

THE FEDERATED STATES OF MICRONESIA INTRODUCTION

by Christopher R. Dahl

Area: 705 sq.km.

Population: Kosrae: 6,607 (1986). Yap: 10,139 (1987). Pohnpei: 28,671 (1985). Chuuk: 52,000 (estimated 1989). Federated States of Micronesia total: 100,789 (estimated 1990).

The Federated States of Micronesia (the FSM) consist of about 45 distinct islands or island complexes scattered over a vast expanse of ocean between latitude 10°N and 1°N and longitude 137°E and 168°E. These islands have in the past been known and are still often referred to by the geographic name the Caroline Islands'. Most are low atolls or raised limestone islands, while four are high volcanic islands. As such, each island is typically comprised of many closely associated smaller islands or islets; thus the total number of individual islands exceeds 600. The four high islands represent most of the land area (92%) within the nation and serve as state centres for the four states within the FSM's federal system of government. These islands, from east to west Kosrae (formerly Kusaie), Pohnpei (Ponape), Chuuk (Truk) and Yap, also provide the state names. Pohnpei and Kosrae, respectively the largest and second largest islands in the FSM, are mountainous extinct and eroded shield volcanos. Chuuk is a large atoll-like formation with numerous volcanic islands in its lagoon. Yap was formed on a tectonic plate boundary by volcanic and tectonic forces. Government services, infrastructure and population are concentrated in the state centres. It is also on these islands that virtually all significant wetland areas are found. The nation, once part of the United Nations Trust Territory of the Pacific Islands administered by the United States, achieved qualified independence in 1986, when it entered into a Compact of Free Association with the U.S. This arrangement governs various security and defence matters and guarantees substantial aid over a fifteen year period while recognising the full sovereignty of the FSM. A two-tiered economy obtains throughout the nation. Much of the population lives primarily within the subsistence sector, depending on agro-forest cultivation and fishing for their primary needs. The money economy is overwhelmingly dependent on foreign aid obtained through the Compact. The climate is hot and humid year round. The daily mean temperature is 27°C, with very little annual variation. Rainfall varies from island to island due to orographic effects. It also varies significantly from east to west. Kosrae receives 6,527 mm per year distributed fairly evenly throughout the year, while Yap, in the extreme west, receives 3,087 mm per year with a distinct dry season from January to May. Tidal fluctuation varies within the FSM, being greater in Kosrae and Yap (1.0 m and 0.9 m mean) and less in Pohnpei and Chuuk (0.7 m and 0.5 m mean). This area experiences the highest frequency of typhoons (cyclones) in the world.

While the Palau Islands (Republic of Belau) are usually considered part of the Caroline Islands, for the purposes of this report this term will refer to only those islands that are now part of the present FSM.

Generally, the western half of the FSM (Chuuk and Yap) are much more subject to typhoons than the eastern half (Pohnpei and Kosrae).

Summary of Wetland Situation

Because all significant wetlands are on high islands and surveys on the low, coralline "outer islands" are limited, this summary is confined to a description of the wetlands on the high islands of Kosrae, Pohnpei, Chuuk and Yap. Wetlands on the low coralline islands are limited to cultivated taro (*Colocasia esculenta* and *Cyrtosperma chamissonis*) swamp and, in a few cases, limited mangrove areas comprised primarily of dwarf *Rhizophora mucronata*, *Bruguiera gymnorrhiza* and *Lumnitzera littorea*.

Like many environments in Micronesia, wetlands have undoubtedly been affected by the continuous presence

