire Danger Warning System for Palau similar to that of Guam. A draft national Wildfire Prevention Plan was made as a product of the first webinar and the goal of the NWP is to have a draft national wildfire prevention plan (NWPP) at the end of 2022 produced by the NWP. A priority need for wildfire suppression training was identified and will be initiated once the COVID-19 pandemic is a reduced risk for travel.

A place-based wildfire awareness curriculum was developed for Palau for grades 6-12 through a partnership of Ebiil Society, USDA-FS-IPIF, Center for Getting Things Started, and the Pacific Fire Exchange and is currently being used in outreach programs of the Ebiil Society with local elementary schools. This curriculum is available on the following website:

<https://www.pacificfireexchange.org/research-publications/wildfire-awareness-curriculum-palauwc>

A video was produced by a Palauan intern, Yubee Isaac, in late 2020 as a partnership between Ebiil Society and the FS on how to prevent the threat of fire to Palau's biodiverse forest where Palauan values of respect ("omengull"), reciprocity and acknowledgment of the essence of the forest

(“chengal”) are taught. (6 min) <https://www.pacificfireexchange.org/research-publications/virtual-workshop-covid19-3t3ed>. Refer to Figure 4.7.

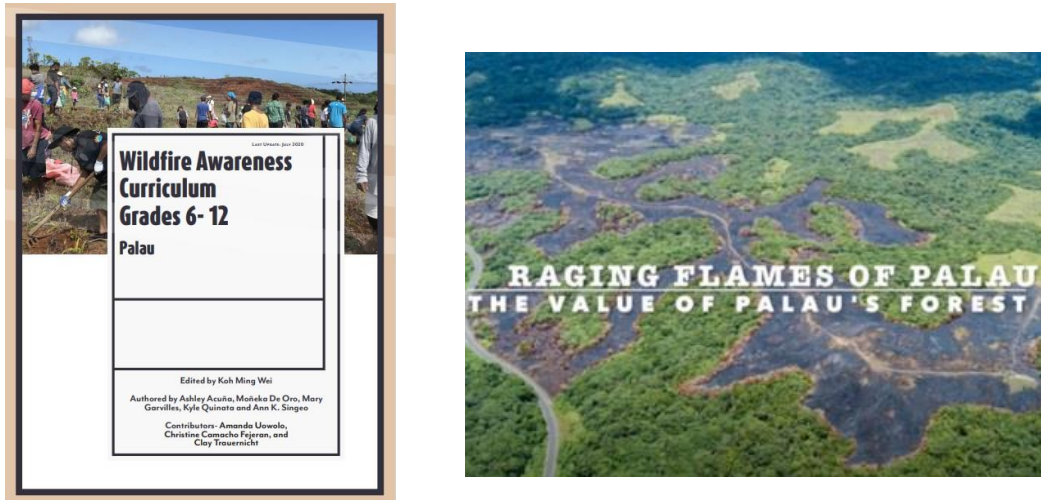


Figure 4.7 A Place-based wildfire awareness curriculum (left) and a video on Fire Prevention.

During 2019 to 2021, the Ebiil Society implemented a program for green shaded fuel break plantings and restoration of wildfire impacted areas. The work was focused on Ngardmau and Melekeok and expanded to other states in Babeldaob. Green shaded fuel breaks were established in 3 areas prone to wildfires in the state of Ngardmau, resulting in the planting of nearly 600 native trees by the Ngardmau community. A greenhouse was established in the Ngardmau protected area site (Ongedechuul System of Conservation Areas) to grow plants used for the green shaded fuel breaks. Refer to Figure 4.7.



Figure 4.8. Children planting lemon grass to serve as fire breaks in Ngardmau with support from Ebiil Society

The USFS-IPIF continues to support wildfire mapping in Palau through their agreement with CRRF. Regular updated fire history database for Palau is available at <http://arcg.is/19C4SKO>. Maps can be customized by land managers or agencies for their specific needs with a request to Julian Dendy who is supported by the USFS-IPIF through an agreement with CRRF.

Measures of Success Issue 4. Wildfire and Public Safety

Measures of success over the past decade on wildfire and public safety are as follows: A database for all fires including frequency, size, location, mitigation & long-term monitoring has been established and a fire vulnerability map has been produced showing areas of repeated fires. A Wildfire Summary Report has been produced. A “Smokey the Biib” mascot has been developed & campaign and radio shows during each spring dry season. A video on fire prevention was produced with a school curriculum. Green strips are being set in priority areas. Imperata grass has been mapped and is being treated with a goal to eradicate them near the National Airport in Airai. Green strips were planted in Ngardmau in priority areas.

The 2021-2030 Forest Action Plan will address Issue 4 Wildfire and Public Safety through the implementation of the following actions over the next decade:

- (1) Develop and implement an Integrated Reporting Permit & Assessment System between EQPB, DFR & BPS as part of the National Sustainable Forest Data Management System;
- (2) Produce 1 brochure on fire prevention;
- (3) Formalize a Fire Hazard Reduction Program for Palau;
- (4) Control *Chromolaena odorata* and other invasive plants at priority sites;
- (5) Set one fire break at priority sites within each State;
- (6) Set up fire suppression demonstration plots;
- (7) Design /implement social marketing campaign around forests to improve attitudes/behavior and valuing forests (including mangroves);
- (8) Design Project and Conduct Stakeholder Analysis on Fire and Forests;
- (9) Establish scholarships and internships for sustainable forestry educational programs related to wildfire research;
- (10) Research available materials on forests and fires;
- (11) Collaborate with NGOs, PCC, and MOE, to develop and disseminate educational materials and a curriculum module on wildfire and public safety;
- (12) Hold an Annual Forum for members of the Forest Advisory Council as well as other partners partners interested in Forest Stewardship and Urban and Community Forestry;
- (13) Collaborate with state governments to identify priority areas (repeated burned) for reforestation efforts (update maps);
- (14) Cooperate with NGOs on a student and community volunteer program;
- (15) Develop adopt, and enforce State Regulations and Legislation on wildfires and public safety and restore degraded forests from impacts fire;
- (16) PALARIS and other partners update vegetation maps and hydrological models;
- (17) Forest Health indices will be developed and used by PAN;
- (18) Develop State of Palau's Forest Report;
- (19) Gather and develop useful wildfire and public safety related information to disseminate to states and other resources users;
- (20) Establish forest resource management requirements in relation to wildfires and public safety and integrate in state land use plans.
- (21) Work with the States and partners to develop Comprehensive State Forest Management Plans addressing climate change, wildfire, watershed protection, conservation, rehabilitation, and sustainable use of forests;
- (22) Consult and visit each state for overall forest management in relation to wildfires and public safety;
- (23) Request Governors to designate a lead person from each state to work with MAFE team;
- (24) Establish either a Memorandum of Agreement (MOA), or Memorandum of Understanding (MoU) or a Letter of Commitment between Palau Forest Service, State, Community, Private Sector, NGOs, and Landowners on roles, responsibilities, and commitments of each party;

- (25) Develop a protocol for data collection, analysis and management of permits, monitoring, and mapping fires in Palau;
- (26) Justify and secure Congressional funds for forestry programs;
- (27) Develop, test, and implement training modules that include guidelines for SFM;
- (28) Create professional development programs;
- (29) Establish and support a core group to engage in Wildfire Network and identify communities for Community Wildfire Protection Plan (CWPP) development;
- (30) Implement fire prevention clearance strips and fire breaks in areas of repeated fires;
- (31) Develop, print, and disseminate educational material on wildfire prevention, invasive species, climate change, the value of mangrove forests and existing forest-related regulations.
- (32) Set up fire suppression demonstration plots for fire breaks and green belts at priority sites;
- (33) Conduct comprehensive state inventories using forest health indicators of HCV forests and endangered species habitats.
- (34) Develop a program to enhance collaboration and institutional strengthening for SFM Partners through biosecurity task force focused on forest health;
- (35) Forest Advisory Council with partners (i.e., GEF Small Grants Program) support sustainable forest projects;
- (36) Invasive species identified, removed, and area measured and mapped, with focus on top 20 worst species (e.g., Macaque monkey, CRB, Mikania, Cycad scale, etc. as determined by NISC);
- (37) Identify and test virulence of OrNV of CRB in Palau;
- (38) Measure and map burnt areas; utilize geospatial data, such as fire history and occurrence maps, to identify communities at greater fire risk
- (39) Plant fire breaks and green belts along fire prone (repeated fires) areas;
- (40) Propagate, collect, and plant at least 20,000 saplings/year for rehabilitation programs using native and fruit bearing trees; map and monitor sites;
- (41) Establish greenhouse network, expand existing greenhouses, and establish greenhouses where needed;
- (44) Propagate, plant, and quantify survival rates of native trees planted in priority sites;
- (45) Create a list of projects that can be done related to sustainable forest management and fire prevention;
- (46) Develop educational and awareness materials (posters, radio shows, videos) related to sustainable forest management, fire prevention, freshwater sources, and the potential ecosystem services of forests;
- (47) Propagate, plant, and monitor survival rates of rehabilitated bare soils.
- (48) Communities identify and remove obstructions to waterflow caused by debris and fallen trees;
- (49) States develop and implement Land Use Plans;
- (50) Establish buffer zones and remove invasive species along the rivers and streams.
- (51) Establish fire breaks and green belts in priority areas in Babeldaob;

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Issue 5 Conservation and Protected Areas

Effective conservation is a challenge as populations grow, local resources decrease, imported resources increase, technology improves and access to habitats increase. On October 1, 2007, the 53 mile (83 km) national highway was officially completed in Babeldaob, Palau's largest island. Secondary impacts have begun with chronic incremental loss of forests for new homes and infrastructure. Previously inaccessible upper watersheds with old growth forests and swamp forests are now vulnerable. Clearing of limestone and volcanic forests, burning, and clearing of savanna and clearing and filling of wetlands and mangroves is causing the loss of forests and potentially impacting the terrestrial species dependent upon them.

The Republic of Palau's National Biodiversity Strategy and Action Plan (NBSAP) required an inventory of all species of plants including the distribution and relative abundance. NBSAP also address the threats and challenges to maintain the integrity of Palau's ecosystems. One of the NBSAP strategies is to protect its terrestrial ecosystems. The Protected Areas Network Act (RPPL No 6-39) of Palau was established to enable States within the Republic to designate areas for protection. Areas can be for restricted non extractive uses, and sustainable uses. Protected areas within the network will be managed mainly for science, wilderness protection, ecosystem protection, conservation of natural features, conservation with management intervention, landscape/seascape conservation and recreation and for sustainable use. Currently Palau has **16 terrestrial PAN sites and a total terrestrial managed area of 102.6km² that are priority areas for USFS funding**. Refer to Table 5.1 and Figure 5.1. Palau's PAN sites contribute to the Micronesian Challenge for long term conservation and protection. PCS Strategic Plan for 2010-2015 is to protect Babeldaob key biodiversity areas and assist in management planning for protected areas.

Table 5.1 Terrestrial Protected Areas by category, size percent of total land and number of sites. State of the Environment (SOE) 2019

| <i>Type of Terrestrial Protected Area</i> | <i>km²</i> | <i>Total land</i> | <i>%</i> | <i># sites</i> |
|---|-----------------------|---------------------|----------|----------------|
| Total Terrestrial Managed Area | 102.6 km ² | 410 km ² | 25% | 20 |
| Total Terrestrial Managed Area, Babeldaob | 42.7 km ² | 362 km ² | 12% | 13 |
| Total No-Take ² Terrestrial Area | 41.59 km ² | 410 km ² | 10% | 14 |
| No-Take Terrestrial Area, Babeldaob | 27.24 km ² | 362 km ² | 8% | 9 |
| Total Terrestrial area in PAN | 40.68 km ² | 410 km ² | 10% | 16 |
| Terrestrial area in PAN, Babeldaob | 33.76 km ² | 362 km ² | 9% | 12 |
| Important Bird Areas (IBA), managed | 85.34 km ² | 243 km ² | 35% | 10 |

Refer to Figure 5.2. The site visits enabled partners to meet and highlight past collaboration and future expanding partnership and projects. The US Forest Service, NRCS, and Science Fellows through the US Embassy have provided resources and trainings opportunities for MCN staff in Palau and abroad, provided funds to build its nursery, donated erosion control devices, and setup Ngardok as the first Forest Dynamic Plot site in Palau. Through this partnership with the US Embassy, PAN is strengthening its capacity to better manage its protected areas. It is the hope that these opportunities will expand in Melekeok, Ngardmau, and to other PAN sites.



Figure 5. 2 Partnership meeting and field trip 2020 <https://www.palaupanfund.org/news-events.html>

Forestry's (now DFLW) Conservation Education program works in partnership with communities to promote opportunities to develop awareness and understanding of environmental issues so citizens will act responsibly to care about and conserve their natural and cultural resources. This Program crosses all other forestry programs and fosters awareness of the interdependence of humans and the natural world. Through this program Forestry increases awareness, knowledge and appreciation of natural and cultural resources and promotes critical thinking skills that enable the people to recognize resource issues complexities within current social, political, scientific, and economic realities. This program fosters individual responsibility to conserve, preserve and wisely use their natural resources. This program produced two calendars that highlight the importance of forests and a mangrove poster that is being produced (Pua Michael, pers. comm. 2010).

Forest Dynamics Monitoring at Ngardok Nature Reserve

In partnership with Palauan State, Government and Non-Government Organizations (NGOs), the Smithsonian Center for Tropical Forest Science (CTFS) established the first permanent forest dynamic plot that will provide information on the growth, survivorship, and mortality of individual plants. This plot will provide baseline information on forest changes and detect recruitment, growth, and death to stressors like climate warming and drought. Professional staff from the DFLW and the Ngardok Nature Reserve participated in a 4-week internship in Hawaii in Spring 2014, where they were mentored by staff from the USDA Forest Service and the Hawaii Permanent Plot Network (HIPNET) <http://www.hippnet.hawaii.edu/>. Following the internship, the professional staff returned to Palau to begin the establishment of the Pacific Island Permanent Plot Network (PIPPNET) in Ngardok Nature Reserve (NRR).

Forest dynamics monitoring at Ngardok Nature Reserve as a partnership of Division of Forest, Land, and Water Management, Melekeok Conservation Network (MCN), and the USDA Forest Service – Institute of Pacific Islands Forestry, a 4-hectare permanent forest monitoring plot was established at Ngardok Nature Reserve of the MCN and was formally accepted in the Spring of 2018 into the

Smithsonian Institution's Forest Global Earth Observatory (ForestGEO). ForestGEO is a global network of scientists and forest sites dedicated to advancing the long-term study of the world's forests. The network is comprised of 67 forest sites in 27 countries, providing detailed information on the growth, survivorship, and mortality of more than 6 million individual trees across the globe of over 12,000 species.

The forest monitoring plot at Ngardok contains nearly 14,000 individual trees of 70 species and the information collected within the plot allow us to look at characteristics of individual trees and the abundance and size distribution of the trees for each species. These data will allow us to investigate how these characteristics change over time and how individual species respond to climate stressors such as drought or severe weather events. The information also will serve as a necessary platform to understand how the ecological properties of a Palauan forest compare with tropical and temperate forests around the world. The forest monitoring plot in Ngardok will be re-measured every 4-5 years through the collaboration of the DFLW, MCN, and the USDA Forest Service. There is a proposal to establish a second dynamic plot in Ngeremlengui Conservation Area (Jack Idechong pers. com July 13, 2021).

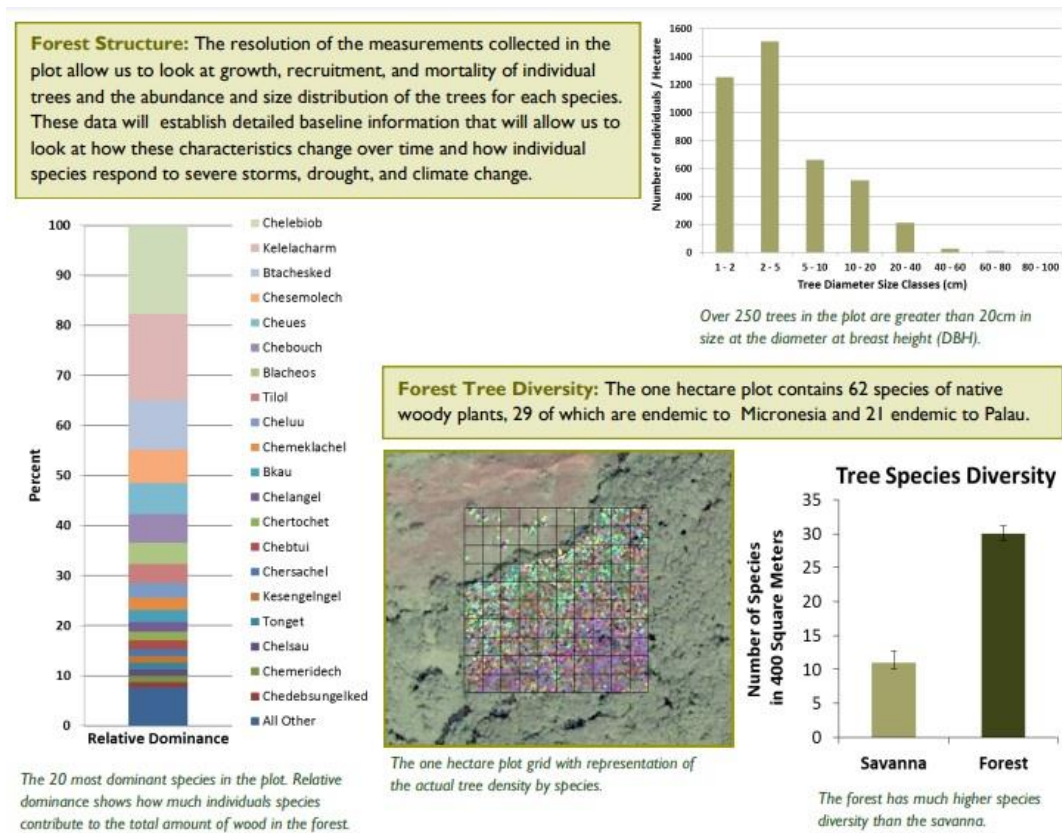


Figure 5.3 Forest Dynamic Plot Summary for Lake Ngardok

Forest Inventory and Analysis (FIA)

The USDA Forest Service Forest Inventory and Analysis (FIA) program in Palau was set up to address long term changes and regular (every 10 years) monitoring of the permanent plots quantifies the impacts and the resilience of Palau's forests to disturbances caused by fires, land clearing, typhoons, and invasive species. Forest growth and loss can be monitored over time to determine if reforestation is working over the long term. The FIA permanent plots were established, measured twice, and data was compiled and mapped and made available to users. The Forest Inventory and Analysis provides baseline information

and broad scale changes. Small scale studies to deal with management issues for a specific habitat or species of tree complements FIA. Existing data on FIA forests plots needs to be shared, archived and retrievable for future planning, forest management and protection.

National Forest Monitoring Program

In 2019, the Palau Protected Areas Network (PAN) Office and the Bureau of Agriculture (responsibility has now moved to the BOE), of the Ministry of Agriculture, Fisheries, and Environment collaborated in the development and implementation of the first national forest monitoring program. In consultation with the US Forest Service Forest Inventory and Analysis (FIA) and in coordination with the Micronesia Conservation Trust (MCT) grant funded by USFS Landscape Scale Restoration (LSR) program, and with other relevant local partners, the design of the monitoring program has been agreed on and the forest monitoring protocol document is being produced. In 2019, Fieldwork was initiated in the terrestrial protected areas. This monitoring program is long-term and aims to detect long-term trends in forest cover and structure. In March 2019, a contract was signed and executed between MCT and the Office of Palau Automated Land and Resource Information System (PALARIS), Bureau of Budget, Ministry of Finance, and the Government of Palau. The contract is supporting the development of an access database to house forest monitoring data, developing a protocol for database accessibility, data entry, and back up, and conducting training with relevant forestry staff on the use of the database. The National Forest Monitoring Program uses a layout similar to FIA plot layout (24ft (6m) radius, 6.8 ft radius sub-plot and a permanent center mark. Forest monitoring plot surveys are completed for 6 out of 8 PAN Sites. The total number of plots is 384, of which 285 are completed and 99 are to be completed by 2021. Data is being stored in Access Database. The team is working with PALARIS for project design, data management and data analysis. Refer to Figures 5.4 and 5.5.

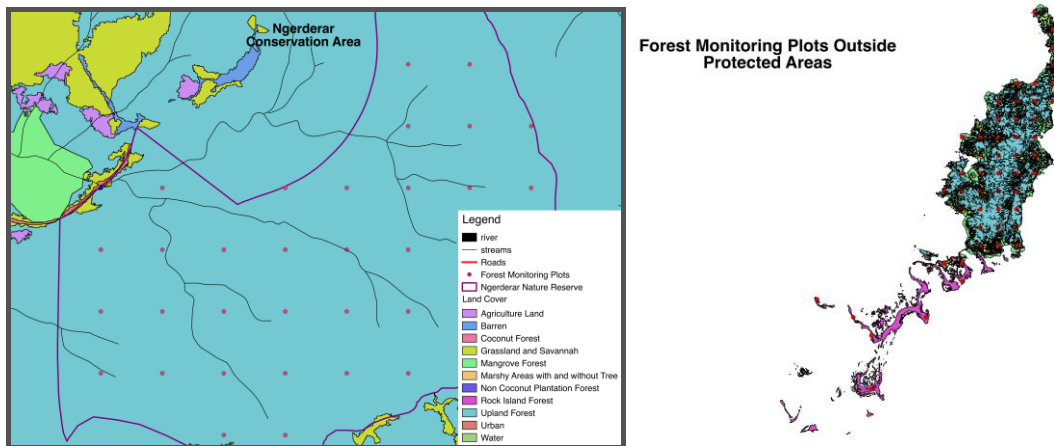


Figure 5.4 National Forest Monitoring Program showing plot design in Ngerderar Conservation Area (upper left) and Forest monitoring plots outside protected areas (upper right)



Figure 5.5 National Forest Monitoring Program showing the Forestry Team at work left to right.

Floristic studies were done within Babeldaob and in the other States of Palau and were expanded over time. A field study of the endangered *Parkia parvifoliola* (kme kumer) indicated that flowers are visited by the native honeyeater, ants, and bees. Pollination and seed dispersal studies of endemic plants by insects, birds and bats are being planned. The fruit bat, *Pteropus mariannus pelewensis* is an endemic subspecies, known to feed upon the nectar and fruits of 67 plant species representing 35 families of which 11 are endemic trees (Wiles et al. 1997). The Preliminary Wildlife Management Plan recommends fossil pollen (palynological) and fossil fauna studies have been initiated in Palau to study the vegetation history and identify changes in climate and human activities. The Wildlife Management Plan recommended more floristic studies and life history studies of endangered species. The Belau National Museum collaborated with the Australia National University through an internship program to train and collaborate on pollen identification, collection, and processing.

