IUCN RED LIST
of
ECOSYSTEMS ASSESSMENTS
www.iucnrle.org

Mangroves of the Tropical Northwestern Pacific

VU

Joanna C. Ellison [1], Zachary B. Williams [2], Richard A. MacKenzie[3], Hannah E. Joss [4], Cara Lin[5], David Adema [6], Ena L. Suárez[7]

[1] School of Geography, Planning and Spatial Sciences, University of Tasmania, Australia.
[2] Pacific Coastal Research & Planning, Saipan, CNMI.
[3] Blue ROOTS, Koror, Palau.
[4] Coral Reef Research Foundation, Koror, Palau.
5 Guam Coral Reef Initiative, Division of Aquatic and Wildlife Resources, Department of Agriculture, Government of Guam.
[6] Dave Adema, Ministry of Finance, Palau.
[7] Red list of Ecosystems Team, International Union for Conservation of Nature IUCN HQ, Gland 1196, Switzerland.

Abstract
Mangroves of the Tropical Northwestern Pacific is a regional ecosystem subgroup (level 4 unit of the IUCN Global Ecosystem Typology). It includes the marine ecoregions of the East Caroline Islands, Mariana Islands and West Caroline Islands. The Tropical Northwestern Pacific mangrove province mapped extent in 2020 was 144.8 km^2, representing 0.1% of the global mangrove area. The biota is characterized by 10-18 species of true mangroves species and 211 species listed as mangrove associates in the IUCN Red List. These include many threatened species occupying relatively small and disconnected habitats between islands.

The diversity of species across a wide range of taxa - including birds, mammals, fishes, sharks, reptiles and invertebrates - underscores the conservation significance of mangrove ecosystems in the Tropical Northwestern Pacific. It highlights the urgency of protecting these ecosystems not only for their ecological functions, but also for the survival of numerous species.

Pacific Island mangroves are largely represented by fringing coastal mangroves, although estuarine mangroves also occur on the larger islands. The greatest threats to mangroves include loss of habitats owing to coastal development, consequences of upland erosion, and increasingly relative sea-level rise (SLR). Rates of SLR for the province are far higher than global rates owing to island subsidence.

The mangrove net area change has been stable at -1.8% since 1996 according to global models and as indicated by a high-resolution spatial change study of Pohnpei. Under a globally modelled high SLR scenario (IPCC RCP 8.5) ≈-22.0% of the Tropical Northwestern Pacific mangroves would be submerged by 2060. Additionally, the area of occupancy (AOO) is restricted and is threatened by land-based pollution, road construction, other coastal development and damage from severe cyclones. Therefore, the Tropical Northwestern Pacific mangrove province is assessed as Vulnerable (VU) for subcriterion B2.

Moreover, 1.2% of the province's mangrove ecosystem is undergoing degradation, with the potential to increase to 3.4% within a 50-year period, based on a vegetation index decay analysis. Overall, the Tropical Northwestern Pacific mangrove ecosystem is assessed as **Vulnerable (VU).**

Citation:
Ellison, J.C., Williams, Z.B., MacKenzie, R.A., Joss, H.E., Lin, C., Adema, D. & Suárez, E. L. (2025). '*IUCN Red List of Ecosystems, Mangroves of the Tropical Northwestern Pacific*'. EcoEvoRxiv.

Corresponding authors:
Ellison, J.C. (joanna.ellison@utas.edu.au) Suárez, E.L. (ena.suarez@iucn.org)

Keywords:
Mangroves; Red List of ecosystems; ecosystem collapse; threats.

Ecosystem classification:
MFT1.2 Intertidal forests and shrublands

Assessment's distribution:
Tropical Northwestern Pacific province

Summary of the assessment:

Criterion	A	B	C	D	E	Overall
Subcriterion 1	**DD**	**LC**	**DD**	**DD**	**NE**	**VU**
Subcriterion 2	**LC**	**VU**	**LC**	**LC**		
Subcriterion 3	**DD**	**NE**	**DD**	**DD**		

VU: Vulnerable, LC: Least Concern, DD: Data Deficient, NE: Not Evaluated

Mangroves of The Tropical Northwestern Pacific

VU

1. Ecosystem Classification

IUCN Global Ecosystem Typology (version 2.1, Keith *et al.* 2022):

Transitional Marine-Freshwater-Terrestrial realm

MFT1 Brackish tidal biome

MFT1.2 Intertidal forests and shrublands

MFT1.2_4_MP_29 Mangroves of the Tropical Northwestern Pacific

IUCN Habitats Classification Scheme (version 3.1, IUCN 2012):

1 Forest

1.7 Forest – Subtropical/tropical mangrove vegetation above high tide level

12 Marine Intertidal

12.7 Mangrove Submerged Roots

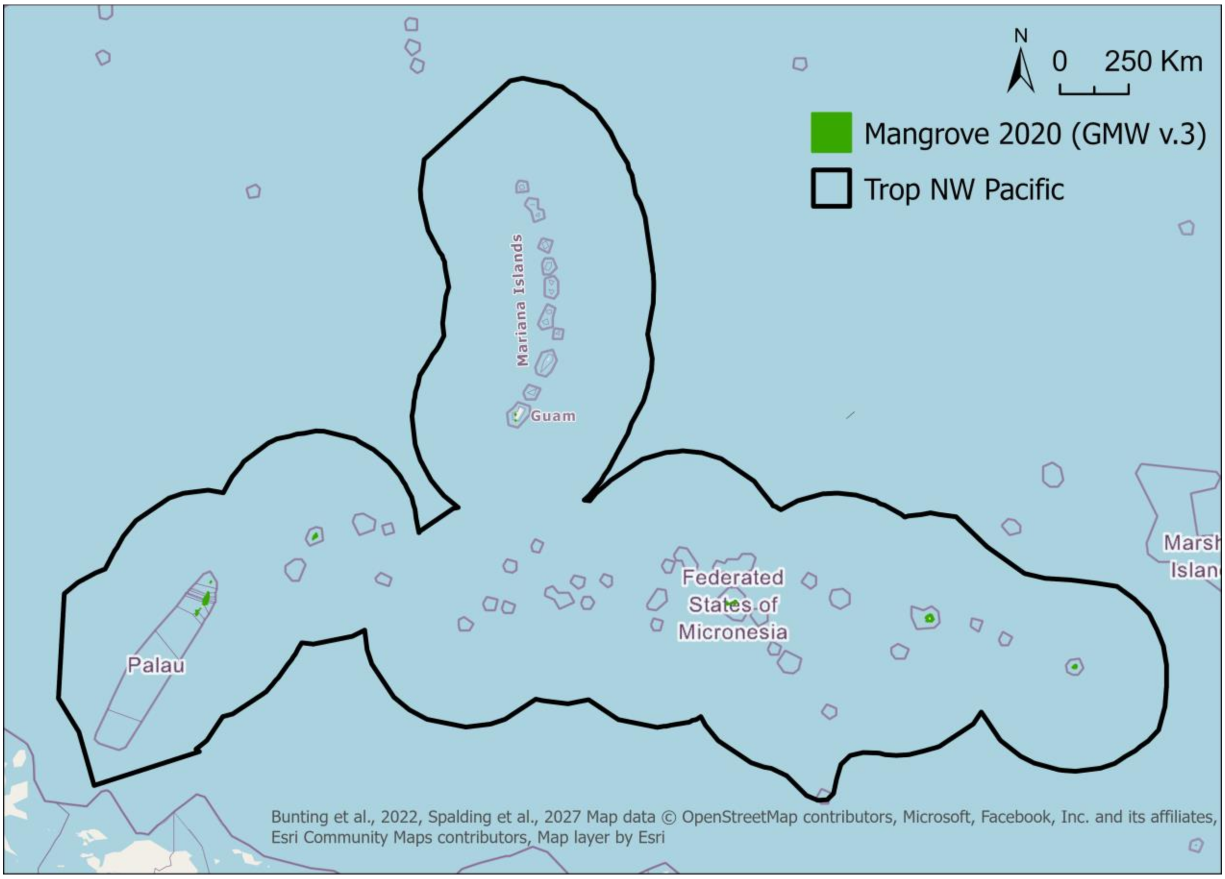

Figure 1. Mangroves of the Tropical Northwestern Pacific.

2. Ecosystem Description

Spatial distribution

The "Mangroves of the Tropical Northwestern Pacific" include intertidal forest and shrublands of the marine ecoregions of the Marshall Islands (Republic of the Marshall Islands), East Caroline Islands (Federated States of Micronesia, FSM), West Caroline Islands (Republic of Palau), and Mariana Islands (Guam and the Commonwealth of the Mariana Islands USA) (Figure 1). Pacific Island mangroves are typically of the open coast/oceanic or estuarine geomorphic type, although there are some inland depressions with mangroves in Palau and the Marshall Islands. The estimated extent of mangroves in this province was144.8 km^2 in 2020, representing about 0.1% of the global mangrove area. There has been a -1.8 % net area change since 1996 (Bunting *et al.,* 2022).

In the Republic of Palau, mangroves can be found on most islands except for the outer islands (Kayangel, Hatetobei, Helena Reef), although stands of mangroves do exist on Merir and Pulo Ana islands (Maragos *et al*., 1994). Even Angaur Island, located outside Palau's protective barrier reef and where the coastline is characterised by high wave energy, has inland patches of *Bruguiera gymnorhiza* mangroves.

More than 70% of Palau's mangroves can be found on Babeldaob island, the second largest island in Micronesia, with 44% located in Babeldaob's Ngaremeduu Bay. Dendy *et al*. (2022) analysed seven timestamps from 1921-2014, which showed stable mangrove cover on Babeldaob island throughout the 93-year study period. Mangrove cover was stable at around 36 to 40 km^2 or about 10% of the island's area; and mean seaward fluctuations of annual loss and gain appeared roughly equal between 1921-2014.

The measured mangrove area since 1921 was corroborated by a recent analysis where 42 km^2 of mangroves were mapped on Babeldaob and 52 km^2 were mapped across the main island groups of Palau (Joss and Ferrier-Loh, 2025). This methodology used a 2021 LiDAR dataset (PALARIS, 2021) to predict extent based on the observed tidal range of Palau mangroves and referenced corresponding aerial imagery to refine the boundaries (Figure 2). Elevation plays a key role in mangrove distribution (Ellison *et al.*, 2022) as seaward expansion of mangroves is facilitated by high rates of upland erosion and coastal sedimentation that lead to newly accreting land; whereas losses are due primarily to clearing for coastal development (MacKenzie *et al.*, 2016, Adema, 2023).

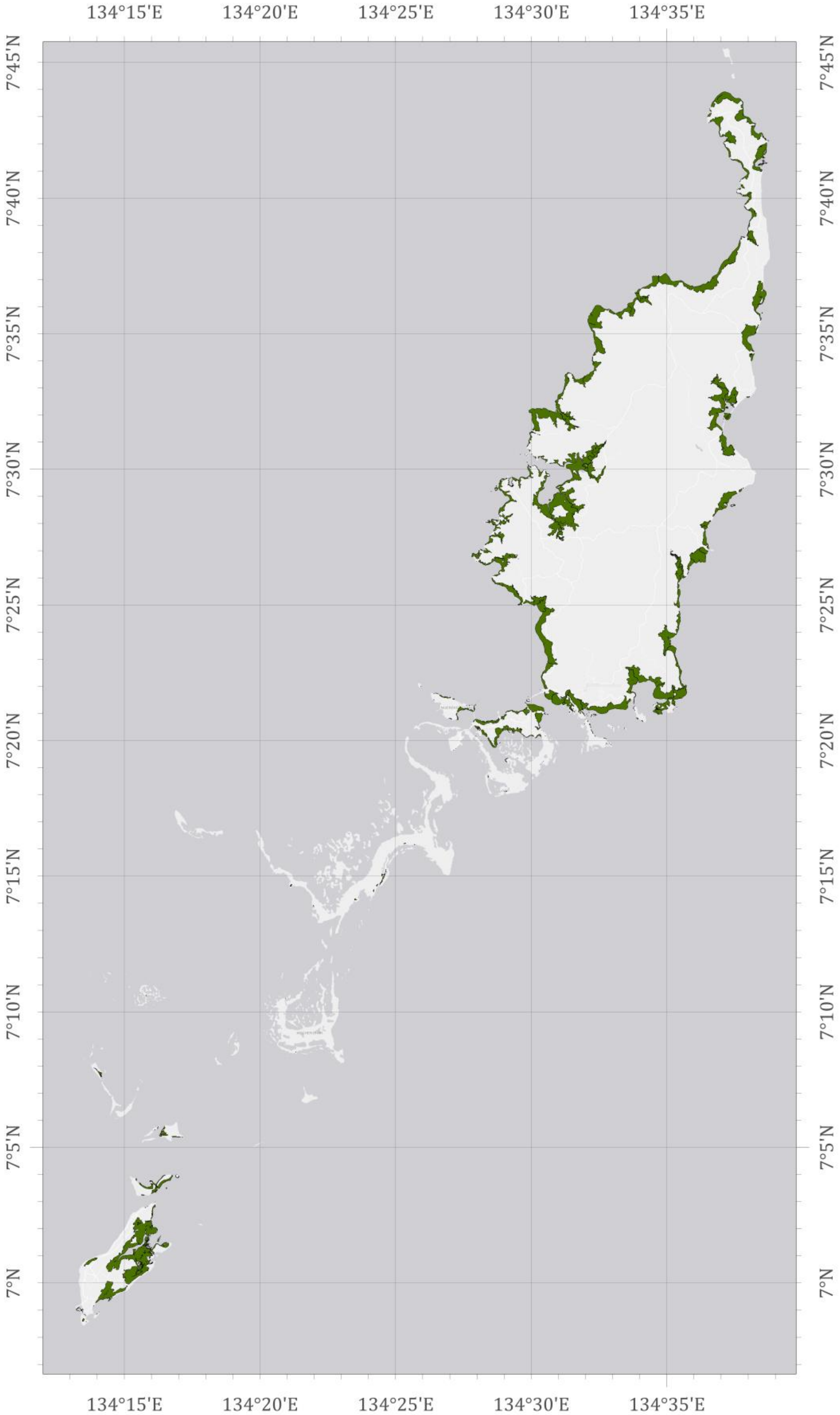

Figure 2. The extent of mangroves (indicated in green) mapped across the Republic of Palau, excluding inland areas, i.e. fringing marine lakes and a stand on Angaur (<0.5 ha) and Merir. Mangrove extent was derived from airborne LiDAR (2021) and validated with extensive ground truth, along with referencing high-resolution aerial imagery. Map produced by Coral Reef Research Foundation (CRRF).

Mangroves are found in all four states of the Federated States of Micronesia (Chuuk, Kosrae, Pohnpei, Yap). Most of the mangroves are found in Pohnpei (5,658 ha), followed by Kosrae (1,397 ha), Chuuk (1287 ha) and Yap (1109 ha; Donnegan *et al.*, 2006; FAO, 2014; Liu, 2011). A more recent change analysis conducted for Pohnpei using higher resolution images and aerial photographs from 1983-2018 reported 6,377 ha of mangroves in 1983; and a small increase in mangrove area to 6,426 ha in 2018 (Woltz *et al*., 2022). The net gain of 49 ha comprised of 65 ha in gross gain from various locations, and 19 ha lost, with more overall change on windward coasts.