of humans on these islands for several thousand years. The region experienced declines in human population after contact with the West in the mid-19th century; populations are only now attaining pre-contact levels. Wetland areas were extensively exploited for timber and charcoal during the Japanese era of administration (1914-1945). Many of these areas have recovered, but given the long history of habitation, no wetlands can be considered pristine. This is most especially true of freshwater areas which are commonly turned over to the cultivation of taro. However, well developed and in some cases unique wetlands are to be found along the shoreline on all four islands. While species diversity generally increases as one moves west toward the Indo-Malay archipelago, the most extensive and significant wetlands in the FSM are found on the more eastern islands of Pohnpei and Kosrae. On both these islands, roughly 15% of land area, if mangroves are included in land area, are wetlands. This is due to the large size of these islands and their wide low-lying coastal plains where hydrologic conditions create extensive wet areas. Greater topography generates more siltation allowing the expansion of mangrove areas on the reef flat. Finally, population densities are lower on these two islands so human disturbance has been correspondingly less. Stemmermann and Proby (1978) divide wetlands in Micronesia into nine major categories: mangrove forest, coastal saline marsh, lowland swamp forest, upland high canopy swamp forest, upland marsh, savannah wetland, cultivated wetland, bomb craters and artificial reservoirs, riparian wetlands and ruderal wetlands. Based on the vegetation surveys of Falanruw et al. (1987a and 1987b), MacLean et al. (1986) and Whitesell et al. (1986), slightly over 85% of wetlands by area are mangrove swamp. The vegetation survey of Chuuk (Falanruw et al., 1987a) omits some islands including the Tol island complex which has significant mangrove forests. These islands were surveyed by Stemmermann and Proby (1978), but no tabular data on wetland areas is included in that report. Based on soil type from USDA soil surveys, the total area of wetlands can be estimated as 1,143 ha of mangroves and 449 ha of freshwater wetlands, giving a total of 1,592 ha. (This is almost triple the area shown for Chuuk in Table 1).

Freshwater swamp forest (found on Pohnpei, Kosrae and Yap) makes up an additional 7%. Other categories used in these surveys correspond imperfectly with Stemmermann and Proby's earlier wetland categories. The remaining distinguishable types are freshwater and saline marshes and native ivory nut palm forests (see Table 1). It is only on Pohnpei that all of these wetland types occur.

Table 1: Wetland areas in the FSM (in hectares). Adapted from the U.S. Forest Service vegetation surveys.

Note: Chuuk data is for Moen, Dublon, Fefan and Eten islands only.

	Kosrae	Pohnpei	Chuuk	Yap	Totals	Per cent
Mangrove forest	1,562	5,525	306	1,171	8,564	85.43%
Swamp forest	345	214	0	155	714	7.12%
Marsh, freshwater	25	149	234	165	573	5.72%
Ivory nut palm forest	0	137	2	0	139	1.39%
Marsh, saline	0	29	0	6	35	0.35%
Total	1,932	6,054	542	1,497	10,025	100.00%

Mangrove forests are most extensive on Pohnpei; approximately 65% of the mangrove forests in the FSM are on this island. Kosrae possesses an additional 18%. While Yap's mangroves are close to Kosrae's in total area, they are generally less well developed. On Kosrae, *Sonneratia alba* dominates on the seaward margin of mangrove forests, while on Pohnpei, *Rhizophora mucronata* var. *stylosa* (or *Rhizophora stylosa* according to some authors) is found on the outer margin. On both islands, *Xylocarpus granatum* and *Lumnitzera littorea* are occasionally found towards the landward margin of the forest. In estuarine areas around river mouths or bays, *Rhizophora mucronata* and *R. apiculata* occur as pure stands or mixed with some *S. alba* and *Bruguiera gymnorrhiza*. Upstream the *Rhizophora* component drops out. *Nypa fruticans* can become dominant in narrow

bands along riverine portions of the inner mangrove. On Chuuk, mangrove forests comprise a relatively narrow shoreline band in which *R. mucronata* dominates, while *R. apiculata* and occasionally *Bruguiera* are found behind the seaward fringe in more extensive areas. *X. granatum* and *S. alba* occur occasionally on the landward fringe. Yap, like Chuuk, has poorly developed mangroves but slightly greater species diversity than the islands to the east. Of tree species, *Dolichandrone spathacea* and *Ceriops tagal* are found along the landward edge of the mangroves only on Yap. *Derris trifoliata*, *Dalbergia candenatensis* and *Smythea lanceata* are common lianas typically found on the inner mangrove fringe. A more detailed discussion of Micronesian mangrove floral assemblages and distribution is given by Fosberg (1975).