The distributions of invasive tree species such as *Falcataria moluccana*, *Adenantha pavonina* and other invasive species were mapped in the Protected Areas Network in Babeldaob and Koror. Further work with support from USFS-FH is needed to implement the invasive species protocol for PAN sites to map, monitor, and effectively control. The Aimeliik System of Conservation Area has successfully implemented several “pulling parties” to remove the invasive Rattan within their sites. Regular surveys with support from USFS-FH are needed to determine if new species to provide and early response to new species incursions in order to maintain forest health in the protected areas.

The Republic of Palau has approximately 702 native vascular plant species: 146 are endemic. Palau’s rate of plant endemism is 20.8% which is higher than Pohnpei at 16.4% (Balick and Kitalong 2021, Lorence & Flynn 2007). The Belau National Museum Herbarium has over 5,000 voucher species of plant species from Palau and serves as national depository for plants and insect species in Palau. The BNM Herbarium works in partnership with the several herbariums throughout the world to safeguard the terrestrial biodiversity. About 61% of Palau’s endemic species cannot be adequately assessed under the IUCN criteria because there is insufficient data (Costion et al. 2009). By 2013, 16 of these species were assessed with sufficient data for establishing a red-list category, reducing Data Deficiency by 20% (Costion 2013). The percent endemism was highest in the limestone islands (Table 5.2). During a 2005 survey of Babeldaob an estimated 54 endemic plants or 37% of known endemics were collected or observed. A mean number of 27 endemic species were found in each state of Babeldaob. (Each state owns and manages all resources up to 12 miles seaward.) The numbers of endemic plants found in Babeldaob were as follows: Airai (34), Ngchesar (33), Ngeremlengui (33), Ngardmau (30), Ngatpang (30), Aimeliik (29), Melekeok (29) than in the northern portion (Ngiwal (22), Ngaraard (22), and Ngarchelong (5). Airai State is the only state of Babeldaob with limestone substrate with limestone islands and plants found only in limestone.

Table 5.2 Percent Endemism (E/km²) in Palau’s flora for each island type
(The areas for substrate type were provided by USDA Natural Resources Conservation Service)
Source: Costion, Kitalong and Holm 2009

| | Endemic Species | Total Area (km ²) | % Endemics (E/km ²) |
|-------------------------|-----------------|-------------------------------|---------------------------------|
| Restricted to Volcanic | 75 | 363 | 21 |
| Restricted to Limestone | 31 | 90 | 34 |
| Generalist | 24 | 453 | 5 |
| Total for Palau | 130 | 453 | 29 |

Southeastern Babeldaob (Ngchesar and Airai) were considered less impacted by human activities in the last few centuries that other parts of Palau (J. Liston, pers. comm. 2007). At least 20% of the land in Palau has been altered by man and it may be as much as 40% (J. Liston pers. comm. 2010). Northern Babeldaob is considered the most impacted by people a few centuries ago. Archeological surveys of Ngiwal suggest

that an estimated 80% of the land of Ngiwal was altered by people over time (Rita Olsudong pers. comm. 2007). Area is an important factor as Ngarchelong (10 km²) and Ngiwal (26 km²) have the smaller land area compared to other States in Babeldaob. Greater endemism tended to be found in states with volcanic and limestone soils, less human disturbance, larger area, and less accessible upper watersheds with major river systems. These protected watersheds would have surface or subsurface water during severe droughts and be more sheltered from storms. More survey work is needed to determine if there is a significant difference in the distribution of endemics in Babeldaob.

During the 2004-2005 Babeldaob surveyed one healthy population of *Parkia parvifoliola* existed within the Ngeremlengui Reserve. *Terminalia crassipes* is restricted to rivers and found along the Tabechding, Ngerderar, Ngerdorch and Ngerikiil Rivers. *Rauvolfia insularis* were found in small, scattered populations in Airai and Melekeok. Less common endemic plants recorded in southern Babeldaob included *Rauvolfia insularis*, *Diospyros ferrea* var. *palauensis*, *Cyrtandra palawensis*, *Manilkara udoido* and *Myrsine palauensis*. Seven of 18 endemic species were restricted to the limestone forests of Koror and Airai and included the palm, *Hydriastele palauensis*, the orchids *Cyclopeltis kingi* and *Crepidium calcarea*, the trees *Garcinia rumiyo* var. *calcicola*, *Maesa palauensis*, and *Melicope palawensis* and the vine, *Peperomia palauensis* C. DC. var. *palauensis*.

During a 2008 survey of the native palm, two small stands of *Ponapea palauensis* were found in Koror: these palms are considered critically endangered using the IUCN criteria. In the spring of 2010 one population of *Ponapea* was reassessed. Four mature trees were broken at the trunk and one of two trees with fruit was covered with an unidentified white insect. One tree has immature fruit, and the others were younger palms. A revisit to this critical habitat on June 13, 2010, showed no further damage, 4 mature trees were in fruit and flower and 4 young saplings were found. Although no damage was observed in June, propagation of this palm is urgent. During 2020, Belau National Museum initiated a study of the distribution of *Ponapea* and have begun propagation trials.

The endangered *Cycas micronesica* is found on limestone islands of Airai and Koror and is now threatened by a cycad scale that has infected an introduced ornamental cycad. As of 2021, no scales have infected the native species of cycad. Regular surveys of the endangered cycad are needed. Malakal Island is a site where *Timonius salsedoi* was found and it is only known from a type specimen (Costion et al. 2009). The Belau National Museum will be surveying Malakal Island in 2021-2022 to determine if the *T. salsedoi* is present. Malakal Island is heavily developed and a priority area to stabilize steep slopes from landslides. Refer to Figure 1.9.

The Belau National Museum was a partner with the MNRET GEF 5 project entitled “R2R: Advancing Sustainable Resources Management to Improve Livelihoods and Protect Biodiversity in Palau.” Through GEF5 support, the BNM successfully propagated 12 natives tree species including the largest endemic trees in Palau, *Serianthes kanehirae* Fosberg var. *kanehirae*, which grows on volcanic and limestone islands. The Nekken Nursery successfully propagated 2 saplings of *Parkia parvifoliola* and provided one to the Belau National Museum Botanical Garden. An IUCN Red list assessment was completed that focused on rare endemic tree species including *Parkia parvifoliola* and *Timonius salsedoi*.

The BNM Botanical Garden is currently propagating and planting the endangered palms *Ponapea palauensis* and *Hydriastele palauensis*, the native cycad, *Cycas micronesica* and the endemic trees *Terminalia crassipes*, *Manilkara udoido*, *Rauvolfia insularis* and other species of endemic trees and orchids. The BNM botanical garden is working in partnership with the Nekken nursery to propagate and provide seedlings of endemic trees of Palau. Mr. Tellei of the Horticulture Division successfully propagated *Parkia parvifoliola* from seed by first scrapped the exocarp. The tree is producing seed pods.

The BNM herbarium is coordinating with the National Tropical Garden in Kauai and the New York Botanical gardens and Australia National University to better understand Palau’s unique terrestrial ecosystem and document the important uses of plants in our culture. The book entitled Ethnobotany of Palau was published in 2021 documenting the uses of over 400 plants and includes an updated checklist of plant species of Palau.

In 2021, the Belau National Museum initiated a 2-year project entitled, “Conservation of the endangered tree *Parkia parvifoliola* (*kmeumer*) and assessment of Critically Endangered species in Palau.” The BNM team has successfully signed Memorandum of Agreements with Ngeremlengui State and Koror State. Refer to Figure 5.5. In 2021, 47 *Parkia parvifoliola* trees were measured and georeferenced in Ngeremlengui State. The largest tree was 1.75 m in diameter and over 30m in height. This survey will be ongoing, and a management plan developed for *kmeumer* by 2022.



Figure 5.5 large *Parkia parvifoliola* (left) b. Signing of Memorandum of Agreement with Ngeremlengui State (Center) c. Measuring largest *Parkia parvifoliola* tree d. Map of *Parkia parvifoliola*

During February 9, 2021, the BNM staff joined Koror State to begin Geo referencing and measuring *Ponapea* populations in Ngermalk Island. A total of 23 trees were geo referenced and measured DBH, estimated height, noted presence and absence of fruit and flowers, and any saplings or seedlings in the area. A few saplings were found, and several trees had flowers and fruits. The team covered an area of 4,000m² (0.4 ha). Refer to Figure 5.6. Propagation trials have begun with ripe seeds. This survey will be ongoing, and a management plan developed for the endangered *Ponapea*. On June 29, 2021, Koror State celebrated its 9th anniversary as a World Heritage Site for its Rock Islands Southern Lagoon as a unique natural and cultural site that was submitted to the UNESCO in 2010. The Governor of Koror signed the Memorandum of Agreement with the BNM Director as part of the program to open their newly established medicinal garden.



Figure 5.6. A preliminary map *Ponapea palauensis* in Ngermalk Island (upper left), propagation trials at BNM nursery (upper right), ripe *Ponapea* fruit (lower left); and signing of MOA on June 29, 2021 (lower right)

The Ngardok Nature reserve covers 1,250 acres and is the first wetland of international importance to be designated in Palau and Palau's first RAMSAR site (Figures 16 and 24). Palau became party to the Ramsar Convention on Wetlands in 2003. This reserve was designated by Melekeok State in 1997 and is the largest natural freshwater lake in Micronesia. The Ramsar Convention provided technical and financial support to manage this wetland. The lake is part of the headwaters of Ngerdorch River Watershed and the water source for Melekeok State. An interpretative trail, eco-tours and educational tours have been developed with support from the Urban and Community Forestry program. The Ngerdorch Watershed and Lake Ngardok and floodplains of the Ngermeskang Watershed and River are important habitats for the water birds including the rare gray duck that uses the native forests to nest and seek shelter. The standard variable circular plot method is not effective in detecting water birds and more secretive very low calling ground doves and the non-vocal Nicobar pigeon. Life history, habitat use, and breeding biology are needed for these endangered species.

The extent of Total Terrestrial Managed Area (102.6 km²) included 20 sites and represented 25% of the total land area. These terrestrial managed areas included Important Bird Areas (35%) total terrestrial managed areas in Babeldaob (12%), Total no take terrestrial area (10%), total terrestrial area in PAN (10%), and terrestrial area in PAN Babeldaob (9%). Refer to Table 5.2.

Forest Monitoring Program Palau

Forest Monitoring Program Palau developed and initiated a Forest Monitoring protocol. This protocol was established, and Palau Forestry initiated forest monitoring plots within the terrestrial Protected Areas Network (PAN) sites. Refer to Figure 5.5. Once all terrestrial PAN sites have been inventoried, plots will be established adjacent to PAN sites to compare forest status from protected areas and non-protected areas. It is with this new initiative that we are hoping to be able to assess the state of Palau's forests with support from the USFS-FH program. During 2021, BOA established an MOA with the Belau National Museum (BNM) to collaborate on plant and bird biodiversity within these Plots.

Endangered Species

The Division of Fish and Wildlife Protection is tasked with the enforcement of laws relating to the protection of identified plants and animals including those listed in the Endangered Species Act. Several of Palau's mammals, birds, snails, and plants are considered either threatened or endangered. Species are

considered threatened due to small population size, or small, restricted, or fragmented habitats or due to past, current, or even perceived future population or habitat decline. A proposed updated Endangered Species Regulations provides a list of species considered endangered, threatened, or vulnerable. The International Union for the Conservation of Nature (IUCN) assesses species on a global scale and is listed below. (Table 5.3). **Nine areas in Palau were proposed for Important Bird Area Status that are priority areas for USFS assistance** (Table 5.4). The Rock Islands and Helen Atoll are fully protected. Ngerutechei in Ngeremlengui is now a Bird Sanctuary. During a one-year survey of species richness of birds in an Important Bird Area of Ngeremlengui, 38 species of birds including 30 resident and 8 migratory species. The white breasted woodswallow was sighted on 16 of 26 occasions (Olsen and Eberdong, 2009). The white breasted woodswallow, *Artamus leucorhynchus pelewensis (mengaluliu)* is currently considered an endemic subspecies and was observed nesting in the Koror Rock Islands in 2018. In 2019, several *mengaluliu* were observed along Ngeremlengui's coast and mangrove. This was the first observation of *mengaluliu* in Babeldaob in five years. The BNM coordinated the revision of the Endangered Species Regulations, a draft was submitted to MAFE for finalization and information on selected species is shown in Table 5.3

Table 5.3 Terrestrial Mammals, forest and migratory bird species that are listed at either critically endangered (CR) endangered (EN), threatened (TH), near threatened (NT), vulnerable (VU) or proposed candidates for national concern based upon the proposed 2018 Endangered Species Regulations
Source: Draft Endangered Species Regulations and SOE 2019.

| Species | Status | | | | Grade |
|---|---------------|---------------------|-----------|---|------------------|
| | IUCN Red List | Global Trend (IUCN) | ESA Palau | Palau Laws Regulations | Palau's Response |
| Mammals | | | | | |
| Pacific sheath tailed Bat | EN | Decreasing | | No Restriction | Poor |
| Palau Fruit Bat | NT | Stable | TH | Ban on Export | Fair |
| Forest Birds | | | | | |
| Micronesian megapode <i>Megapodius laperouse</i> | EN | Decreasing | EN | Protected Land Life Act Chapter 14 Title 24 | Poor |
| Palau ground dove, <i>Gallicolumba canifrones</i> | EN | | VU | | Fair |
| Nicobar pigeon, <i>Caloenas nicobarica</i> | NT | | VU | | Good |
| Greater white eye, <i>Megazosterops palauensis</i> | NT | | NT | | Good |
| Micronesian Imperial Pigeon | NT | | EN/VU | | Fair |
| White breasted woodswallow <i>Artamus leucorhynchus pelewensis</i> | | | CR | | Poor-Decreasing |
| Migratory Birds | | | | | |
| Far Eastern Curlew | EN | Decreasing | CR | | Fair |
| Great Knot | EN | | | | |
| Bar Tailed Godwit | NT | | | | |
| Curlew Sandpiper | NT | | | | |
| Invertebrates | | | | | |
| Great, White Palau Tree Snail | CR | Unknown | | No Restrictions | Poor |
| Palau Pandanus Tree Snail | EN | Unknown | | | |
| Plants | | | | | |
| <i>Cycas micronesica</i> | EN | Decreasing | | No Restrictions | Fair |
| <i>Parkia parvifoliola</i> | VU | Unknown | EN | Chapter 14 Title 24 | Fair |
| <i>Ponapea palauensis</i> | | | EN | | Fair |
| Timonius salsedoi | | | CR | No Restriction | Poor |

Table 5.4 Site, area and birds found in Important Bird Areas (IBAs) of Palau (Gupta 2006, Belau National Museum, Palau Conservation Society 2020).

| Site | Area | Bird |
|---------------------------------------|--------------|--|
| Ngeriungs Island | Kayangel | Micronesian megapode |
| Middle Ridge | Babeldaob | |
| Western Ridge | Babeldaob | Palau Ground Dove, |
| Ngerutechei (Part of Middle Ridge) | Ngeremlengui | Palau Ground Dove White Breasted Woodswallow |
| Rock Islands | Koror | Micronesian megapode Palau Ground Dove |
| Peleliu Island | Peleliu | Palau Ground Dove, Greater White Eye |
| Peleliu Lkes Island | Peleliu | Far Eastern curlew, Great Know, Bar tailed Godwit, Curlew Sandpiper |
| Fanna Island | Sonsorol | Sea bird colonies |
| Helen Atoll | Hatohobei | Sea bird colonies |

Abundance of Birds in Palau based on Surveys in 2005 (VanderWerf and Dittimar 2020)

The avifauna of Palau is the most diverse in Micronesia because of the relatively large size of the islands and its proximity to Australasia (MacArthur and Wilson 2001). A total of 168 bird species have been documented in Palau, of which 45 are resident breeding species, 72 are regular migrants, 47 are considered vagrants, and 4 were introduced. Palau is a regional biodiversity hotspot, with 10 endemic species and 8 endemic subspecies. A previous quantitative assessment of the status of birds in Palau was conducted in 1991 (Engbring 1992). More up to date information on the status of birds in Palau is needed to help guide conservation efforts and assess management actions and needs. In 2003, the Palau Conservation Society (PCS) obtained funding to conduct quantitative bird surveys and for identifying Important Bird Areas in Palau. The goal of the surveys was to assess the status and population trends of bird species in Palau by replicating the quantitative surveys conducted in 1991. The surveys were conducted in April and May of 2005. The survey results were partially analyzed and reported by VanderWerf (2007), but those analyses included only data on relative abundance. In 2020, analyses and results of the surveys conducted in 2005, including relative abundance, population density, and population size was completed. The 2005 surveys used the same standard variable circular plot methods used by Engbring (1992) and that are used worldwide. The cumulative evidence indicated that 11 species increased from 1991 to 2005, four species declined at least locally, 14 species showed no change, and for three species the trend was unclear because they were rare and difficult to detect. Most of the changes in species abundance that occurred from 1991 to 2005 were related to development and changes in habitat. Most species that exhibited declines since 1991, such as the Slaty-legged Crake, occur primarily in forested habitats, suggesting loss of forest habitat was the cause of decline. The species that increased from 1991 to 2005 occurred in disturbed open habitats and roadsides, such as the introduced Chestnut Munia, or that are able to use a variety of habitats including secondary forest, agroforest, and suburban areas, such as the Banded Rail, Micronesian Myzomela, Palau Fantail, and Palau Flycatcher. Species that are sometimes hunted, including the Micronesian Imperial Pigeon, Palau Fruit-dove, and Nicobar Pigeon, were stable or even increasing, indicating their populations were not being seriously affected. The survey results from 2005 are now 15 years old and it would be beneficial to repeat the surveys again to provide more current information. A nation-wide bird survey is planned for the spring of 2022.

Education Campaign for Migratory Birds of Palau

In 2020, the Belau National Museum (BNM) launched a two-year Education Campaign for Migratory Birds of Palau. BNM is the focal point for the National Bird Program for the Republic of Palau. The Palau Conservation Society is the focal point for Bird Life International that works with countries to establish Important Bird Areas (IBAs). Kaudiais is a local women's group in Peleliu that is active in community activities. The Belau National Museum has been working in partnership with PCS and Kaudiais local group in Peleliu to raise awareness about the Lkes IBA through the following efforts. These partners have begun an educational campaign on the Northern Peleliu Lkes (sand flats), in Peleliu. Lkes is an established IBA, and IUCN Key Biodiversity Area (KBA) recognized by Birdlife International and IUCN in 2016. The goal of this project is that there is local (Peleliu) and National Support for the protection of the Northern Peleliu Lkes and other Palau IBA/migratory bird habitats. The Five Objectives of this project are as follows: (1) At least 90% of the residents (including school children) in Peleliu proper are aware of the importance of the Northern Peleliu Lkes and other Palau IBA/migratory bird habitats. (2) an educational module of The Northern Peleliu Lkes IBA and the migratory bird species that utilize this sand flat and other relevant Palau IBA/migratory bird habitats is produced for integration into science curriculum. (3) Actions needed to reinforce and sustain an educational campaign of the Northern Peleliu Lkes IBA and other relevant Palau IBA/migratory bird habitats have been identified and communicated to relevant actors. (4) A case study based on field data is developed that includes actions needed to meet Palau's international obligations with respect to the migratory species at the Northern Peleliu Lkes IBA and other Palau IBA/migratory bird habitats have been identified and communicated to the relevant agencies. (5) Key stakeholders including school children in bird conservation have increased awareness and opportunities to participate in the conservation management of the Northern Peleliu Lkes IBA and other Palau IBA/migratory bird habitats.

Palau Terrestrial, Aquatic, and Marine Taxonomic Needs and Capacity Assessment

Kitalong and Otto (2020) compiled Palau Terrestrial, Aquatic, and Marine Taxonomic Needs and Capacity Assessment to identify the taxonomic information required for sustainable land and aquatic management. This assessment fulfilled, in part, Palau's obligations under the Convention on Biological Diversity and one of the activities under of the Global Environmental Fund (GEF5) work plan. The Belau National Museum (BNM) targeted terrestrial and freshwater aquatic species and the Palau International Coral Reef Center (PICRC) targeted marine species. A workshop was conducted to gather key information from national, state, private agencies, and other NGOs in their taxonomic information needs and priorities using the CBD Questionnaire entitled Taxonomic Needs and Capacity Assessment. Most respondents worked at the species level and use off island taxonomists for identification of species. Most respondents have difficulty accessing local taxonomists, especially for fungi and microorganism identification. Few respondents were engaged in taxonomic networking in Palau. Few respondents were aware of innovative taxonomic tools such as DNA sequencing although there has been a DNA laboratory in Palau for the last 5 years. Recommendations are as follows: (1) Create a national terrestrial and aquatic strategic framework to address specific taxonomic needs and priorities on biodiversity, document scientific research and strengthen the Palau National Invasive Species Strategy, National Biodiversity Strategy and Action Plan, and on RPPL 10-28 for Access and Benefit-Sharing. (2) Create a National Database and Repository for specimens. (3) Conduct workshops for information sharing. (4) Provide support for infrastructure and facilities and national regulations or mandates that house live species/specimens. (5) Streamline regulations on permits for scientific research on species and their habitats. (6) Collaborate with institutions specializing in fungi and microorganism and freshwater organisms to build taxonomic capacity in Palau. (7) Request specialists to provide training for the taxa they study. (8) Provide support for taxonomists to build capacity on taxonomic groups that we lack information and expertise.

The Division of Fish and Wildlife is responsible to enforce the provisions of Title 24 and 27 of the Palau National Code related to protected sea and land life, illegal methods of capture and to enforce laws related to protected areas in Palau. The DFWP created the Environmentally Friendly Restaurant Program in late 2005 to promote conservation and reduce violations of the laws. The DFWP began a database to track locations of endangered species and works with Bureau of Agriculture to control invasive monkeys with the Palau Animal Welfare Society with technical support from BOA. The Division of Fish and Wildlife (DFW) currently has 7 officers and 1 functional boat (1 non-operational, and 1 undergoing service). They are unable to monitor the marine coasts due to lack of fuel. The field officers are dependent upon incoming calls to respond and use the Chief and Lieutenant vehicles for enforcement. The officers work closely with the PAN conservation officers. The PAN Office supplies fuel for the DFW vehicles to protect the terrestrial sites. (Sargent Ben Masters, pers. comm August 30, 2021).

A qualified wildlife biologist is needed to work at the Division of Fish and Wildlife and collaborate with BOE and Belau National Museum to assess population of endangered populations and their habitats and in the development of management plans. Biologists at the Belau National Museum are working in cooperation with BOE and DFWP. Gavenda et al. 2005 recommended the development of a wildlife habitat management plan for the estuarine crocodiles within the Ngerikiil Watershed that included the re-establishment of a riparian forest buffer along the river to provide critical habitat to the animal and an education program. ThMarine Conservation and Protected Areas Program developed a Management Plan for crocodiles and turtles that are in need of funding for implementation. These endangered marine species utilize coastal forests and mangroves for nesting and reproduction. The coastal forests prevent erosion of the sandy habitats as the roots hold the sandy soils. The vegetation also helps camouflage the nests from hunters.

The Belau National Museum Natural History Section has identified areas of high biodiversity for plants, birds, and insects within protected terrestrial sites. A Bird Reserve has been established in Ngeremlengui because of its exceptional diversity. These areas may be potential sites for an Assessment of Need for the Forest Legacy Program if under private ownership. There are chronic problems with hunters within the reserve and more enforcement and education is needed. An executive order passed in 2010 that designates the Belau National Museum as the center for national monitoring of birds.

