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Federated States of Micronesia (FSM) International Waters Ridge to Reef Project

Tofol Watershed Catchment Biological Rapid Assessment, Kosrae State, FSM



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Prepared by Carlos Jose Cianchini

Produced by GEF Pacific International Waters Ridge to Reef Regional Project,
Pacific Community (SPC), Suva, Fiji



Suva, Fiji, 2021

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Original text: English

Citation: Cianchini, C. J. 2021. Tofol Watershed Catchment Biological Rapid Assessment, Kosrae State, FSM. SPC, 13 pp

Reviewed by John A. Carreon, Samasoni Sauni, Fononga Vainga Mangisi-Mafileo, Aliti Vunisea.

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Produced by GEF Pacific International Waters Ridge to Reef Regional Project, Pacific Community (SPC), Suva, Fiji.

Cover Photo by Dr. Nick Zoa, Entrance to the Innem river

Layout and Design by Navneet Lal/Pacific Community (SPC)

Prepared for publication at SPC's Suva Regional Office, Private Mail Bag, Suva, Fiji, 2021

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Printed by Quality Print, Suva, Fiji, 2021

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ABBREVIATIONS

FSM – Federated States of Micronesia

GEF – Global Environment Fund

R2R IW –Ridge to Reef International Waters Project

LMPA – Lelu Marine Protected Area

TMCF – Tropical Montane Cloud Forest

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ACKNOWLEDGEMENTS

We wish to acknowledge and say thank you to all the people who helped us during this watershed assessment, including but not limited to KIRMA's Administrator Blair Charley, State Forester Maxon Nithan, and GIS expert Betwin Tilfas for their information, maps, and support. We are thankful to all the landowners in the Tofol area who allowed us to pass through their yards, farms, and forests to access the Tofol, Srungansralu and Innem Rivers. We thank TreeLodge and Nautilus Resorts for the use of their kayaks. Dr. Rich Mackenzie provided the photos of the male gobies. Finally, we thank Andy George and Faith Siba for their advice, supervision, and coordination of this project.

1. INTRODUCTION

The Pacific Regional International Waters Ridge to Reef Project is a five-year initiative funded by the Global Environment Facility (GEF) aimed to test the mainstreaming of ridge to reef (R2R), climate resilient approaches to integrated land, water, forest, and coastal management in the PICs through strategic planning, capacity building and piloted local actions to sustain and preserve ecosystem services. The GEF investment for this program contributes to the GEF-5 focal areas:

- Land degradation
- Biodiversity conservation
- Sustainable land and forest management
- Climate change adaptation and mitigation

This is a multi-agency initiative involving the United Nations Development Program (UNDP), the UN Food and Agriculture Organization and the UN Environmental Program as GEF implementing agencies.

The Pacific Ridge to Reef International Waters Project (GEF Pacific R2R IW) is designed to strengthen synergies between government, communities, and the private sector. The FSM IW-R2R Project is implemented in partnership between the Department of Environment, Climate Change and Emergency Management (National Government) and The Kosrae Conservation and Safety Organization.

The FSM's IW R2R Project demonstration area is in Lelu Municipality, extending from Mutunneneah to Tofol, the administrative center of Kosrae. The three rivers which are found in this area are the Tofol, Srungansralu and Innem Rivers. The watersheds of these three rivers receive rainfall from the Mahkontowe Conservation Area.

Kosrae is a tropical island located at 5.3° north and 163° east. The population of Kosrae is 6,732 according to projections by the 2020 census. The total area of the island is roughly 110 km².

One of the key benefits of this project will be the development and establishment of a Tofol Area Watershed Management Plan. This plan will promote effective management of water, land, forest, and coastal ecosystems using the ridge to reef approach.

2. METHODOLOGY

The biological assessment was carried out in Tofol River (March 21 and 28 2021), Innem River (March 31, 2021) and Srungansralu River (April 1, 2021) (Table 1) while three estuaries were visited on April 2, 2021. The biological assessment was done through collection of fauna (previously it was planned that snorkelling would be used but the water was too shallow). A GPS app was used to collect location data which was accurate to within 10 metres. Photos of the collected fauna were taken and samples such as two snails were collected for further identification. Literature review of species was used for further identification noting that there have been previous river surveys with similar methodology conducted by the principal researcher of this report in collaboration with the US Forest Service (unpublished).

For the biological assessment, tables of flora and fauna were populated for Tofol, Srungansralu and Innem rivers. The scientific names, habitat, and common names (used in Lelu) were provided. Amongst the numerous species of flora and fauna, key species such as endemic and invasive species were highlighted. Visual assessments of the turbidity of water were made and were recorded based on various weather conditions including during and after torrential rains occurring on April 17th, 2021 (Appendix 1). Water quality parameter data could not be performed as the lack of a laboratory with capabilities to analyze those parameters.



3. RESULTS

Water quality data was visually assessed. Table 1 shows the descriptive and visual observations of Tofol, sInnem and Srungansralu rivers.

Table 1: River names, dates of visit and description of visual observations of water quality.

River names	Dates of visit	Description and visual observations of water quality
Tofol River	March 21 and 28 2021	The Tofol River was clean and clear in undeveloped areas at high elevation. The only causes of water quality degradation are the easily eroded clay banks and riverbed. From the legislature to the radio station, human activity caused some cloudiness. Near the mangroves, inflow from tides brought in coral silt from Lelu Harbor.
Innem River	March 31 2021	Unlike the North Srungansralu on the south side of the Innem Valley, the Innem River remained clean and clear down to the bridge on the main road. This is due to five reasons: (1) The Innem drains a larger part of the watershed, so it has more water. (2) The Innem is at a slightly higher elevation than the Srungansralu, so it remains a fast-flowing stream all the way to the main road. (3) There is little farming upstream. No ditches have been dug to drain the farmlands. (4) The houses are at least 200 yards from the river. (5) The banks of the Innem are forested or covered with vegetation; whereas the Srungansralu has tidal mud flats on both banks.
Srungansralu River	April 1 2021	The water in the North Srungansralu started at a spring that is clean enough for cooking and cleaning. Yet 500 yards downstream, it was a muddy, brackish estuary due to runoff from homes and agriculture and tides flowing through a silt-filled marsh. The South Srungansralu carried more water than the North Srungansralu because it drained a larger watershed. When it was not raining, this river stayed fairly clean due to its high-water flow and the fact that there were no homes and less farming in this valley. It was likely that, during times of heavy rain, silt from the hospital construction site contaminated this stream and was carried to the alluvial marsh downstream.