In 2018, mangrove cover between the landward and seaward zones on Pohnpei showed an average width of ~1,500 meters on the leeward side where there is more development, and 400 meters on the windward (East-Northeast) side. Area gained between 1983 and 2018 occurred primarily at the seaward edge of mangroves, which was likely facilitated by upland erosion leading to increased coastal sedimentation and newly accreting land, as in Palau. Areas of mangrove loss were due primarily to human activities such as the building of roads and channels, commercial and residential areas, constructed ponds and tree-harvesting. No high-resolution spatial assessments of mangrove areas were found for other islands in the province.

Estuarine landward zone mangroves of Sapwalap, Pohnpei, FSM, comprising Bruguiera, Sonneratia, Lumnitzera and Rhizophora species (photo credit: J Ellison).

In the Commonwealth of the Mariana Islands (CNMI), mangroves are restricted to the island of Saipan, along the western lagoon, where they form fringing forest with a few riverine and basin stands inland. Presently there are no robust inventories to provide an accurate estimate of mangrove area, but some assessments of select areas which include mangroves have been conducted (e.g. Greene *et al*., 2019). Estimates of mangrove area vary, with approximately 1.7 ha being a conservative estimate, but this value may be greater based on the inclusion of forest stands including but not dominated by mangroves, or expanded if other CNMI islands, where *Pemphis acidula* forms mangrove-like habitat in the absence of “true” mangroves, are included.

Mangroves are found in Guam around the southern coast and in Apra Harbor. According to the US National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP), approximately 63.9 ha of mangroves exist in Apra Harbor, and 7.9 ha along the southern coast. These estimates include C-CAP's "estuarine forested wetland" and "estuarine scrub shrub wetland" categories, but excludes the "estuarine emerging vegetation" category.

Although C-CAP data is based on remote sensing, it matches ground-based observations. Mangroves form a narrow fringe in the village of Malesso, approximately from Jaotan Point to Suyafe River. A small area of mangroves is also found in an inlet in the village of Inalahan known as Aga Bay. *Nypa* palms can be found in river mouths, including Talofofo Bay and Pago Bay. In Apra Harbor, mangroves are found in the Atantano wetland, Abo Cove, and Sasa Bay Marine Preserve.

Biotic components of the ecosystem (characteristic native biota)

The mangroves of the Tropical Northwestern Pacific province occur along a diversity gradient, with 18 true mangrove species found in the western most Palau islands and 10 true mangrove species found in the eastern most island of Kosrae. All are listed as Least Concern (LC) on the IUCN Red List of Threatened Species (IUCN, 2022). They include members of the families Rhizophoraceae (e.g. *Rhizophora apiculata*, *R. x lamarkii, R. mucronata*, *R. stylosa, Bruguiera gymnorhiza*, *Ceriops tagal)* Acanthaceae (e.g. *Acanthus ebracteatus*, *Avicennia marina*, *Avicennia alba*), Euphorbiaceae (*Excoecaria agallocha)*, Fabaceae (*Cynometra iripa*), Combretaceae (*Lumnitzera littorea*), Lythraceae (*Sonneratia alba*), Rubiaceae (S*cyphiphora hydrophyllacea*), Malvaceae (*Heritiera littoralis*), Meliaceae (*Xylocarpus granatum*, *X. mollucensis*), the palm *Nypa fruticans* (Arecaceae), and the fern *Acrostichum speciosum* (Pteridaceae).

Sonneratia alba at Nan Madol, Pohnpei, FSM, a large city constructed before 1500 CE, later abandoned owing to island subsidence and inundation, now largely occupied by mangroves (Photo credit: J. Ellison).

Most Pacific Island mangroves are characterized by narrow, fringing coastal mangroves, although there are also estuarine mangroves. In Palau and the FSM, the mangrove ocean ecotone is typically dominated by the flood tolerant species *Sonneratia alba* and/or *Rhizophora stylosa*; whereas interior areas are typically dominated by *Heritiera littoralis*, *Lumnitzera littorea*, and *Xylocarpus granatum* (Figure 3). Mangroves in Guam are dominated by *Rhizophora stylosa, Rhizophora apiculata, Bruguiera gymnorhiza,* and *Avicennia marina.* Additionally, *Lumnitzera littorea* and *Acrostichum aureum* are found in Sasa Bay and Atantano wetlands, but have not been reported in Southern Guam.

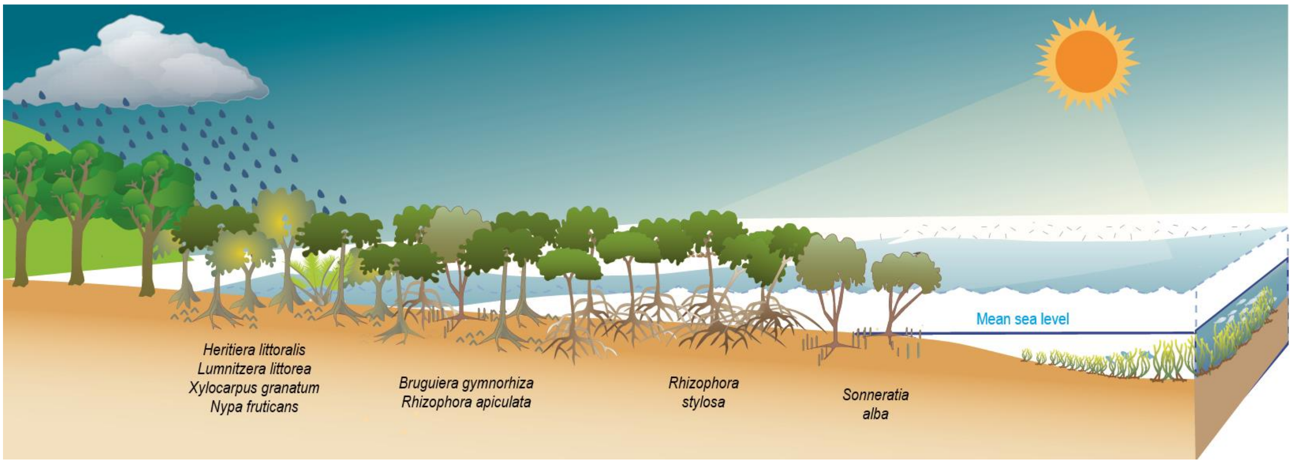

Figure 3. Species zonation of the more commonly occurring true mangroves of the Tropical NW Pacific (adapted from Ellison *et al.*, 2022)

Mangroves in the CNMI are restricted to the island of Saipan, where they are found on only a small stretch of the western shoreline along Saipan Lagoon. The existing mangroves are monospecific stands of *Bruguiera gymnorhiza* with associated species (e.g. *Acrostichum aureum*, *Hibiscus tiliaceus*, *Pemphis acidula*) forming primarily fringing forest, with select riverine and basin stands within the American Memorial Park and along several artificial drainages and natural streams extending several hundred meters inland.

Little monitoring or long-term data exist to determine the historical extent of mangroves on Saipan, although they have undergone widespread disturbance via Spanish, German, Japanese, and American colonial development; wartime (WWII) activities, munitions and residential waste-dumping, and contemporary development activities. Archeological and paleoecological studies on Saipan have found evidence for more widespread and biodiverse mangrove forests (Butler, 1995, Athens and Ward, 2004), including now extirpated species:*Rhizophora mucronata*, *R. apiculata*, and *Lumnitzera littorea,* as far south as Susupe and into northern Achugao watersheds. The decline of mangrove abundance in the areas under study correlates with sea-level changes (receding) around 2,500 years before present, as well as the presence of charcoal indicating human settlement (Butler, 1995). More recently, efforts by local organisations, including the CNMI Division of Coastal Resources Management, US National Park Service, and Pacific Coastal Research & Planning, have been working towards reforestation of the historically degraded mangrove forest and reintroduction of the aforementioned extirpated species via seed and propagule collection from nearby Guam for propagation and out-planting on Saipan.

A total of 211 species associated with mangrove ecosystems in the Tropical Northwestern Pacific are listed in the IUCN Red List of Threatened Species (2022) (see Appendix 2). These species span 11 taxonomic classes, reflecting the ecological richness and functional diversity of mangrove-associated biodiversity in the region. The majority belong to ray-finned fishes (Actinopterygii, 118 species), followed by birds (Aves, 41), flowering plants (Magnoliopsida, 18), gastropods (Gastropoda, 8), monocots (Liliopsida, 7), reptiles (Reptilia, 6), mammals (Mammalia, 5), sharks and rays (Chondrichthyes, 4), sea cucumbers (Holothuroidea, 2), one amphibian (Amphibia) species and one coral (Anthozoa) species. Two of these species are classified by IUCN as Critically Endangered (CR), 10 are Endangered (EN), and six are Vulnerable (VU). In addition, epiphytes, lianas and fungi grow on mangrove trees in Pohnpei owing to the equatorial climate with rainfall throughout the year.

Epiphytes, lianas, and fungi on mangrove trees at Enipoas and Sapwalap (Pohnpei, FSM)
(Photo credits: Kevin Buffington of USGS, and J. Ellison).

Among birds (Aves), there are eight threatened species: five are Endangered (EN): the Mariana swiftlet (*Aerodramus bartschi*), Mariana moorhen (Gallinula chloropus guami), Caroline ground-dove (*Pampusana kubaryi*), Pohnpei cicadabird (*Edolisoma insperatum*), and Chuuk monarch (M*etabolus rugensis*); and three are Vulnerable (VU): the Micronesian imperial-pigeon (D*ucula oceanica*), Pohnpei kingfisher (*Todiramphus reichenbachii*), and shortjaw bonefish (*Albula glossodonta*), which belongs to Actinopterygii but is sometimes grouped with the coastal fauna due to its habitat association.

Among sharks and rays (*Chondrichthyes*), four species are threatened: the dwarf sawfish (*Pristis clavata*, CR), sharptooth lemon shark (*Negaprion acutidens*, EN), mangrove whipray (*Urogymnus granulatus*, EN), and blacktip reef shark (C*archarhinus melanopterus*, VU). Past reports by fishers and recent eDNA analysis suggests scalloped hammerhead sharks thought to be associated with mangroves may live in Guam's Sasa Bay Marine Preserve (CR) (Budd *et al*., 2021).

All five threatened mammal species are flying foxes and fruit bats of the genus *Pteropus*, which are highly dependent on intact mangroves and other coastal forests. These include four Endangered (EN) species: the Mariana fruit bat (*Pteropus mariannus*), Pohnpei flying fox (*Pteropus molossinus*), Chuuk flying fox

(*Pteropus pelagicus*), and Kosrae flying fox (*Pteropus ualanus*); and one Vulnerable (VU) species: the Palau flying fox (*Pteropus pelewensis*). Additionally, the hawksbill turtle (*Eretmochelys imbricata*) is listed as Critically Endangered (CR), and the sea cucumber *Holothuria scabra* as Endangered (EN). The diversity of animal species across a wide range of taxa underscores the conservation significance of mangrove ecosystems in the Tropical Northwestern Pacific. It highlights the urgency to protect these ecosystems not only for their ecological functions, but also for the survival of numerous species.

Abiotic Components of the Ecosystem

Based on the typology of Worthington et al. (2020), mangroves of the Tropical NW Pacific province are classified as estuarine, lagoonal and open coast formations. Sediments in mangroves on high islands are derived from catchment runoff of very low grain size originating from basaltic bedrocks. Fringe and seaward mangroves may grow on calcareous sediments from coral reefs or seagrass beds. Tidal ranges are microtidal, but with variable mean sea positions. Locations within about 15° of the Equator in this province have large interannual variability of sea level peak-to-peak amplitudes as large as 50 cm associated with ENSO events (Colin, 2009). These trends increase inundation threats on the mangroves in addition to relative sea-level rise caused by global warming (Ellison *et al.*, 2022).

Regional distributions are influenced by distance, with habitats becoming increasingly separated along longitudinal gradients (Ellison, 2009). Rainfall and sediment supply from rivers and currents promotes mangrove establishment and persistence, while waves and storm action can destabilise and erode mangrove substrata, mediating local-scale dynamics in ecosystem distributions. High rainfall reduces salinity stress and increases nutrient loading from adjacent catchments, while tidal flushing also regulates salinity.

Key processes and interactions

Mangroves act as structural engineers having adaptations such as specialised aboveground root structures (e.g., pneumatophores, prop roots) (Figure 3), salt excretion glands, vivipary, and propagule buoyancy to allow survival and recruitment in poorly aerated, saline, mobile, and tidally inundated substrata (Hogarth, 2015). They exhibit high efficiency in nitrogen use and nutrient resorption (Reef et al. 2010). Mangroves produce large amounts of vegetation detritus, becoming either buried in waterlogged sediments, consumed by crabs and gastropods, and then decomposed further by meiofauna, fungi and bacteria, to mobilise carbon and nutrients to higher trophic levels (Alongi, 2009). Mangrove ecosystems also serve as major blue carbon sinks, incorporating organic matter into sediments and living biomass.

Equatorial mangroves from the high islands of FSM show the highest levels of productivity and biomass relative to other mangroves (Twilley *et al*., 2017; Kauffman *et al*., 2020). Total ecosystem carbon stocks (above and belowground C) have been reported from Kosrae (1187.9 ± 347.9 Mg C ha^{-1}), Pohnpei (1391.0 ± 439.7 Mg C ha^{-1}), and Yap (1177.3 ± 389.8 Mg C $^{ha-1}$) (Donato *et al.*, 2011; MacKenzie *et al*., unpublished).

From measurement of 273 plots along transects across all shorelines of Pohnpei through 2016-2017 (Woltz *et al*., 2022), mangrove density varied from 32 to 3,247 trees/ha with a mean of 890 ± 32 trees/ha. Total mean basal area was 39 ± 2 m^2/ha. Mean aboveground biomass was 344 ± 22 Mg/ha. Total basal area was higher on the windward (East-Northeast) side of the island, but mangroves were less dense there. Basal area was lower in the seaward fringe sites, but the mangroves were denser than in the landward zone. Similar patterns have also been observed in Yap and were attributed to more frequent typhoons that come from the East (Kauffman and Cole, 2010).

In 2010, an extensive network of 100 mangrove plots was established around the island of Babeldaob to monitor the condition and structure of Palau's mangroves. Biomass and carbon stocks data were derived from fixed-radius plots of live mangrove trees, dead downed woody debris, and soil samples. Analysis of a subset of these plots reported a total ecosystem carbon of 830 (683-977) Mg C ha^{-1}, which was dominated by belowground soil C (699 (587-812) Mg C ha^{-1}). Biomass and C contributions were dominated by the larger *Sonneratia alba* and *Xylocarpus granatum* trees (Donato *et al*., 2011).

Adema (2023) used the plot data with a 2021 LiDAR dataset to conduct a Palau-wide carbon assessment and found that Palau mangrove carbon stocks were ~3.3 million Mg C. Analysis of Palau's mangrove plot data also revealed that nearly 50% of plots were dominated by dwarf mangroves (tree height <3 m), which may reflect the condition of the Babeldaob plots; however across all of Palau only 6% of mangroves were found to be shorter than 3 m (Joss and Ferrier-Loh, 2025). A consistent belt of dwarf mangroves exists around Babeldaob, often located between the taller mangroves which dominate the seaward fringe and landward interior (Figures 4-6).