Wiles (1991) recommended ecological reserves, bag limits, closed seasons, and restrictions on hunting methods of the fruit bat *P. mariannus pelowensis*. There is still very little specific information about the breeding phenology and movement of fruit bats in Palau, where they feed, and what specific niche they inhabit in forest ecology.

The Marine Conservation and Protected Areas Program (MCAP) is working with the Protected Areas Network to identify the most crucial habitat for crocodiles, ideal areas for the relocation of nuisance crocodiles, and to develop regulations regarding public interactions with crocodiles. From 2005 to 2008 a total of 87 surveys were conducted and a total of 178 crocodiles were observed. Crocodile habitat includes the wetlands and swamp forests of the Ngerikiil, Ngerdorch, and Ngermeksang Watersheds (Nash et al. 2008).

The green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*) nest regularly in Palau. These endangered species have cultural and economic significance. The critically endangered hawksbill turtle nests mainly in the southern lagoon of Koror. Refer to Figure 5.7. The endangered green turtle nests mainly in the Southwest islands (Kitalong, 2005). Coastal erosion threatens the nesting habitat of both turtle species. The hawksbill is especially vulnerable as it uses the roots of native coastal trees and vegetation to hide its nests. Goals for future research and management include the following:

- Identify threats across all critical life stage habitats and to eggs, hatchlings, sub-adults, and adults – including from people and climate change
- Understand movements through life stages and during the inter-nesting period
- International collaboration and the opportunity to develop a regional strategy through the Micronesia Challenge.

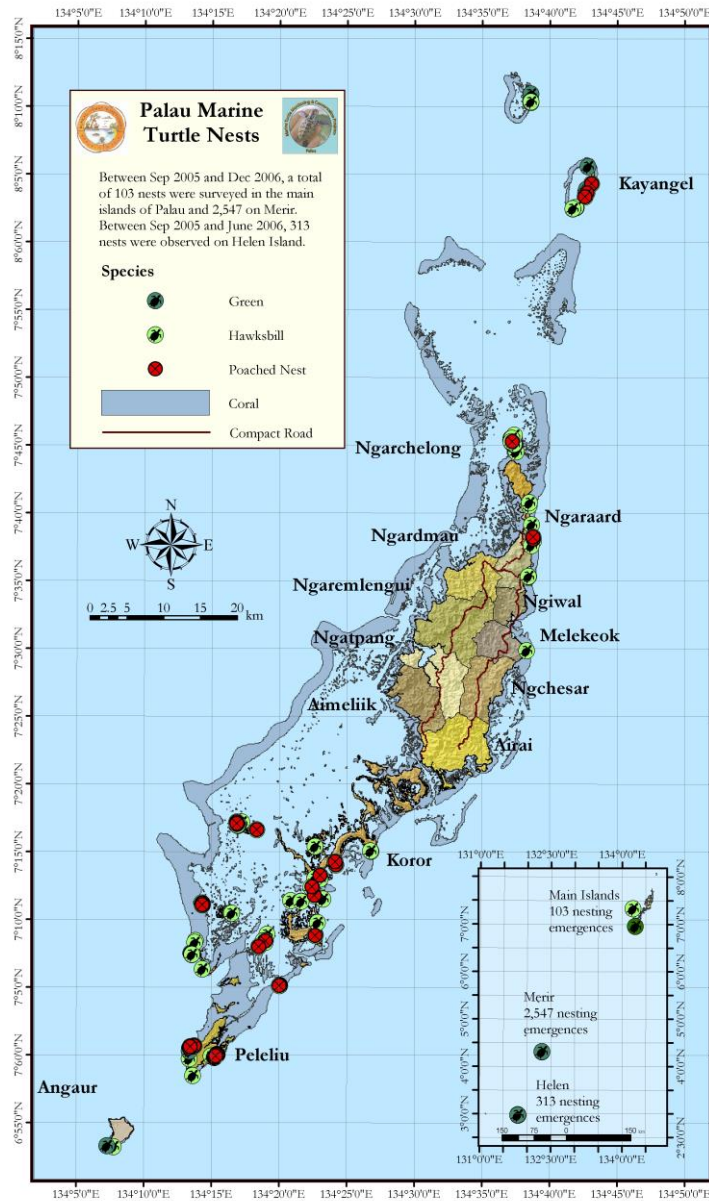


Figure 5.7 Map of observed turtle nests, 2003-2005.
Source: Bureau of Marine Resources

Invasive Species

Invasive plants are one of the greatest threats to forests, agriculture, and natural ecosystems worldwide. It was considered one of the top threats during a 2008 meeting of environmental and conservation professionals in Palau and stakeholder meetings for SWARS. Palau Forestry Health Program developed a 2009-2014 Strategic plan based upon a survey and assessment invasive species. During 2010 to 2015, the invasive species team planned to control the spread of the worst invasive species in Palau including *Praxelis clematidea*, *Mikania micrantha*, *Imperata cylindrica*, and *Spathodea campanulata*. The Invasive species team planned to assess and control the spread of *Antigonon leptopus*, *Melia azedarach*, *Arundo donax*, *Melaleuca quinquenervia* and *Calamus* species and the Rattan Palm. The Bureau of Agriculture conducted a survey of invasive species at the Long Island Conservation Area and within the habitat of the largest population of the endangered *Ponapea palauensis*. The BOA team found the invasive *Mikania micrantha* covered an area 2,313 m² within the *Ponapea palauensis* habitat. The BOA team found sixteen species of invasive species including the invasive tree *Adenanthera pavonina* within the Long Island Park Area. The Koror Rangers conduct monthly monitoring to control invasive species in conservation areas of Koror. The 2021-2030 **priority** is to conduct surveys and assessment of these invasive species. Refer to Figure 5.8.



Figure 5.8 Invasive species survey at Long Island Park and the habitat of the largest population of the endangered *Ponapea palauensis*. Bureau of Agriculture

Ngerikiil Watershed *Imperata cylindrica* or Kerosene Grass

The introduction and spread of invasive plant species, *Imperata cylindrica* (referred to as kerosene grass in Palau because it burns so readily) was being treated and controlled adjacent to the National Airport within the Ngerikiil Watershed in Airai State during 2009. In 2016, an *Imperata* Eradication Plan was developed with the assistance of Dr. Joel Miles. Available resources were put in place to move forward with initial eradication steps. Refer to Figure 5.7 and 5.9. *Imperata* grass was a threat to nearby farms and ongoing treatment and monitoring was required. *Pennisetum* grass and the climbing Siam weed *Chromolaena odorata* had served as a catalyst for fire as they easily invade savanna and forests and can easily burn. The 2021-2030 **priority action** is to follow up with the treatment and monitoring of *Imperata cylindrica* (Dr. Joel Miles, pers. comm. 2021).



Figure 5.9 View of airport within Ngerikiil Watershed showing plots of treated areas (4 acres or 16,187 m²) and untreated areas for *Imperata cylindrica* grass. Bureau of Agriculture.



Figure 5.10 View of airport within Ngerikiil Watershed showing extent of *Imperata cylindrica* Grass at the airport 26,793 m² and nearby agroforest covering 5,171 m² Bureau of Agriculture

During 2010 to 2015, the Bureau of Agriculture planned to conduct a feasibility assessment for the control of two large invasive trees in the family Fabaceae: *Adenanthera pavonina* and *Falcataria moluccana* that were planted for agricultural purposes (Mayo 1954). These successful invasive trees are members of the Fabaceae family and grow in poor soils because the roots can fix nitrogen. (The Fabaceae Family is the second largest family of plants found in Palau and includes 111 species of which 91 are introduced including 24 invasive species.) *Adenanthera pavonina* was common in Ngarchelong and found in Uruktabel Island, Koror, Melekeok and Ngatpang. *Falcataria moluccana* was common in Ngeremlengui (Figure 14b) where it was planted by Japanese farmers as a shade tree for cacao plantations (Kitalong & Holm 2004, Costion & Kitalong 2006).

Endress (2002) found that *F. moluccana* dominated early successional forest stands in Ngeremlengui, but was not dominate in mid-successional forests and was not found in mature forests. It is important to map and monitor this large tree at other study sites to determine if it has become dominant in mature forests in other parts of Babeldaob or if it is excluded by native trees. Biological and chemical controls can be used if needed as has been done successfully in Samoa. The Bureau planned to assess, map, and seek bio controls for the widespread *Clidemia hirta* in site of Aimeliik with a focus on Nekken Station.

Community clean-ups have been ongoing to control of *Clidemia* to prevent widespread distribution. Palau's government and communities (Figure 5.7) have put in significant effort into Invasive and Alien Species (IAS) removal and control, and it appears that this is holding the threat of IAS steady (rather than allowing the threat to grow). Rats have been eradicated on some islands in Kayangel, the Southwest Islands, and the Rock Islands. In those places, it appears that agricultural production has increased and endangered Micronesian Megapode populations are either steady or increasing (Island Conservation video: <https://www.islandconservation.org/palau/>).

The Bureau of Environment will continue its ongoing program to control the native vine, *Merremia peltata* that grows rapidly in disturbed or open areas overgrowing and killing trees within 100 m of the national highway with support from USFS (Figure 5.11). A 2017-2018 kebeas (*Merremia peltata*) Control Project supported the removal of the vine in several states throughout Palau. Refer to Figure 5.12. Over 6 days in 2017, volunteers and employees removed at least 24.7 ha (0.24 km²) of kebeas. This consisted of 8.9 ha in Ngchesar, 12 ha in Melekeok, and 3.8 ha in Airai. A section in Ngaraard was also cleared. The level of effort (for Ngchesar, Melekeok, and Airai) was 73 person-days (~0.33 ha/person/day). In 2018, another 0.16 ha was cleared in Ngkeklau (Ngaraard) and 13.5 ha in Ngardmau. Additional areas on Babeldaob and Koror were targeted for 2019. In some cases, the removal of the invasive vine opened up taro patches and agro-forest areas for renewed cultivation. In Kayangel, 2.88 ha of forest area was cleared of kebeas.



Figure 5.11 National highway along east coast of Airai State with *Merremia pelta*



Palau's 6th National Report to the Convention on Biological Diversity, December 2019

Figure 5.12. *Merremia peltata* (kebeas) clean up in (upper center) Kayangel shown as a red square on the areal map, and along the Compact Road in Babeldaob (lower right and left photographs) (Palau's 6th National Report to the Convention on Biological Diversity, December 2019)

Islands and island countries are especially at risk from invasive plants, and Palau is no exception. Palau has been fortunate in that, while numerous invasive plants have established themselves in the country, most natural ecosystems are still intact. However, the introductions of serious invasive plants such as mile-a-minute (*Mikania micrantha*), Cogon Grass (*Imperata cylindrica*), and *Chromolaena odorata* have increased the threat to forests and grasslands. The potential spread of longer-term introductions such as African tulip tree (*Spathodea campanulata*), *Falcataria moluccana* and *Adenanthera* (*Adenanthera pavonina*), and numerous invasive plants used for landscaping, makes it urgent to educate and take preventive action now. An assessment of *Acacia* plantations was conducted through the Forest Stewardship and Forest Health programs to determine if this species is expanding its range and requires further monitoring and control. The highest frequency of invasive species has been found in Koror (Figure 5.8). A study of *Falcataria moluccana* was initiated in 2010. However, it was not completed due to community concerns on the loss of *Falcataria moluccana* trees

The Forest Health program has had strong community support in Peleliu to control *Mikania micrantha* with support from the National Invasive Species Task Force. *Mikania* is a threat to native trees as it covers and kills trees if not controlled. There is an ongoing program to control the monkey populations

throughout Palau through the Palau Animal Welfare Society with technical support from the Invasive Species Program that the Forest Health Program supports. These programs contribute towards forest health as the monkey is a threat to the agroforests throughout Palau

The greater Sulphur-crested cockatoo, *Cacatua galerita* was introduced to Palau in the 1940's and has established populations in the limestone islands (Engbring 1988). Cockatoos were rare in the Ngerukuid Preserve as only 2 pairs were reported during the 1988 survey. Cockatoos feed on the hearts of endemic palm, *Hydriastele palauensis* and are responsible for killing large stands of these trees. An estimated 5% of the trees surveyed in the Preserve were *H. palauensis* at risk, and the effects of cockatoos on this palm should be reassessed. It was recommended that seeds of this palm be collected for propagation (Birkeland and Manner 1989). The cockatoo has expanded into Babeldaob and its impact on native trees in Babeldaob also needs to be assessed.

Palau has an active invasive plant control program within its Forest Health Program that operates with the support of the National Invasive Species Committee (NISC), the Invasive Weeds Committee of the Palau Natural Resource Council, and several partner agencies and organizations. The USFS can assist as well. Key species have been targeted for eradication and/or control, and information has been provided to assist Quarantine officers in preventing new introductions.

Protocol for Detection of Invasive Plants in Palau's Terrestrial Protected Areas

In 2015, a protocol for detection of invasive plants in Palau's terrestrial Protected Areas was produced (Adam Radford, Teya Penniman, and Joel Miles 2015). The protocol was tested in the Protected Areas as part of training and capacity building through BOA. Training was conducted from October 6-16, by Mr. Adam Radford of the Maui Invasive Species Committee, with support from Palau's Forestry Division and the PAN Office. The training consisted of a combination of lectures, demonstrations, and hands-on learning. During the second week of the training, surveys were initiated in nine protected areas in Koror and Babeldaob, spending ½ day at each site. Maps were developed for each PAN site and the location and types of invasives found. In 2015, the Ngerderar Watershed Conservation Area, now part of the Aimeliik's System of Conservation Areas (ASCA) held two community "pulling parties" to remove the invasive Rattan seedlings and saplings from their conservation area. Refer to Figure 5.13.



Figure 5.13. Rattan sapling

Field Guide for Invasive Plant Species

A field guide of the 20 most serious invasive plant threats to Palau's forests which was prepared for the training. There were additional "plants of interest" which were not in the original guide but were found in at least two of the sites surveyed.

Palau's National Invasive Species and Biosecurity Strategic Action Plan 2018-2022 Palau NISSAP

A workshop was held for members and partners of the Palau National Invasive Species Committee (NISC) on April 4, 2018, with the purpose of updating the National Invasive Species Strategic Action Plan (NISSAP). Workshop participants carried out a review of the goals and objectives of the previous NISC action plan (2012-17). The goals were then revised and adopted, and Goals and Actions were agreed to. The consultants have added estimated costs to ensure that activities in the plan are adequately resourced. The Goals and Objectives were updated for this plan to define the role of the NISC as a coordination and facilitation body, and to provide activities for NISC members and partner agencies including the USFS. The 2016 **Biosecurity Act RPPL 9.58** was passed to enable protection of Palau's unique biodiversity especially at our borders with effective screening and

quarantine. This was a priority action for the 2018 NISSAP. The locations of some invasive species were identified in 2010. Regular monitoring, and management was implemented in the protected areas. Refer to Figure 5.14.

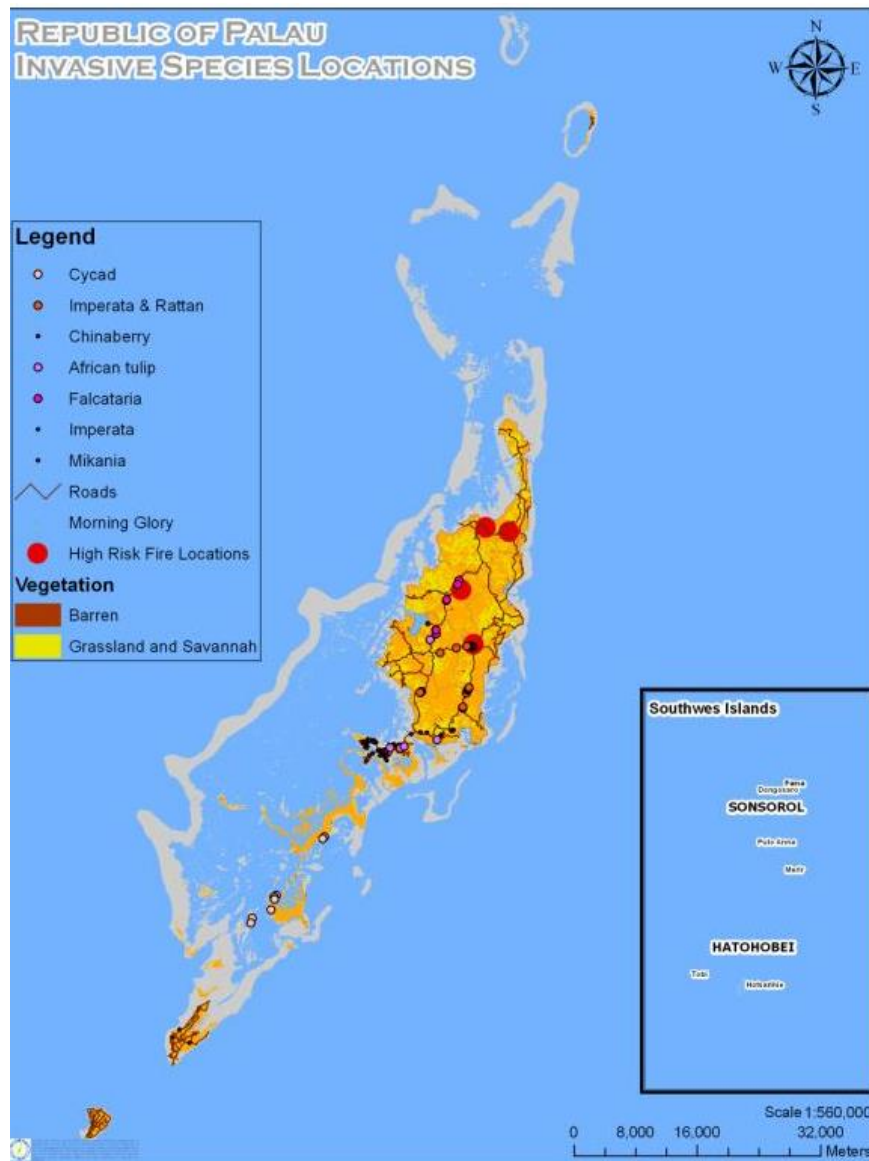


Figure 5.14 Locations of some invasive species in the Republic of Palau in 2010. Cycad refers to introduced cycads infested with the cycad scale. Source: PALARIS 2010

The 2021-2030 **priority conservation areas** include the **protected terrestrial areas and habitats for endangered plants and animals**. The endangered *Ponapea palauensis* is only found in the Ngermid Complex and the critically endangered and perhaps extinct *Timonius salsedoi* was only found on Malakal Island Koror. The endangered *Parkia parvifoliola* (*kmeumer*) population is found within the Ngermeskang Reserve that is within the Ngaremeduu Watershed. High plant diversity is found in the Ngerdorch Reserve; Priority areas to establish stream and river buffers within conservation sites and had potential for tree planting in areas of either barren or savanna areas covering 130, 056 ha in

Ngeremlengui, Ngerdorch and Ngiwal Reserves where there are slopes less than 12%. Refer to Figure 5.14. The threatened *Parkia parvifoliola* within Ngeremlengui watershed is currently being surveyed and propagation trials will begin in 2021. The critically endangered *Ponapea* found in Koror is now being assessed and monitored and propagation trials are underway through an Memorandum of Agreement between BNM and Ngeremlengui State.

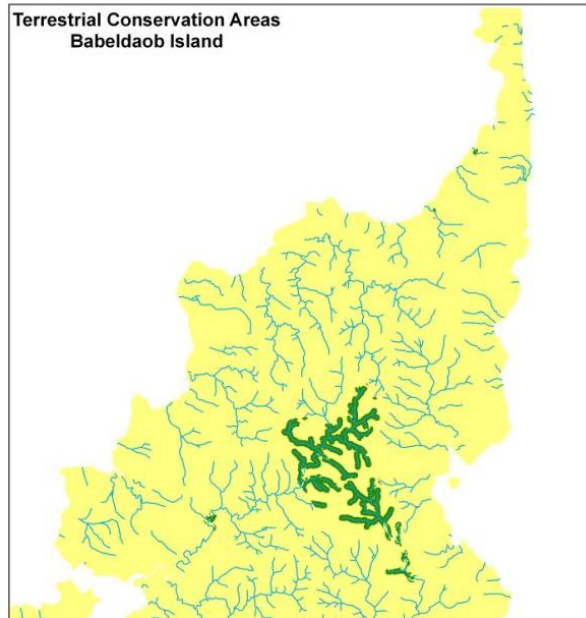


Figure 5.15 Dark green areas indicate **priority areas** for reforestation activities for protected areas in Ngeremlengui, Ngerdorch & Ngiwal for 2021-2031.

Important Bird Areas (IBAs) were identified for Palau including the central ridge of Babeldaob, Peleliu and Lkes Island in Peleliu, Fanna Island in Sonsorol State for migratory birds, and coastal forests for the endangered megapode birds and critically endangered hawksbill turtles. The forest habitats of these endangered animals require protection and regular monitoring. The BNM is working with PAN and Conservation officers to development monitoring programs. The critically endangered *Ponapea* is vulnerable because one of only two small stands is located on a limestone island that is linked by a causeway and already developed area. The invasive tree *Falcataria moluccana* is within the Ngeremlengui Reserve and a risk assessment is needed. If any of these critical habitats are on private land, the habitats may be candidate for an assessment of need for easements under the Forest Legacy Program.

Scoping Introduced & Invasive Species Challenges and Opportunities in Palau

A 2021 TNC report provided actions towards challenges and opportunities stemmed from mosquitos, rats, coconut rhinoceros beetles, and fruit flies. Actions are set on a national scale to safeguard health, national economy, food security, and biodiversity (figure 5.15). This report was prepared upon the request of his Excellency President Surangel Whipps Jr.