From the biological assessment of flora, it was found that species most commonly occurring in Tofol, Srungansralu and Innem rivers were *Crenimugil crenilabi*, *Kuhlia rupestris*, *Lutjanus argentimaculatus*, *Lutjanus fulvus*, *Neritina pulcherrima* and *Siganus punctatus*. Species that were found in Tofol and Innem rivers only, were *Anguilla marmorata* and *Stiphodon elegans*. Species that were only found in Srungansralu and Innem rivers were *Caridina* sp., *Egretta sacra* and *Periopthalmus argentilineatus*. Only one species was found in both Tofol and Srungansralu river and that was *Macrobrachium lar*.

Table 2: Species commonly found in Tofol, Srungansralu and Innem rivers.

Species Name	Tofol	Srungansralu	Innem
<i>Anguilla marmorata</i>	✓		✓
<i>Caridina sp.</i>		✓	✓
<i>Crenimugil crenilabis</i>	✓	✓	✓
<i>Egretta sacra</i>		✓	✓
<i>Kuhlia rupestris</i>	✓	✓	✓
<i>Lutjanus argentimaculatus</i>	✓	✓	✓
<i>Lutjanus fulvus</i>	✓	✓	✓
<i>Macrobrachium lar</i>	✓	✓	
<i>Neritina pulcherrima</i>	✓	✓	✓
<i>Periopthalmus argentilineatus</i>		✓	✓
<i>Siganus punctatus</i>	✓	✓	✓
<i>Stiphodon elegans</i>	✓		✓

The species from Table 2 were then classified into their sampling areas whether they were in developed areas, estuaries, upland or occurred in more than one of those areas. *Anguilla marmorata* was the only species that occurred in developed areas. *Egretta sacra*, *Lutjanus argentimaculatus*, *Lutjanus fulvus* and *Periopthalmus argentilineatus* were only found in estuaries. *Caridina sp.* and *Stiphodon elegans* were only found upland. Species that occurred in developed areas and estuaries were *Crenimugil crenilabis* and *Siganus punctatus*. Species that occurred in developed areas and upland were *Kuhlia rupestris*, *Macrobrachium lar* and *Neritina pulcherrima*. There were no species that occurred in both estuaries and upland.

Table 3: Species commonly found in developed areas, estuaries, and upland

Species Name	Developed Area	Estuary	Upland
<i>Anguilla marmorata</i>	✓		
<i>Caridina sp.</i>			✓
<i>Crenimugil crenilabis</i>	✓	✓	
<i>Egretta sacra</i>		✓	
<i>Kuhlia rupestris</i>	✓		✓
<i>Lutjanus argentimaculatus</i>		✓	
<i>Lutjanus fulvus</i>		✓	
<i>Macrobrachium lar</i>	✓		✓
<i>Neritina pulcherrima</i>	✓		✓
<i>Periopthalmus argentilineatus</i>		✓	
<i>Siganus punctatus</i>	✓	✓	
<i>Stiphodon elegans</i>			✓

It is important to note that there were no flora recorded in Tofol and Table 4 documents the spatial distribution of species according to developed areas, estuaries, and upland. Species that occurred in all three areas were *Asplenium nidus* and *Phragmites karka*. Species that occurred in both developed areas and estuaries only were *Derris trifoliata*, *Hibiscus tiliaceus* and *Nypa fruticans*. Species that occurred in developed areas and upland only were *Manihot esculenta*, *Merremia peltata* (invasive species) and *Terminalia carolinensis* (endemic species). Species that occurred in estuaries and upland only were *Sonneratia alba* (amongst mangroves). It was also noted that *Bruguiera gymnorrhiza* occurred only in estuaries and, *Sphaeropteris lunulata*, *Sphaeropteris nigricans* and *Tectaria grandiflora* only occurred upland.

Table 4: Species distribution in developed areas, estuaries and upland for species that occur in both Srungansralu and Innem rivers.

Species Name	Developed Area	Estuary	Upland
<i>Asplenium nidus</i>	✓	✓	✓
<i>Barringtonia racemosa</i>	✓		
<i>Bruguiera gymnorrhiza</i>		✓ (mangrove)	
<i>Costus speciosus</i> (invasive)	✓		✓
<i>Derris trifoliata</i>	✓	✓	
<i>Hibiscus tiliaceus</i>	✓	✓	
<i>Horsfieldia irya</i>			✓
<i>Manihot esculenta</i>	✓		✓
<i>Merremia peltata</i> (invasive)	✓		
<i>Nephrolepis obliterated</i>			✓
<i>Nypa fruticans</i>	✓	✓	
<i>Phragmites karka</i>	✓	✓	✓
<i>Sonneratia alba</i>		✓ (mangrove)	✓
<i>Sphaeropteris lunulata</i>			✓
<i>Sphaeropteris nigricans</i>			✓
<i>Tectaria grandiflora</i>			✓
<i>Terminalia carolinensis</i>	✓		

4. DISCUSSION

Data was collected in the three rivers that discharged into parts of the marine protected area (MPA) in Lelu harbour. These rivers were Tofol, Srungansralu and Innem rivers which were geographically close to and shared many common species depicted in Table 2.