On most of the east and south coasts of Kosrae, a sand berm varying in width from several hundred yards to a few feet wide separates the mangrove forest from open reef flat. *Sonneratia* is the most common and typically the largest tree species in the mangrove forest; usually it is festooned with the epiphytic ferns *Nephrolepis acutifolia* and *Asplenium* spp. On Pohnpei, an offshore barrier reef encloses a large lagoon which protects the shoreline from significant wave action, allowing mangroves to grow on most of the shoreline. Mangrove forests are most extensive, up to two km wide, along the leeward west and south coasts. Extensive areas of low dense growth, with *Rhizophora* sp. dominating, in the interior of large mangrove areas is a salient characteristic of Pohnpei's mangrove forest. In some areas, trees are dwarfed and scattered creating an open canopy.

Swamp forest and cultivated marsh are common on the landward side of the mangroves. These wetlands are also characteristic of river bottoms. Stemmermann and Proby (1978) further delineate swamp forest as high canopy, low canopy, open canopy and cultivated phases, and regard these as related to the level of human disturbance. They note that because rainfall is extremely high (Kosrae: 6,527 mm/year, Pohnpei: 4,928 mm/yr) there may be many localised small wetlands in upland forest areas, but no detailed surveys have been undertaken. Indeed, even delineating classifiable wetland areas in the uplands is difficult when rainfall is so great. Most soils are saturated all year round, especially in flat areas. In the high canopy phase common on Kosrae and Pohnpei, *Terminalia carolensis* often dominates; *Horsfeldia nunu* may co-dominate in the swamps of Kosrae. There is usually a distinct break between the landward margin of mangrove forest and high canopy swamp forest where the shoreline abruptly rises about one metre above sea level. *Heritiera littoralis* is common along this strand on all high islands. This high canopy swamp forest is limited on Yap and non-existent in Chuuk. (Of the 155 ha of swamp forest on Yap, only 41 ha are classed as trees averaging over 30 cm diameter at breast height). Other tree species include *Camptosperma brevipedicelata*, *Pandanus* spp. and *Barringtonia racemosa*. The low canopy phase, which are generally areas of disturbed high canopy forest, is characterised by *Hibiscus tiliaceus*, *Barringtonia* spp. and *Macaranga* spp. The open canopy or freshwater marsh phase is unusual; it is most common on Pohnpei where four sites have been identified; one site is known from Kosrae. These freshwater marshes are found adjacent to or even in mangrove areas and surrounded by swamp forest. Thus they are typically difficult to reach and have not been fully surveyed. These marshes are characterised by sedges but may also have 50% or more cover of woody species. Tree species are *Camptosperma brevipedicelata* and *Lumnitzera littorea*. Common herbaceous species include *Eleocharis geniculata* and *Lycopodium scandens*. Possibly endemic members of the genus *Liparis* (Orchidaceae) were found in the single marsh on Pohnpei surveyed by Stemmermann and Proby. The only marsh of this type on Kosrae was found to be partially cultivated and without any unique associated plants.

Ivory nut palm forests where the species *Metroxylon amicarum* (endemic to Pohnpei and Chuuk) predominates can also be considered a wetland as this tree grows in swampy areas. *Metroxylon* swamps are mainly found on Pohnpei at all elevations.

Of the other types of wetlands identified by Stemmermann and Proby, none is especially significant. Saline marshes are found on all four islands but are limited in extent and poorly developed. These marshes occur along the coastal strand, especially in Chuuk where mangrove forests have been more disturbed by clearing

and blockage of water circulation. However, because of their small size, none was distinguished in the Chuuk vegetation survey (Falanruw et al, 1987a). On Kosrae and Yap, they may be found in an occasional narrow band between the mangroves and the coastal strand and are uncommon on Pohnpei. *Paspalum distichum*, *Vigna marina*, *Cyperus javanicus*, *Wedelia bra* and *Fimbristylis cymosa* are common species. On Chuuk and Yap, the fern *Acrostichum aureum* may also be found. Most freshwater swamps are cultivated as taro swamps. Taro swamps are the major wetlands found on the many low coralline islands that comprise the rest of the FSM. Aside from the cultivated species, a relatively diverse assemblage of weeds, virtually all cosmopolitan species, are found. Upland marshes on Pohnpei and savannah wetlands on Yap may be either anthropogenic or natural in origin. As noted above, upland marshes have not been adequately surveyed.