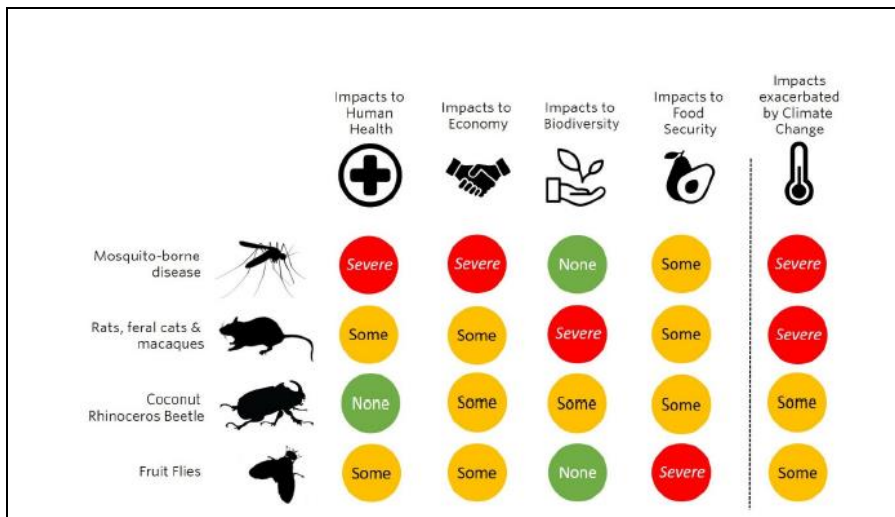


Figure 5.16 Generalized direct and indirect impacts from mosquitos, invasive mammals, coconut rhinoceros beetles and fruit flies. Source: The Nature Conservancy 2021

Measures of Success for Issue 5 Conservation and Protected Areas

The Belau National Museum in partnership with the Forestry Division and State of Koror is conducting a 2-year study (2020-2022) on the health of *Ponapea* palm. It is unknown if *Ponapea* is a host for CRB. The plan is to set a permanent plot (Smithsonian Plot) for long term monitoring by 2025. A Survey of invasive species was conducted at the *Ponapea* site and ongoing measures are being conducted to control spread of these invasives including *Mikania macrantha*. Report on health of *Cycas micronesica* was completed. A research ecologist was hired to work with PAN and the Forest Division. Two staff were trained to set and monitor forest plots. The Belau National Museum has an ongoing study to report on the status of the endangered *Parkia*, *Ponapea*, and *Timonius*. A Report on IUCN red list assessment report for Palau’s rare & threatened endemics including *Parkia* & *Timonius* to meet the CBD target was completed. The Belau National Museum produces an annual State of the Birds Report that addresses status of threatened and endangered birds. The BOA developed an invasive species protocol, conducted a training for PAN staff for each state and produced maps for each PAN site and locations and areas of invasive species. The Aimeliik System of Conservation Areas conduct regular “pull parties” to remove Rattan (*Calamus* species) and report the number of plants removed. A Field Guide on invasive species including *Adenantha pavonine* was produced and one pilot project at Long Island to assess *Adenantha pavonine*. The was a nationwide effort to control the spread of *Merremia peltata*.

The 2021-2030 Forest Action Plan will address Issue 5 Conservation and Protected Areas through the implementation of the following actions over the next decade:

- (1) Establish a Sustainable Forest Database system, and staff trained to track landowners assisted, number of species propagated and planted, and survival rates, number, and size of demonstration agroforest plots, acres of important forest resources areas and acres of sustainably managed forest resource areas on public and private lands, develop and implement FSP and UCF Plans. Use & supplement existing SMART system;
- (2) Conduct spatial analysis to inventory and assess underrepresented forest ecosystems and other HCV forests (PAN sites, habitats of endangered species);
- (3) Assist states to Identify HCV Forests (including cultural sites, endangered species, and their habitat);
- (4) Assess the health of endangered species, including *Parkia*, *Ponapea* and *Hydriastele* & extent of damage from introduced Sulfur Crested Cockatoo and rats;

- (5) Produce an annual report on survey of threatened & endangered plants;
- (6) Control of *Praxelis* and *Imperata cylindrica* and other invasive species as designated by NISC;
- (7) Conduct an Assessment of Need for conservation easements to protect critical ecosystems on private land;
- (8) Conduct annual assessments and map of invasive species including *Adenantha pavonine* and *Falcataria*;
- (9) Conduct annual technical training on geospatial analysis;
- (10) Conduct a spatial analysis of PAN sites for HCV forests and endangered species;
- (11) Design /implement social marketing campaign around forests to improve attitudes/behavior and valuing forests (including mangroves);
- (12) Design project and conduct stakeholder analysis on Forest Biodiversity and Conservation;
- (13) Research available materials on Forest Biodiversity and Conservation;
- (14) Collaborate with NGOs, PCC, and MOE to develop and disseminate educational materials and a curriculum module for forest biodiversity and conservation;
- (15)) Hold an Annual Forum for members of the Forest Advisory Council as well as other partners partners interested in Forest Stewardship and Urban and Community Forestry;
- (16) Collaborate with state governments to identify priority areas for reforestation efforts (produce updated maps on an annual basis);
- (17) Cooperate with NGOs on a student and community volunteer programs;
- (18) Develop, adopt, and enforce State Regulations to protect forests of HCV;
- (19) Conduct comprehensive State inventories of HCV forests including habitats for endangered species;
- (20) Design and implement Rapid Forest Assessment for HCV forests post typhoons, post severe droughts, and other natural or human induced impacts and recovery plan (reforestation, green waste recycling);
- (21) Conduct assessments of all Terrestrial PAN sites and other Terrestrial Conservation Sites Assessments of HCV and underrepresented forest habitats (e.g., swamp forests);
- (22) PALARIS and other partners will update vegetation maps and hydrological models;
- (23) Standardize PAN Forest Survey methodology and implement in PAN sites
- (24) Develop Forest Health indices and use at PAN sites;
- (25) Enhance forest monitoring programs using birds and water quality as a health indicator for each state;
- (26) Develop an annual State of Palau's Forest Report;
- (27) Gather and develop useful forest related information to disseminate to states and other resources users;
- (28) Establish Forest Resource Management requirements and integrate into national and state planning;
- (29) Work with the States and partners to develop Comprehensive State Forest Management Plans; addressing climate change, wildfire, watershed protection, conservation, rehabilitation, and sustainable use of forests;
- (30) Consult and visit each to develop forest management plans;
- (31) Request Governors to designate a lead person from each state to work with MAFE team;
- (32) MAFE- Forest Stewardship Council will support PAN Technical Committee and PAN coordinator to designate forests protected areas to be included in PAN;
- (33) Establish either a Memorandum of Agreement (MOA), or Memorandum of Understanding (MoU) or a Letter of Commitment between Palau Forest Service, State, Community, Private Sector, NGOs, and Landowners on roles, responsibilities, and commitments of each party;
- (34) Develop a protocol for data collection, analysis and management of permits, monitoring, and mapping fires in Palau;
- (35) MAFE will justify and secure Congressional funds for forestry programs;
- (36) Develop, test, and implement training modules that include guidelines for SFM;
- (37) Create professional development programs;
- (38) Develop, print, and disseminate educational material on invasive species and fire prevention, climate change, the value of mangrove forests and existing forest-related regulations;

- (39) Conduct comprehensive State Inventories using forest health indicators of HCV forests and endangered species habitats;
- (40) Develop a program to enhance collaboration and institutional strengthening for SFM Partners through biosecurity task force focused on forest health;
- (41) Develop a program to support agroforesters resilience to unwanted invasive species or pests (fruitflies)
- (42) Forest Advisory Council with partners (i.e. GEF Small Grants Program) will support sustainable forest projects;
- (43) Invasive species will be identified, removed and area measured and mapped with focus on top 20 worst species (e.g. Macaque monkey, CRB, *Mikania*, the Cycad scale, etc. as determined by NISC);
- (44) Identify and test virulence of OrNV of CRB in Palau;
- (45) Propagate, collect, and plant at least 20,000 saplings/year for rehabilitation programs using native and fruit bearing trees; map and monitor sites;
- (46) Develop and implement training module for estimated carbon stocks/carbon trading and ecosystem services of forests (e.g. i-tree training);
- (47) Estimate Potential Ecosystem Services (PES) Value for protected and impacted forests
- (48) Establish greenhouse network, expand existing greenhouses, and establish greenhouses where needed;
- (49) Propagate, plant, quantify survival rates and map reforested priority areas;
- (50) Develop ecotours and reforestation activities in urban forests;
- (51) Create a list of projects that can be done related to forest conservation;
- (52) Develop educational and awareness materials (posters, radio shows, videos) related to forest conservation, freshwater sources, and the potential ecosystem services of forests;
- (53) Communities identify and remove obstructions to waterflow caused by debris and fallen trees;
- (54) Establish Buffer zones and remove invasive species along the rivers and streams;
- (55) Conduct an “Assessment of Need” for Forest Legacy Program and other funding for easements from private landowners for permanent buffer areas of high priority watershed areas and HCV forests;
- (56) Develop at least one watershed management plan for either an upper watershed that provides drinking water or a PAN site;
- (57) Establish a programmatic agreement with the military for large military projects on forest habitats.

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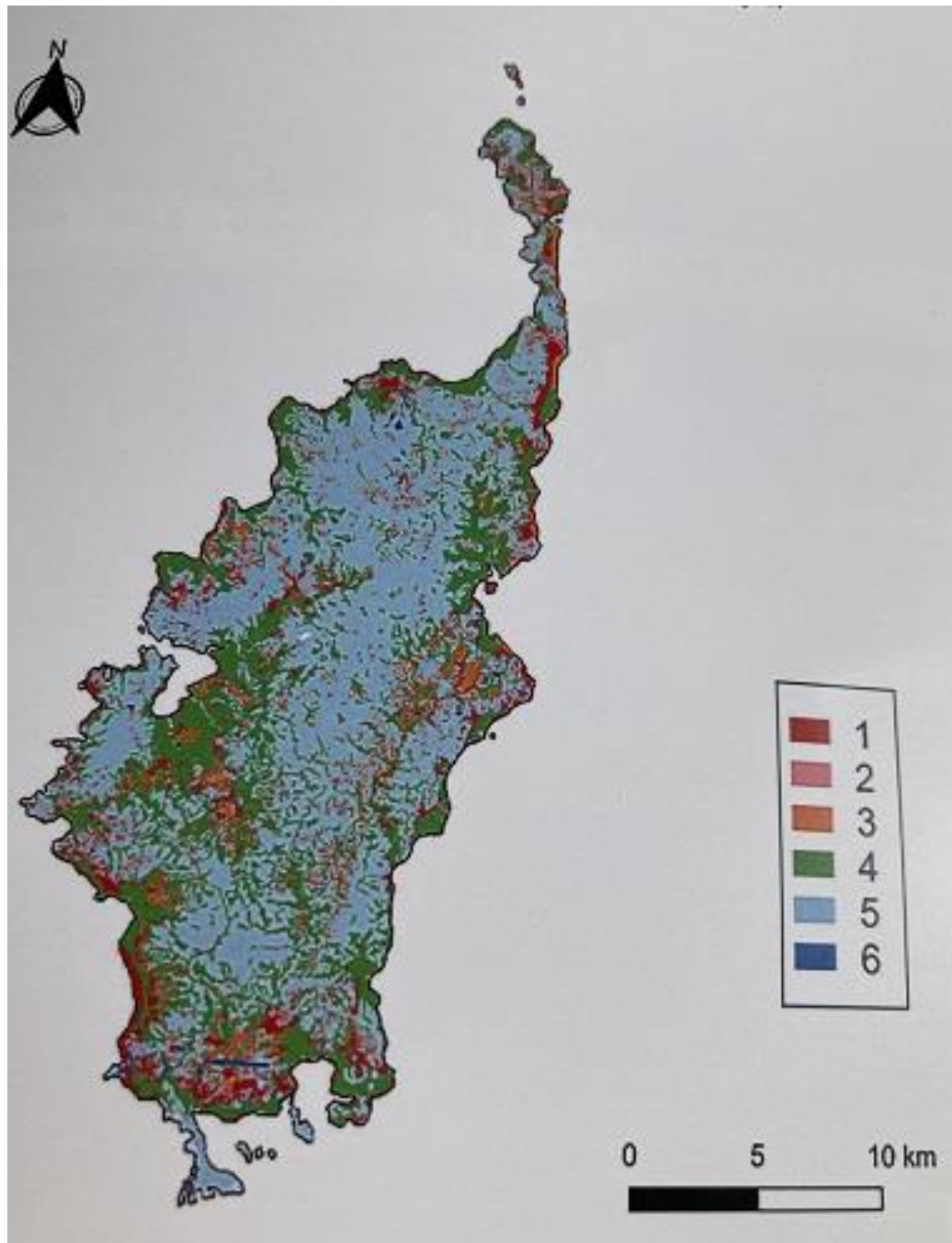


Figure 6.2 Spatial distribution of lands of each category of agricultural development in Babeldaob. Category 1-3 land recommended for agriculture, and Category 4 land recommended for agroforestry. Categories 5 and 6 not suitable for either agriculture or agroforestry (Categories 5 and 6). Tetsuro Kikuchi 2021.

Nekken Station

The Republic of Palau has mandated the Bureau of Agriculture through the Nekken Agriculture Station in Aimeliik to ensure that Palau's forests are sustained for each generation (Figure 6.3 and Table 6.1).

Nekken Agriculture Station is a priority site for forestry demonstrations and training. The Nekken station was opened in 1938 under the Japanese Administration covering an area of 15 ha. The facilities were destroyed during World War II. Over time Aimeliik has reclaimed a majority of the land for conservation and crop and livestock production. The Station covers an area of 262.5 ha that consists of

conservation areas, forestry demonstration areas, a tree nursery and several large stands of mahogany and smaller stands of fruit trees like mangosteen. Refer to Figures 6.4 and 6.5. The main objectives of the Nekken Station are to 1) operate as a focal demonstration center for sustainable agroforestry and forestry and includes a tree nursery, native species propagation area, tree farm models, agroforestry model, composting and traditional agriculture; 2) provide a location to support increased food security and sustainable livelihoods; 3) function as a training center and 4) produce and distribute planting materials. A proposed Nekken Land Use Plan was developed in 2005. An ecotourism project is proposed for this site.



Figure 6.3 Map of Nekken Agricultural Station, Code of plots, plot name and area and plot use.
Source: Nekken Agriculture Station Plan 2005.

Table 6.1 Plot number, name, area and use at Nekken Agricultural Station (Refer to Figure 6.3)
Source: Nekken Agriculture Station Plan 2005

| Area No. | Land Use | Area (m ²) | Specific use |
|--------------------------------------|---|------------------------|---|
| 1 | Plant experiment & multiplication plot, poultry hatchery unit, dorms, offices, and facilities | 67,011 | <ul style="list-style-type: none"> ➤ Trial plot for new varieties of root crops & vegetables ➤ Plot for reproducing plant materials for distribution ➤ Poultry hatchery facility |
| 2 | Taiwan Technical Mission Demonstration Plot | 347,756 | TTM demonstration farm for training and trails |
| 3 | Sublek Farm | 95,715 | Formerly occupied by the Ministry of Justice |
| 4 | OISCA Farm | 256,608 | OISCA Training Center for students |
| 5 | Fruit tree production plot & TTM Facilities | 75,536 | <ul style="list-style-type: none"> ➤ Plot for fruit tree experiments & production ➤ Facilities for TTM to produce and market food products |
| 6 | Small ruminant experiment and production plot | 386,498 | <ul style="list-style-type: none"> ➤ Watershed protection ➤ Ecotourism ➤ Buffer zone demonstration |
| 7 | Water buffalo grazing plot | 632,598 | Planned for water buffalo production |
| 8 | Native Forest Protection | 200,068 | <ul style="list-style-type: none"> ➤ Watershed protection ➤ Ecotourism, ➤ Buffer zone demonstration |
| 9 | Native Forest Protection | 169,197 | <ul style="list-style-type: none"> ➤ Watershed protection ➤ Ecotourism ➤ Buffer zone demonstration |
| 10 | Native Forest and Watershed Protection | 329,297 | <ul style="list-style-type: none"> ➤ Watershed protection ➤ Ecotourism, ➤ Buffer zone demonstration |
| 11 | Fruit trees and forest plot | 64,861 | Demonstration timber & fruit plots for sustainable harvest |
| Total Area = 2,625,145 square meters | | | |



Figure 6.4 *Swietenia macrophylla* 25-30 yr old Plantation Stand Nekken Station, Aimeliik State

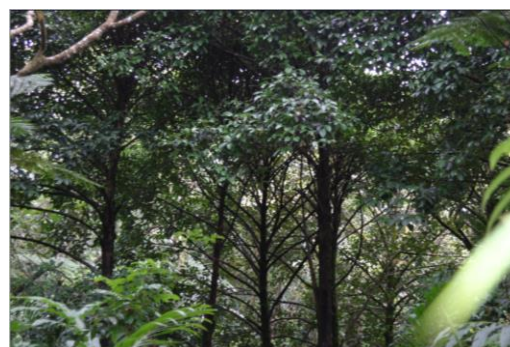


Figure 6.5 *Garcinia mangostana* (mangosteen) orchard at Nekken Station, Aimeliik State.

Breadfruit Agroforestry

Forestry staff attended arboriculture training in Honolulu in April 2019. DFLW staff and Palau community nursery managers attended tree nursery training in Guam in August 2019. During March 2019, staff from DFLW, Land Grant, and Ngardok State attended training in Hilo, Hawaii with financial assistance from the USDA Forest Service (Research and S&PF) to study breadfruit pruning, propagation, and processing. Forestry distributed 650 breadfruit plants to states throughout Palau. As one example, the Ngaraioll women's group out planted these breadfruits in Melekeok in October 2019. This Forest Stewardship project restored the degraded land areas in Ngeremlengui and Ngiual (Ngiwal). A total of 74 household owners were trained and engaged and 720 tree planting volunteers planted 2,416 trees and restored 13 acres in Ngiual and Ngeremlengui. When trees mature in three to five years, an estimated reduction of soil loss will be 34 tons/year. A total of 200 plants were tagged for monitoring tree species growth. Trees planted in Ngeremlengui and Ngiual had an average survival rate of 90%. A total of 39 sediment traps which constituted planting of 2,115 lemon grass with log fences was installed in the area to reduce soil erosion and manage stormwater. This provided for immediate prevention of soil loss and sedimentation offload into the watershed, and an enforcement to the longterm solution of reforestation. Four members of the staff received training and capacity building through US Forest Service on grants management, arboriculture, and nursery management. This resulted in significant improvement to the project, in terms of plant collection, propagation, maintenance in nursery, monitoring, and financial reporting.

Coconut

Cole et al. (1987) identified a separate and larger vegetation type for Coconut Plantations that covered 100ha. Efforts to reforest with *Cocos* continue today. *Cocos nucifera* has been in Palau since thousands of years before the present and considered a native tree in Palau. Coconut plantations were developed in Palau during the German administration from 1899 to 1914. Copra was the top industry in Palau until the 1970's when the tuna fishery was top industry and recent years the tourism industry has taken top ranking economically. Agro-tourism is being initiated in recent years. The coconut is marketed globally by the tourism industry as a symbol of an idyllic paradise. The taste of coconut is found in many tropical foods served to visitors in Palau. Coconut is a keystone species for Palau with over 40 documented uses. Parts of this tree can be used as food, shelter, clothing, medicine, and art – all aspects of traditional culture (Kitalong et al.2009). It is recommended that coconut plantations be assessed to determine the health of the trees and the potential for replanting a mixture of agroforest trees at these locations.

In 2010, Ngarchelong and Ngaraard had the highest percent land coverage of coconut trees. Refer to Figures 6.5 and 6.6 and Table 6.2. In Ngerchelung, Ngercherur Island was 13% (4.1ha) coconut forest and Ngerekeklaui Island was 100% coconut/mixed forest (6.2ha). In Kayangel, Ngcheangel Island was 72% (72 ha), coconut forest. In Peleliu, Ngedebus was 66% (59ha) coconut forest. The southwest islands consisted of 64.5 ha (17%) of coconut forest and 42.5 ha (11.3%) of coconut and mixed forest. At Hatohobei, 30.4ha (40.5%) was coconut forest. At Merir Island, 5.6 ha (5.6%) was coconut forest. In Pulo Anna, 35% (13.3 ha) was coconut forest. In Sonsorol, 11.5 ha (9.5%) is coconut forest, and 42.5 ha (35%) was coconut and mixed forest. In 2012, President Toribiong launched a green revolution that called for planting 10,000 coconut trees in the 10 States of Babeldaob. Each State designated an area for a coconut plantation. The 2015 Agricultural Census surveyed coconut plantations in four additional states. Refer to Figure 5.6

Table 6.2 State, location, total hectares, and percent of total land area that is covered by either coconut plantations or coconut trees with mixed forest from PALARIS/USFS Maps and from Land surveys during the 2015 Agricultural Survey.

| State | Location | Total hectares of (coconut /mixed forest) | Percent of total land area | 2015 Farm Survey Hectares |
|--------------|---------------------|---|----------------------------|---------------------------|
| Kayangel | | | 42.0 | |
| | Ngcheangel Island | 72 | 72 | |
| Ngarchelong | | 146 | 18.96 | 0.7 |
| | Ngerekeklaui Island | 6.2 | 100 | |
| | Ngercherur Island | 4.1 | 13 | |
| Ngaraard | | 158 | 5.12 | |
| Ngiwal | | 25.6 | 0.69 | |
| Melekeok | | 2.1 | 0.09 | 3.5 |
| Ngaraard | | | | 0.7 |
| Ngardmau | | | | 1.4 |
| Ngatpang | | | | 9.7 |
| Ngchesar | | 2.95 | 0.07 | |
| Ngeremlengui | | | | 2.6 |
| Aimeliik | | 9.65 | 0.17 | |
| Airai | | 9.10 | 0.14 | 1.4 |
| Peleliu | | | 5.30 | |
| | Ngedebus Island | 59 | 66 | |
| Sonsorol | | | 11.4(11.7) | |
| | Sonsorol Island | 11.5 (42.5) | 9.5 (35) | |
| | Pulo Anna Island | 13.3 | 35 | |
| | Fanna Island | 3.7 | 9.3 | |
| | Merir Island | 5.6 | 5.6 | |
| Hatohobei | | | 38.9 | |
| | Hatohobei Island | 30.4 | 40.5 | |
| | | 559.4 (42.5) | | |