Figure 2: Tofol, Srungansralu and Innem rivers

The vegetation in the three rivers was similar, but it was found that some trees were present in only one of the rivers (see the list of species at each river which includes the common names of the flora and fauna of Kosrae). The fauna of the rivers was also very similar due to some of the river fauna having diadromous life cycles. They have evolved dependency on the stream habitat, but produce larvae that develop in the ocean, (Macioleck, J. A. 1987). Examples of this life cycle are crustaceans, snails, and fishes. This is evidence that it is essential that a cross-sectoral (ridge-to-reef) management approach is needed when managing these natural environments and resources.

The fauna in these rivers are shared in Oceania. Some of the crustaceans in Kosrae's rivers can be found from India to the Marquesas Islands, (Buden, D.W. 2001) and the fishes and snails also found in the Pacific Ocean.

The mangrove ecosystem that the three rivers shared is included as a Conservation Target in the "A Blueprint for Conserving the Biodiversity of the FSM" (Figure 3). Below are other conservation targets that can be found in the study area which includes the Micronesian imperial pigeon (*Ducula oceanica*) and arno skink (*Emoia arnoensis*), both found in the upland forests, the Kosrae flying fox (*Pteropus mariannus ualrus*) on Yen Island, Noddy and White terns - which use Mutunneneah channel as nesting areas. It is also notable that mangrove forests surround most of the LMPA, and

areas of interest for conservation also include montane cloud forests, riparian upland forests and swamp forests.

Flora of interest sampled in the current project included *Mikania micrantha* which is an invasive species found in this study to occur only in Srungansralu river and, *Piper ponapense* (found in Srungansralu river only) and *Terminalia carolinensis* (found in both Srungansralu and Innem rivers) which are both endemic species.



Figure 3: Kosrae conservation targets

Another influx from freshwater into the Protected Area, is from the Mutunneneah channel. A major river, Pukusrik and a few intermittent streams brought in freshwater into the Protected Area. This channel also inputted sediments after heavy rain. It has been suggested that opening the channel at Insrefusur, will clear the water at Lelu harbor. According to anecdotes by Doug Ramsey (coastal engineer) this strategy will not work, because the opened channel will encourage the siphoning of sand and lead to a clogging of the opened channel. The channel was opened in 1905 (Buck, 2005), to ease the transportation from Tafunsak to Lelu. To improve the water quality of the bay and LMPA, replacing the causeway with more arches would increase the water flow from the reef flat to the harbour.

4.1 Challenges and Threats

Threats to the LMPA were sedimentation and pollution (garbage). Landscaping for infrastructure leaves the soil exposed which allows for rain to wash sediments into the Protected Area. There is a lot of construction in Tofol, and the sedimentation barriers are not maintained. The sedimentation input is worse in the Tofol and Srungansralu rivers. Trash was also noted in the rivers all the way to the estuary. Heavy rains on April 17, 2021, discharged large amounts of sediments from the three rivers researched in this study as well as the Mutunneneah channel and the Tafeyat river. During low tide, the sediment plume was clearly seen outside Lelu's Harbour into the open sea, which would have affected the coral reefs negatively.

4.2 Vegetation and Fauna Summary

Starting from the estuaries of the three rivers at Lelu's harbour, the vegetation was similar. At the mouth of the rivers, it was found that *Sonneratia alba* and *Nypa fruticans* were the dominant trees. Upriver, it was found that *Bruguiera gymnorrhiza* replaced *Sonneratia* as the dominant tree. Only one *Rhizophora sp.* individual was seen in these three rivers. Going upstream, the freshwater wetland was reached and *Hibiscus tiliaceus*, *Inocarpus fagifer*, *Xylocarpus granatum*, *Derris trifoliata* and the grasses *Ischaemum polystachium* and *Phragmites karka* were seen. Epiphytes in this area included the orchid, *Dendrobium sp.* and the ferns *Asplenium nidus* and *Davalia solida*. Dominant vegetation here was Hibiscus, Derris, and the grasses.

The fauna found in the estuaries were fishes – *Lutjanus fulvus*, *L. argentimaculatus*, *Crenimugil crenilabis*, *Siganus punctatus*, *Chanos*, *Periophthalmus argenteolineatus*. The more prominent fishes found in this area were the mudskippers and the snappers. Birds seen here included the Pacific reef heron, the white-eyes, starlings, and a whimbrel rookery at the Innem river mouth during fall and winter. The invertebrates collected were the gastropods, *Neritina variegata*, *Septaria sp.* with *Littorina sp* being the dominant species. The crustaceans present in this area included the *Uca crassipes* - fiddler crab, the *Sesarma sp.* (Tikuhl) and an unidentified dark crab found in the mud. These crustaceans were common in the estuary. One crustacean that was not seen but was expected to be in this area was the mangrove crab *Scylla serrata*. The introduced monitor lizard *Varanus indicus* was also seen to be widespread in the entire island.

Upstream from the estuary, which included the mangrove and the freshwater swamp, the river passed through developed areas – in this case, by the Tofol area. In these areas, herbaceous (grasses) vegetation dominated the riverbanks. Trees in this area included *Hibiscus tiliaceus*, *Prenna serratifolia* as the dominant ones, some *Terminalia carolinensis*, *Barringtonia racemosa*, *Ficus prolixa*, *Neubergia celebica*, *Inocarpus fagifer* and *Nypa fruticans*.

The grasses found here were: *Ischaemum polystachium*, *Phragmites karka* and *Centosteca lappacea*. Ferns found were *Asplenium nidus*, *Microsorium scolopendria* where *Nephrolepis oblitterat* was found to be the dominant fern in this disturbed area. Vines included *Derris trifoliata*, *Ipomea littoralis* and the invasives, *Merremia peltata* and *Mikania michrantha*. The invasive *Costus speciosus* was also commonly found in this area. Other plants in this area that were significant due to their use for food were *Cyrtosperma merkusii* (swamp taro), *Colocasia esculenta* (soft taro), *Manihot esculenta* (tapioca) and *Musa paradisiaca* (bananas). All these floras were the most seen species during the sampling period.