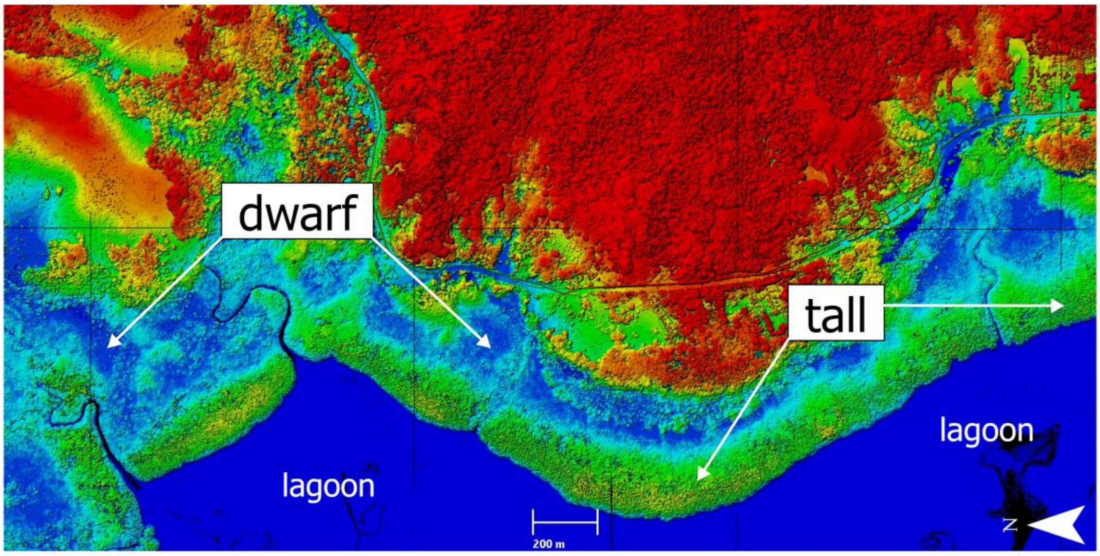

Figure 4. Airborne LiDAR image showing position of dwarf mangroves (tree height < 3 m, blue shades) between tall mangroves (tree height >6 m, green/yellow shades) in Airai State on the western coast of Babeldaob in Palau. Map made with data from PALARIS and produced by CRRF.

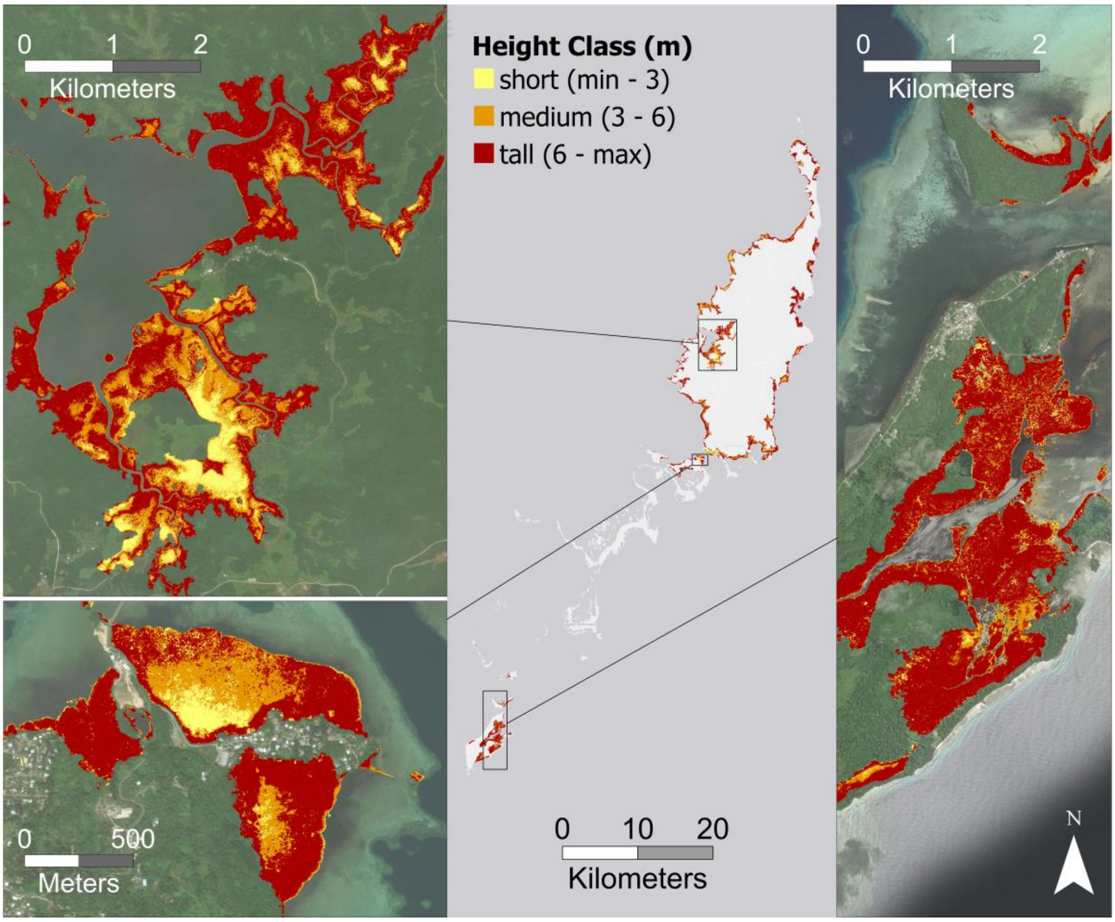

Figure 5. Categorized canopy height model results from LiDAR derived mapping across Palau, showcasing the spatial patterns of dwarf (<3 m tall) mangroves relative to the surrounding forest structure. Canopy height classes displayed across Palau's main island group (center), Ngaremeduu Bay in Babeldaob (upper left), northwest Koror (lower left), and Peleliu's eastern shoreline (right). Map produced by CRRF.

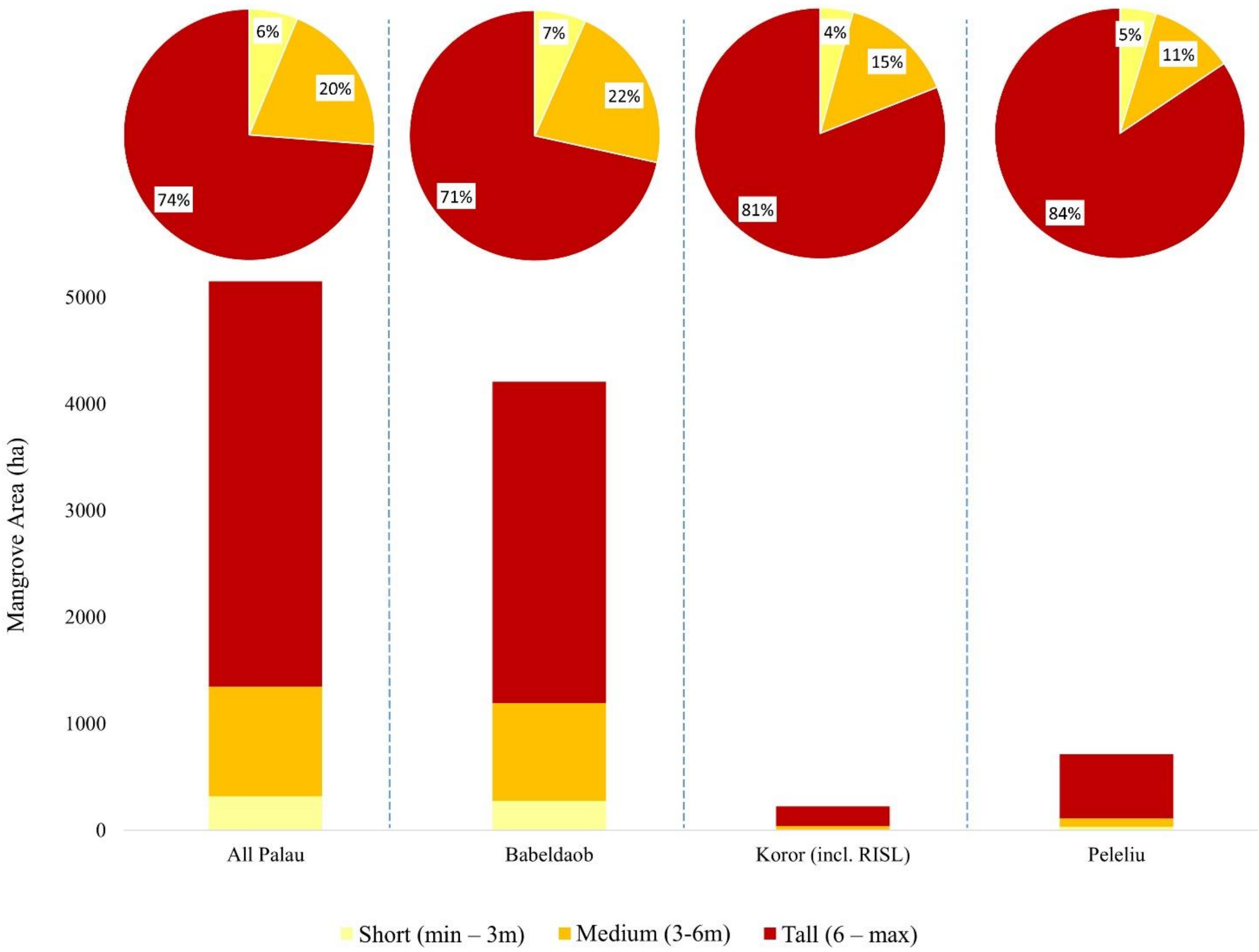

Figure 6. A breakdown of mangrove height classes derived from LiDAR-based mapping across Palau in 2025, describing the areal coverage of mangrove within all of Palau and within each island group (bars) and the percentage of short (<3 m), medium (3-6 m), and tall (>6 m) trees within each respective area (pie charts).

Using paired tall and dwarf plots, Thomas and Sisior (2025) reported that dwarf mangroves are probably due to phosphorous limitation. Taller trees on the fringes were utilising upland phosphorus before it could reach the dwarf mangroves in the interior. As a result, these trees are investing more in belowground roots to find the limited amounts of phosphorus. This has also resulted in higher soil carbon stocks in dwarf mangroves than tall ones (MacKenzie *et al.,* unpublished data).

Remeasurement of a subset of Palau's plots in 2015 revealed an average annual production of 5.4 Mg C ha^{-1} with tall trees sequestering 2.0 Mg C ha^{-1} annually and dwarf trees 8.9 Mg C ha^{-1} (MacKenzie *et al.* upublished). Applying these new estimates for annual production within dwarf versus tall mangroves in Palau, and based on the remote measurements of mangrove tree heights across the nation (Figure 6; Joss and Ferrier-Loh, 2025), annual carbon sequestration rates may range from 12,500 to 15,000 Mg C yr^{-1}, which in terms of local productivity, especially for dwarf mangroves, is quite high (Ali *et al.*, 2025).

At present, there are no studies focused on carbon sequestration or storage by the CNMI mangroves. pollutants in Saipan's mangrove forests include discharged oils, untreated sewage, animal waste, heavy metals, polychlorinated biphenyls (PCB), land-based sediments, and plastic debris. These are derived from both contemporary and historical (i.e., WWII era) sources (Plentovich *et al.*, 2020). Typhoons have had an impact on mangroves in Saipan, particularly in the Lower Base riverine stand, which saw significant losses following several typhoons culminating in Super Typhoon Yutu in 2018. The resulting woody debris remains within the stream estuary; however, much of the *B. gymnorhiza* has subsequently recovered.

3. Ecosystem Threats and Vulnerabilities

Main threatening processes and pathways to degradation

Mangrove area losses arise from various impacts, including aquaculture, urbanisation and associated coastal development, over-harvesting, and pollution stemming from domestic, industrial, and agricultural land use (Spalding *et al*., 2010). The location of mangrove forests within intertidal elevations also renders them very vulnerable to relative sea-level rise (SLR), including from climate change impacts (Ellison, 2015).

US Forest Service analyses of imagery 1983-2018 revealed that 19 ha of mangrove were lost from the largest mangrove areas of the province on Pohnpei (Woltz *et al*., 2022). Evidence showed that losses were primarily due to human activities such as the building of roads, channels, commercial and residential areas, constructed ponds, and harvesting of trees.

Deforestation for agriculture, poorly designed roads, and other developments have also led to increased erosion rates and sediment inputs to mangroves in Palau and FSM (Golbuu *et al*., 2003; 2008). Sediment sources for Pacific high islands are derived largely from upland erosion, which has contributed to their response to sea-level rise (Krauss *et al*., 2010; Krauss *et al*., 2014). Sediment- trapping is a natural and important function of mangrove forests; however, too much destabilisation of soils within the watershed can threaten mangroves. Excess sediments can impair tree health by burying gas-exchanging pores along pneumatophores, prop roots and young stems (Ewel *et al*., 1998; Ellison, 1999). Conversely, inundation stress is a threat to mangroves where surface elevation does not keep pace with relative SLR; and this is widely recognised as the most significant climate change threat to mangroves (Cooley *et al.*, 2022).

Satellite altimeter data provide information on large-scale spatial change in absolute sea level, including variability associated with the El Niño Southern Oscillation (ENSO). Notably, the western Pacific, including the Tropical Northwestern Pacific, exhibits some of the highest sea level variability globally, with rates reaching up to 6 mm year^{-1} (Aucan, 2018). Inter-annual sea level variability is also most pronounced owing to ENSO, meaning a storm or wave event can create a more damaging inundation event (Aucan, 2018). Additional risk factors include tectonic subsidence (Figure 7), which further increases relative SLR. For example, the dating of mangrove cores indicates tectonic subsidence on Pohnpei (FSM) over the last 5,700 years (Sefton *et al*., 2022).

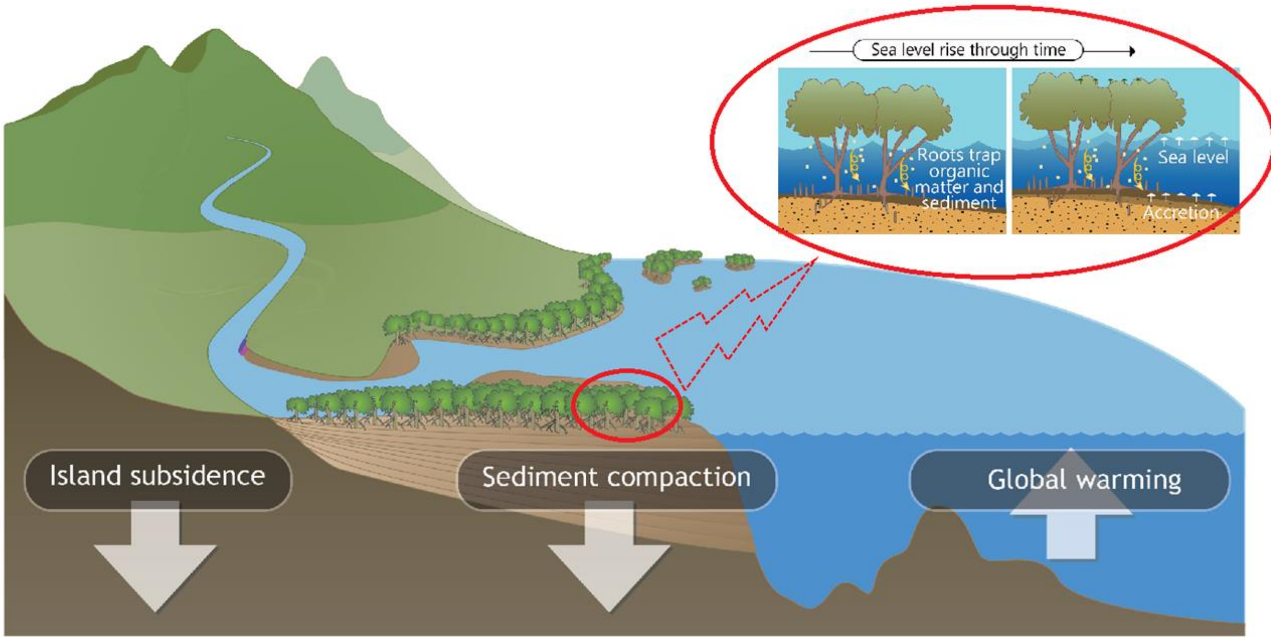

Figure 7. Processes causing relative sea-level rise impacts on mangroves of the Tropical NW Pacific province (adapted from Ellison, 2015).