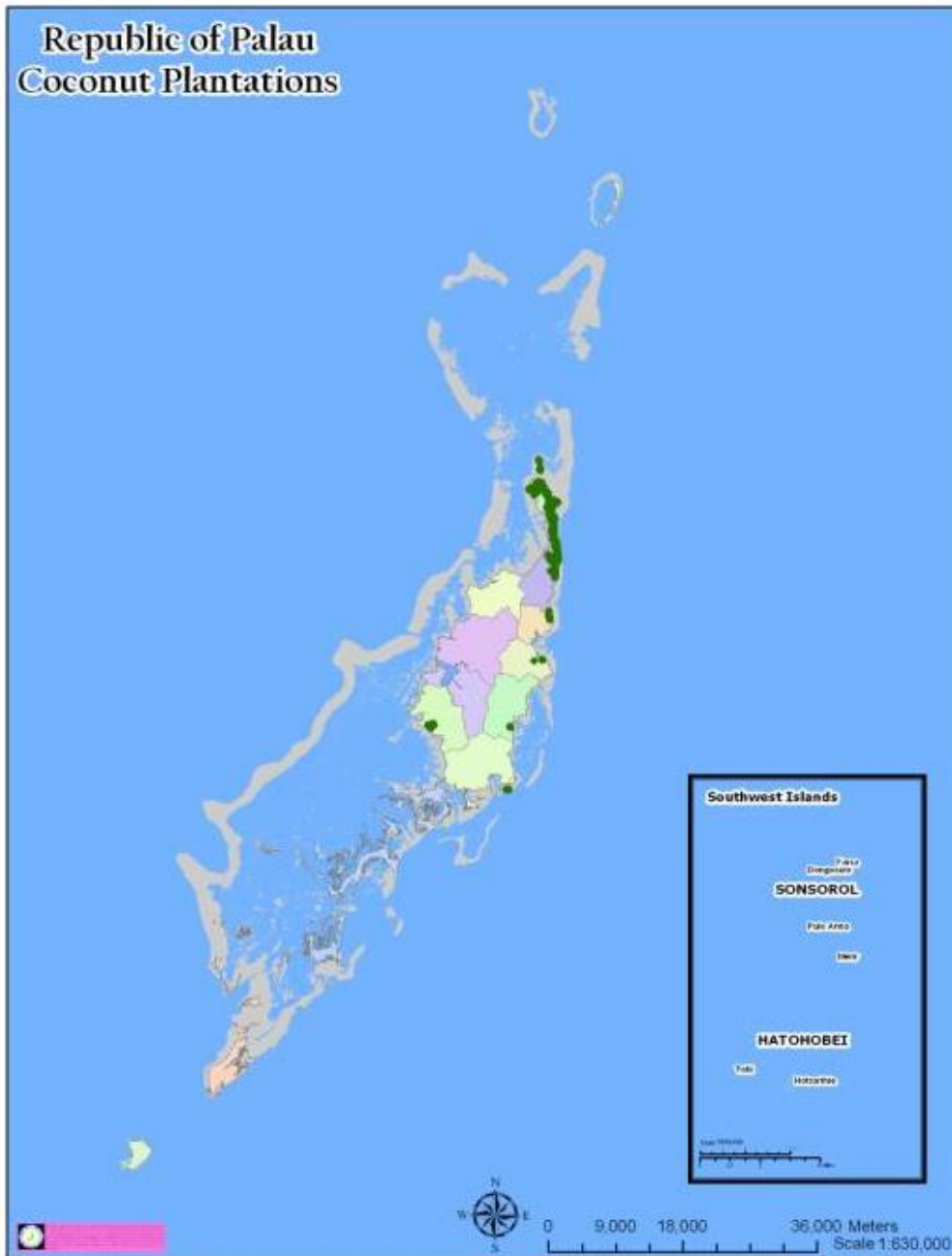


Figure 6.6 Coconut plantations and **priority sites** for assessment of CRB in the Republic of Palau PALARIS 2010

During 2009 to 2012, The Institute for Sustainable Living (SIUL) initiated the Tree of Life project in Palau with support from the GEF Small Grants Program. A micro-mill plant was built in Ngchesar State to demonstrate an appropriate technology for dispersed small-scale oil production in the villages of Palau; and develop secondary industries. A fully operational mill can produce 10 gals/ day, 6 days/week, producing 240 gal/month. During the Japanese administration, Babeldaob sustained up to 95 coconut mills with a peak production at 452,000 gallons/yr. If a very conservative 10% of those original 813 hectares are productive, Palau can potentially support 9 mills/yr if they reach full production (Patricia Leon pers. comm. 2010). Table 38 shows annual projections for coconut oil production. There is a need to conduct an assessment and survey of existing coconut plantations Active participation and support for coconut oil production cottage industries requires ongoing support

Table 6.3 Coconut Oil Production projections for small coconut oil mill in Ngchesar

| Months | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Gallons | 64 | 64 | 80 | 80 | 96 | 96 | 120 | 120 | 120 | 120 | 136 | 160 |
| Liters | 243 | 243 | 303 | 303 | 364 | 364 | 455 | 455 | 455 | 455 | 515 | 606 |
| No. of Coconuts | 3396 | 3396 | 4245 | 4245 | 5094 | 5094 | 6367 | 6367 | 6367 | 6367 | 7216 | 8490 |
| No. of Coconuts | 3,849 | 3,849 | 4,812 | 4,812 | 5,774 | 5,774 | 7,218 | 7,218 | 7,218 | 7,218 | 8,180 | 9,624 |

Source: Institute for Sustainable Living (SIUL) 2010.

Insect pests

The impact of insect pests, especially the Coconut Rhinoceros Beetle and the Super Typhoons in 2012, 2013 and 2021 reduced the size and health of the coconut plantations in Palau. Refer to Figure 1.4 and 1.5. There are at least five known insect pests that threaten the health of *Cocos nucifera*: long horned grasshopper, *Segestes unicolor*, the coconut scale, *Aspidiotus destructor*, the coconut leaf beetle, *Brontispa palauensis*, the red coconut scale, *Furcaspis oceanica*, the coconut mealybug, *Nipaecoccus nipae* (maskell) and the coconut rhinoceros beetle, *Oryctes rhinoceros*. The rhinoceros beetle also feeds on betel nut palms.

Biological Control of the Coconut Rhinoceros Beetle

The coconut rhinoceros beetle, *Oryctes rhinoceros* feeds on coconut and betel nut palms. A virus disease of the rhinoceros beetle, called *Rhinoceros baculovirus* was imported from Samoa in 1983 and released in different locations in Palau. In 2003, the virus was applied to healthy beetles in Sonsorol (Esquerra and Del Rosario 2007). A collaboration effort between agriculture and forestry and the College of Research and Extension at Palau Community College and the communities assessed the effectiveness of the virus and overall health of coconut plantations throughout Palau. Kitalong, C. et al. (2018) found that there are two biotypes of Coconut Rhinoceros Beetle (CRB), a.k.a. *Oryctes rhinoceros* in Palau: CRB-S & CRB-G. The CRB is an invasive insect that kills coconut trees and other palm species by feeding on the plant's crown. Damage Assessment Surveys were conducted on coconut trees in several locations in all of the 16 states in Palau in 2016, 2017 and 2018. The 2015 FIA survey indicated that 40% of the coconut trees were damaged by CRB. These surveys were made to determine the amount of damage done by the beetles. Specialized traps were used along with manual searches through debris to collect and determine distribution of CRBG and incidence of *Oryctes* Nudivirus (OrNV) infection. The Damage Assessment Surveys show slow recovery/reduced damage in coconut tree fronds. An analysis of biotype and viral detection show a very high rate of infection of all CRB with the nudivirus (CRB: 92%; CRB-G: 83%). The reduced tree damage and high rate of infection of the beetles, and visual assessments of CRB samples gut damage, suggest that the OrNV in Palau CRB is virulent. Further assessment is necessary but immediate focus should be made to identify and test virulence of OrNV in Palau in order to control CRBG for the region. A 2021 assessment of the CRB damage indicated a slight increase in damage (Thomas, R. 2021 power point presentation). The USFS can assist landowners with the establishment of

state forestry extension officers to assist coconut plantation owners with tree maintenance and production and marketing of coconuts and other timber and tree products.

Mahogany

Several large mahogany plantations are located at the Nekken Station. In 2010, 161 *Swietenia macrophylla* were measured with a total basal area of 2.79 ft² and a total volume of 2,763 ft³ that were valued ranging from \$132,896 to \$265,768. Refer to Figure 6.6. These values are based upon a value of \$4-\$8/board feet. The raw data was provided by Pua Michael, Head Forester. Sustainable harvest of mahogany at Nekken could provide funding for the Forest Stewardship Programs. Mahogany plantations were established in over 100 locations. During the 1980's, 40,000 to 60,000 tree saplings were propagated and distributed annually. During the 1990's, 10,000 saplings of *Acacia* and mahogany were propagated and distributed annually. In the 2000's, production was the same with larger distributions (1,000-5,000 saplings) to private landowners in Airai, Aimeliik, Ngchesar, and Ngatpang States. In 1994, there was a demand for mahogany trees that were 20-36" in diameter at a price of \$100/tree in the construction of the Airai View Hotel. Thirty-five year-old trees sold for \$100.00/tree. *Swietenia macrophylla* is a fast growing and valuable timber with an average price of \$1,300.00/m³ in the United States in 2010. Mahogany reaches commercial size in 30 to 120 years. It is heavily exploited with few natural populations in the wild. Establishing plantations should not jeopardize native forests (Costion 2004). In 2010, the Blue Moon Exotic Wood company processed and exported *Swietenia mahogani* or Cuban Mahogany and the native *Calophyllum inophyllum* (btaches) or Alexandria laurel. Their plantation was located in Ngchesar State and covered 100 acres with an additional 200 acres for expansion. The Company operated for 4 years and is no longer in operation. Mr. Toribiong Basilius processed wood at a sawmill in Ngchesar that had to be cut to grade and treated and all US permits completed before shipment off island (Ephram Polycarp pers. comm. September 13, 2021).

Currently there is one local commercial operation that has been processing mahogany for the last 5 years. Philip Reklai's company shipped 3 containers of mahogany logs to Japan, China, and Taiwan. The logs sold at \$24.00/board feet. He found that it was not economical to ship whole logs and began to cut the logs into 4 side slabs. Then the COVID19 pandemic began and exporting mahogany stopped. He now sells locally at \$15.00/board feet for 4-sided cut boards. The cost is cheaper than imported wood. Wood can remain termite free if it is kept dry and treated. It took over a year to begin processing mahogany and a challenge to convince the former government that cutting mahogany was sustainable as it is an introduced tree (Phillip Reklai, pers. comm. September 13, 2021). Refer to Figure 6.8.



Figure 6. 8 Reklai Mahogany Processing in Aimeliik State Sept 21, 2021

A Draft Forest Management Plan (Bell 1994) recommended buffers strips of 130m wide (65m on either side) be left in fully forested states along all perennial streams to protect stream channels and act as sediment traps. A draft Forestry legislation (House Bill No. 5-132-5) recommended that no more than 50% of the basal area of mature trees on any harvesting site or acre be logged and state permits be required for all cutting.

Aimeliik Forest Survey for timber

In 2010, The Forestry Division conducted a survey within Aimeliik to determine the density and size distribution of timber trees especially *Gmelina palawensis* as a hotel is requesting 200 trees for construction. Aimeliik State was concerned that the demand was greater than what the State could sustainably harvest. The forestry team surveyed Ngerderar (Protected Area) and adjacent buffer zone with 51 plots in the protected area, 49 plots in the buffer zone. Refer to Figure 6.9. The data was analyzed in 2017 with greater number and diversity of trees within the protected areas, and more seedlings and saplings in the buffer zone. Based upon the results of this survey, a permitting system was developed for Aimeliik State. The need for timber was not well documented – yet many local community centers, the traditional bai, and summer rest houses use local wood that are durable and lasting. State inventories for sustainable harvest and propagation of native timber is needed in each State.

During 2004, Craig Costion with the Forestry Division staff developed a tree planting guide for *Nephelium lappaceum* (rambotang), *Garcinia mangostana* (mangosteen), *Annona muricata* (sausab), *Citrus mitis* (kingkang) *Mangifera indica* (iedel), *Persea americana* (bata), *Calophyllum inophyllum* (btaches), *Intsia bijuga* (dort), *Serianthes kanehirae* (ukall) *Swientenia macrophylla* (big leaf mahogany) and *Pterocarpus indicus* (las). *Garcinia mangostana* is a delicious and unique fruit that is thought by some to be one of the world’s best-flavored fruit (Figure 6.5). It is difficult to cultivate, and no successful widespread commercialization was known. More production of this fruit trees as part of a healthy diet for school lunches in Palau is recommended. In 2020, PCC-CRE developed technical materials to further guide in the successful propagation of fruit trees for landowners.

Casuarina equisetifolia, a native species, is among the most successful colonizers of denuded areas, new surfaces, and fresh sand flats. This species has nitrogen-fixing bacterial root nodules and produces carpets of “needles” that exclude other plants. This tree occurs on volcanic and limestone substrate at high and low elevations and on all types of slopes in the Northern Mariannas (Mueller-Dombois and Fosberg 1998). *Casuarina* forests covered 451 hectares or 20% of the coral islands of Palau in 1987. Angaur and Peleliu have large stands of this tree as well as the Ngemelis Complex and many rock islands. This successful native pioneer species is commonly found along shore areas that were either settlements in the past or are currently used as temporary shelters. Long term monitoring is needed to determine if this tree may be out-competing other native rock island trees on some rock islands. During Super-typhoon Bopha many *Casuarina* trees fell in Peleliu and Angaur. A portable sawmill to clear and cut areas impacted by storms to provide local firewood to communities of Palau is recommended.



Figure 6.10 Nekken Station nursery at Aimeliik State Sept 21, 2021

During 2005 to 2009, 79,384 saplings were produced and distributed at Nekken State Nursery to over 133 landowners (Figure 6.10 and Table 6.4). A total of 68 people in 8 states of Babeldaob received 59,376 trees covering more than 133 acres or 54 hectares. The top saplings distributed were *Morinda citrifolia* (ngel or noni) (50,532 saplings) and *Swientenia macrophylla* mahogany (8,804 saplings). Refer to Figure 6.10. The landowners who requested the most mahogany resided in Ngardmau, Ngatpang, Ngarchelong, and Ngeremlengui. Landowners living in Ngeremlengui, Ngarchelong and Ngiwal requested more *Morinda* saplings than other states (Table 6.4). Other saplings produced and distributed included *Areca catechu* (buuch) (10,988 saplings) and *Nephelium lappaceum* or rambotang (1,391 saplings). In 2009, more native trees were propagated than in previous years including 500 saplings of *Ixora casei* (kerdeu) and 169 saplings of *Trichospermum ledermanni* (chelsau). The distribution of *Morinda citrifolia* (ngel or noni) and mahogany trees by Nekken State Nursery by state is shown on Table 6.4. The Nekken State Nursery distributed more mahogany saplings to Ngardmau, Ngatpang, Ngarchelong, and Ngeremlengui than other states. The number of *Morinda citrifolia* (ngel) saplings distributed by the Nekken nurseries were higher for Ngeremlengui, Ngerchelong, Ngiwal, and Ngatpang than other states. Currently there is also tree sapling propagation and distribution at the Ngchesar Agricultural Station. Refer to Figure 6.10.

The Agricultural Station at Ngchesar has established a new tree nursery for the BoA. Refer to Figure 6.12. Total seedling production from 2011 to 2020 show a high production in 2011 (over 10,000 seedlings) with a marked reduction by 2020. The DFLW initiated a program to charge for tree seedlings the previous administration. It is thought that the cost of seedlings (\$0.25/ea.) was a major deterrent to production, as previously seedlings were free (Larry Mamis, pers. comm. 2021). Refer to Figure 6.13 and Table 6.5. Seedling distribution were primarily to the states of Ngardmau, Aimeliik, Airai, and Ngeremlengui. Refer to Figure 6.14 and Table 6.6. The top tree seedlings distributed were mahogany seedlings. There were years when specialty fruits, rambotang and mangosteen, were distributed. Refer to Figure 6.15 and Table 6.7.

| State | Number of Landowners | Scientific name | Common name | total | acre | Hectare |
|--------------|----------------------|---------------------------|-------------|--------|--------|---------|
| Ngardmau | 3 | <i>Swientenia</i> sp. | mahogany | 2,450 | 5.68 | 2.3 |
| Ngatpang | 4 | <i>Swientenia</i> sp. | mahogany | 2,150 | 8.25 | 3.3 |
| Ngarchelong | 2 | <i>Swientenia</i> sp. | mahogany | 1,486 | 3.45 | 1.4 |
| Ngeremlengui | 5 | <i>Swientenia</i> sp. | mahogany | 1,358 | 2.41 | 1 |
| Melekeok | 2 | <i>Swientenia</i> sp. | mahogany | 900 | 4.1 | 1.6 |
| Ngiwal | 2 | <i>Swientenia</i> sp. | mahogany | 400 | 1.32 | 0.5 |
| Aimeliik | 2 | <i>Swientenia</i> sp. | mahogany | 100 | 0.33 | 0.13 |
| Subtotal | | | | 8,844 | | 10.23 |
| Ngeremlengui | 9 | <i>Morinda citrifolia</i> | ngel | 13,400 | 33 | 14.3 |
| Ngarchelong | 14 | <i>Morinda citrifolia</i> | ngel | 11,170 | 21 | 8.5 |
| Ngiwal | 4 | <i>Morinda citrifolia</i> | ngel | 9,100 | 12.38 | 5 |
| Ngaraard | 6 | <i>Morinda citrifolia</i> | ngel | 5,900 | 16.83 | 6.8 |
| Ngatpang | 7 | <i>Morinda citrifolia</i> | ngel | 5,587 | 11.8 | 4.8 |
| Aimeliik | 5 | <i>Morinda citrifolia</i> | ngel | 3,800 | 8.16 | 3.3 |
| Melekeok | 2 | <i>Morinda citrifolia</i> | ngel | 825 | 2.73 | 1.1 |
| Ngardmau | 1 | <i>Morinda citrifolia</i> | ngel | 750 | 1.62 | 0.6 |
| Subtotal | | | | 50,532 | | 30.1 |
| Total | 68 | | | 59,376 | 133.06 | 54.63 |

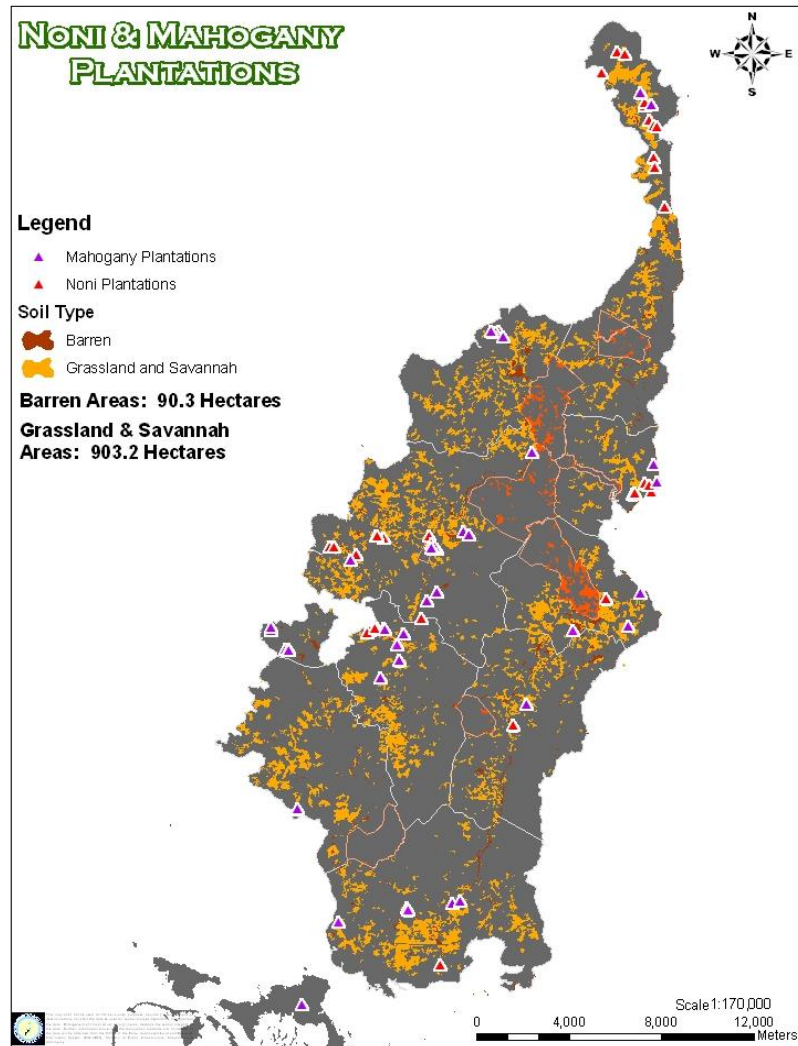


Figure 6.11 Locations of plantations on private lands of mahogany and noni (*Morinda citrifolia* or ngel) and **priority sites** for sustainable forestry production for timber and medicine in 2021-2030. Data provided by the Forest Stewardship Program and Nekken Nursery Bureau of Agriculture 2010



Figure 6.12 Ngchesar Agriculture Station tree nursery June 25, 2021

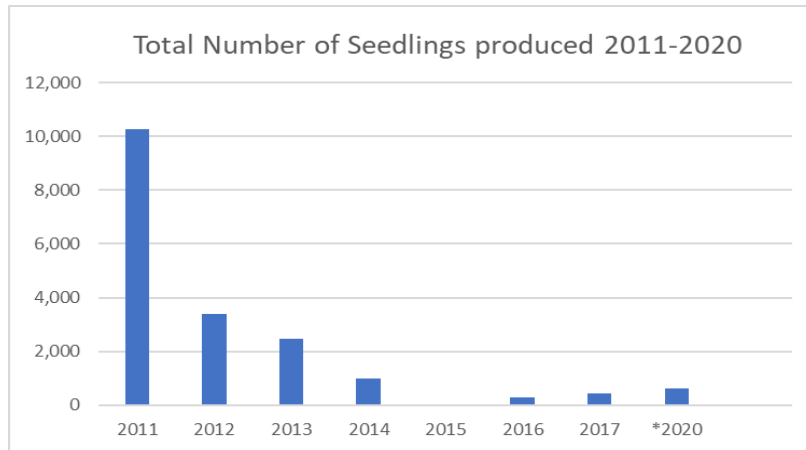


Figure 6.13 Nursery production of seedlings during 2011 to 2020. There was no available records for 2018, and 2019, and partial data for 2020. Source: BoAForestry Division

Table 6.5 Total seedlings produced by year (2011-17, 2020) at Nekken Station

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | *2020 |
|------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|
| No. of Seedlings | 10,275 | 3,396 | 2,455 | 981 | 32 | 275 | 442 | 622 |

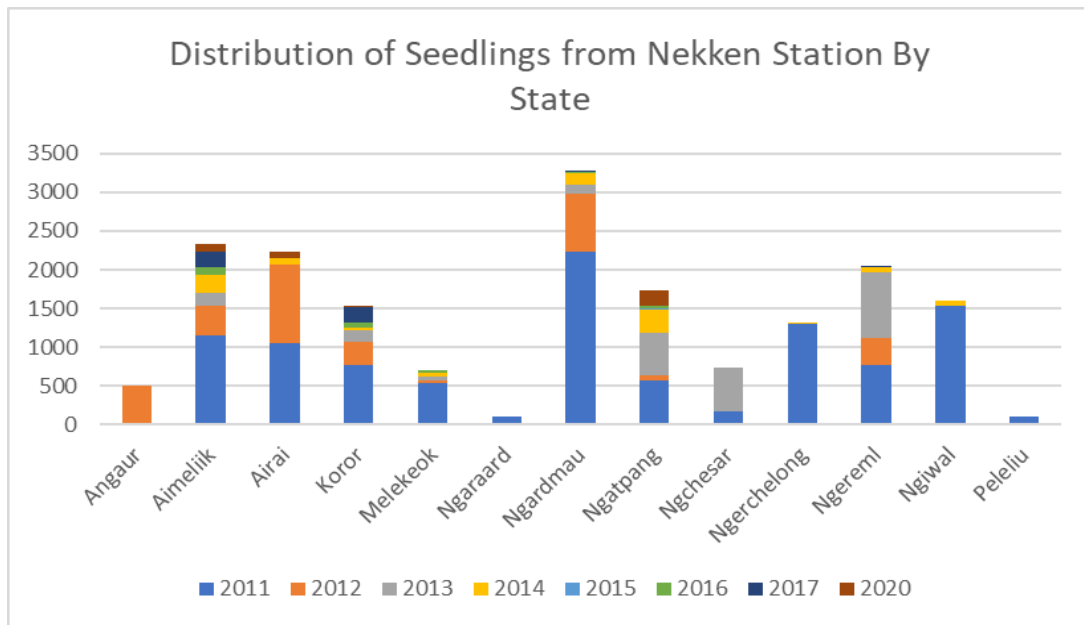


Figure 6.14 Distribution of seedlings from Nekken Station by State Source: Forestry Division