The fauna from the developed area included the fishes, *Crenimugil crenilabis*, *Anguilla marmorata*, *Lutjanus fulvus* and common *Kuhlia rupestris*. The gastropod *Neritina pulcherina* and a dragonfly, *Tholomis tillagra* were also seen (Buden and Paulson 2003). Two species of ducks, northern pintail

(*Anas acuta*) and the northern shoveler (*Anas clypeata*) were seen on the oxidation ponds next to the Tofol river. The pintail is known to be a common visitor during fall and winter.

Above all developed areas, trees were dominant again on the riverbanks. The common trees and ferns in the upland part of the river included: *Terminalia carolinensis*, *Horsfieldia irya*, *Neubergia celebica*, *Camptosperma brevipetiolata* and *Hibiscus tiliaceus*. Ferns were common as well and included *Asplenium nidus*, *A. laserpitifolium*, *Nephrolepis oblitterata*, *Angiopteris evecta*, *Bolbotis heteroclita*, *Sphraopteris lunulate*, *S. nigricans*, *Antrophyllum callifolium*, *Davalia solida*, *Tectaria grandiflora* and *Huperzia phlegmaria*. The grasses seen were *Ischmaemum polystachium*, *Phragmites karka*, *Bambusa vulgaris* and *Centosteca lappacea*. These three grasses were in an upstream area in the Innem River, which was previously used for agriculture and is the reason these grasses occur in the area. Invasive species were also observed, but to a much lesser extent than the previously mentioned grasses. These were *Merremia peltata*, *Mikania michrantha* and *Costus speciosus*. Other plants in this area were: *Scirpodendrum ghaeri*, *Piper ponapense*, *Dendrobium sp.* *Musa paradisiaca* and *Manihot esculenta*. *Dendrobium sp.* *Musa paradisiaca* and *Manihot esculenta* were also present in the Innem river area that had previously been used for agriculture. A major concern in this area is the spreading of invasive species: *Costus* and *Merremia* species.

Fauna in the upland part of the rivers included the gastropods *Neritina pulcherina*, *Neritina sp.*, a *Septaria sp.* and another unidentified snail. The *Septaria* found upriver (unidentifiable) has different pattern of lines in the shell than the *Septaria* found in the estuary, which are notably known to also be found in different salinities. Shrimps present and common in this area included *Machrobrachium lar*, *M. latimanus* and *Caridina sp.* Fishes found in this area include *Kuhlia rupestris*, *Stiphodon elegans*, *Stiphodon caeurulus*, *Anguilla marmorata* and an unidentified fish. The *Kuhlia* and the two gobies were notably common in this area as first documented by Maciolek and Ford (1987). Two dragonflies seen in the area include *Diplacoides bipunctata* and *Tholomys tillagra*.

Because of the limited time to visit the upper reaches of watersheds, previous visits to Innem and Tofol watersheds and literature research to identify the flora and the fauna in this area were used – notably a study by Maxwell (1982) where species compositions were categorised into different habitats at different levels of elevations.

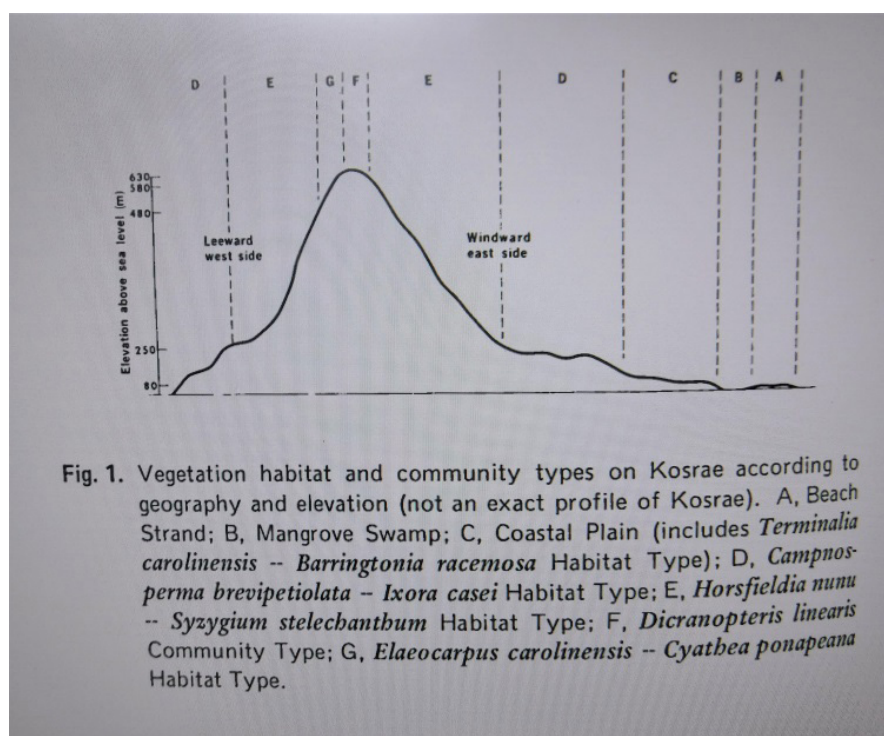


Figure 4: Vegetation habitat and community types

According to Figure 4, Habitats A and B were coastal habitats. Vegetation in Type C habitats (below 80 m elevation) included *Terminalia*, *Barringtonia racemosa*, *Neubergia*, *Horsfeldia*, *Hibiscus*, *Derris trifoliata*, *Scirpodendrum* and various ferns.

Vegetation in Habitat D, *Camptosperma/Ixora* Type, at the 50 m – 250 m elevation range, included *Camptosperma*, *Adenantha*, *Horsfeldia*, *Neubergia*, *Elaeocarpus*, *Ficus tinctoria*, *Syzygium stelechanthoides* (endemic), *Ixora*, *Sphaeropteris* spp. Common ferns found included *Cyclosorus*, *Nephrolepis*, *Asplenium*, *Davallia* and *Microsorium*.