Fortunately, mangrove forests are dynamic ecosystems that can adjust to SLR by maintaining their forest floor elevation relative to local sea levels (Ellison and Stoddart, 1991; Woodroffe, 1995; McKee *et al.*, 2007; Woodroffe *et al*., 2016). This is typically accomplished via: 1) contributions of organic matter (e.g., roots) to soil volume, 2) surface sedimentation, and 3) resistance to compaction and erosion (Krauss *et al*., 2014, Woodroffe *et al.,* 2016, Cahoon *et al*., 2020). However, an Indo-Pacific mangrove vulnerability assessment using tidal prism, elevation change, and suspended sediment data reported that mangroves in low tidal prism regions with low suspended sediment levels are most vulnerable, including mangroves in the Tropical NW Pacific province (Lovelock *et al*., 2015).

Sediment is an important component in mangrove response to SLR in the Tropical NW Pacific, but this varies across islands. The naturally occurring radionuclide, ^{210}Pb, revealed that only 1 of 12 mangrove plots in Palau had changes in surface elevation greater than or equal to SLR. This was attributed to upland erosion, deforestation, and the construction of a circum-island road that led to increased surface sedimentation rates in the mangroves (MacKenzie *et al*., 2016). In Pohnpei, ^{210}Pb revealed that only 8 out of 34 plots had changes in surface elevation that were greater than or equal to SLR despite these mangroves also receiving high loads of upland sediment from deforestation for agriculture (MacKenzie *et al.*, 2024; MacKenzie *et al*., unpublished). A time series analysis of each core revealed that sediment inputs from deforestation significantly increased surface elevation at many sites, but this benefit, which also resulted in the loss of substantial amounts of upland forest, was short-lived and lasted less than 10 years.

Additional analysis revealed that belowground mangrove root growth was a more important factor driving surface elevation change than surface deposition of mineral sediments (MacKenzie *et al*., unpublished). Data collected using surface elevation tables from Pohnpei supported these findings, which coupled with other field parameters, parameterized a mangrove sea-level rise vulnerability assessment (Buffington *et al.*, 2024). This accounted for species interactions and the belowground processes that dictate soil elevation building relative to sea levels.

Another threat to Pacific Island mangroves includes altered hydrology and sediment loading that result from poorly designed roads or increased impervious surfaces (Golbuu *et al*., 2003; MacKenzie, 2008; Buffington *et al*., 2024). For example, after construction of a new airport runway on Yap, adjacent mangroves on the coastal side died back and did not subsequently recover. The loss was attributed partially to altered water and sediment inputs from the construction activities (Falanruw; *pers. comm.*), but was due primarily to Typhoon Sudal, which impacted the west coast of Yap in 2004 (Cannon *et al*., 2014). In Palau, the construction of a circum-island road around Babeldaob led to increased sediment runoff into coastal ecosystems. Mangroves only trapped an estimated 30% of the sediment, while the rest has impacted negatively on seagrasses and coral reefs (Golbuu et al. 2003). This has allowed mangroves to colonize intertidal areas (Dendy *et al.*, 2022) that are now higher in the tidal prism due to sediment increasing nearshore floor elevations. The ability of Palau's mangroves to keep up with recent rates of sea-level rise has been attributed to the increased inputs of sediment.

Mangrove areas where Palau's Ngerikiil River enters Airai Bay demonstrate evidence of extensive disturbances in the catchment (e.g., construction of the Koror Airport in 1978-82) and resultant sedimentation rates of ~1 cm/yr (Golbuu *et al.*, 2003). Aerial imagery captured in 1946, 2000 and 2021 shows an ~4.35 ha increase in mangroves along a 1.3 km stretch of shoreline (Figure 8; adapted from Colin, 2009). In the 54 years between 1946 and 2000, 2.8 ha of mangrove extended across the shoreline, largely on the southwest side of the river mouth. In the following 21 years (2000 to 2021), another 1.4 ha of mangrove was gained, largely in the form of patchy, fringing stands on the southwest of Ngerikiil River mouth. This expansion in mangroves likely represents an increase in suitable elevations from the sediment deposited at the mouth of the river. However, the remaining sediment runoff deposited throughout the Bay has contributed to a phase shift from coral-dominated to algae-dominated sediment covered reefs (Golbuu *et al*., 2003).

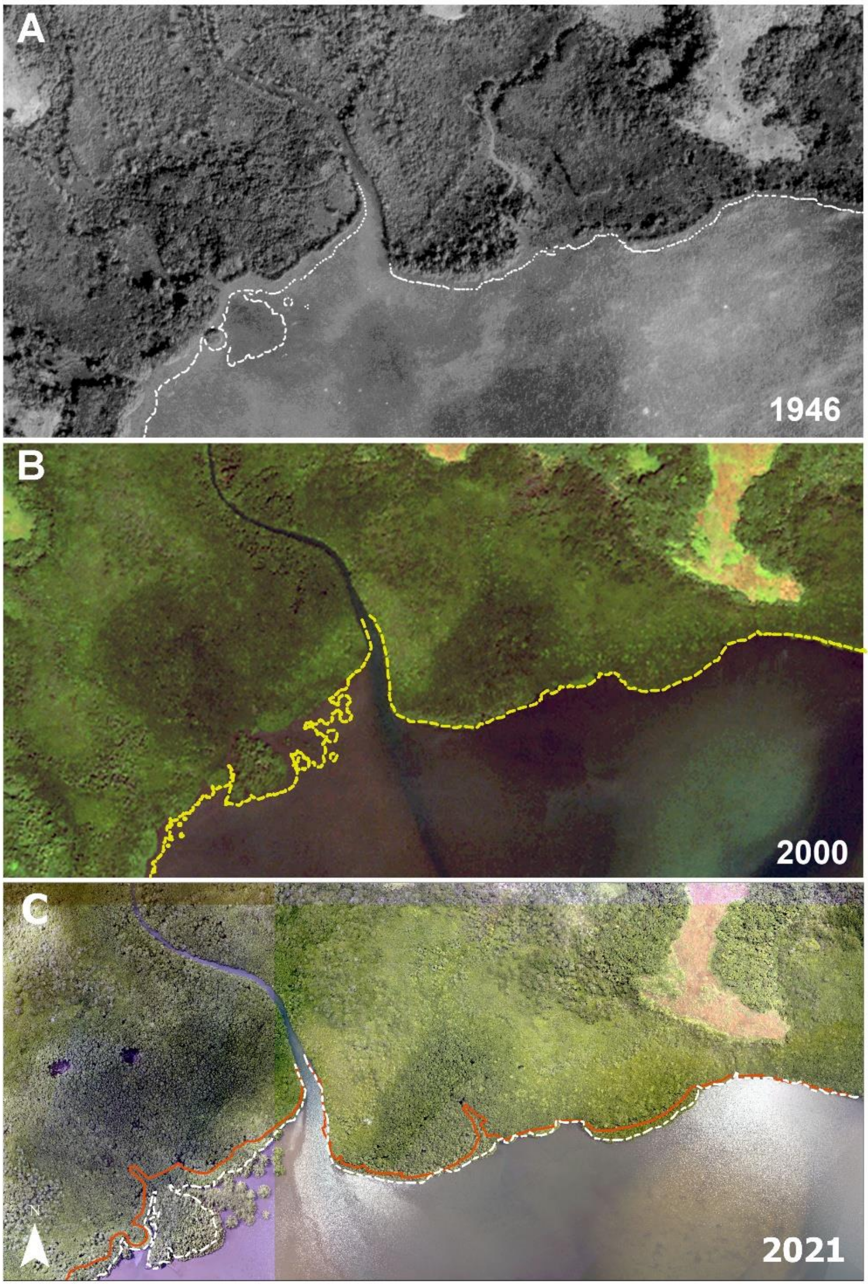

Figure 8. Examples of expanding mangrove surrounding Ngerikiil River estuary in Airai Bay, Palau. Imagery in (A) is from 1946 with a white dashed line representing 2000 mangrove extent, imagery in (B) is from 2000 with a yellow dashed line representing 2021 mangrove extent. In (C) the aerial imagery is from a 2021 LiDAR survey with an orange line represents 1946 extent and the white dashed line representing 2000 mangrove extent. (A) and (B) are adapted from Colin (2009).

This increase in mangrove area shows some resilience in the face of SLR, however, proposed clearing and continued construction is unrelenting in regions seeking increased development and economic prospects. Sometime in the late 1980s to early 1990s, an area of mangrove (approximately 14 ha) in Ngatpang State on Babeldaob's west coast was intentionally flooded and cleared to make way for a fish farm. A berm was built in front of a mangrove stand, isolating the interior of the stand from tidal influence, causing the mangroves to die off (Figure 9; P. Colin, *pers. comm.*). Looking forward, Palau's second most populous state, Airai State, has an approved EA to clear over 27 ha of mangrove for a Commercial Park (Thomas and Sisior, 2023). By

2025, a portion of the proposed work has been completed, resulting in clearing and filling of ~4 ha of mangrove.

Figure 9. An aerial image taken by Pat Colin in 2000, capturing the die-off of mangroves in Ngatpang, Palau as the area was being converted to a fish farm.

Few data exist on the full extent and composition of mangroves on Saipan, and therefore there is no reliable estimate for mangrove change in the CNMI. Known threats include land-based sources of pollution, particularly heavy metals (e.g. lead) and polychlorinated biphenyls (PCB) (Plentovich *et al.*, 2020; Knee *et al.*, 2025). Additionally, cutting of mangroves occurs through encroachment of the buffer zone for roadside right-of-way maintenance and by local fisherman for small boat access. Climate change and increasing typhoon intensity also threaten the remaining mangrove stands on Saipan, with mortality observed during Super Typhoon Yutu, and dramatic shoreline change occurring along the shoreline of Saipan Lagoon. Coastal development has reduced the area of viable mangrove habitat, such as the loss of mangrove forest with the development of Governor Eloy S. Inos Peace Park (Greene *et al.*, 2019). As with inland forests, invasive species have spread into the edges of mangrove forests, particularly *Pluchea indica* and aggressive vine species (e.g. *Mikania scandens*).

In Guam, mangroves in Sasa Bay Marine Preserve and Achang Reef Flat Marine Preserve are protected from removal or harvesting. However, illegal clearing in Southern Guam has occurred in the past, and mangroves may be at risk of removal for water access or views. Mangroves in Apra Harbor have also been killed, or otherwise impacted, by oil spills from pipelines. Current research indicates that a micromoth impacts L*umnitzera littorea* seeds, with an estimated 97% of sampled seeds in Sasa Bay affected (unpublished data).

Guam's local extinction of bird pollinators due to the invasive brown tree snake (*Boiga irregularis*), may also impact reproduction rates of species that rely on bird pollination, such as *Bruguiera gymnorhiza*. A large percentage of Guam's mangroves exist on lands/waters controlled by the US Navy, particularly Atantano wetlands and Abo Cove. Although mangroves have not been removed on military lands recently, they could be a risk of future development for military purposes. Wildfire and development of upland areas in Guam could also affect sediment input or water flow into mangrove areas.

Definition of the collapsed state of the ecosystem

Ecosystem collapse is recognized when the tree cover of diagnostic true mangrove species dwindles to zero, indicating complete loss (100%), as exemplified in Figure 9 showing mangrove die-off in Palau following coastal construction.

While mangroves exhibit remarkable dynamism, with species distributions adapting to local shifts in sediment distributions, tidal patterns, and variations in local inundation and salinity gradients, disruptive processes can trigger shifts in this dynamism, potentially leading to ecosystem collapse. Ecosystem collapse may manifest through the following mechanisms: a) restricted recruitment and survival of diagnostic true mangroves due to adverse climatic conditions (e.g., low temperatures); b) alterations in rainfall, river inputs, waves, and tidal currents that destabilize and erode substrata, hindering recruitment and growth; c) shifts in rainfall patterns and tidal flushing altering salinity stress and nutrient loadings, impacting overall survival; d) eradication of mangrove stands with development-motivated filling and/or harvest.

Threat Classification

IUCN Threat Classification (version 3.3, IUCN-CMP, 2022) relevant to mangroves of the Tropical Northwestern Pacific province:

1. Residential & commercial development
- 1.1 Housing & urban areas
- 1.2 Commercial & industrial areas
- 1.3 Tourism & recreation areas

4. Transportation & service corridors
- 4.1 Roads & railroads
- 4.3 Shipping lanes
- 4.4 Flight paths

5. Biological resource use
- 5.2 Gathering terrestrial plants
  - 5.2.1 Intentional use (species being assessed is the target)
  - 5.2.2 Unintentional effects (species being assessed is not the target)
- 5.3 Logging & wood harvesting
  - 5.3.1 Intentional use: subsistence/small scale (species being assessed is the target [harvest]
  - 5.3.3 Unintentional effects: subsistence/small scale (species being assessed is not the target)[harvest]
  - 5.3.4 Unintentional effects: large scale (species being assessed is not the target) [harvest]
  - 5.3.5 Motivation Unknown/Unrecorded
- 5.4 Fishing & harvesting aquatic resources

    - 5.4.1 Intentional use: subsistence/small scale (species being assessed is the target) [harvest]
    - 5.4.3 Unintentional effects: subsistence/small scale (species being assessed is not the target) [harvest]

6. Human intrusions & disturbance
- 6.2 War, civil unrest & military exercises
- 6.3 Work & other activities

7. Natural system modifications
- 7.3 Other ecosystem modifications

8. Invasive & other problematic species, genes & diseases
- 8.1 Invasive non-native/alien species/diseases
    - 8.1.2 Named species

9. Pollution
- 9.1 Domestic & urban waste water
    - 9.1.1 Sewage
    - 9.1.2 Run-off
    - 9.1.3 Type Unknown/Unrecorded
- 9.2 Industrial & military effluents
    - 9.2.1 Oil spills
    - 9.2.2 Seepage from mining
    - 9.2.3 Type Unknown/Unrecorded
- 9.3 Agricultural & forestry effluents
    - 9.3.1 Nutrient loads
    - 9.3.2 Soil erosion, sedimentation
    - 9.3.4 Type Unknown/Unrecorded
- 9.4 Garbage & solid waste

11. Climate change & severe weather
- 11.1 Habitat shifting & alteration
- 11.4 Storms & flooding
- 11.5 Other impacts

4. Ecosystem Assessment

Criterion A: Reduction in Geographic Distribution

Subcriterion A1 measures the trend in ecosystem extent during the last 50-year time window. Unfortunately, (Bunting *et al*., 2022) found no common regional dataset or national data that provides information for the entire target area in 1970. Therefore, the Tropical Northwestern Pacific mangrove ecosystem is classified as **Data Deficient (DD)** for this subcriterion.