Table 6.6 Total Seedling Distribution by State from Nekken Nursery for 2011-2017 and 2020.

| Year | Anggur | Almejik | Arai | Koror | Melekok | Ngaraard | Ngaromau | Ngatpang | Nghesar | Ngerdolong | Ngeremlengui | Ngiwal | Pelétu | unknown |
|-------|--------|---------|------|-------|---------|----------|----------|----------|---------|------------|--------------|--------|--------|---------|
| 2011 | 0 | 1146 | 1045 | 760 | 531 | 96 | 2233 | 570 | 174 | 1305 | 773 | 1534 | 108 | |
| 2012 | 500 | 388 | 1018 | 307 | 38 | 0 | 745 | 60 | 0 | 0 | 340 | 0 | 0 | |
| 2013 | 0 | 159 | 0 | 154 | 50 | 0 | 120 | 552 | 560 | 0 | 860 | 0 | 0 | |
| 2014 | 0 | 242 | 81 | 34 | 48 | 0 | 142 | 309 | 0 | 5 | 60 | 60 | 0 | |
| 2015 | | | | | | | | 13 | | | | | | |
| 2016 | | 96 | | 62 | 28 | | 22 | 32 | | | | | | 2 |
| 2017 | | 200 | | 200 | | | 21 | | | | 21 | | | |
| 2020 | | 96 | 86 | 5 | | | 0 | 200 | | | | | | |
| Total | 500 | 2327 | 2230 | 1522 | 695 | 96 | 3283 | 1736 | 734 | 1310 | 2054 | 1594 | 108 | 2 |

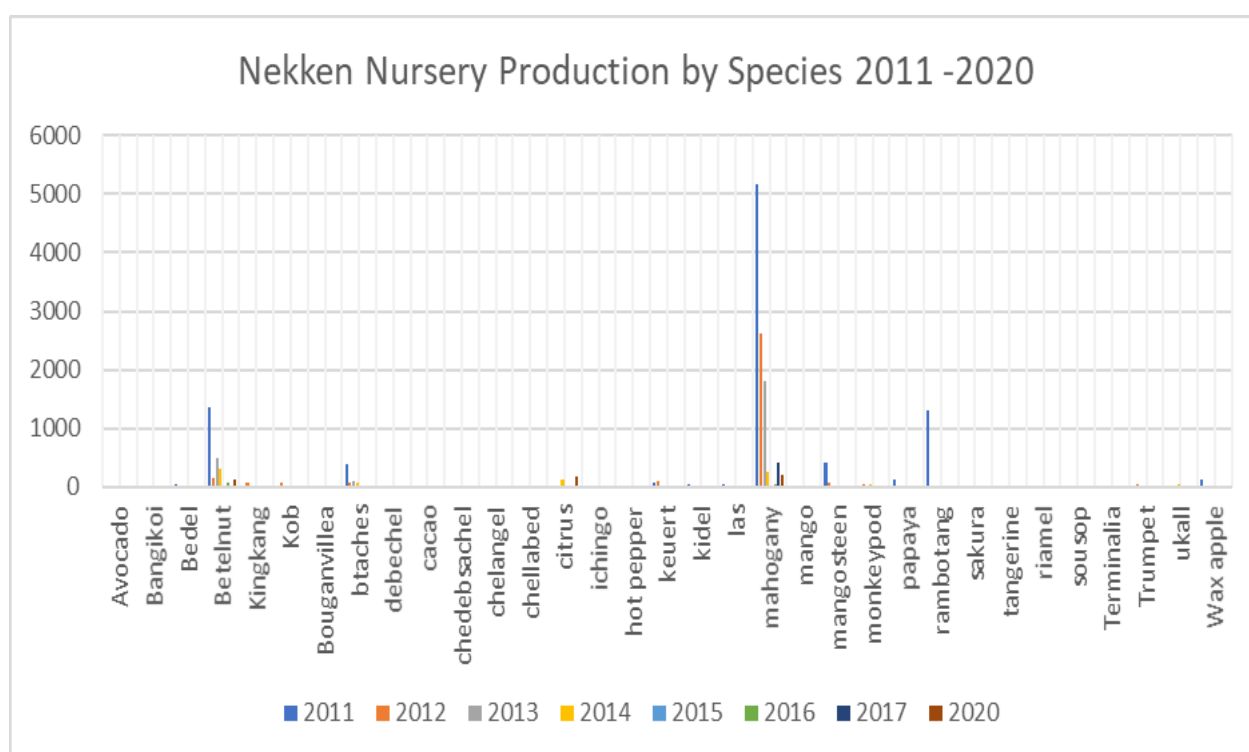


Figure 6.15 Nursery production of seedlings by species by year BoA Division of Forestry.

Table 6.7 Species trees and plants distributed by year (2011-2017 and 2020) Forestry Division

| Year | | Total | 2011 | 2012 | 2013 | 2014 | 2016 | 2017 | 2020 |
|---------------------|---|-------|------|------|------|------|------|------|------|
| Palauan/common name | Scientific Name | | | | | | | | |
| Avocado | <i>Persea americana</i> | 58 | 15 | 16 | 3 | | | 6 | 18 |
| Bangkok | | 5 | | 5 | | | | | |
| Bedel | <i>Macaranga carolinensis</i> | 50 | 50 | | | | | | |
| Buuch | <i>Areca catechu</i> | 2550 | 1362 | 167 | 495 | 306 | 84 | | 136 |
| Kingkang | <i>Citrus microcarpa</i> | 84 | 7 | 65 | | | | | 12 |
| Kob | <i>Polyscias scutellaria</i> | 84 | | 84 | | | | | |
| Bougainvillea | <i>Bougainvillea</i> spp. | 1 | 1 | | | | | | |
| btaches | <i>Calophyllum inophyllum</i> | 661 | 380 | 65 | 100 | 90 | | 26 | |
| debechel | <i>Citrus hystrix</i> | 9 | | | | 7 | | | 2 |
| sukelatei | <i>Theobroma cacao</i> | 10 | | | | | 10 | | |
| chedebsachel | <i>Syzygium aqueum</i> | 2 | | | | | 2 | | |
| chelangel | <i>Planchonella obovata</i> | 11 | | 11 | | | | | |
| chellabed | <i>Syzygium</i> sp. | 10 | 10 | | | | | | |
| citrus | <i>Citrus</i> sp. | 413 | 26 | 15 | 34 | 138 | 27 | | 173 |
| ichingo | | 6 | | | | | | 6 | |
| meringel | <i>Capsicum annum</i> | 53 | 23 | 25 | 5 | | | | |
| keuert | <i>Drypetes nitidai</i> | 177 | 72 | 105 | | | | | |
| kidel | <i>Syzygium malaccense</i> | 61 | 57 | | 4 | | | | |
| las | <i>Pterocarpus indicus</i> | 60 | 60 | | | | | | |
| mahogany | <i>Swietenia macrophylla</i> <i>Swietenia mahogani</i> | 10487 | 5166 | 2610 | 1796 | 250 | 50 | 405 | 210 |
| iedel | <i>Mangifera indica</i> | 23 | 6 | 1 | 2 | 2 | 10 | | 2 |
| mangkostin | <i>Garcinia mangostana</i> | 496 | 416 | 80 | | | | | |
| monkeypod | | 105 | | 55 | | 50 | | | |
| papaya | <i>Carica papaya</i> | 172 | 136 | | 6 | 25 | 5 | | |
| rambotang | <i>Nephelium lappaceum</i> | 1355 | 1316 | 1 | | 0 | 22 | | 16 |
| sakura | | 21 | 21 | | | | | | |
| tangerine | <i>Citrus reticulata</i> | 2 | 2 | | | | | | |
| riamel | <i>Pangium edule</i> | | | | | | | | 30 |
| sausab | <i>Annona muricata</i> | 31 | | 22 | 6 | | | | 3 |
| miich | <i>Terminalia catappa</i> | 29 | 1 | 14 | | 14 | | | |
| Trumpet | | 43 | | 43 | | | | | |
| ukall | <i>Serianthes kanehirae</i> | 63 | | | | 58 | | | 5 |
| Wax apple | <i>Syzygium</i> sp. | 166 | 137 | 10 | 4 | | | | 15 |

Ebiil Society Nursery Production

During 2013 to 2021, the Ebiil Society Nursery produced 24,722 seedlings and saplings for reforestation projects in Ngarchelong, Ngeremlengui, Ngiwal, Ngardmau, and Helen Reef. The average production has been 3,090 saplings a year. The main species of plants propagated are *Calophyllum inophyllum* and *Calophyllum inophyllum* var. *wakamatsui* (btachesked), *Serianthes kanehirae* Fosberg var *kanehirae* (ukall), *Pongamia pinnata* (kisaks) *Pterocarpus indicus* (las), *Terminalia catappa* (miich), *Syzygium samarangense* (rebotel) and planted as a mixed population for restoration. Some species propagated for coastal restoration include *Syzygium samarangense* (rebotel), *Pongamia pinnata* (kisaks) *Pandanus aimiriikensis* (chertochet), *Intsia bijuga* (dort), *Heritiera littoralis* (chebibeche), *Pandanus dubius* (buuk), *Cordia subcordata* (kelau), *Polyscias macgillivarayi* (bngei), *Ochrosia oppositifolia* (uaoch) (Margie Olsudong, pers. comm. 8/20/21).

| Year | Location | Number |
|-----------------------------|-------------------------|--------|
| 2013-2015 | Ngarchelong | 12,000 |
| 2016-2018 | Ngeremlengui | 2,138 |
| 2018-2019 | Ngiual | 306 |
| 2020-2021 | Ngardmau: | 9,379 |
| 2021 | Ngarchelong Ngarkeklau* | 379 |
| 2021 | Helen Reef | 520 |
| Total | | 24,722 |
| Annual production | | 3,090 |
| *Coastal strand restoration | | |



Figure 6.16 Ebiil Society Nursery Site Visit with Margie Olsudong, August 20, 2021.

The 2015 Agricultural Survey/Census

The 2015 Agricultural/Agroforest surveyed 137 agroforests, 224 upland farms, 10 mesei/wetland and 2 dechel/semi-wetland sites. Refer to Tables 6.5, 6.6 and 6.7. The States of Ngarchelong, Ngeremlengui, and Ngaraard had more agroforests compared to other states. Most of the land ownership was private and had commercial, semi commercial, and private land uses. Mahogany trees were observed at 110 of these sites. Ngaraard, Ngeremlengui, and Aimeliik had more farms/agroforests with mahogany than other states. The common medicinal plant, *Morinda citrifolia* (ngel) was more frequently found on agroforests of Ngerchelung, Ngeremlengui and Ngatpang States than other states. Refer to Table 6.12.

Table 6.9 The Number of Agroforests, Land Ownership Type and Land Use Type from the 2015 Agriculture Census.

| State | Number of Agroforests | LAND OWNERSHIP TYPE | | | | LAND USE TYPE | | | |
|-----------------------|-----------------------|---------------------|-------|---------|-------|-----------------------------|---------|------|-----|
| | | CLAN | LEASE | PRIVATE | N / A | COMMERCIAL/ SEMI COMMERCIAL | PRIVATE | BOTH | N/A |
| Kayangel | 2 | 0 | 0 | 9 | 0 | 0 | 0 | 9 | 0 |
| Ngerchelong | 27 | 0 | 0 | 42 | 0 | 12 | 11 | 16 | 3 |
| Ngaraard | 18 | 0 | 4 | 29 | 0 | 8 | 0 | 25 | 0 |
| Ngiwal | 4 | 0 | 0 | 11 | 3 | 2 | 0 | 10 | 2 |
| Melekeok | 5 | 0 | 1 | 6 | 1 | 1 | 0 | 6 | 1 |
| Ngesarch/ Ngchesar | 9 | 0 | 0 | 11 | 0 | 3 | 1 | 7 | 0 |
| Airai | 11 | 0 | 3 | 15 | 0 | 1 | 0 | 16 | 1 |
| Ngardmau | 6 | 2 | 2 | 6 | 0 | 3 | 5 | 2 | 0 |
| Ngeremlengui | 23 | 1 | 9 | 20 | 0 | 14 | 3 | 13 | 0 |
| Ngatpang | 14 | 0 | 4 | 17 | 0 | 3 | 8 | 10 | 0 |
| Aimeliik | 5 | 0 | 4 | 16 | 0 | 6 | 0 | 14 | 0 |
| Koror | 8 | 0 | 1 | 9 | 1 | 0 | 2 | 9 | 0 |
| Peleliu | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 0 |
| Angaur | 2 | 0 | 0 | 4 | 0 | 2 | 0 | 2 | 0 |
| Sonsorol | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hatohobei | 2 | 0 | 0 | 5 | 0 | 0 | 5 | 0 | 0 |
| Total | 137 | 3 | 28 | 202 | 5 | 55 | 35 | 141 | 7 |

Table 6.10 The Forestry Farm Type by State from the 2015 Agricultural Survey

| State | FORESTRY FARM TYPE | | | |
|-----------------------|--------------------|-------------------|-------------------------|-----|
| | SERS/ UPLAND | MESEI/ WETLAND | DECHEL/ SEMI WETLAND | N/A |
| Kayangel | 8 | 1 | 0 | 0 |
| Ngarchelong | 41 | 1 | 0 | 0 |
| Ngaraard | 29 | 3 | 0 | 1 |
| Ngiwal | 13 | 0 | 1 | 0 |
| Melekeok | 8 | 0 | 0 | 0 |
| Ngesarch/ Ngchesar | 11 | 0 | 0 | 0 |
| Airai | 17 | 0 | 0 | 1 |
| Ngardmau | 10 | 0 | 0 | 0 |
| Ngeremlengui | 30 | 0 | 0 | 0 |
| Ngatpang | 21 | 0 | 0 | 0 |
| Aimeliik | 18 | 2 | 0 | 0 |
| Koror | 10 | 0 | 1 | 0 |
| Peleliu | 2 | 0 | 0 | 0 |
| Angaur | 4 | 0 | 0 | 0 |
| Sonsorol | 0 | 0 | 0 | 0 |
| Hatohobei | 2 | 3 | 0 | 0 |
| Total | 224 | 10 | 2 | 2 |

Table 6.11 The number of agroforests/farms with mahogany and teak trees by State from the 2015 Agricultural Census

| State | TIMBER | | |
|-------------------|----------|------|-----------------|
| | MAHOGANY | TEAK | OTHER TIMBER |
| Kayangel | 0 | 0 | 0 |
| Ngarchelong | 8 | 0 | 0 |
| Ngaraard | 16 | 0 | 0 |
| Ngiwal | 10 | 0 | 0 |
| Melekeok | 7 | 0 | 2 |
| Ngesarch/Ngchesar | 6 | 1 | 0 |
| Airai | 11 | 0 | 0 |
| Ngardmau | 7 | 1 | 0 |
| Ngeremlengui | 14 | 0 | 0 |
| Ngatpang | 6 | 0 | 0 |
| Aimeliik | 14 | 1 | 1 |
| Koror | 10 | 0 | 0 |
| Peleliu | 0 | 0 | 0 |
| Angaur | 1 | 0 | 0 |
| Sonsorol | 0 | 0 | 0 |
| Hatohobei | 0 | 0 | 0 |
| Total | 110 | 3 | 3 |

Table 6.12. The number of agroforests/farms with medicinal plants survey during the 2015 Agricultural Survey

| State | MEDICINAL PLANTS | | | |
|-------------------|---|---|---|--------------------------------|
| | <i>Phaleria nisidai</i> (DELAL A KAR) | <i>Morinda citrifolia</i> (NGEL) | <i>Syzygium samarangense</i> (REBOTEL) | MEDICINAL PLANTS/ OTHERS |
| Kayangel | 0 | 7 | 1 | 0 |
| Ngerchelong | 1 | 29 | 0 | 9 |
| Ngaraard | 0 | 5 | 0 | 0 |
| Ngiwal | 1 | 3 | 0 | 1 |
| Melekeok | 1 | 0 | 0 | 0 |
| Ngesarch/Ngchesar | 0 | 1 | 0 | 0 |
| Airai | 0 | 3 | 0 | 0 |
| Ngardmau | 0 | 1 | 0 | 0 |
| Ngeremlengui | 1 | 20 | 0 | 1 |
| Ngatpang | 1 | 13 | 0 | 2 |
| Aimeliik | 0 | 6 | 0 | 0 |
| Koror | 0 | 5 | 0 | 0 |
| Peleliu | 0 | 2 | 0 | 0 |
| Angaur | 0 | 2 | 0 | 1 |
| Sonsorol | 0 | 0 | 0 | 0 |
| Hatohobei | 0 | 3 | 0 | 0 |
| Total | 5 | 100 | 1 | 14 |

Forest Stewardship Program

The Forest Stewardship Program (FSP) provided the Ebiil Society with a 2018-2021 grant for organizational development and program improvement, including finances to hire personnel, training and capacity building in nursery training, forest health training, finance and project management training, and other critical knowledge for successful development and implementation of FSP in three states. Nursery productivity and reforestation efforts increased.

Ngeremlengui Forest Stewardship Ebiil Project: The project objective was to restore the degraded land area in Ngeremlengui. Since April 2018 the number of plants collected totals 2,735 of which 1,460 were planted. Over 300 community volunteers from Ngeremlengui and from various local schools and organizations, including international universities and groups have participated in the planting of these trees. This project engaged communities beyond the project site of Ngeremlengui based on requests from schools and household owners from other communities. A total of 1,728 trees were planted or donated for tree planting events as requested. From May 2018 until the end of the year several trainings were held on topics such as forest and watershed protection, soil and water management, ethnobotany, and tree planting. A little over 100 people have participated in these trainings and more training has been scheduled for the future.

Ngiwal and Ngardmau Forest Stewardship Ebiil Project: The Forest Stewardship Ebiil Project prioritized a Ngiwal State housing development area of 15 acres and Ngardmau's bauxite mine fields forest restoration of 20 acres. Soil and water management training were conducted with the residents of Ngiwal site. Households needing improved vegetative cover and flooding control was enabled to plant lemon grass, native medicinal and fruit trees, and shrubs to reduce soil erosion and flooding. All activities were conducted with the State resource management office to ensure sustainability of knowledge and practices.

In March 2020, the efforts on tree planting to recover the Ngardmau mine fields was exceptionally strong. The total number of landowners assisted was 31, for soil and water conservation, plants for their land, and education on planting to mitigate soil erosion, preserving soil quality, and property protection. A total of 634 landowners, community members, science teachers, students and youth participated in Ebiil's community mobilization events including tree planting and Ebiil's Outdoor-Classroom in forest ecology. Two acres of Ngiwal degraded land area was planted for restoration while 8 acres in Ngardmau was restored with a total of 5,377 trees. A total of 5,404 seedlings were propagated for reforestation purposes, in addition to 81 ounces of seed of ukall (*Serianthes kanehirae*) and dort (*Intsia bijuga*), endangered and rare trees that are faced with overharvesting pressure for lumber. A project management plan for Ngardmau mine site was written.

During 2020, the Protected Areas Network (PAN) Ongedechuul System of Conservation Areas (OSCA) with partners (Ebiil Society, PCS, US Embassy Science Fellows, and Ngatpang, Aimeliik, and Melekeok PAN) coordinated and launched a Forest Restoration Project to reforest 100 acres of bauxite terraces in Ngardmau. Over 1,000 trees native to Palau that can survive the terrain were planted with Ngardmau Elementary school students. Ngardmau PAN and partners continue to plant on the bare terraces. This activity was in commemoration of International Day of Forests on March 21, 2020. <https://www.palaupanfund.org/news-events.html>. Refer to Figures 6.13 and 6.14.



Figure 6.17 PAN and Partners Streamline Terrestrial Management Efforts

<https://www.palaupanfund.org/news-events.html>



Figure 6.18 Youth Adopt Tree Planting Project in Melekeok State December 2019. The Palau Red Cross Society with its People Empowerment program assisted in tree planting efforts in Melekeok State.

In 2020, Palau submitted a “Forest Stewardship Program Priority Area” (Figure 6.19) to satisfy changing USDA Forest Service Forest Stewardship Program (FSP) requirements. This indicates that nearly all upland areas on Babeldaob are a “**priority**” for FSP funding. Mangrove forests and marshes on Babeldaob are “not priority” though they are eligible, and urban areas and islands other than Babeldaob are “not eligible.” This map may be updated every March with advice from the Forest Stewardship Committee but without a full Forest Action Plan update. All rural public and private land in Palau are expected to be eligible, but new map revisions will need to indicate a “priority” area smaller than the “not priority” area.

Plantations on private land are eligible for Forest Stewardship technical assistance including the development of forest management plans. The sizes of these plantations need to be measured in order to do a spatial analysis. In 2010 forestry had point locations of plantations that could not be analyzed with the other layers. These plantations consisted mainly of coconut, mahogany and noni trees and a variety of other trees. Coconut plantations were mapped. During 2020 and 2021, the health of these plantations was assessed from Kayangel to Sonsorol in relation to the Coconut Rhinoceros Beetle (CRB) through PCC-CRE and PAIR. There is funding support under the Forest Health Program for this program.