Habitat E, *Horsfeldia/Ixora* Type above 250 m commonly had *Horsfeldia*. Other species found were *Elaeocarpus*, *Ponapea ledermaniana* (palm), *Camptosperma*, *Hibiscus*, *Syzygium*. Less commonly found species were *Neubergia*, *Astrodinium*, *Pandanus kusiacolus* (endemic), *Cinammomun*, *Syzygium stelachantoides* (endemic) and *Sphaeropteris* spp.

Habitat F, the cloud forest, was classified as species found in the 480 m – 654 m elevation. The trees here were stunted and bent, rarely attaining 5 m. Several inches of green to reddish brown bryophytes enveloped and hid most of the ground and branches of tree trunks. *Dicranopteris linearis* was seen to be the dominating fern in this area. Vegetation in the uppermost part of the watersheds were: *Elaeocarpus*, *Astrodinium*, *Camptosperma*, *Cinnamomum*, *Ponapea*, *Sphaeropteris* spp. Angiopteris, *Elaphoglossum*, and various orchids and most of the endemic plants on Kosrae were found at higher elevations. These were *Astrodinium carolinense*, *Bulbophyllum fukuyamae*, *Cyrtandra kusaimontana*, *Elatostema kusaiense*, *Medinella diversifolia*, *Psychotria rhombocarpa* and *Syzygium stelanchantoides*.

Kosrae supported more Tropical Montane Cloud Forest than Pohnpei, with 70 hectares. This cloud forest habitat, which ranges down to 480 m in elevation, represented the lowest elevation in the world for a tropical montane cloud forest. Disturbance by humans is limited in this area by steep slopes that dominate the interior of the island (Merlin and Juvik 1993). Tropical montane cloud forests are important for providing shelter to many native and endemic species (FSM Department of Resources and Development 2020).

Fauna found further upland in the watershed included the threatened Micronesian imperial pigeon (Ule), and the endemics, fruit dove (Fon) (*Ptilinopus hernsheimi*) and white-eye (Tuhram). Other birds found here were the starling (Wac) and the migratory island cuckoo, *Eudynamis taitensis* (Won Pangpang Mos). All the bird species populations were stable except for the imperial pigeon, which was hunted resulting in their current low numbers. Various skinks and geckos were found here and at least two land snails, which were unidentifiable.

The effects of climate change appear very likely to upset the current dynamic equilibrium of the cloud forest. Impacts will include biodiversity loss, altitude shifts of species ranges and subsequent community reshuffling to possible forest death (Foster 2001).

Some fauna that were unidentifiable include one goby-like fish in upland Innem, two snails of the genus *Septaria* and an unidentified *Neritina* upstream. Other organisms that were expected but were not sampled in this study were the shrimp *Atyoides pilipes*, which had been commonly collected in Kosrae and would be commonly found in water filtered by strong currents. These strong currents may have contributed to the difficulty in sampling these shrimps. The fish kulunsracl (*Ophicara* sp.) was not seen in the murky waters of the estuary but is a known common fish in this environment. More biodiversity was found upland, where there was less erosion and therefore less sediments covering the rocks, which affected the habitat and feeding grounds of snails, gobies, and shrimp.

Reptiles that could be seen in the study area were found in different areas of the watershed. Skinks found in the forested areas included *Emoia arnoensis*, *E. boettgeri*, *E. caeruleocauda*, *E. impar* and

Lamprolepis smaragdina (found in lower areas of the watershed). In the developed areas with less vegetation and more buildings, reptiles such as *E. cyanura*, *E. impar* and *Lamprolepis smaragdina* were found. Geckos found in developed areas include the invasive *Hemidactylus frenatus* and the natives, *Gehyra oceanic*, *Lepidactylus lugubris*, *L. moestus* and *Perochirus ateles* – which can also be seen in forested areas (Buden 2016). The introduced and invasive cane toad, *Rhinella marina* was the only amphibian sampled in Kosrae. However, it was also observed in the developed area and in the lower elevations of the upland forests.

The other birds that live in these watersheds and have not been listed are white tern, *Gygis alba*; island swiftlet, *Aerodramus inquietus*; the honey eater, *Myzomela rubrata* and the blue faced parrotfinch, *Erythura trichroa*, which lives in the areas with short grasses (Hayes et al. 2016).

The water quality of the rivers varied. In the upland the water was clean with less sediment. The rivers had primary vegetation that reduced erosion and the upland area had higher flora and fauna biodiversity. Once it reached developed areas, the quality of the water was more turbid and was seemingly visually more degraded with the input of sediments from construction sites and organic waste from pig pens. More grasses were present here because of the deforestation in this area and the biodiversity of flora and fauna was observed to decrease except for the presence of the fish species, *Kuhlia rupestris*. Erosion was also observed to be greater, where sediments clog the rivers leading to floods that import sediments into the estuary, Lelu Harbour and eventually offshore. The sedimentation control measures such as nets, were placed at the beginning of projects were not maintained, hence limiting their effectiveness.

There are a few laws on Kosrae for the protection of the watersheds and Protected Areas. Kosrae State Code, Title 19; Environmental Protection and Management, Chapter 8, Terrestrial and Marine Protection Areas of 2010, include protection of Mangrove Forests, Watershed Forests and Prohibited Activities Within Kosrae State PA Systems. Apart from these laws, the Japanese Line is known to protect the highlands of Kosrae, and this consists of a separation of private from public land in the interior of the island (Figure 5). However, the process of reclaiming these upland areas is currently being revised by the Kosrae Legislature. The study area has two protected areas: one is the Lelu MPA on the mangrove and the harbour side next to the three river estuaries; and the Mahkontowe Protected Area at the watershed headwaters.