Table 1. Mangrove extent in the Tropical Northwestern Pacific (1996–2020) Source: Global Mangrove Watch V.3.0 (Bunting *et al*., 2018; 2022)

Year	Mangrove Extent (km²)
1996	147.45
2007	145.13
2008	145.05
2009	144.89
2010	147.17
2015	147.69
2016	147.72
2017	148.04
2018	148.07
2019	145.22
2020	144.82

Subcriterion A2 evaluates changes in ecosystem extent over any 50-year period, including projected future trends. In the Tropical Northwestern Pacific province, mangroves declined from 147.45 km² in 1996 to 144.82 km² in 2020, representing a net loss of –1.8% over 24 years according to the Global Mangrove Watch dataset (Bunting *et al*., 2022). This corresponds to an average net loss rate of –0.074% per year. The trend includes fluctuations with temporary gains in extent between 2010 and 2018, followed by a slight decline (Table 1). The overall time series shows low interannual variability and a relatively stable extent with a gentle negative trend. If the observed decline rate continues, a projected 3.75% loss is expected over the next 50 years.

These spatial change results are validated by higher resolution spatial change study of Pohnpei. Late last century, mangrove areas of 5,525 ha were recorded on Pohnpei (Metz, 1996; Cole *et al*., 1999). The mangrove area increased to 5,658 ha in the years 1976-2006 (Donnegan et al. 2006) USFS analyses showed a gain of 49 ha of mangroves from 6,377 ha to 6,426 ha over the 35 years from 1983 to 2018 (Woltz *et al*., 2022). As found for the Central Pacific province (Ellison *et al*., 2024), owing to the small extent of many mangrove areas, more higher resolution spatial analyses are needed to assess subcriterion A2 (Crameri and Ellison, 2022), particularly in regions such as Kosrae and Yap, the CNMI, and most of Palau. Therefore, it is not possible to assess criteria A2 across the whole province, and the Topical NW Pacific is considered as **Data Deficient (DD)** for subcriterion A2.

Subcriterion A3 measures changes in mangrove area since 1750. Unfortunately, there are no reliable data on the mangrove extent for the entire province during this period, and therefore the Tropical Northwestern Pacific mangrove ecosystem is classified as **Data Deficient (DD)** for this subcriterion.

Overall, the ecosystem is assessed as **Data Deficient (DD)** under criterion A.

Criterion B: Restricted Geographic Distribution

Criterion B measures the risk of ecosystem collapse associated with restricted geographical distribution, based on standard metrics (Extent of Occurrence EOO, Area of Occupancy AOO, and Threat-defined locations). These parameters were calculated based on the 2020 Tropical Northwestern Pacific province mangrove extent (GMW v.3). This assessment follows the updated IUCN Red List of Ecosystems guidelines (IUCN, 2024), which recommend refining AOO by excluding the smallest grid cells that collectively represent the lowest 1% of the total mapped area. This differs from earlier assessments (e.g. Central Pacific), which excluded individual grid cells based on whether each cell contained <1% of mangrove cover. In this way we are only excluding marginal or spurious occurrences. For 2020, AOO and EOO were measured as 55 grid cells 10 x 10 km and 1,306,462 km^2, respectively (Figure 10). Based on this high EOO value, Criterion B1 is **assessed as Least Concern (LC)**.

Province	**Extent of Occurrence EOO (km^2)**	**Area of Occupancy (AOO)**	**Criterion B**
The Tropical Northwestern Pacific	1,306,462	37	**LC**

To exclude marginal or potentially spurious occurrences, we ranked the grid cells by area contribution in ascending order and removed the smallest ones that collectively represented the first 1% of the total mapped ecosystem area, following the recommendations in the updated IUCN guidelines (IUCN, 2024). After this refinement, the adjusted AOO consists of 37 grid cells, each contributing to the remaining ≥99% of the ecosystem's area (shown in red in Figure 10). This meets the Vulnerable threshold (AOO < 50).

In addition to restricted AOO, there is evidence of ongoing threatening processes likely to cause continuing deterioration of environmental quality within the next 20 years (B2b)). These processes include land-based pollution (e.g., heavy metals and PCBs), road construction blocking hydrological exchange and excess sedimentation, loss of mangroves to coastal development, and damage from severe cyclones. Threatening processes also include impacts on mangroves from higher relative sea-level rise rates (reviewed in Section 3). These threats occur across multiple islands in the province and are not restricted to ≤5 threat-defined locations; thus, Subcriterion B2(c) is not triggered.

Based on restricted AOO combined with ongoing threatening processes affecting environmental quality, the ecosystem is assessed as **Vulnerable (VU) under Criterion B2(b).**

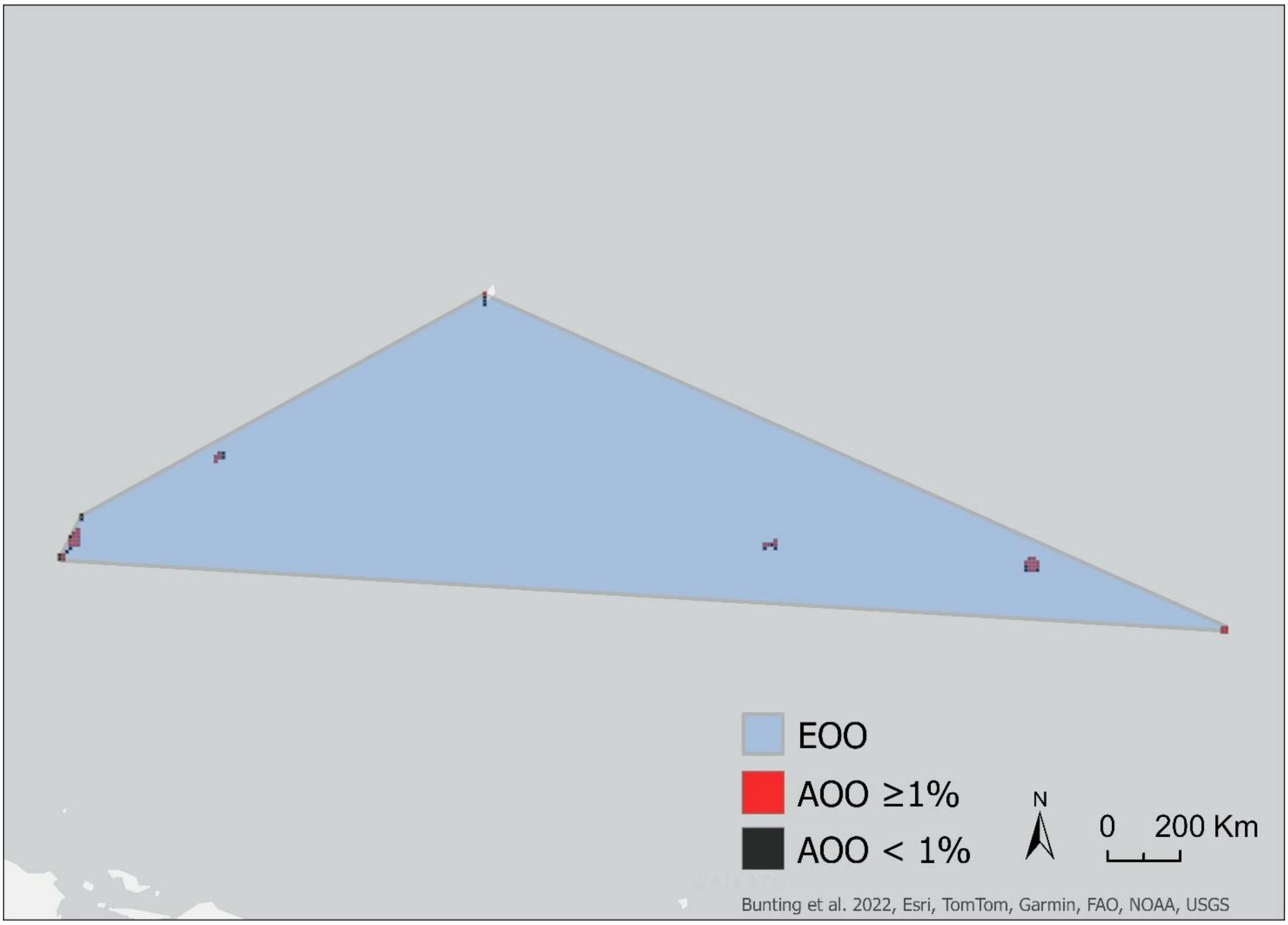

Figure 10. The Tropical Northwestern Pacific mangrove Extent of Occurrence (EOO) and Area of Occupancy (AOO) in 2020. Estimates based on 2020 GMW v3.0 spatial layer (Bunting *et al.,* 2022). Red 10 × 10 km grid cells (n = 37) represent the refined AOO after excluding cells that cumulatively account for the lowest 1% of mapped area (black cells, n = 18).

Criterion C: Environmental Degradation

Criterion C measures the environmental degradation of abiotic variables necessary to support the ecosystem.

Subcriterion C1 measures environmental degradation over the past 50 years. There are no reliable data to evaluate this subcriterion for the entire province, and therefore the Tropical Northwestern Pacific mangrove ecosystem is classified as **Data Deficient (DD)** for subcriterion C1.

Subcriterion C2 measures environmental degradation in the future, or over any 50-year period, including from the present. In this context, the impact of future sea-level rise (SLR)on mangrove ecosystems was assessed by adopting the methodology presented by Schuerch *et al.* (2018), which was designed to calculate both absolute and relative change in the extent of wetland ecosystems under various regional SLR scenarios (i.e medium: RCP 4.5 and high: RCP 8.5), with consideration for sediment accretion. The Schuerch *et al.* (2018) model was applied to the Tropical Northwestern Pacific mangrove ecosystem boundary, using the spatial extent in 2010 (Giri *et al*., 2018), and assuming mangrove landward migration was not possible.

Under an extreme SLR scenario of a 1.1-meter rise by 2100, the projected submerged area is ~ -22.0% by 2060, which remains below the 30% risk threshold. Considering that no mangrove recruitment can occur in a submerged system (100% relative severity), but that -22.0% of the ecosystem extent will be affected by SLR, the Tropical Northwestern Pacific mangrove ecosystem is assessed as Least Concern (LC) for subcriterion C2.

However, the scenarios used by Schuerch *et al*. (2018), while including continental deltaic subsidence, did not include tectonic subsidence (Figure 7), which has been shown to be prevalent in parts of the Tropical Northwestern Pacific province. Long tide gauge records in the province (Guam, Yap, Chuuk, Pohnpei) show trends of SLR that are much higher than global rates (Church *et al.*, 2006; Merrifield *et al*., 2012; Ellison *et al.*, 2022), as confirmed by millennial sealevel reconstructions (Sefton *et al.*, 2022).

Modelling SLR scenarios, using field data for surface-elevation dynamics, was done by Buffington *et al.* (2024) across large areas of Pohnpei's mangroves, representative of similar settings on the major mangrove islands of Kosrae and Babeldaob. Results (Buffington *et al*. 2024's Fig. 5) showed substantial reductions in mangrove tree species percent areas from ~2050 for low scenarios SSP 1-2.6, and from ~2040 for high scenarios SSP-5-8.5, with variability between species. By 2075 there would be >30% loss in *Rhizophora stylosa*, *Xylocarpus granatum* and *R. apiculata* under low SLR scenarios and near total (>50%) loss under higher SLR scenarios (Buffington *et al.* 2024's Fig. 5). These species dominate most mangrove areas (Woltz *et al*. 2022), demonstrating an abiotic impact affecting >50% of the ecosystem within a 50-year period (IUCN, 2024). Further study is required to evaluate whether this threat is pervasive throughout the province, but at present this highlights a significant risk in Pohnpei that needs to be monitored in the future, and which may be of significant concern throughout the entire province.

Subcriterion C3 measures change in abiotic variables since 1750. There is a lack of reliable historic data on environmental degradation covering the entire province, and therefore the Tropical Northwestern Pacific province is classified as **Data Deficient (DD)** for this subcriterion.

Overall, the ecosystem is assessed as **Vulnerable (VU)** under criterion C.

Criterion D: Disruption of biotic processes or interactions

The global mangrove degradation map developed by Worthington and Spalding (2018) was used to assess the level of biotic degradation in the Tropical Northwestern Pacific province. This map is based on degradation metrics calculated from vegetation indices (NDVI, EVI, SAVI, NDMI) using Landsat time series (≈2000 and 2017). These indices represent vegetation greenness and moisture condition.

Mangrove degradation was calculated at a pixel scale (30m resolution) on areas intersecting with the 2017 mangrove extent map (GMW v2). Mangrove pixels were classified as degraded if two conditions were met: 1) at least 10 out of 12 degradation indices showed a decrease of more than 40% compared to the previous period; and 2) all twelve indices did not recover to within 20% of their pre-2000 value (detailed methods and data are available at: maps.oceanwealth.org/mangrove-restoration/).

The decay in vegetation indices has been used to identify mangrove degradation and abrupt changes, including mangrove die-back events, clear-cutting, fire damage, and logging; as well as to track mangrove regeneration (Lovelock *et al.,* 2017; Santana *et al.,* 2018; Murray *et al.,* 2020; Aljahdali *et al.,* 2021; Lee *et al.,* 2021). However, it is important to consider that changes observed in the vegetation indices can also be influenced by data artifacts (Akbar *et al.,* 2020). Therefore, a relative severity level of more than 50%, but less than 80%, was assumed.

The results from this analysis show that over a period of 17 years (~2000 to 2017), 0.8% of the Tropical Northwestern Pacific mangrove area is classified as degraded, resulting in an average annual rate of degradation of 0.05%. Assuming this trend remains constant, +2.4% of the Tropical Northwestern Pacific mangrove area will become degraded over a 50-year period. Since less than 30% of the ecosystem will meet the category thresholds for criterion D, the Tropical Northwestern Pacific mangrove ecosystem is assessed as **Least Concern (LC)** under subcriterion D2b. However, it remains unlikely that the trend in degradation will remain constant due to the increased threat from relative SLR predicted later this century (Buffington *et al.,* 2024).

No data were found to assess the disruption of biotic processes and degradation over the past 50 years (subcriterion D1) or since 1750 (subcriterion D3). Thus, both subcriteria are classified as **Data Deficient (DD).**

Overall, the Tropical Northwestern Pacific mangrove ecosystem remains **Least Concern (LC)** under criterion D.

Criterion E: Quantitative Risk

No model was available to quantitatively assess the risk of ecosystem collapse for this ecosystem; hence criterion E was **Not Evaluated (NE)**.

5. Summary of the Assessment

CRITERION			
A. Reduction in Geographic Distribution	**A1** Past 50 years	**A2** Future or any 50y period	**A3** Historical (1750)
	DD	LC	DD
B. Restricted Geo. Distribution	**B1** Extent of Occurrence	**B2** Area of Occupancy	**B3** # Threat-defined Locations < 5?
	LC	VU	NE
C. Environmental Degradation	**C1** Past 50 years (1970)	**C2** Future or any 50y period	**C3** Historical (1750)
	DD	LC	DD
D. Disruption of biotic processes	**D1** Past 50 years (1970)	**D2** Future or Any 50y period	**D3** Historical (1750)
	DD	LC	DD
E. Quantitative Risk analysis	NE		
OVERALL RISK CATEGORY	VU		

DD = Data Deficient; LC = Least Concern; NE = Not Evaluated;VU = Vulnerable; EN = Endangered.