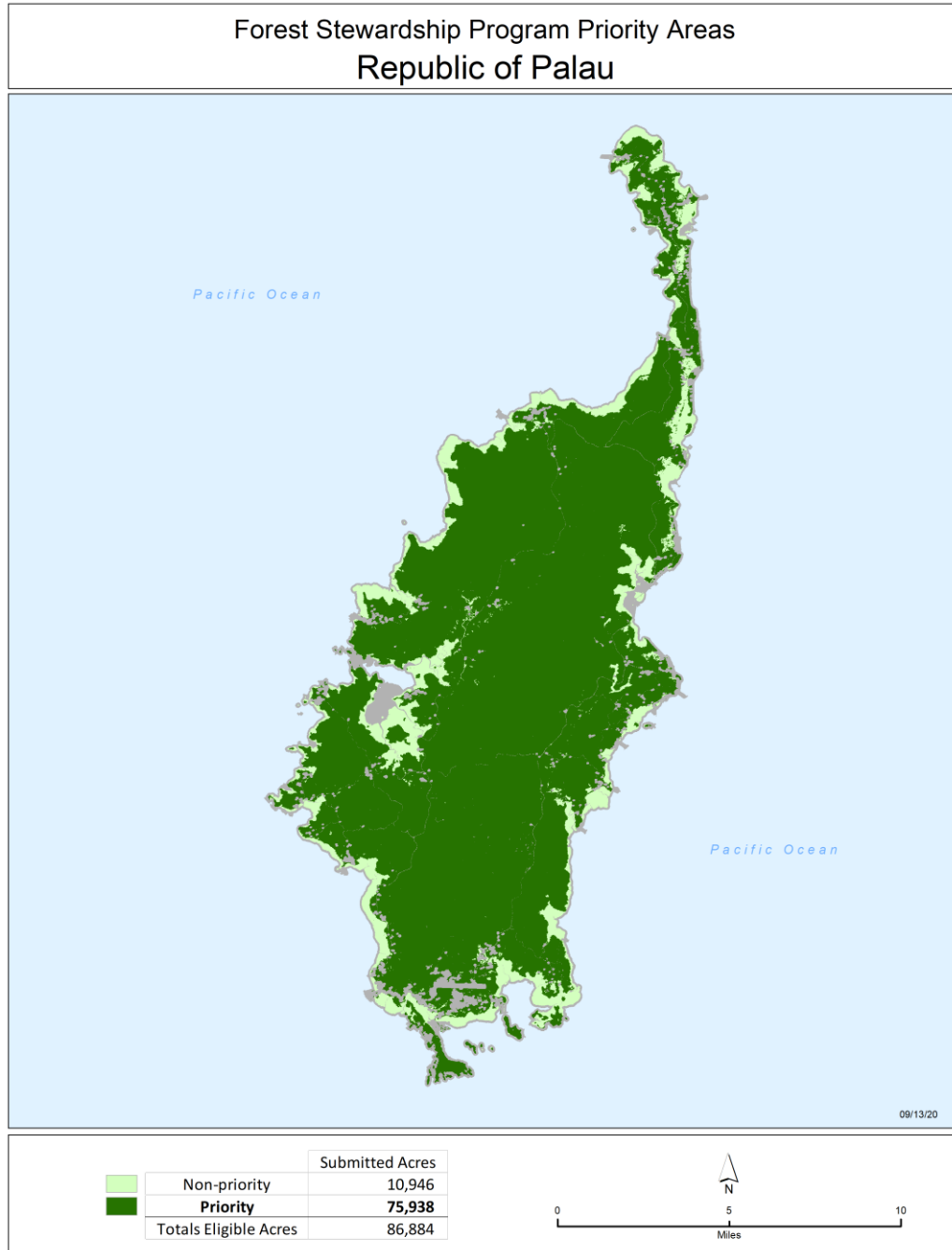


Figure 6.19. Forest Stewardship **Priority** Land Map.

Priority areas for reforestation were bare areas and grasslands with highly erodable soils, vulnerable coastal areas subject to flooding where coconuts and other low lying coastal shrubs grow well (Figure 6.7). Reforestation with native timber is needed within the secondary buffer zone and areas with slopes less than 12% or where the soil is highly erodable and urgently needs tree vegetation. The existing plantations require assessment and forest plans on private lands through the Forest Stewardship Program and (public lands might also be eligible for the Urban and Community Forestry program). Establishment of agroforests including coconuts, timber trees and fruit trees is an ongoing process at forestry. Focusing these efforts in top priority watershed areas is important. Mature mahogany stands at Nekken and

elsewhere can be sustainably harvested, and funds generated used to support local community programs. Fruits from mature stands of rambotang and mangosteen can be propagated and distributed. *Falcataria*, *Adenanthera* and *Casuarina* and *Coconut* can also be assessed for biomass utilization.

During 2021 to 2030 **priority sites** for future efforts are Nekken Station as a demonstration center, mahogany plantations in Ngchesar, Aimeliik, and Airai; coconut plantations in Babeldaob, Hatohobei, Sonsorol, Kayangel, Angaur, and Peleliu; and *Casuarina* Plantations in Angaur and Peleliu; and mahogany forests for sustainable harvest demonstration projects in the Ngerikiil, Ngerdorch, and Ngeremeduu Watersheds. These priority areas have existing plantations that need to be assessed and sustainably harvested as markets exist for local uses. The coconut tree has the most local uses and a viable market for its products already exists. *Casuarina* forests can be sustainably harvested for firewood as was being done in Peleliu. Fruit trees and important native timber trees continue to be propagated. Through existing forestry programs, ongoing tree planting efforts should be well reported, mapped, and monitored to ensure successful revegetation and production in areas that need to be reforested in priority areas both in poor soils and in areas with good potential for reforestation.

Measures of Success for Issue 6 Sustainable Uses of Forest Resources

Over the past decade, the 2018 Sustainable Forest Management Policy was established. A National Environmental Symposium covering marine and terrestrial ecosystems was held. The 1st Annual Terrestrial Science Seminar was hosted by the Ministry of Natural Resources, the Environment, and Tourism (now referred to as MAFE) in March 2018. Presentations were given by staff from MAFE, Belau Museum, USDA Forest Service – Institute of Pacific Islands Forestry, Smithsonian Institution, Ebiil Society, Coral Reef Research Foundation, and Palau Conservation Society. This seminar was an opportunity to present and discuss current and relevant terrestrial science of Palau for local stakeholders. A Demonstration of the harvest of mahogany trees at Nekken Station was conducted. Landowners were assisted and species of trees were propagated and planted in Ngeremlengui degraded areas, Ngiwal Housing Area, and Ngardmau bauxite mines. Workshops and training were provided to the landowners. A 2015 Agricultural Census surveyed the acres off agroforests and farms in Palau. The Forest service certified one arborist for Palau.

The 2021-2030 Forest Action Plan will address Issue 6 Sustainable Uses of Forest Resources through the implementation of the following actions over the next decade:

- (1) Establish a Sustainable Forest Database system will be established that is integrated with the SMART database used in the Forest Stewardship Program to track landowners assisted, number of species propagated and planted, and survival rates, number and size of demonstration agroforest plots, acres of important forest resources areas and acres of sustainably managed forest resource areas;
- (2) Staff will be trained to develop and implement Forest Stewardship and UCF plans;
- (3) The Nekken Station Land Use Plan will be updated and implemented including demonstration plots for sustainable agroforestry using best management practices;
- (4) Guidelines for sustainable forest management will be produced;
- (5) Model management plans for coconut plantations that includes surveys, maps, and trees marked for sustainable rotational harvest & inspected for the *Rhinoceros* beetle;
- (6) Plantations and wild populations of *Casuarina* will be surveyed & trees marked for sustainable rotational harvest;
- (7) Spatial analysis of *Casuarina*, coconut, mahogany, and other important trees other using aerials & IKONOS, LIDAR & SAR will be conducted;
- (8) State Regulations or legislation designating SFM measures for forests will be established;
- (9) Design /implement social marketing campaign around forests to improve attitudes/behavior and valuing forests (including mangroves);
- (10) Design a Project and Conduct Stakeholder Analysis on Sustainable Use of Forest Resources;

- (11) Research available materials on Sustainable Use of Forest Resources for educational materials;
- (12) Collaborate with NGOs, PCC, and MOE to develop and disseminated educational materials and a curriculum module for sustainable use of Palau's forest resources;
- (13) Hold an Annual Forum for members of the Forest Advisory Council as well as other partners partners interested in Forest Stewardship and Urban and Community Forestry;
- (14) Collaborate with state governments to identify priority areas for reforestation efforts (produce updated maps);
- (15) Cooperate with NGOs on a student and community volunteer forestry program;
- (16) State regulations and legislation developed, adopted, and enforced for the sustainable use of forest resources;
- (17) PALARIS and other partners will update vegetation maps and hydrological models;
- (18) Produce an annual State of Palau's Forest Report;
- (19) Gather and develop useful forest related information to disseminate to states and other resources users;
- (20) Develop and implement the Palau SFM Plan and Best Practices;
- (21) Establish Forest Resource Management Requirements and integrate with State plans;
- (22) Work with the States and partners to develop Comprehensive State Forest Management Plans addressing climate change, wildfire, watershed protection, conservation, rehabilitation, and sustainable use of forests;
- (23) Consult and visit states to produce forest management plans;
- (24) Request Governors to designate a lead person from each state to work with MAFE team;
- (25) Establish either a Memorandum of Agreement (*MoA*), or Memorandum of Understanding (*MoU*) or a Letter of Commitment between Palau Forest Service, State, Community, Private Sector, NGOs, and Landowners on roles, responsibilities, and commitments of each party;
- (26) Justify and secure Congressional funds for forestry programs;
- (27) Develop, test, and implement training modules that include guidelines for SFM;
- (28) Create professional development programs in forestry management;
- (29) Develop a program to enhance collaboration and institutional strengthening for SFM Partners through biosecurity task force focused on forest health;
- (30) Forest Advisory Council with partners (i.e. GEF Small Grants Program), will support sustainable forest projects;
- (31) Invasive species will be identified, removed and area measured and mapped with a focus on top 20 worst species (e.g. Macaque monkey, CRB, *Mikania*, Cycad scale, etc. as determined by NISC)
- (32) Identify and test virulence of OrNV of CRB in Palau;
- (33) Propagate, collect, and plant at least 20,000 saplings/year for rehabilitation programs using native and fruit bearing trees; map and monitor sites at priority sites;
- (34) Develop and implement a training module for estimated carbon stocks/carbon trading and ecosystem services of forests (e.g. i-tree training);
- (35) Establish a greenhouse network, expand existing greenhouses, and establish greenhouses where needed;
- (36) Native trees will be propagated, planted, and survival rates quantified;
- (37) Conduct annual inventory/profile of small-scale forest plantations (including fruit trees) and enterprises selling local wood products;
- (39) Provide incentives and opportunities for forest related businesses;
- (40) Forestry staff will be trained to develop, implement, and report on FS and UCF projects with landowners and the community;
- (41) Develop ecotours and reforestation activities in urban forests;
- (42) Effective management and marketing training for landowners of economical valuable trees for timber, food, and medicine will be conducted;
- (43) Conduct national spatial analysis of *Casuarina*, coconut, mahogany and other important trees and landownership using aerials, IKONOS, LIDAR & SAR, and ground truth information;

- (44) Interview State officials and entrepreneurs to determine forest products availability and revenues generated;
- (45) Design, develop, and implement a demonstration ecotour at Nekken State;
- (46) Collaborate with NGOs and partners to develop and distribute promotional materials for at least 2 non-timber products (cultural -storyboards, jewelry, bowls) or medicinal in nature;
- (47) Create a list of projects that can be done related to sustainable forest management and resource use;
- (48) Develop educational and awareness materials (posters, radio shows, videos) related to sustainable forest management and resource use, freshwater sources, and the potential ecosystem services of forests;
- (49) Communities will identify and remove obstructions to waterflow caused by debris and fallen trees;

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Issue 7 Urban Forest Sustainability

Trees and forests in urban areas represent valuable natural and cultural resources. Impervious surface has increased in urban areas with more primary and secondary roads and buildings, parking lots. Urbanization in the city of Koror, Koror state, the Ngerikiil Watershed in Airai state, the National Capitol in Melekeok, and Ngarchelong state means there is a need for continued education and management of the urban forest. The widening of roads has resulted in the loss of many large shade trees, including large mango trees along Koror’s main street. Target areas include initiatives to landscape public areas like the roadsides, parks, and bus stops. The Palau Urban and Community Forestry Council’s seven goals link with two national priorities (themes): Enhance Public Benefits and Protect Forests from Harm. Refer to Table 7.1.

Table 7.1 Urban and Community Forest goals that link with national themes

| Urban and Community Forest Goals | National (US) Priority |
|--|-------------------------------|
| Enhance & organize planting of trees | Enhance Public Benefits |
| Protect the integrity of our ecosystem | Protect Forests from Harm |
| Develop forest-based sources of livelihood | Enhance Public Benefits |
| Gather & share information & assist communities | Enhance Public Benefits |
| Raise awareness of the value of trees | Enhance Public Benefits |
| Foster self-reliant communities | Enhance Public Benefits |
| Promote the connection between trees & our culture | Enhance Public Benefits |

The council seeks to establish and improve community forests and sustain the vital interconnection between peoples’ forests and culture. Since its inception in 1997, the Urban and Community Forestry Council, otherwise later known as the Forest Advisory Council, has supported over 23 projects to meet its goals of which 6 projects were completed since 2010. Table 7.2 and Figures 7.1-7.3. The projects include assistance with the restoration of reservoirs, forests, development of medicinal gardens, and eco tours, nursery construction, invasive weed removal in urban areas in 10 states: Melekeok, Ngeremlengui, Ngarchelong, Airai, Ngardmau, Ngiwal, Ngchesar, Ngatpang, Aimeliik, and Koror. Refer to Figure 7.4. The Council supports the development of educational materials (posters, videos, and books) and programs about the importance of trees. State nurseries, tree planting activities within communities, and restoration of urban landscapes in Koror and Airai are other projects supported by the Council. The council worked with Ngarameliwei to restore a traditional urban landscape. Refer to Figure 7.2.

Table 7.2 Urban and Community Forestry Projects over the past 20 years

| | Project Name | Year | Organization | Description |
|---|--|-------------|---|---|
| 1 | Greenhouse & Agricultural Tools Project | 2010-2012 | Ngatpang Belau Modekngai School (BMS) & Ibobang Community | Greenhouse for plant production |
| 2 | Tree Planting (Phase II) | 2010-2012 | Melekeok State Ngerubesang Men's Club | Improving Ngerubesang Hamlet |
| 3 | Tree Awareness and connectivity with Palauan Culture | 2010-2012 | Ngerchelong State Bngal A Klikm Association | Clean-Up and creation of irrigation system of "Oltachel" water reservoir in Mengellang Hamlet |
| 4 | Tree Planting | 2010-2012 | Aimeliik State Youth Association | Improving Aimeliik State's sustainability thru planting fruit trees and medicinal trees |
| 5 | Re vegetation | 2010-2012 | Ngarcholtitch Imeong Village Ngeremlengui State | Re-Vegetation – to Restore the Sacred Remains. |
| 6 | Tree nursery and beautification | 2013 | Koror Elementary School | Children learn to propagate and plant seedlings for school garden and agroforest |

Urban and Community Forest Projects 2010-2013

Six community projects were implemented during 2010 to 2013. USFS funding was not secured for projects from 2014 to 2020.

1. Aimeliik State Government (Youth Association) – Improving Aimeliik State's sustainability thru planting fruit trees and medicinal trees.
2. Belau Modekngai School (BMS) with the Community of Ibobang – Greenhouse & Agricultural Tools Project.
3. Ngerubesang Men's Club – Improving Ngerubesang Hamlet in Melekeok State through Tree Planting (Phase II)
4. Ngarchelong Bngal A Klikm Association – Tree Awareness and connectivity with Palauan Culture through Clean-Up and creation of irrigation system of "Oltachel" water reservoir in Mengellang Hamlet, Ngarchelong State.
5. Imeong Village Re-Vegetation – to Restore the Sacred Remains.
6. Koror Elementary School nursery

Aimeliik Youth Association

The Aimeliik Youth Association (AYA) planted native trees and shrubs at the Aimeliik land fill for beautification purposes. The AYA cleared Grounds for planting medicinal trees at Bai Rekeai. The Women's Organizations discussed medicinal trees and their values. Ngermeliik, a registered historic site, was designated for planting due to its significance as the body of Ngerbuns. Medicinal shrubs such as (*Eurya nitida* (cheskiik), *Melicope denhamii* (kertub), *Decaspermum parviflorum* (kertaku), and *Cordyline fruticosa* (sis) or Ti leaves shrubs were used to demarcate the path leading to the Ngermeliik. Calamansi (lemon trees) were planted by the bus stop area as a food source and to enhance the landscape. The AYA planted fruit trees by the bus stop and medicinal plants and native plants by the entrance of the Aimeliik State Sign and successfully completed the project (pers. comm. Sherry Koshiba 9/13/21). Refer to Figure 7.1.



Figure 7.1 Aimeliik Youth Association Photographs by Sherry Koshiba

Ngerubesang Men's Club Phase II

A total of 500 coconut seedlings, 350 *Calophyllum* seedlings, and 50 *Terminalia* seedlings were planted at Green Revolution Project site across from intersection to Ngerubesang from Ngchesar and the Melekeok Water Treatment. The Club members fertilized previously planted seedlings and wild tree's seedlings on the hills. Each member produced 15 seedlings of native Palauan plants using 15 plastic seedling pots. Prepared seedlings were inspected on February 26, 2011, and 38 members successfully prepared 570 seedlings in March 2011. Mature fruit trees were transferred from residential construction sites to other sites. Planting endemic species along the bare hills of Melekeok and the treatment plant was ongoing. The Green Revolution Area was expanded with more coconut saplings. More endemic trees were planted on bare hills. Plants were nurtured along the coast to reduce erosion from rain and rising tides. Bare hills were weeded, and young wild plant fertilized. Endemic plant seedlings were propagated monthly. Quarterly beautification days were held for the hamlet. Community service included planting trees at the historical sites and the traditional village. The tree species propagated and planted were as follows: *Artocarpus* sp., *Mangifera indica* (iedel), *Citrus* sp., *Averrhoa carambola* (kemim) *Swietenia mahogany*, *Mussaenda philippica* (cherecheroi), *Areca catechu* (bauch) *Hibiscus* sp., *Ixora casei* (kerdeu), *Zoysia* sp., *Freycinetia* sp. (iul), *Ipomoea batatas* (chemutii), *Desmodium triflorum* (olumud), and *Vigna marina* (kldellel). Plants were nurtured and cared for by monthly visits and cutting weeds about 5 to 6 feet in radius around the trunk until the trees were mature enough to over grow the weeds. Reforestation was conducted on bare soils areas, a former construction stockpile site, conservation areas, burnt areas, areas recommended by DFLW and the Melekeok State Government Conservation Commission. The Ngerubesang Men's Club successfully completed Phase II of the tree planting project and continue to maintain and monitor the trees (Trebkul Tellei, pers. comm. Sept 13, 2021). Refer to Figure 7.2.

Green Revolution-Tree Planting



“Lets work with our children”



Figure 7.2 Ngerubessang Men's Club at work. Photographs from Power Point Presentation Jefferson Thomas Trebkul Tellei Chris Debengek

Ngarchelong Bngal A Klikm Association (NBAKA)

Tree awareness and connectivity with Palauan culture through Clean-Up and creation of irrigation system of “Oltachel” water reservoir in Mengellang Hamlet, Ngarchelong State. The project aimed to promote community awareness of healthy forests and irrigation for water reservoir and connectivity and strengthening of the cultural conservation of “Oltachel”. The project built capacity and trained members on planning, clean up, creation of irrigation system and education implementations in the “Oltachel” water reservoir, and provided support for the on-going development of ecotourism of cultural heritage of Ngarchelong State. NBAKA members were supported by UCF program in 2006 for eradication of “Kebeas” and in 2010 for the restoration of “Euatel” in Ngerbau Hamlet, Ngarchelong. The NBAKA cleaned one site at Ngeriil hamlet and other in Ollei hamlet. In Ngeriil, they cleaned more than 1,500 m², and planted 100 btaches, 100 kelelacharm, and varieties of local trees such as bedel and ngolm. In Ollei hamlet, they cleaned a similar size of land, and planted different species of native trees. After planting, they continued to monitor the project and clean the area to ensure survival. Each member was assigned to produce 20 seedlings of any native tree. Prepared seedlings were inspected, and all the members successfully propagated their seedlings. Members began to plant in April 2012. The NBAKA planted over 350 different species of native trees, ornamentals, and fruit trees.

Imeong Village Re-Vegetation Project

Ngarcholtitch restored the stone paths, platforms, and monoliths in Imeong village to prevent degradation by incessant erosion. Ngarcholtitch worked with local experts to resurrect the fallen monoliths, restore the stone paths and platforms, and re-vegetate. The organization worked with the local plants experts to identify native fast growing and traditionally valued ornamental and medicinal trees and plants to re-vegetate the bare areas, provide erosion buffers, and beautify the village. Each month the association continued to work on the stone path, nursery, and seedlings. The women prepared seedlings at their homes. A total of 40 members participated.

Koror Elementary School

In 2013, Koror Elementary School (KES) procured shaded cloth for their tree nursery and tools. The tree nursery was erected by volunteer parents during weekend hours. This was a small structure just enough to house their seedlings. DFLW staff were able to make 3 school visits to the 5th grade classes to demonstrate proper care of tree seedlings. We will continue to work with KES to ensure continuation of this project as the students change year to year. The UCF Coordinator along with the Coordinator of Volunteers continued to visit schools to raise awareness of the important of trees and the importance of not setting fires. They visited schools upon the request of science teachers. During this period, they visited Palau High School, Koror Elementary School, Harris Elementary School, and Meyuns Elementary School.