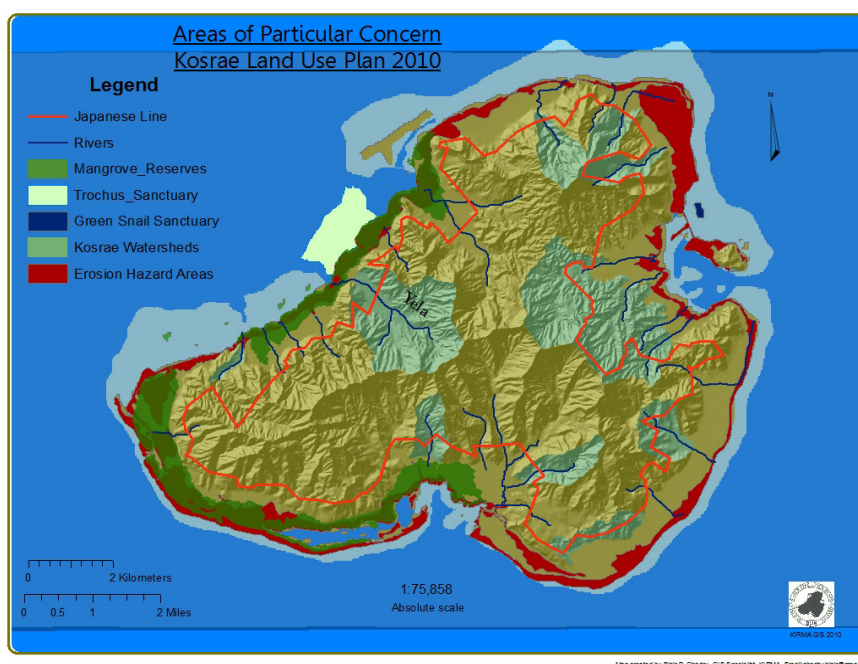


Figure 5: Areas of Particular Concern - Kosrae Land Use Plan 2010

5. CONCLUSION AND RECOMMENDATIONS

The current study provided a comprehensive list of the spatial distribution of the observed and identifiable species of flora and fauna across Tofol, Srungansralu and Innem rivers in upland forests, in estuaries and in developed areas across all three rivers. This biological assessment has also provided baselines, notably for endemic and invasive species. It was observed that along the ridge-to-reef continuum, the upland areas had higher biodiversity and visually better quality of water and the developed areas had lower biodiversity, noting that pig pens and industrial areas are sources of pollutants discharged into the environment, which is made more apparent during periods of heavy rainfall, thus decreasing the visual quality of water.

While the current study documented useful narratives and recent data, it is strongly recommended that future monitoring and sampling be undertaken through collection of quantitative data through transect lines to groundtruth the qualitative narratives in this study. In the future, determining the current state and continued projected trends in water quality, data sampling and monitoring should be prepared beforehand noting logistical arrangements for transportation of samples to laboratories with the appropriate equipment. Quantitative water quality data such as nutrient levels, pH, dissolved oxygen, and salinity provide specific information that can be directly comparable to acceptable standards and thresholds that have been highly researched and widely accepted in the international scientific community.

Standardised data collection and methodologies ensure comparability with trends in similar and differing ecosystems. This would provide development organisations, institutions, and decision makers with the scientific information to justify and validate the necessary and most appropriate and accurate interventions. Current and historical anecdotes and perceptions can also be legitimised and, on the other hand, may also be disproven. Through standardised scientific data collection and monitoring, trends may also arise that were previously seemingly unremarkable and inconspicuous.

Data in the current study provides baseline information that can progress the development of local capacity in collection of adequate scientific data and identifying key monitoring sites. Preliminary results in this study support and build knowledge on previous assessments. Future studies could focus on determining certain observations of expected species that were not seen in this study and the reasons for this, as well as have a key focus on endemic and invasive species. Due to the threats that ongoing development poses to the environment, this study supports the need for monitoring of Tofol, Srungansralu and Innem rivers. These rivers have ecological and socioeconomic significance. Along the ridge-to-reef continuum, these rivers play a clear significant role in sustaining lives of the communities and decisions in conserving them must be of great concern.

6. REFERENCES

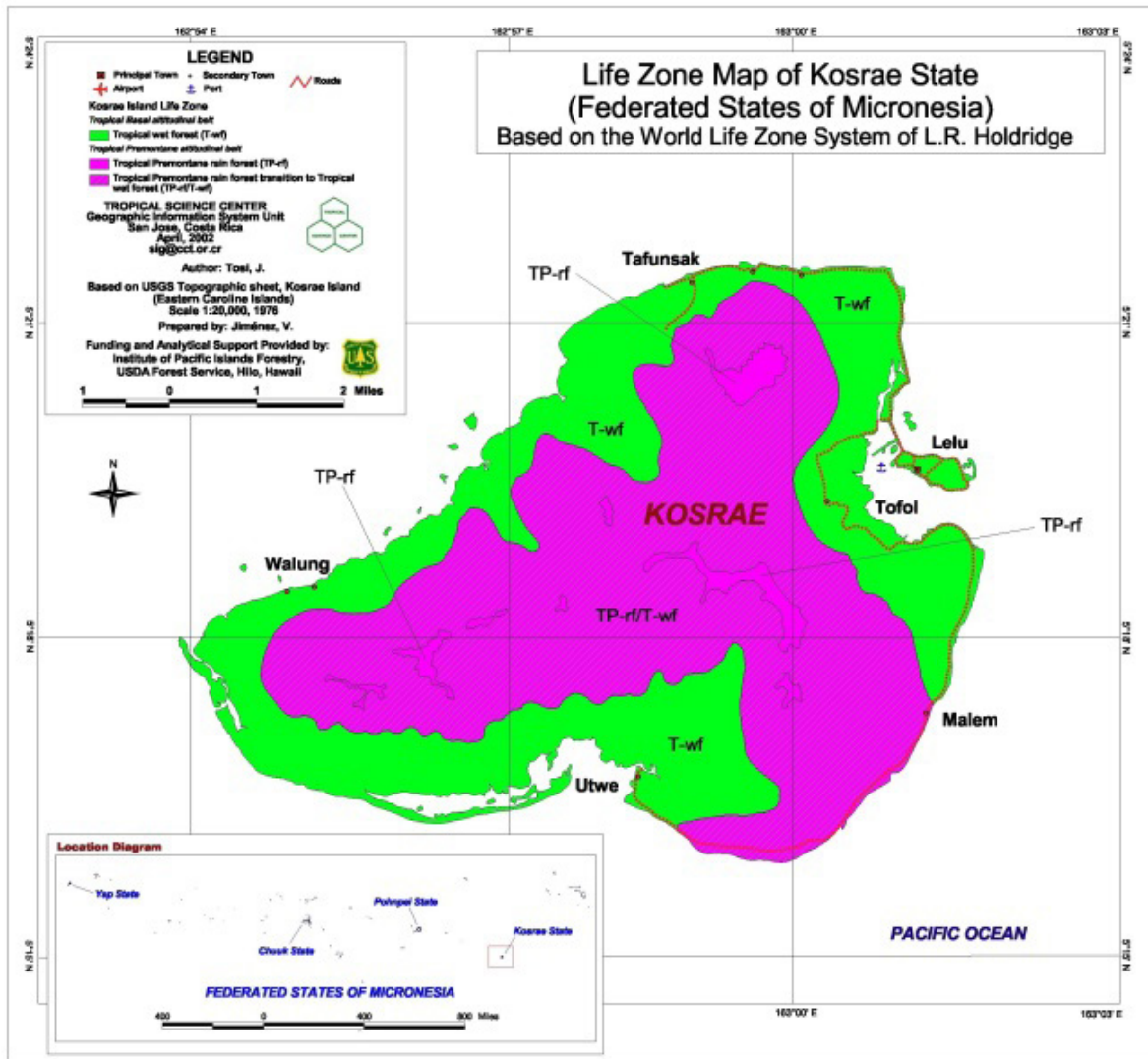
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7. APPENDICES