Overall, the Tropical Northwestern Pacific mangrove ecosystem is assessed as **Vulnerable (VU).**

6. References

Adema, D., & Halpin, P. (2023). LIDAR-based analysis of mangrove forest structure & carbon stocks of the Republic of Palau (Masters project, Duke University). https://dukespace.lib.duke.edu/server/api/core/bitstreams/d1cc9c62-d2a4-41b5-b5ee-08ea39ea4613/content

Akbar, M. R., Arisanto, P. A. A., Sukirno, B. A., Merdeka, P. H., Priadhi, M. M., & Zallesa, S. (2020). Mangrove vegetation health index analysis by implementing NDVI (normalized difference vegetation index) classification method on sentinel-2 image data case study: Segara Anakan, Kabupaten Cilacap. *IOP Conference Series: Earth and Environmental Science*, 584(1), p. 012069. https://doi.org/10.1088/1755-1315/584/1/012069

Ali, S., Dey, G., Nuong, N. H. K., Rahman, A., Wang, L-C., Sukul, U., Das, K., Sharma, R. J., Wang, S-L., & Chen, C. Y. (2025). Carbon sequestration in mangrove ecosystems: Sources, transportation pathways, influencing factors, and its role in the carbon budget. *Earth-Science Reviews*, 269, 105184. https://doi.org/10.1016/j.earscirev.2025.105184

Aljahdali, M. O., Munawar, S., & Khan, W. R. (2021). Monitoring mangrove forest degradation and regeneration: Landsat Time Series analysis of moisture and vegetation indices at Rabigh Lagoon, Red Sea. *Forests*, *12*(1), 52.

Allen, J. A., Ewel, K. C., & Jack, J. (2001). Patterns of natural and anthropogenic disturbance of the mangroves on the Pacific Island of Kosrae. *Wetlands Ecology and Management*, 9(3), 291-301. https://doi.org/10.1023/A:1011125310794

Alongi, D. M. (2009). The energetics of mangrove forests. *Dordrecht: Springer Netherlands*.

Athens, J. S., & Ward, J. V. (2004). Holocene paleoenviroment of Saipan: Analysis of a core from Lake Susupe. International Archaeological Research Institute, Inc. Prepared for: *Division of Historic Preservation, Department of Community and Cultural Affairs*. Saipan, MP.

Aucan, J. (2018). Effects of climate change on sea levels and inundation relevant to the Pacific islands. Pacific *Marine Climate Change Report Card,* 2018, 43–49. Centre for Environment, Fisheries and Aquaculture Science.

Budd, A. M., Cooper, M. K., Le Port, A., Schils, T., Mills, M. S., Deinhart, M. E., Huerlimann, R. & Strugnell, J. M. (2021). First detection of critically endangered scalloped hammerhead sharks (Sphyrna lewini) in Guam, Micronesia, in five decades using environmental DNA. *Ecological Indicators*, 127, 107649. https://doi.org/10.1016/j.ecolind.2021.107649

Buffington, K. J., Carr, J. A., MacKenzie, R. A., Apwong, M., Krauss, K. W., & Thorne, K. M. (2024). Projecting mangrove forest resilience to sea-level rise on a Pacific Island: species dynamics and ecological thresholds. *Estuaries and Coasts*, 47(8), 2174-2189. https://doi.org/10.1007/s12237-024-01422-y

Bunting, P., Rosenqvist, A., Hilarides, L., Lucas, R. M., Thomas, N., Tadono, T., Worthington, T. A., Spalding, M.D., Murray, N. J., & Rebelo, L.-M. (2022). Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. *Remote Sensing*, *14*(15), 3657. https://doi.org/10.3390/rs14153657

Bunting, P., Rosenqvist, A., Lucas, R., Rebelo, L.-M., Hilarides, L., Thomas, N., Hardy, A., Itoh, T., Shimada, M., & Finlayson, C.M. (2018). The Global MangroveWatch—A new 2010 global baseline of mangrove extent. *Remote Sensing*, 10, 1669.

Butler, B. M. (editor). (1995). Archeological Investigations in the Achugao and Matansa Areas of Saipan, Mariana Islands. *Micronesian Archaeological Survey, Report No. 30*. Division of Historic Preservation, Department of Community and Cultural Affairs. Saipan, MP.

Cahoon, D. R., McKee, K. L., & Morris, J. T. (2021). How plants influence resilience of salt marsh and mangrove wetlands to sea-level rise. *Estuaries and Coasts*, 44, 883-898. https://doi.org/10.1007/s12237-020-00834-w

Cannon, P. G., Falanruw, M., Ruegorong, F., MacKenzie, R., Friday, K., Ross-Davis, A. L., Ashiglar, S. M., Klopfenstein, N. B., Liu, Z., Golabi, M., & Iyekar, C. T. (2014). The causes of mangrove death on Yap, Palau, Pohnpei and Kosrae [Chapter II]. In: Cannon, Phil. 2014. Forest pathology in Yap, Palau, Pohnpei, Kosrae, Guam and Saipan, Sept. 2013. Trip Report. Vallejo, CA: U.S. Department of Agriculture, Forest Service, Region 5, *Forest Health Protection*. p. 13-37. https://www.fs.usda.gov/rm/pubs_journals/2014/rmrs_2014_cannon_p003.pdf

Church, J. A., White, N. J., & Hunter, J. R. (2006). Sea-level rise at tropical Pacific and Indian Ocean islands. *Global and Planetary Change*, 53(3), 155-168. https://doi.org/10.1016/j.gloplacha.2006.04.001

Cole, T. G., Ewel, K. C., & Devoe, N. N. (1999). Structure of mangrove trees and forests in Micronesia. *Forest Ecology and Management*, 117(1-3), 95-109. https://doi.org/10.1016/S0378-1127(98)00474-5

Colin, P. L. (2009). Marine Environments of Palau. Coral Reef Research Foundation; *Indo-Pacific Press.*

Cooley, S., Schoeman, D., Bopp, L., Boyd, P., Donner, S., Ghebrehiwet, D. Y., *et al.* (2022). Oceans and coastal ecosystems and their services. In H. O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, *et al.* (Eds.), Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 379–550). *Cambridge University Press*.

Crameri, N. J. & Ellison, J. C., (2022). Atoll inland and coastal mangrove climate change vulnerability assessment. Wetlands Ecology and Management, 30(3), 527-546. https://doi.org/10.1007/s11273-022-09878-0

Dendy, J., Collins, P., Mesubed, D., Cordell, S., Giardina, C. P., Uowolo, A., & Iida, A., (2022). Centennial-scale land-cover change on Babeldaob Island, Palau. Land, 11(6), p.830. https://doi.org/10.3390/land11060830

Donato, D. C., Kauffman, J. B., Murdiyarso, D., Kurnianto, S., Stidham, M. & Kanninen, M. (2011). Mangroves among the most carbon-rich forests in the tropics. *Nature Geoscience*, 4(5), 293-297.

Donnegan, J. A., Butler, S. L., Kuegler, O. & Hiserote, B. A., (2011). Federated States of Micronesia's forest resources. (2006). *Resource Bulletin* PNW-RB-262. Pacific Northwest Research Station. https://doi.org/10.2737/PNW-RB-261

Ellison, J. C. (1999). Impacts of sediment burial on mangroves. *Marine Pollution Bulletin*, 37(8-12), 420-426. https://doi.org/10.1016/S0025-326X(98)00122-2

Ellison, J. C. (2009). Wetlands of the Pacific Island region. *Wetlands Ecology and Management*, 17(3), 169-206. https://doi.org/10.1007/s11273-008-9097-3

Ellison, J. C., (2015). Vulnerability assessment of mangroves to climate change and sea-level rise impacts. *Wetlands Ecology and Management,* 23, 115–137. https://doi.org/10.1007/s11273-014-9397-8

Ellison, J. C., & Stoddart, D. R. (1991). Mangrove ecosystem collapse during predicted sea-level rise: Holocene analogues and implications. *Journal of Coastal* Research, 7(1),151-165.

Ellison, J. C., Buffington, K. J., Thorne, K. M., Gesch, D., Irwin, J., & Danielson, J. (2022). Elevations of mangrove forests of Pohnpei, Micronesia. Estuarine, *Coastal and Shelf Science*, 268, 107780. https://doi.org/10.1016/j.ecss.2022.107780

Ellison, J. C., Crameri, N. J., & Suárez, E., 2024. IUCN Red List of Ecosystems, Mangroves of the Central Pacific. https://doi.org/10.32942/X2904X

Ewel, K. C., Twilley, R. R., & Ong, J. E. (1998). Different Kinds of Mangrove Forests Provide Different Goods and Services. *Global Ecology and Biogeography Letters*, 7(1), 83. https://doi.org/10.2307/2997700

Food and Agriculture Organization of the United Nations (FAO). (2015). Global Forest Resources Assessment 2015: Desk Reference. Rome, Italy: FAO

Giri, C., Ochieng, E., Tieszen, L. L., Zhu, Z., Singh, A., Loveland, T., Masak, J., & Duke, N. C. (2011). Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography, 20*(54–159). https://doi.org/10.1111/j.1466-8238.2010.00584.x

Greene, R., Skeele-Jordan, B., Chojnacki, J., & Donaldson, T. J. (2019). Natural Resource Condition Assessment: American Memorial Park. Natural Resource Report NPS/AMME/NRR—2019/1976. Department of the Interior, National Park Service (NPS), Fort Collins, CO, USA.

Golbuu, Y., Victor, S., Wolanski, E., & Richmond, R. H. (2003). Trapping of fine sediment in a semi-enclosed bay, Palau, Micronesia. *Estuarine, Coastal and Shelf Science*, 57(5-6), 941-949. https://doi.org/10.1016/S0272-7714(02)00424-9

Hogarth, P. J. (2015). The Biology of Mangroves and Seagrasses. Oxford University Press, Oxford, 3rd edition.

IUCN (2012). *IUCN Habitats classification scheme* (3.1). [Data set]. https://www.iucnredlist.org/resources/habitat-classification-scheme

IUCN (2022). *The IUCN Red List of Threatened Species.* (Version 2022-2) [Data set]. https://www.iucnredlist.org

IUCN-CMP (2022). *Unified Classification of Direct Threats* (3.3) [Data set]. https://www.iucnredlist.org/resources/threat-classification-scheme

IUCN (2024). Guidelines for the application of IUCN Red List of Ecosystems, Version 2.0. Keith, D. A., Ferrer-Paris, J. R., Ghoraba, S. M. M., Henriksen, S., Monyeki, M., Murray, N. J., Nicholson, E., Rowland, J., Skowno, A., Slingsby, J. A., Storeng, A. B., Valderrábano, M. & Zager, I. (Eds.). Gland, Switzerland: IUCN. https://doi.org/10.2305/CJDF9122

Joss, H. E. & Ferrier-Loh, A. (2025). Mangroves Across the Main Island Group of Palau: Using a LiDAR derived elevation model to inform mangrove extent and tree height distribution. Technical Report, Coral Reef Research Foundation, 1-18. https://coralreefpalau.org/wp-content/uploads/2025/11/CRRF-Mangrove-Mapping-Technical-Report-2025.pdf

Kauffman, J. B. and Cole, T. G., (2010). Micronesian mangrove forest structure and tree responses to a severe typhoon. Wetlands, 30(6), 1077-1084.

Keith, D. A., Ferrer-Paris, J. R., Nicholson, E., & Kingsford, R. T. (Eds.) (2020). *IUCN Global Ecosystem Typology 2.0: Descriptive profiles for biomes and ecosystem functional groups*. IUCN, International Union for Conservation of Nature. https://doi.org/10.2305/IUCN.CH.2020.13.en

Knee, L. K., Jericho, A., & Kim, K. (2025). Dissolved metal concentrations in coastal seawater and groundwater in Saipan, Commonwealth of the Northern Mariana Islands, USA. Marine Pollution Bulletin, 212. https://doi.org/10.1016/j.marpolbul.2024.117508

Krauss, K. W., Cahoon, D. R., Allen, J. A., Ewel, K. C., Lynch, J. C., & Cormier, N. (2010). Surface elevation change and susceptibility of different mangrove zones to sea-level rise on Pacific high islands of Micronesia. Ecosystems, 13(1), 129-143. https://doi.org/10.1007/s10021-009-9307-8

Krauss, K. W., McKee, K. L., Lovelock, C. E., Cahoon, D. R., Saintilan, N., Reef, R., & Chen, L. (2014). How mangrove forests adjust to rising sea level. *New Phytologist,* 202:19-34. https://doi.org/10.1111/nph.12605

Lee, C. K. F., Duncan, C., Nicholson, E., Fatoyinbo, T. E., Lagomasino, D., Thomas, N., Worthington, T. A., & Murray, N. J. (2021). Mapping the extent of mangrove ecosystem degradation by integrating an ecological conceptual model with satellite data. *Remote Sensing*, *13*(11), 2047. https://doi.org/10.3390/rs13112047

Liu, Z. (2011). Mangrove decline, 2003-2010, on the Yap Islands of Micronesia. Forest Service Technical Report. 1 page.

Lovelock, C. E., Cahoon, D. R., Friess, D. A., Guntenspergen, G. R., Krauss, K. W., Reef, R., Rogers, K., Saunders, M. L., Sidik, F., Swales, A., & Saintilan, N. (2015). The vulnerability of Indo-Pacific mangrove forests to sea-level rise. *Nature*, 526(7574), 559–563. https://doi.org/10.1038/nature15538

Lovelock, C. E., Feller, I. C., Reef, R., Hickey, S., & Ball, M. C. (2017). Mangrove dieback during fluctuating sea levels. *Scientific Reports*, *7*(1), 1680. https://doi.org/10.1038/s41598-017-01927-6

MacKenzie, R. A., Foulk, P. B., Klump, J. V., Weckerly, K., Purbospito, J., Murdiyarso, D., Donato, D. C. & Nam, V. N., (2016). Sedimentation and belowground carbon accumulation rates in mangrove forests that differ in diversity and land use: a tale of two mangroves. *Wetlands Ecology and Management*, 24(2), 245-261.

MacKenzie, R. A., Krauss, K. W., Cormier, N., Eperiam, E., van Aardt, J., Kargar, A. R., Grow, J. & Klump, J. V. (2024). Relative effectiveness of a radionuclide (210Pb), surface elevation table (SET), and LiDAR at monitoring mangrove forest surface elevation change. *Estuaries and Coasts*, 47(7), 2080-2092. https://doi.org/10.1007/s11273-016-9481-3

Maragos, J. E., Kepler, A. K., Hunter-Anderson, R. L., Donaldson, T. J., Geermans, S. H., McDermid, K. J., Idechong, N., Patris, S., Cook, C., Smith, B., Smith, R., & Meier, K. Z. (1994). Synthesis Report: Rapid Ecological Assessment of Palau: Part 1 June 1992. *Natural and Cultural Resources Survey of the Southwest Islands of Palau.*

McKee, K. L., D. R. Cahoon, & I. C. Feller. (2007). Caribbean mangroves adjust to rising sea level through biotic controls on change in soil elevation. *Global Ecology and Biogeography,* 16, 545-556. https://doi.org/10.1111/j.1466-8238.2007.00317.x

Merrifield, M. A., Thompson, P. R., & Lander, M. (2012). Multidecadal sea level anomalies and trends in the western tropical Pacific. Geophysical Research Letters, 39(13). https://doi.org/10.1029/2012GL052032

Murray, N. J., Keith, D. A., Tizard, R., Duncan, A., Htut, W. T., Oo, A. H., Ya, K. Z., & Grantham, M. (2020). *Threatened ecosystems of Myanmar: An IUCN Red List of Ecosystems Assessment. Version 1*. Wildlife Conservation Society. https://doi.org/10.19121/2019.Report.37457

PALARIS. (2021). Topo-bathy LiDAR Survey – Palau. Joint Airborne Lidar Bathymetry Technical Center of Expertise.