Figure 7.3 Leonard Basilius of PCCA demonstration of composting and planting trees and shrubs to the homeowner and children Didil Belau Inc. green yard project supported by Seeds of Promise, PCS, PCAA, NRCS, UCF and a homeowner in Airai

Urban Forest Sustainability Map Babeldaob Island

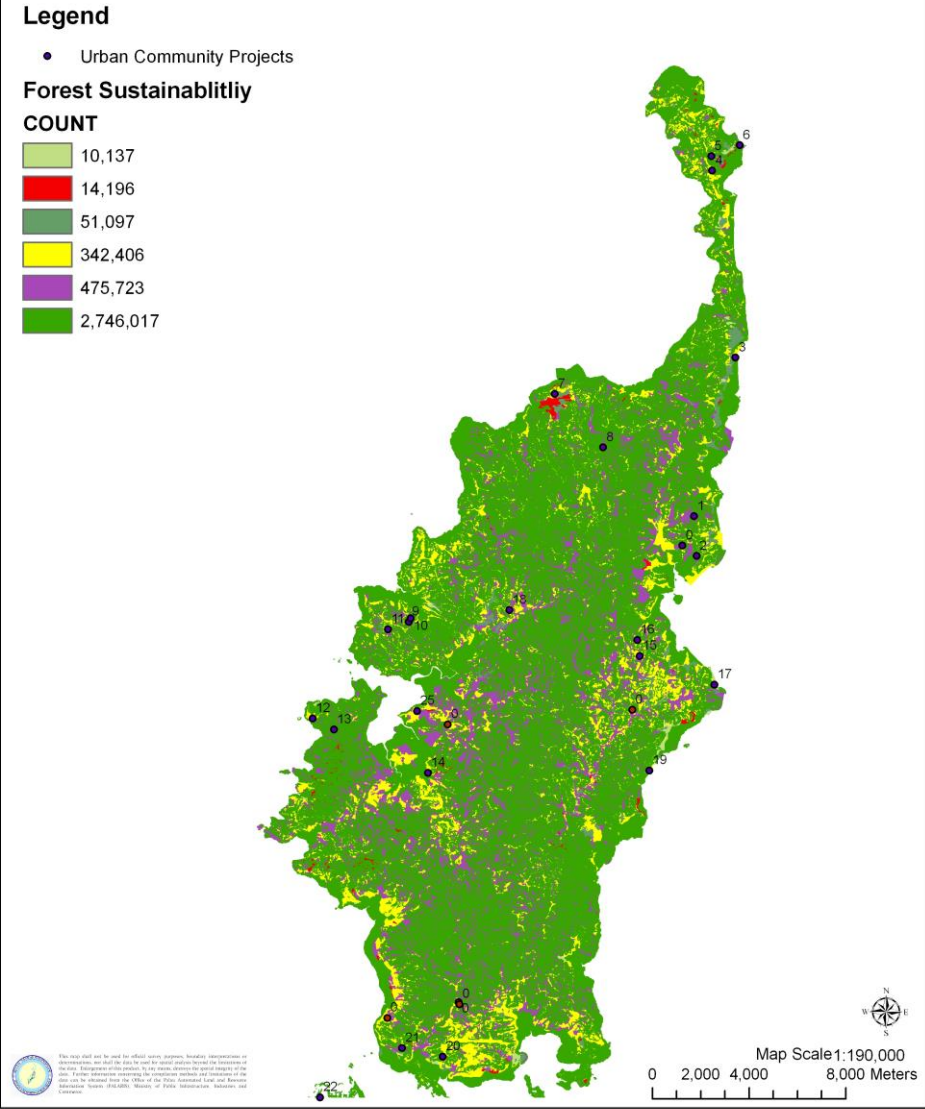


Figure 7.6 Map showing locations of urban community forest projects.
Refer to table below for color codes for forest types and reforestation suitability from 2010 SWARS

| Color | Forest Type and reforestation suitability |
|-------------|---|
| Light green | Agroforest |
| Red | Secondary forest- good soil for reforestation |
| Pine green | Wetland |
| Yellow | Infrastructure or bare areas |
| Lavender | Suitable for reforestation |
| Green | Forest |

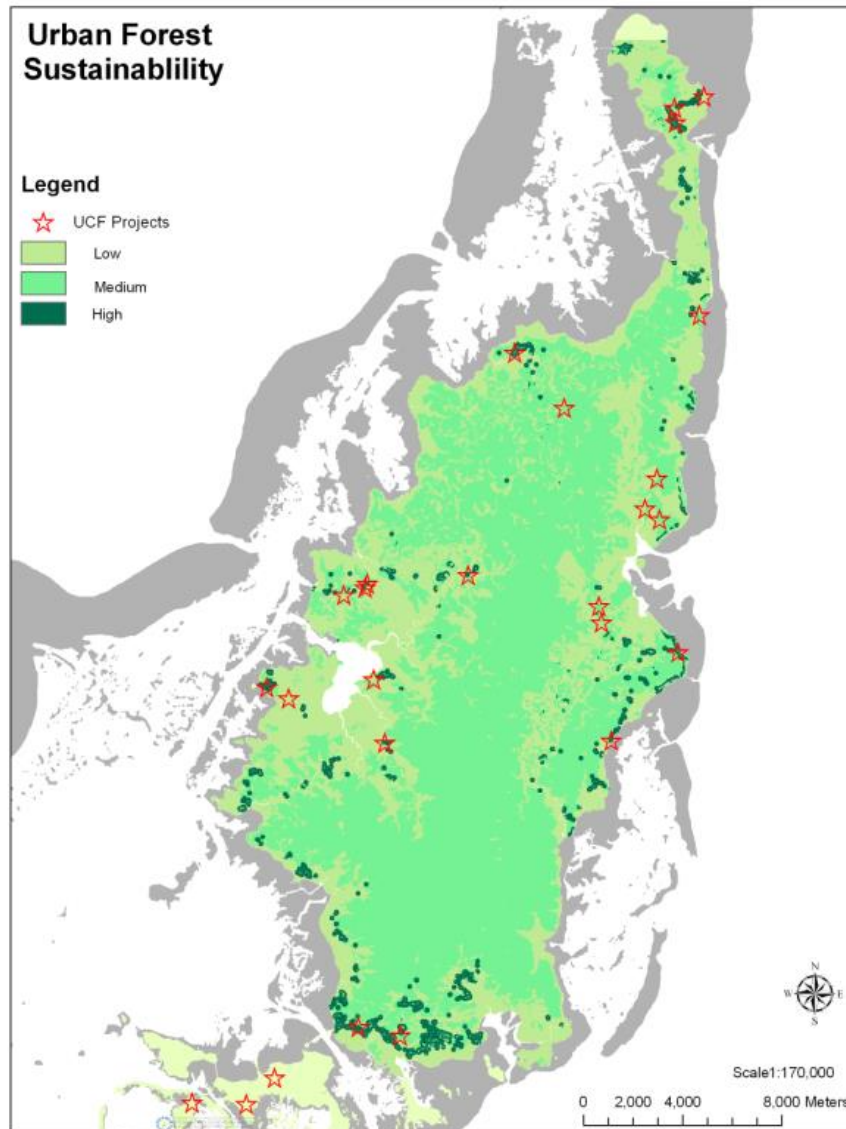


Figure 7.7 Priority sites for urban forest activities in Palau based upon spatial analysis **High priority** is dark green, medium priority is light green and lower priority is yellowish green with urban projects as red stars. 2010 SWARS. These are **priority areas for 2021-2031** UCF projects.

In 2010, urban forests covered at least 2,102 acres of land with over 500,000 potential areas suitable for agroforest in Babeldaob. Priority areas for reforestation activities are shown in dark green. Refer to Figure 7.6. Many UFC projects were near infrastructure or bare areas. The highest priority areas for reforestation in urban areas and locations of urban projects. Refer to Figure 7.7. The 2010 UCF projects were in priority areas. The 2021-2030 UCF **priority areas** are in Koror and Airai State with the highest population densities in Palau. Urban areas such as **housing developments** in the Ngerikiil Watershed, Aimeliik State, Ngeremlengui State, Ngiwal State, and proposed housing development in Melekeok are **prime areas** for tree planting to landscape homes and roads. Traditional landscapes incorporated proper storm water management and selection of trees for different parts of the landscape that better hold the soil in place along streams and slopes. Integration of traditional urban landscapes with modern urban landscapes that have a higher percentage of impervious surfaces, and more storm water drainage is needed.

Parks, Gardens, Ecotourism

The Belau National Museum Botanical Garden has over 700 native plants and serves as the national depository for Palau's terrestrial biodiversity with over 10,000 specimens. The BNM is a resource for managers and researchers and the local community. Refer to Figure 7.8. The terrestrial conservation sites, PAN sites, and registered cultural sites have signage about the cultural and ecological significance of the trees and plants at their sites. The Long Island Park Medicinal Garden opened on June 29, 2021, in commemoration of the 9th Anniversary of the RISL World Heritage Site showcasing its unique terrestrial biodiversity. Refer to Figure 7.9. The Ngermeskang Bird Sanctuary Visitors Center has a botanical garden showcasing its unique terrestrial biodiversity. Refer to Figure 7.10. The Lake Ngardok Reserve is the home to Micronesia's largest lake and has a botanical garden and trail. Refer to Figure 7.11. Aimeliik State established a botanical garden within the Ngerderar Watershed Conservation Area. Refer to Figure 7.11. In 2020, the Aimeliik System of Conservation Areas developed an Ecotourism Management Plan. In 2021, the PANFUND is further developing Ecotourism Management Plans for the PAN sites in Melekeok, Ngardmau and Ngiwal States. The Terrestrial and Cultural Conservation and PAN sites in all the States of Palau incorporate interpretative signage that highlights the unique history and biodiversity of these sites. There are at least **20 public parks are found in Angaur, Peleliu, Koror and Babeldaob**. A total of 5 of the 20 or 25% of the public parks are found in Koror State. Refer to Figure 7.12 and Table 7.2 These parks are **priority areas** for urban gardens in Palau.



Figure 7.8 Belau National Museum botanical garden



Figure 7.9 Long Island Park Medicinal Garden 2021



Figure 7.10 Ngeremlengui Botanic Garden 2021

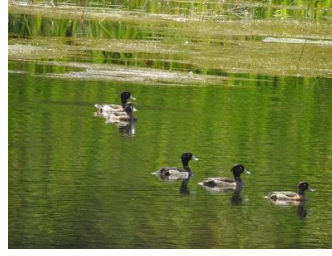


Figure 7.11 Ngardok Lake Reserve Signage (left) and ducks found in the Lake (center); ASCA Aimeliik Ngerderar Park and Garden 2020 (right).

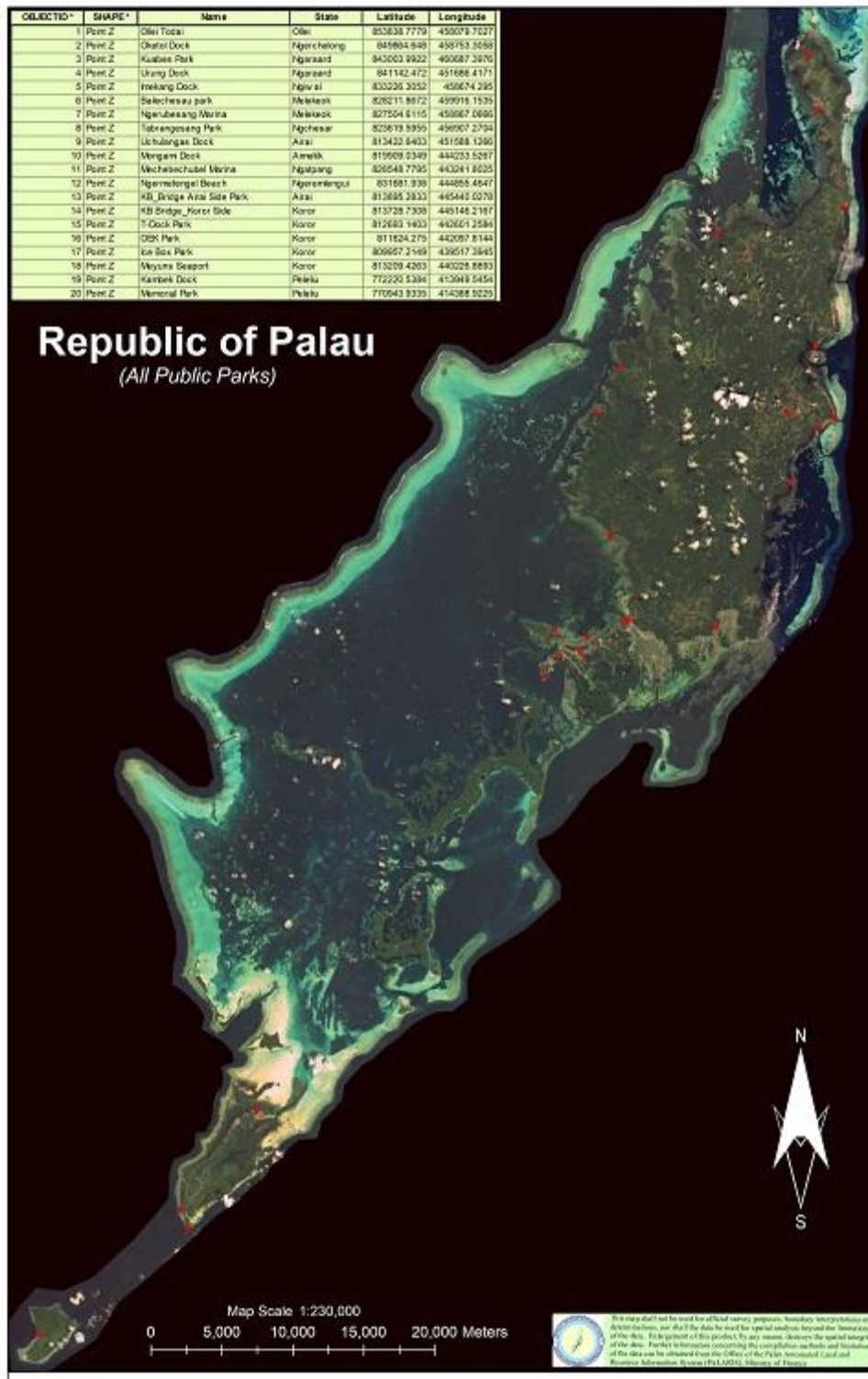


Figure 7.12 Public Parks that are **priority areas** for UCF projects.

Table 7.2. List of Public Parks by Name, State, and location in Palau. PALARIS

| Name | State | Latitude | Longitude |
|---------------------------|--------------|-------------|-------------|
| Ollei Todai | Ollei | 853838.7779 | 458079.7027 |
| Oketol Dock | Ngerchelong | 849864.648 | 458753.3058 |
| Kuabes Park | Ngaraard | 843003.9922 | 460687.3976 |
| Urung Dock | Ngaraard | 841142.472 | 451686.4171 |
| Imekang Dock | Ngirwal | 833226.3052 | 458674.295 |
| Bailechesau park | Melekeok | 828211.8672 | 459916.1535 |
| Ngerubasang Marina | Melekeok | 827504.6115 | 458867.0666 |
| Tabrangesang Park | Ngchesar | 823619.5955 | 456907.2704 |
| Uchulangas Dock | Airai | 813422.6403 | 451588.1266 |
| Mongami Dock | Aimeliik | 819909.0349 | 444233.5267 |
| Mechebechubel Marina | Ngatpang | 828548.7795 | 443241.8025 |
| Ngermetengel Beach | Ngeremlengui | 831681.938 | 444855.4647 |
| KB_Bridge Airai Side Park | Airai | 813895.2833 | 445440.0278 |
| KB Bridge_Koror Side | Koror | 813728.7308 | 445146.2167 |
| T-Dock Park | Koror | 812693.1403 | 442601.2584 |
| OEK Park | Koror | 811624.275 | 442097.8144 |
| Ice Box Park | Koror | 809957.2149 | 439517.3945 |
| Meyuns Seaport | Koror | 813209.4263 | 440226.8893 |
| Kambek Dock | Peleliu | 772220.5384 | 413949.5454 |
| Memorial Park | Peleliu | 770943.9335 | 414388.9225 |

Educational Materials

The Belau National Museum has been producing the State of Palau's Birds for over a decade (Olsen et al 2011-2017, Kitalong et al 2018-2020). The publications raise awareness on the importance of birds and their forest and shore habitats. These publications are distributed to the leadership and schools of Palau each year. The BNM published several books on plant identification and their traditional uses with support from the Urban and Community Forest Program, and our partners. Dr. Miles produced a Field Guide for Invasive Species in 2015. Refer to Figure 7.13. The PCC-CRE produced, Agriculture in Palau A Manual for Production through Soil Assessment that includes update maps identifying areas for agroforestry and technical information on fruit tree production. Refer to Figure 7.14.

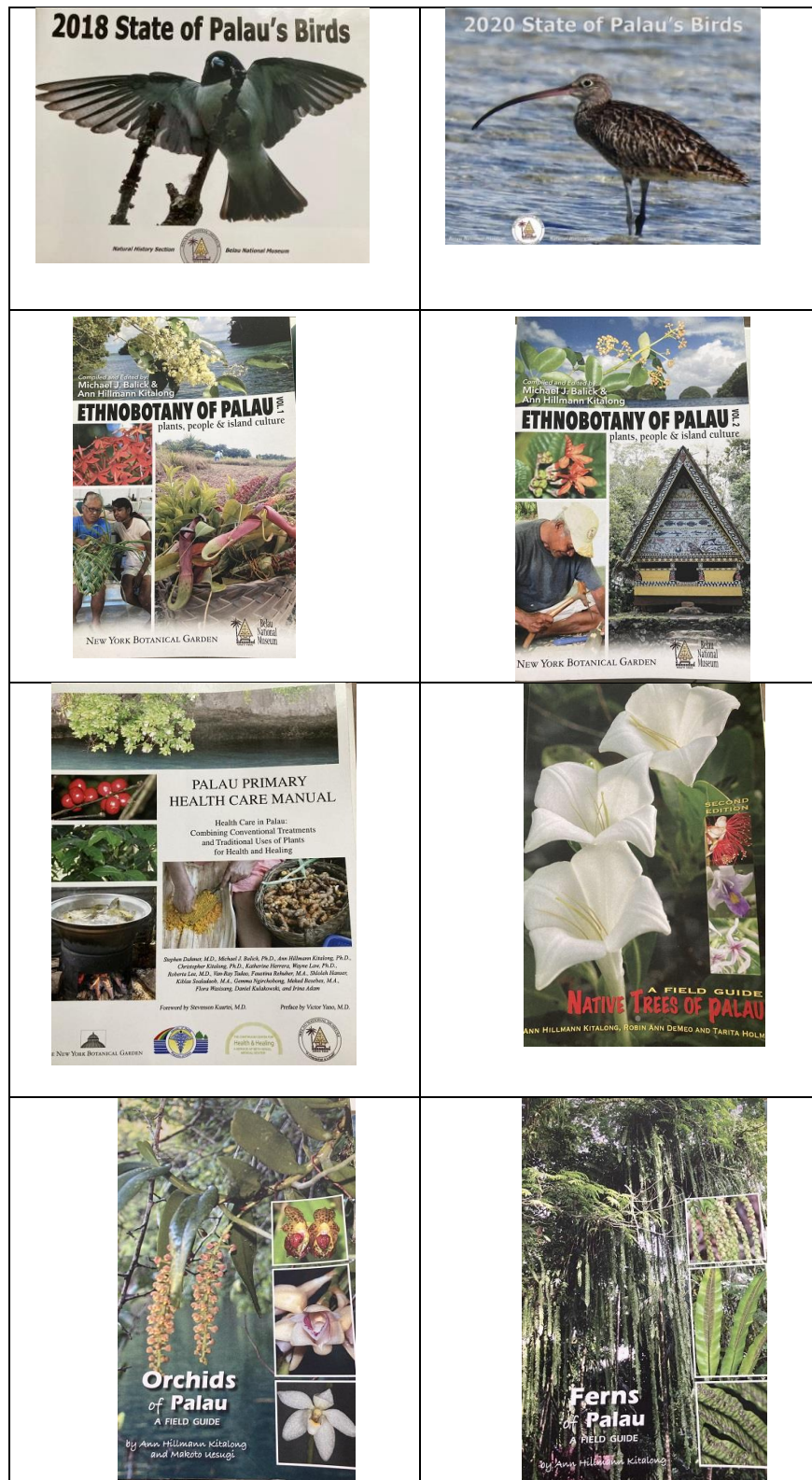


Figure 7.13 Educational books on Terrestrial biodiversity and ethnobotany available at the Belau National Museum

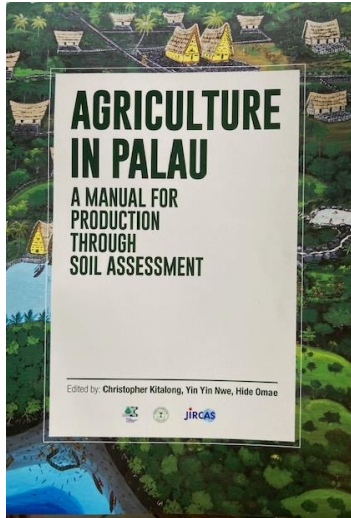


Figure 7.14. Publication with support from PCC-CRE, BoA and JIRCAS

Measures of Success for Issue 7 Urban Forest Sustainability

Over the past decade, measures of success included the following: (1) Urban gardens were established at Long Island Park, the visitor centers at the terrestrial PAN sites in Aimeliik, Ngeremlengui, Melekeok. Ecotours have been established in Koror, Airai, Aimeliik, Ngerchelung, and strategic ecotourism plans are being developed for Melekeok, Ngardmau, and Ngiwal. Books have been published on orchids, ferns, trees and shrubs, primary health focused on medicinal plants, ethnobotany of Palau, and Agriculture in Palau a manual for production through soil assessment. Community meetings to raise awareness on tree value were conducted in Ngiwal, Ngeremlengui, Ngardmau, and Airai. The Belau National Museum developed a brochure for its garden.

The 2021-2030 Forest Action Plan will address Issue 7 Urban Forest Sustainability through the implementation of the following actions over the next decade:

- (1) A Sustainable Forest Database system will be established, and staff trained to track landowners in urban areas assisted, number of species propagated and planted, and survival rates, number, and size of demonstration agroforest plots, acres of important forest resources areas and acres of sustainably managed forest resource areas on public and private lands, develop and implement FSP and UCF Plans. Use & supplement existing SMART and CARS System;
- (2) Establish urban gardens in priority sites;
- (3) Conduct Annual Forestry Council meeting & field trips to assess projects;
- (4) Develop an Urban and Community Data System for annual reporting to USFS Community Action Reporting System
- (5) Create educational, informative, and promotional materials on the value of forests and what they provide (socially, economically, culturally) that can be utilized by partners, states, schools, and resource users among others (calendars, videos, bibliography etc.).
- (6) Assess status of Ngiwal Botanical Gardens;
- (7) Assessment of Need for easements for HCV urban forests or cultural significant forested areas;
- (8) Design /implement social marketing campaign around forests to improve attitudes/behavior and valuing forests (including mangroves);
- (9) Design project and conduct stakeholder analysis on Urban Forests;

- (10) Research available materials on forest biodiversity and conservation;
- (11) Hold an Annual Forum for members of the Forest Advisory Council as well as other partners partners interested in Forest Stewardship and Urban and Community Forestry;
- (12) Nekken Station Land Use Plan updated and implemented including demonstration plots for sustainable agroforestry using best management practices;
- (13) Collaborate with state governments to identify priority areas for reforestation efforts (produce maps);
- (14) Cooperate with NGOs on a student and community volunteer program;
- (15) State Regulations and legislation developed, adopted, and enforced to protect urban forests and restore degraded forests from impacts of population growth and infrastructure expansion;
- (16) PALARIS and other partners update vegetation maps and hydrological models;
- (17) Develop State of Palau's Forest Report;
- (18) Develop and implement Palau SFM Plan and Best Practices;
- (19) Forest Resource Management Requirements are established and integrated in the Forestry Programs;
- (20) Work with the States and partners to develop Comprehensive State Forest Management Plans; addressing climate change, wildfire, watershed protection, conservation, rehabilitation, and sustainable use of forests;
- (21) State consultations and visits detailed planning in each state for overall forest management;
- (22) Request the Governors to designate a lead person from each state to work with MAFE team;
- (23) Establish either a Memorandum of Agreement (MoA), or Memorandum of Understanding (MoU) or a Letter of Commitment between Palau Forest Service, State, Community, Private Sector, NGOs, and Landowners on roles, responsibilities, and commitments of each party;
- (24) MAFE justify and secure Congressional funds for forestry programs;
- (25) Develop, test, and implement training modules that include guidelines for SFM as well as professional development programs.
- (26)
- (27) Develop a program to enhance collaboration and institutional strengthening for SFM partners through biosecurity task force focused on forest health;
- (28) Forest Advisory Council with partners, such as GEF Small Grants Program, support sustainable forest projects;
- (29) Invasive species are identified, removed, and area measured and mapped with a focus on top 20 worst species (e.g. Macaque monkey, CRB, Mikania, Cycad scale, etc. as determined by NISC);
- (30) Propagate, collect, and plant at least 20,000 saplings/year for rehabilitation programs using native and fruit bearing trees; map and monitor sites;
- (31) Develop, implement, urban agroforest plans;
- (32) Map and monitor agroforest gardens;
- (33) Establish greenhouse network, expand existing greenhouses, and establish greenhouses where needed;
- (34) Native trees propagated, planted, and survival rates quantified;
- (35) Review literature and interview local experts to determine the number of plant species of economic and cultural value;
- (36) Forestry staff are trained to develop, implement, and report on FS and UCF projects with landowners and the community;
- (37) Develop ecotours and reforestation activities in urban forests) with native trees and plants;
- (38)
- (39) Design, develop, implement a demonstration ecotour at Nekken State;.
- (40)
- (41) Create a list of projects that can be done related to sustainable urban forest management;
- (42) Propagate, plant, and monitor survival rates of trees in rehabilitated bare soils;

(43) Communities identify and remove obstructions to waterflow caused by debris and fallen trees;

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