7.1 Maps of Lelu Marine Protected Area and Kosrae Life Zones



Lelu MPA



Kosrae Life Zones

7.2 Species Tables of Tofol, Innem and Srugansralu Rivers

Biological Assessment of the Tofol River

Scientific name	Common name	Habitat
Flora		
<i>Sonneratia alba</i>	Fulohfohl	Mangrove
<i>Nypa fruticans</i>	Fasuc	Estuary
<i>Hibiscus tiliaces</i>	Lo	Estuary, developed areas
<i>Derris trifoliata</i>	Ohsrah	Estuary, developed areas
<i>Clerodendrum inerme</i>	Kwacwak	Estuary
<i>Bruguiera gymnorrhiza</i>	Sroal	Mangrove
<i>Ischaemum polystachium</i>	Ma	Estuary, developed areas
<i>Premna serratifolia</i>	Fienkack	Developed areas
<i>Nephrolepis obliterated</i>	Fah	Developed area, upland
<i>Centosteca lappacea</i>	Mah	Developed areas
<i>Phragmites karka</i>	Loa	Developed areas
<i>Merremia peltata</i> (invasive)	Puhlah	Developed areas, upstream
<i>Mikania michrantha</i> (invasive)	Mah Tepat	Developed areas.
<i>Ipomea littoralis</i>	Oa	Developed areas
<i>Costus speciosus</i> (invasive)		Developed areas, upland
<i>Aeschynomene indica</i> (invasive)		Developed areas
<i>Musa paradisiaca</i>	Usr	Developed areas
<i>Manihot esculenta</i>	Tepyuka	Developed areas
<i>Terminalia carolinensis</i>	Ka	Developed areas, upland
<i>Horsfeldia irya</i>	Nunu	Upland
<i>Neubergia celebica</i>	Tohoh	Upland
<i>Camposperma brevipetiolata</i>	Elahk	Upland
<i>Angiopteris evecta</i>	Kalme	Upland
<i>Asplenium nidus</i>	Muhlihklihk	Upland
<i>Asplenium laserpitifolium</i>	Fah	Upland
<i>Bolbotis evecta</i>	fah	Upland
<i>Sphaeropteris lunulata</i>	Po	Upland
<i>Sphaeropteris nigicans</i>	Po	Upland
<i>Davalia solida</i>	Fah	Upland
<i>Anthrophyllummcallifolium</i>	Fah	Upland
<i>Rubus molucanus</i>	Kokihl	Upland
<i>Piper ponapense</i>		Upland
<i>Curcuma australasica</i>	Ahng	Upland
<i>Scirpodendrum ghaeri</i>	Srohoh	Upland

Scientific name

Common name

Habitat

Fauna

<i>Varanus indicus</i> (invasive)	Kinaul koasr	Mangrove, estuary, upland
<i>Crenimugil crenilabis</i>	Epal	Mangrove, estuary
<i>Neritina pulcherina</i>	Kimo	Developed areas, upland
<i>Siganus punctatus</i>	Mwe Ohsrah	Mangrove, estuary
<i>Lutjanus fulvus</i>	Niahluh	Mangrove, estuary
<i>L. argentimaculatus</i>	Long	Mangrove, estuary
<i>Anguilla marmorata</i>	Ton	Estuary, upland
<i>Kuhlia rupestris</i>	Srohsrohl	Developed areas, upland
<i>Ophicara sp.</i>	Kukunsracl	Mangrove, estuary
<i>Stiphodon elegans</i>	goby	Upland
<i>Stiphodon caeruleus</i>	goby	Upland
<i>Macrobrachium lar</i>	Sresre	Upland
<i>Zenarchopterus sp.</i>	Halfbeak	Mangrove, estuary