Plentovich, S., Mizerek, T., Reeves, M. K., Amidon, F., Miller, S. E., & Nanbara, M. (2020). Coastal strand and mangrove swamps of the Mariana Islands. *Encyclopedia of the World's Biomes*, 1, 185-197.

Reef, R., Feller, I. C. and Lovelock, C. E., (2010). Nutrition of mangroves. *Tree Physiology*, 30(9), pp.1148-1160. https://doi.org/10.1093/treephys/tpq048

Santana, N. (2018). Fire Recurrence and Normalized Difference Vegetation Index (NDVI) Dynamics in Brazilian Savanna. *Fire*, *2*(1), 1. https://doi.org/10.3390/fire2010001

Schuerch, M., Spencer, T., Temmerman, S., Kirwan, M. L., Wolff, C., Lincke, D., McOwen, C. J., Pickering, M. D., Reef, R., Vafeidis, A. T., Hinkel, J., Nicholls, R. J., & Brown, S. (2018). Future response of global coastal wetlands to sea-level rise. *Nature*, *561*(7722), 231–234. https://doi.org/10.1038/s41586-018-0476-5

Sefton, J. P., Kemp, A. C., Engelhart, S. E., Ellison, J. C., Karegar, M. A., Charley, B., & McCoy, M. D. (2022). Implications of anomalous relative sea-level rise for the peopling of Remote Oceania. *Proceedings of the National Academy of Sciences*, 119(52), e2210863119. https://doi.org/10.1073/pnas.2210863119

Spalding, M., Kainuma, M., Collins, L., 2010. World Atlas of Mangroves. Earthscan, London and Washington D.C.

Spalding, M. D., Fox, H. E., Allen, G. R., Davidson, N., Ferdaña, Z. A., Finlayson, M., Halpern, B. S., Jorge, M. A., Lombana, A., Lourie, S. A., Martin, K. D., McManus, E., Molnar, J., Recchia, C. A., & Robertson, J. (2007). Marine ecoregions of the world: A bioregionalization of coastal and shelf areas. *BioScience*, *57*(7), 573–583. https://doi.org/10.1641/B570707

Thomas, L. E., & Sisior, G. (2023). Environmental Assessment - Airai State Commercial Park Fill. https://www.palaugov.pw/wp-content/uploads/Airai-State-Commercial-Park-Fill.pdf

Twilley, R. R., Castañeda-Moya, E., Rivera-Monroy, V. H., & Rovai, A. (2017). Productivity and carbon dynamics in mangrove wetlands." In Mangrove ecosystems: A global biogeographic perspective: Structure, function, and services, pp. 113-162. Cham: *Springer International Publishing*

Woltz, V. L., Peneva-Reed, E. I., Zhu, Z., Bullock, E. L., MacKenzie, R. A., Apwong, M., Krauss, K. W., & Gesch, D. B., (2022). A comprehensive assessment of mangrove species and carbon stock on Pohnpei, Micronesia. Plos one, 17(7), p.e0271589. https://doi.org/10.1371/journal.pone.0271589

Woodroffe, C. D. (1995). Response of tide-dominated mangrove shorelines in Northern Australia to anticipated sea-level rise. *Earth Surface Processes and Landforms,* 20:65-85.

Woodroffe, C. D., Rogers, K., McKee, K. L., Lovelock, C. E., Mendelssohn, I., & Saintilan, N. (2016). Mangrove sedimentation and response to relative sea-level rise. *Annual Review of Marine Science*, 8:243-266. https://doi.org/10.1146/annurev-marine-122414-034025

Worthington, T. A., & Spalding, M. D. (2018). Mangrove Restoration Potential: A global map highlighting a critical opportunity. A*pollo - University of Cambridge Repository*. https://doi.org/10.17863/CAM.39153

Worthington, T. A., Zu Ermgassen, P. S. E., Friess, D. A., Krauss, K. W., Lovelock, C. E., Thorley, J., Tingey, R., Woodroffe, C. D., Bunting, P., Cormier, N., Lagomasino, D., Lucas, R., Murray, N. J., Sutherland, W. J., & Spalding, M. D. (2020). A global biophysical typology of mangroves and its relevance for ecosystem structure and deforestation. *Scientific Reports*, *10*(1), 14652. https://doi.org/10.1038/s41598-020-71194-5

Authors:

Ellison, J.C., Williams, Z.B., MacKenzie, R.A., Joss, H.E., Lin, C., Adema, D. & Suárez, E. L.

Acknowledgments

The Tropical Northwestern Pacific Mangrove Red List of Ecosystems authors thank the IUCN SSC Mangrove Specialist Group and the Global Mangrove Alliance Science Working group, for their support in the delineation of the level 4 mangrove units that were the basis for this analysis. Special thanks to José Rafael Ferrer-Paris for his contribution to the production of the general ecosystem description template for the RLE mangrove assessments and to PALARIS - Land and Resource Information System Office, Palau for providing the 2021 LiDAR dataset, which was integral in creating all the updated maps of Palau mangrove. We also wish to acknowledge Pat Colin at CRRF for his many contributions in historical imagery and information on mangroves across Palau and Thomas Worthington for kindly providing the spatial data on mangrove degradation.

Peer revision:

Sean McGregor
Don Macintosh

Web portal:

http://iucnrle.org/

7. Appendices

1. List of Key Mangrove Species

List of plant species considered true mangroves according to Red List of Threatened Species (RLTS) spatial data (IUCN, 2022). We included species whose range maps intersected with the boundary of the marine provinces/ecoregions described in the distribution section.

Class	Order	Family	Scientific name	RLTS category
Liliopsida	Arecales	Arecaceae	*Nypa fruticans*	LC
Magnoliopsida	Gentianales	Rubiaceae	*Scyphiphora hydrophylacea*	LC
Magnoliopsida	Lamiales	Acanthaceae	*Avicennia alba*	LC
Magnoliopsida	Lamiales	Acanthaceae	*Avicennia marina*	LC
Magnoliopsida	Malpighiales	Euphorbiaceae	*Excoecaria agallocha*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Bruguiera gymnorhiza*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Ceriops tagal*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Rhizophora apiculata*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Rhizophora mucronata*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Rhizophora stylosa*	LC
Magnoliopsida	Myrtales	Combretaceae	*Lumnitzera littorea*	LC
Magnoliopsida	Myrtales	Lythraceae	*Sonneratia alba*	LC
Magnoliopsida	Sapindales	Meliaceae	*Xylocarpus granatum*	LC

2. List of Associated Species

List of taxa that are associated with mangrove habitats in the Red List of Threatened Species (RLTS) database (IUCN, 2022). We included only species with entries for Habitat 1.7: “Forest - Subtropical/Tropical Mangrove Vegetation Above High Tide Level” or Habitat 12.7 for “Marine Intertidal - Mangrove Submerged Roots”, and with suitability recorded as “Suitable”, with “Major Importance” recorded as “Yes”, and any value of seasonality except “Passage”. We further filtered species with spatial point records in the GBIF (some species are excluded due to mismatch in taxonomic names, or lack of georeferenced records). The common names are those shown in the RLTS, except common names in brackets, which are from other sources.

Class	Order	Family	Scientific name	RLTS category	Common name
Liliopsida	Alismatales	Cymodoceaceae	*Halodule pinifolia*	LC	
Liliopsida	Alismatales	Cymodoceaceae	*Halodule uninervis*	LC	
Liliopsida	Alismatales	Cymodoceaceae	*Thalassodendron ciliatum*	LC	
Liliopsida	Alismatales	Hydrocharitaceae	*Enhalus acoroides*	LC	
Liliopsida	Alismatales	Hydrocharitaceae	*Halophila ovalis*	LC	
Liliopsida	Pandanales	Pandanaceae	*Pandanus dubius*	LC	Knob-fruited Screwpine
Liliopsida	Pandanales	Pandanaceae	*Pandanus tectorius*	LC	Beach Pandanus
Magnoliopsida	Apiales	Araliaceae	*Polyscias macgillivrayi*	LC	
Magnoliopsida	Boraginales	Cordiaceae	*Cordia subcordata*	LC	
Magnoliopsida	Ericales	Lecythidaceae	*Barringtonia asiatica*	LC	
Magnoliopsida	Ericales	Lecythidaceae	*Barringtonia racemosa*	LC	

Class	Order	Family	Scientific name	RLTS category	Common name
Magnoliopsida	Fabales	Fabaceae	*Cynometra ramiflora*	LC	Katong
Magnoliopsida	Fabales	Fabaceae	*Dalbergia beccarii*	LC	
Magnoliopsida	Fabales	Fabaceae	*Dalbergia candenatensis*	LC	
Magnoliopsida	Fabales	Fabaceae	*Dalbergia ferruginea*	LC	Akar langsa
Magnoliopsida	Fabales	Fabaceae	*Inocarpus fagifer*	LC	Tahitian Chestnut
Magnoliopsida	Fabales	Fabaceae	*Intsia bijuga*	NT	Merbau
Magnoliopsida	Lamiales	Acanthaceae	*Acanthus ebracteatus*	LC	
Magnoliopsida	Lamiales	Bignoniaceae	*Dolichandrone spathacea*	LC	
Magnoliopsida	Magnoliales	Myristicaceae	*Horsfieldia irya*	LC	
Magnoliopsida	Malvales	Malvaceae	*Heritiera littoralis*	LC	
Magnoliopsida	Malvales	Malvaceae	*Thespesia populnea*	LC	Portia Tree
Magnoliopsida	Myrtales	Combretaceae	*Terminalia catappa*	LC	Tavola
Magnoliopsida	Myrtales	Lythraceae	*Pemphis acidula*	LC	
Magnoliopsida	Santalales	Olacaceae	*Olax imbricata*	LC	
Actinopterygii	Albuliformes	Albulidae	*Albula glossodonta*	VU	Shortjaw Bonefish
Actinopterygii	Anguilliformes	Muraenidae	*Uropterygius concolor*	LC	Brown Moray Eel
Actinopterygii	Anguilliformes	Ophichthidae	*Scolecenchelys macroptera*	LC	
Actinopterygii	Atheriniformes	Atherinidae	*Atherinomorus lacunosus*	LC	Hardyhead Silverside
Actinopterygii	Aulopiformes	Synodontidae	*Saurida nebulosa*	LC	Clouded Lizardfish
Actinopterygii	Beloniformes	Zenarchopteridae	*Zenarchopterus buffonis*	LC	Buffonâ€™s River Garfish
Actinopterygii	Beloniformes	Zenarchopteridae	*Zenarchopterus dispar*	LC	Feathered River-garfish
Actinopterygii	Beloniformes	Zenarchopteridae	*Zenarchopterus gilli*	LC	Shortnose River Garfish
Actinopterygii	Clupeiformes	Engraulidae	*Encrasicholina punctifer*	LC	Buccaneer anchovy
Actinopterygii	Elopiformes	Elopidae	*Elops hawaiensis*	DD	Giant Herring
Actinopterygii	Elopiformes	Megalopidae	*Megalops cyprinoides*	DD	Indo-Pacific Tarpon
Actinopterygii	Gobiiformes	Eleotridae	*Bostrychus sinensis*	LC	Four-eyed Sleeper
Actinopterygii	Gobiiformes	Eleotridae	*Butis amboinensis*	LC	Ambon Gudgeon
Actinopterygii	Gobiiformes	Eleotridae	*Butis butis*	LC	Crimson-tipped Gudgeon
Actinopterygii	Gobiiformes	Eleotridae	*Butis gymnopomus*	LC	Striped Crazy Fish
Actinopterygii	Gobiiformes	Eleotridae	*Eleotris acanthopomus*	LC	Spine-cheek Gudgeon
Actinopterygii	Gobiiformes	Eleotridae	*Eleotris fusca*	LC	Brown Spinecheek Gudgeon
Actinopterygii	Gobiiformes	Eleotridae	*Eleotris melanosoma*	LC	Broadhead Sleeper
Actinopterygii	Gobiiformes	Gobiidae	*Amblyeleotris gymnocephala*	LC	Masked Shrimpgoby
Actinopterygii	Gobiiformes	Gobiidae	*Amblygobius buanensis*	LC	Buan Goby

Class	Order	Family	Scientific name	RLTS category	Common name
Actinopterygii	Gobiiformes	Gobiidae	*Amblygobius esakiae*	LC	Snout-spot Goby
Actinopterygii	Gobiiformes	Gobiidae	*Amblygobius linki*	LC	Link's Goby
Actinopterygii	Gobiiformes	Gobiidae	*Asterropteryx semipunctata*	LC	
Actinopterygii	Gobiiformes	Gobiidae	*Cryptocentrus leptocephalus*	LC	Pink-speckled Shrimpgoby
Actinopterygii	Gobiiformes	Gobiidae	*Drombus triangularis*	LC	Brown Drombus
Actinopterygii	Gobiiformes	Gobiidae	*Eviota storthynx*	LC	Belly-spotted Pygmy-goby
Actinopterygii	Gobiiformes	Gobiidae	*Exyrias puntang*	LC	Puntang Goby
Actinopterygii	Gobiiformes	Gobiidae	*Feia nympha*	LC	Nymph Goby
Actinopterygii	Gobiiformes	Gobiidae	*Glossogobius circumspectus*	LC	Circumspect Goby
Actinopterygii	Gobiiformes	Gobiidae	*Istigobius ornatus*	LC	Ornate Goby
Actinopterygii	Gobiiformes	Gobiidae	*Mahidolia mystacina*	LC	Flagfin Prawn Goby
Actinopterygii	Gobiiformes	Gobiidae	*Mangarinus waterousi*	DD	Uchiwahaze
Actinopterygii	Gobiiformes	Gobiidae	*Mugilogobius cavifrons*	LC	Bandfin Mangrove Goby
Actinopterygii	Gobiiformes	Gobiidae	*Mugilogobius platystoma*	LC	Indonesian Goby
Actinopterygii	Gobiiformes	Gobiidae	*Oligolepis acutipennis*	LC	Paintedfin Goby
Actinopterygii	Gobiiformes	Gobiidae	*Oxyurichthys lonchotus*	LC	Speartail Mudgoby
Actinopterygii	Gobiiformes	Gobiidae	*Oxyurichthys microlepis*	LC	Maned Goby
Actinopterygii	Gobiiformes	Gobiidae	*Oxyurichthys ophthalmonema*	LC	Eyebrow Goby
Actinopterygii	Gobiiformes	Gobiidae	*Oxyurichthys takagi*	LC	
Actinopterygii	Gobiiformes	Gobiidae	*Periophthalmus argentilineatus*	LC	Barred Mudskipper
Actinopterygii	Gobiiformes	Gobiidae	*Periophthalmus kalolo*	LC	Kalolo Mudskipper
Actinopterygii	Gobiiformes	Gobiidae	*Psammogobius biocellatus*	LC	Sleepy Goby
Actinopterygii	Gobiiformes	Gobiidae	*Pseudogobius melanosticta*	LC	Black-spotted Goby
Actinopterygii	Gobiiformes	Gobiidae	*Redigobius balteatus*	LC	Girdled Goby
Actinopterygii	Gobiiformes	Gobiidae	*Stenogobius fehlmanni*	LC	
Actinopterygii	Gobiiformes	Gobiidae	*Trypauchen vagina*	LC	Burrowing Goby
Actinopterygii	Gobiiformes	Gobiidae	*Trypauchenopsis intermedia*	LC	Bearded Eel Goby
Actinopterygii	Gobiiformes	Gobiidae	*Yongeichthys nebulosus*	LC	Shadow Goby
Actinopterygii	Lophiiformes	Antennariidae	*Antennarius biocellatus*	DD	Brackish Water Anglerfish
Actinopterygii	Ophidiiformes	Carapidae	*Encheliophis homei*	LC	Silver Pearlfish
Actinopterygii	Perciformes	Ambassidae	*Ambassis buruensis*	DD	Buru Glassfish
Actinopterygii	Perciformes	Ambassidae	*Ambassis interrupta*	LC	Long-spined Glassfish
Actinopterygii	Perciformes	Ambassidae	*Ambassis nalua*	LC	Scalloped Perchlet
Actinopterygii	Perciformes	Ambassidae	*Ambassis urotaenia*	LC	Bleeker's Glass Perchlet