Biological Assessment of the Innem River

Scientific name	Common name	Habitat
Flora		
<i>Sonneratia alba</i>	Fulohfohl	Mangrove, estuary
<i>Nypa fruticans</i>	Fasuc	Estuary
<i>Bruguiera gymnorrhiza</i>	Sroal	Mangrove, estuary
<i>Hibiscus tiliaceus</i>	Lo	Estuary
<i>Pandanus tectorius</i>	Mweng	Estuary
<i>Inocarpus fagifer</i>	Kihrak	Estuary, developed area
<i>Bambusa vulgaris</i>	Pahmpu	Estuary, upland
<i>Phragmites karka</i>	Loa	Estuary, developed area, upland
<i>Derris trifoliata</i>	Ohsrah	Estuary
<i>Barringtonia racemosa</i>	Kwenguhi	Developed area
<i>Ficus prolixa</i>	Kohnyah	Developed area
<i>Neubergia celebica</i>	Tohoh	developed area, upland
<i>Centosteca lappacea</i>	Mah	Developed area
<i>Asplenium nidus</i>	Muhlihklihk	Developed area, upland
<i>Musa paradisiaca</i>	Usr	Developed area, upland
<i>Horsfeldia irya</i>	Nunu	Upland
<i>Terminalia carolinensis</i>	Ka	Upland
<i>Merremia peltata</i> (invasive)	Puhlah	Upland
<i>Nephrolepis obliterated</i>	Fah	Upland
<i>Tectaria grandiflora</i>	Fah	Upland
<i>Angiopteris evecta</i>	Kalme	Upland
<i>Sphaeropteris lunulata</i>	Po	Upland
<i>Sphaeropteris nigricans</i>	Po	Upland
<i>Huperzia phlegmaria</i>	fah	Upland
<i>Costus speciosus</i> (Invasive)		Upland
<i>Manihot esculenta</i>	Tepyuka	Upland

Fauna

<i>Neritina variegata</i>	Kimo	Estuary
<i>Littorina sp.</i>	Gastropod	Estuary
<i>Uca crassipes</i>	Kaho	Estuary
<i>Septaria sp.</i>	Gastropod	Estuary
<i>Septaria sp. 2?</i>	gastropod	Upland
<i>Lutjanus argentimaculatus</i>	Long	Estuary
<i>L. fulvus</i>	Nialuh	Estuary
<i>Periopthalmus argenteolineatus</i>	Ik Srosro	Estuary
<i>Aplonis opaca</i>	Wac	Estuary
<i>Numius phaeopus</i>	Katkat	Estuary
<i>Kuhlia rupestris</i>	Srosrohl	Developed area, upland
<i>Anguilla marmorata</i>	Ton	Developed area, upland
<i>Neritina pulcherina</i>	Kimo	Upland
<i>Machrobrachium latimanus</i>	Sresre	Upland
Unidentified fish		Upland
<i>Stiphodom elegans</i>	Goby	Upland
<i>Caridina sp.</i>	Sresre	Upland
<i>Siganus punctatus</i>	MweOhsrah	Developed area, upland
<i>Crenimugil crenilabis</i>	Epal	Developed area
<i>Egretta sacra</i>	Noklahp	Estuary
<i>Zenarchopterus sp.</i>	Halfbeak	Estuary

Biological Assessment of the Sragunsrulu River

Scientific name	Common name	Habitat
Flora		
<i>Sonneratia alba</i>	Fulohfohl	Mangrove, estuary
<i>Nypafriticans</i>	Fahsuc	Estuary, developed area
<i>Rhizophora sp.</i>	Suhkasrihk	Mangrove, estuary
<i>Bruguiera gymnorrhiza</i>	Sroal	Mangrove, estuary
<i>Xylocarpus granatum</i>	Tuhi	Estuary
<i>Hibiscus tiliaceus</i>	Lo	Estuary, developed area
<i>Asplenium nidus</i>	Muhlihklihk	Estuary, developed area
<i>Davalia solida</i>	Fah	Estuary
<i>Derris trifoliata</i>	Ohsrah	Estuary, developed area
<i>Barringtonia racemosa</i>	Kwenguhl	Developed area
<i>Premna serratifolia</i>	Fienkack	Developed area
<i>Terminalia carolinensis</i>	Ka	Developed area
<i>Ischaemum polystachium</i>	Mah	Developed area, upland
<i>Phragmites karka</i>	Loa	Developed area
<i>Pennisetum purpureum</i>		Developed area
<i>Microsorium scolopendria</i>	Kwemkwem	Developed area
<i>Merremia peltata</i> (invasive)	Puhlah	Developed area, upland
<i>Mikania michrantha</i> (invasive)	Mahtepat	Developed area, upland
<i>Costus speciosus</i> (invasive)		Developed area, upland
<i>Cyrtosperma merkusii</i>	Pahsruhk	Developed area
<i>Colocasia esculenta</i>	Kuhtak	Developed area
<i>Manihot esculenta</i>	Tepyuka	Developed area
<i>Horsfeldia irya</i>	Nunu	Upland
<i>Nephrolepis obliterated</i>	Fah	Upland
<i>Tectaria grandiflora</i>	Fah	Upland
<i>Sphaeropteris lunulata</i>	Po	Upland
<i>Sphaeropteris nigricans</i>	Po	Upland
<i>Piper ponapense</i>		Upland
<i>Scirpodendrom ghaeri</i>	Srohoh	Upland

Fauna

<i>Sesarma sp.</i>	Tikuhl	Estuary
<i>Lutjanusfulvus</i>	Nialuh	Estuary
<i>L. argentimaculatus</i>	Long	Estuary
<i>Crenimugil crenilabis</i>	Epal	Estuary
<i>Periopthalmus argenteolineatus</i>	IkSrosro	Estuary
<i>Siganus punctatus</i>	Mweoshsrah	Estuary
<i>Zosterops cinereus</i>	Tuhrahm	Estuary
<i>Egretta sacra</i>	Noklahp	Estuary
<i>Neritina pulcherina</i>	Kimo	Developed area, upland
<i>Kuhlia rupestris</i>	Srosrol	Developed area, upland
<i>Unidentified snail</i>		Upland
<i>Neritina sp.</i>	Kimo	Upland
<i>Machrobrachium lar</i>	Sresre	Upland
<i>Caridina sp.</i>	Sresre	Upland
<i>Diplacoides bipunctata</i>	Iri	Upland
<i>Tholomys tillagra</i>	Iri	Upland