Class	Order	Family	Scientific name	RLTS category	Common name
Actinopterygii	Perciformes	Apogonidae	*Apogon amboinensis*	DD	Ambon Cardinalfish
Actinopterygii	Perciformes	Apogonidae	*Apogonichthyoides melas*	LC	Black Cardinalfish
Actinopterygii	Perciformes	Apogonidae	*Fowleria variegata*	LC	Variegated Cardinalfish
Actinopterygii	Perciformes	Apogonidae	*Ostorhinchus lateralis*	LC	Humpback Cardinal
Actinopterygii	Perciformes	Apogonidae	*Pseudamia amblyuroptera*	LC	White-jawed Cardinalfish
Actinopterygii	Perciformes	Apogonidae	*Sphaeramia orbicularis*	LC	Orbiculate Cardinalfish
Actinopterygii	Perciformes	Apogonidae	*Taeniamia buruensis*	LC	Buru Cardinalfish
Actinopterygii	Perciformes	Apogonidae	*Yarica hyalosoma*	LC	Mangrove Cardinalfish
Actinopterygii	Perciformes	Blenniidae	*Omobranchus obliquus*	LC	Mangrove Blenny
Actinopterygii	Perciformes	Blenniidae	*Omox biporos*	LC	Omox Blenny
Actinopterygii	Perciformes	Caesionidae	*Caesio cuning*	LC	Redbelly yellowtail fusilier
Actinopterygii	Perciformes	Carangidae	*Atule mate*	LC	Yellowtail Scad
Actinopterygii	Perciformes	Ephippidae	*Platax orbicularis*	LC	Orbiculate Batfish
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus coioides*	LC	Orange-spotted Grouper
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus malabaricus*	LC	
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus miliaris*	LC	Netfin Grouper
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus tauvina*	DD	Greasy Grouper
Actinopterygii	Perciformes	Gerreidae	*Gerres erythrourus*	LC	Deep-bodied Mojarra
Actinopterygii	Perciformes	Gerreidae	*Gerres filamentosus*	LC	Whipfin Mojarra
Actinopterygii	Perciformes	Haemulidae	*Plectorhinchus gibbosus*	LC	Brown Sweetlips
Actinopterygii	Perciformes	Haemulidae	*Pomadasys argenteus*	LC	Silver Javelin
Actinopterygii	Perciformes	Labridae	*Novaculichthys macrolepidotus*	LC	
Actinopterygii	Perciformes	Leiognathidae	*Gazza minuta*	LC	Toothed Ponyfish
Actinopterygii	Perciformes	Leiognathidae	*Leiognathus equulus*	LC	Common Ponyfish
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus genivittatus*	LC	
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus harak*	LC	Thumbprint Emperor
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus ornatus*	LC	Ornate Emperor
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus semicinctus*	LC	Black-Spot Emperor
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus ehrenbergii*	LC	Blackspot Snapper
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus fulviflamma*	LC	Dory Snapper
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus fulvus*	LC	Blacktail Snapper
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus russellii*	LC	Russell's Snapper

Class	Order	Family	Scientific name	RLTS category	Common name
Actinopterygii	Perciformes	Microdesmidae	*Parioglossus formosus*	LC	
Actinopterygii	Perciformes	Microdesmidae	*Parioglossus lineatus*	DD	
Actinopterygii	Perciformes	Microdesmidae	*Parioglossus palustris*	LC	
Actinopterygii	Perciformes	Microdesmidae	*Parioglossus rainfordi*	LC	
Actinopterygii	Perciformes	Microdesmidae	*Parioglossus raoi*	LC	Yellow Dartfish
Actinopterygii	Perciformes	Microdesmidae	*Parioglossus taeniatus*	LC	Striped Dartfish
Actinopterygii	Perciformes	Monodactylidae	*Monodactylus argenteus*	LC	Silver Moony
Actinopterygii	Perciformes	Mullidae	*Parupeneus barberinus*	LC	Dash-and-dot goatfish
Actinopterygii	Perciformes	Nemipteridae	*Scolopsis ciliata*	LC	Saw-jawed Monocle Bream
Actinopterygii	Perciformes	Pomacentridae	*Dascyllus trimaculatus*	LC	Threespot Damselfish
Actinopterygii	Perciformes	Pomacentridae	*Dischistodus perspicillatus*	LC	White Damsel
Actinopterygii	Perciformes	Pomacentridae	*Neopomacentrus taeniurus*	DD	Freshwater Damsel
Actinopterygii	Perciformes	Pomacentridae	*Pomacentrus taeniometopon*	LC	
Actinopterygii	Perciformes	Scatophagidae	*Scatophagus argus*	LC	Spotted Scat
Actinopterygii	Perciformes	Siganidae	*Siganus guttatus*	LC	Golden Rabbitfish
Actinopterygii	Perciformes	Siganidae	*Siganus lineatus*	LC	Lined Rabbitfish
Actinopterygii	Perciformes	Siganidae	*Siganus randalli*	LC	Randall's Rabbitfish
Actinopterygii	Perciformes	Siganidae	*Siganus vermiculatus*	LC	Vermiculated Spinefoot
Actinopterygii	Pleuronectiformes	Paralichthyidae	*Pseudorhombus arsius*	LC	Largetooth Flounder
Actinopterygii	Scorpaeniformes	Platycephalidae	*Cociella punctata*	LC	Spotted Flathead
Actinopterygii	Scorpaeniformes	Platycephalidae	*Cymbacephalus beauforti*	LC	Crocodile Fish
Actinopterygii	Scorpaeniformes	Tetrarogidae	*Tetraroge barbata*	LC	
Actinopterygii	Syngnathiformes	Syngnathidae	*Bhanotia nuda*	LC	Naked Pipefish
Actinopterygii	Syngnathiformes	Syngnathidae	*Choeroichthys sculptus*	LC	Sculptured Pipefish
Actinopterygii	Syngnathiformes	Syngnathidae	*Hippichthys cyanospilos*	LC	Bluespeckled Pipefish
Actinopterygii	Syngnathiformes	Syngnathidae	*Hippichthys spicifer*	LC	Bellybarred Pipefish
Actinopterygii	Tetraodontiformes	Tetraodontidae	*Arothron hispidus*	LC	White-spotted Puffer
Actinopterygii	Tetraodontiformes	Tetraodontidae	*Arothron manilensis*	LC	Narrow-lined Puffer
Actinopterygii	Tetraodontiformes	Tetraodontidae	*Arothron reticularis*	LC	Reticulated Pufferfish
Actinopterygii	Tetraodontiformes	Tetraodontidae	*Arothron stellatus*	LC	Stellate Puffer
Actinopterygii	Tetraodontiformes	Tetraodontidae	*Chelonodontops patoca*	LC	Milkspotted Puffer
Actinopterygii	Tetraodontiformes	Tetraodontidae	*Takifugu oblongus*	LC	Lattice Blaasop
Amphibia	Anura	Ceratobatrachidae	*Cornufer pelewensis*	LC	Palau Wrinkled Ground Frog
Anthozoa	Scleractinia	Rhizangiidae	*Siderastrea savignyana*	LC	

Class	Order	Family	Scientific name	RLTS category	Common name
Aves	Caprimulgiformes	Apodidae	*Aerodramus bartschi*	EN	Mariana Swiftlet
Aves	Caprimulgiformes	Caprimulgidae	*Caprimulgus phalaena*	NT	Palau Nightjar
Aves	Charadriiformes	Charadriidae	*Charadrius mongolus*	LC	Lesser Sandplover
Aves	Charadriiformes	Scolopacidae	*Actitis hypoleucos*	LC	Common Sandpiper
Aves	Charadriiformes	Scolopacidae	*Numenius arquata*	NT	Eurasian Curlew
Aves	Charadriiformes	Scolopacidae	*Numenius phaeopus*	LC	Whimbrel
Aves	Charadriiformes	Scolopacidae	*Tringa nebularia*	LC	Common Greenshank
Aves	Columbiformes	Columbidae	*Caloenas nicobarica*	NT	Nicobar Pigeon
Aves	Columbiformes	Columbidae	*Ducula oceanica*	VU	Micronesian Imperial-pigeon
Aves	Columbiformes	Columbidae	*Pampusana kubaryi*	EN	Caroline Ground-dove
Aves	Columbiformes	Columbidae	*Ptilinopus hernsheimi*	LC	Kosrae Fruit-dove
Aves	Columbiformes	Columbidae	*Ptilinopus pelewensis*	LC	Palau Fruit-dove
Aves	Columbiformes	Columbidae	*Ptilinopus ponapensis*	LC	Pohnpei Fruit-dove
Aves	Columbiformes	Columbidae	*Ptilinopus roseicapilla*	NT	Mariana Fruit-dove
Aves	Coraciiformes	Alcedinidae	*Todiramphus chloris*	LC	Collared Kingfisher
Aves	Coraciiformes	Alcedinidae	*Todiramphus pelewensis*	NT	Palau Kingfisher
Aves	Coraciiformes	Alcedinidae	*Todiramphus reichenbachii*	VU	Pohnpei Kingfisher
Aves	Gruiformes	Rallidae	*Amaurornis cinerea*	LC	White-browed Crake
Aves	Gruiformes	Rallidae	*Amaurornis phoenicurus*	LC	White-breasted Waterhen
Aves	Gruiformes	Rallidae	*Hypotaenidia philippensis*	LC	Buff-banded Rail
Aves	Gruiformes	Rallidae	*Rallina eurizonoides*	LC	Slaty-legged Crake
Aves	Passeriformes	Artamidae	*Artamus leucoryn*	LC	White-breasted Woodswallow
Aves	Passeriformes	Campephagidae	*Edolisoma insperatum*	EN	Pohnpei Cicadabird
Aves	Passeriformes	Campephagidae	*Edolisoma monacha*	LC	Palau Cicadabird
Aves	Passeriformes	Campephagidae	*Edolisoma tenuirostre*	LC	Slender-billed Cicadabird
Aves	Passeriformes	Estrildidae	*Erythrura trichroa*	LC	Blue-faced Parrotfinch
Aves	Passeriformes	Meliphagidae	*Myzomela rubratra*	LC	Micronesian Myzomela
Aves	Passeriformes	Monarchidae	*Metabolus godeffroyi*	NT	Yap Monarch
Aves	Passeriformes	Monarchidae	*Metabolus rugensis*	EN	Chuuk Monarch
Aves	Passeriformes	Monarchidae	*Myiagra erythrops*	LC	Palau Flycatcher
Aves	Passeriformes	Rhipiduridae	*Rhipidura lepida*	LC	Palau Fantail
Aves	Passeriformes	Rhipiduridae	*Rhipidura rufifrons*	LC	Rufous Fantail
Aves	Passeriformes	Zosteropidae	*Zosterops oleagineus*	NT	Yap Olive White-eye

Class	Order	Family	Scientific name	RLTS category	Common name
Aves	Pelecaniformes	Ardeidae	*Ardea intermedia*	LC	Intermediate Egret
Aves	Pelecaniformes	Ardeidae	*Egretta garzetta*	LC	Little Egret
Aves	Pelecaniformes	Ardeidae	*Ixobrychus sinensis*	LC	Yellow Bittern
Aves	Pelecaniformes	Ardeidae	*Nycticorax caledonicus*	LC	Rufous Night-heron
Aves	Strigiformes	Strigidae	*Pyrroglaux podargina*	LC	Palau Owl
Aves	Suliformes	Fregatidae	*Fregata ariel*	LC	Lesser Frigatebird
Aves	Suliformes	Fregatidae	*Fregata minor*	LC	Great Frigatebird
Aves	Suliformes	Phalacrocoracidae	*Microcarbo melanoleucos*	LC	Little Pied Cormorant
Chondrichthyes	Carcharhiniformes	Carcharhinidae	*Carcharhinus melanopterus*	VU	Blacktip Reef Shark
Chondrichthyes	Carcharhiniformes	Carcharhinidae	*Negaprion acutidens*	EN	Sharptooth Lemon Shark
Chondrichthyes	Myliobatiformes	Dasyatidae	*Urogymnus granulatus*	VU	Mangrove Whipray
Chondrichthyes	Rhinopristiformes	Pristidae	*Pristis clavata*	CR	Dwarf Sawfish
Gastropoda	Cycloneritida	Neritidae	*Neritina zigzag*	LC	
Gastropoda	Cycloneritida	Neritidae	*Neritodryas subsulcata*	DD	Weakly Cut Nerite
Gastropoda	Ellobiida	Ellobiidae	*Ellobium chinense*	DD	
Gastropoda	Littorinimorpha	Littorinidae	*Littoraria undulata*	LC	
Gastropoda	Neogastropoda	Conidae	*Conus frigidus*	LC	Frigid Cone
Gastropoda	Neogastropoda	Conidae	*Conus varius*	LC	
Gastropoda	Sorbeoconcha	Potamididae	*Cerithium coralium*	LC	Coral Cerith
Gastropoda	Stylommatophora	Achatinellidae	*Lamellidea pusilla*	LC	
Holothuroidea	Aspidochirotida	Holothuriidae	*Holothuria impatiens*	DD	
Holothuroidea	Aspidochirotida	Holothuriidae	*Holothuria scabra*	EN	
Mammalia	Chiroptera	Pteropodidae	*Pteropus mariannus*	EN	Mariana Fruit Bat
Mammalia	Chiroptera	Pteropodidae	*Pteropus molossinus*	EN	Pohnpei Flying Fox
Mammalia	Chiroptera	Pteropodidae	*Pteropus pelagicus*	EN	Chuuk Flying Fox
Mammalia	Chiroptera	Pteropodidae	*Pteropus pelewensis*	VU	Palau Flying Fox
Mammalia	Chiroptera	Pteropodidae	*Pteropus ualanus*	EN	Kosrae Flying Fox
Reptilia	Squamata	Elapidae	*Laticauda colubrina*	LC	
Reptilia	Squamata	Elapidae	*Laticauda laticaudata*	LC	
Reptilia	Squamata	Gekkonidae	*Lepidodactylus lugubris*	LC	Mourning Gecko
Reptilia	Squamata	Scincidae	*Emoia atrocostata*	LC	Littoral Whiptail-skink
Reptilia	Squamata	Varanidae	*Varanus indicus*	LC	Mangrove Monitor
Reptilia	Testudines	Cheloniidae	*Eretmochelys imbricata*	CR	Hawksbill Turtle