Mangrove forests are of great subsistence and commercial importance on all four islands. They are exploited on both a subsistence and commercial basis for firewood, timber, wood for carved handicrafts and fisheries products. Mangrove forests are also a source of building materials for more traditional dwellings (mangrove poles and nipa thatch) and various medicinal products. Fish species commonly captured in the mangroves include members of the genera *Lutjanus*, *Labroides* and *Siganus*. The mangrove crab (*Scylla serrata*) is of commercial importance on Pohnpei and Kosrae where a significant local fishery and limited export fishery exists. Commercial saw mills have operated intermittently on all the islands but most consistently on Pohnpei where at least two mills have been in operation at any given time since just after World War II. High canopy swamp forests are not at the moment being commercially logged. The most well developed stands of *Terninalia* and *Horsfeldia* are in fairly inaccessible parts of Kosrae. However, as noted, much swamp forest had been degraded and/or converted to agricultural use.

Mangroves are also recognised for a variety of environmental services they provide. Mangrove forest is prime habitat for a variety of sea and shore birds including the Great Frigatebird (*Fregata minor*), Pacific Reef Heron (*Egretta sacra*), terns (*Sterna* spp.), noddies (*Anous* spp.) and the Micronesian Kingfisher (Pohnpei subspecies: *Halcyon cinnamomina reichenbachii*) as well as the Marianas Fruit Bat (*Pteropus mariannus*). On small tropical islands, mangrove forests are also one element in a dynamic hydrological system that allows coral reefs, which require clear nutrient-low water, to exist in close proximity to islands with very high rates of freshwater run-off. In the more typhoon-prone islands of Chuuk and Yap, mangroves protect shorelines from storm wave inundation and erosion.

Human impacts on wetlands vary from island to island. Because of historic high population densities on Yap and current high densities on Chuuk, the wetlands of these islands have been more significantly degraded than those of Pohnpei and Kosrae. The FSM as a whole is experiencing a very rapid rate of population growth (3.1% per year) accompanied by rising material expectations. These demographic trends are putting increasing pressure on all natural environments including wetlands. Major threats to wetlands in all states include unmanaged timber harvests, filling and/or conversion of wetlands for agriculture or to create developable land, development-related changes in local salinity due to impoundment, dumping of toxic materials into coastal areas, and dredging. Impacts in Kosrae are relatively minor; some semi-commercial firewood and timber harvesting occurs, but their effects tend to be fairly localised. Ongoing construction of a coastal circumferential road, aside from direct impacts, has resulted in an increase in unregulated firewood harvesting in now accessible areas. Planned road expansion will allow access to significant areas of mature *Terminalia* swamp forest. Virtually all of Pohnpei's mangrove forest show evidence of wood harvesting. Devoe (1991) notes that "field reconnaissance indicates that active degradation of mangrove is extensive... of all the mangrove covered (during surveys) in 1990 and 1991, not a single site was without evident harvesting." Little information exists on the current status of wetlands in Chuuk; however filling, conversion and over cutting, impoundment and waste oil pollution are known problems. Filling to create developable land is another significant threat, particularly on Pohnpei, Chuuk and Yap. Road construction and/or improvement, occurring on all the islands, has had localised impacts where mangrove areas are impounded by turnpike type roads that have an inadequate number of culverts, thus reducing salinity level. Toxic pollution has killed mangroves in localised areas on Pohnpei and, as mentioned, on Chuuk.

Five wetland areas of national and possibly international significance have been thus far identified. Three are on Kosrae and two are on Pohnpei. On Kosrae the Okat mangrove forest is a relatively extensive forest on the north coast of the island bordering the Okat river drainage. It boasts the largest examples of *Sonneratia alba* found anywhere in the Caroline Islands with individuals as high as 30 m. The Yela river drainage, also on the north coast, is probably the most extensive and least disturbed example of *Terminalia* dominant high canopy swamp forest. This area was extensively logged during the Japanese administration, but has apparently now recovered. Finally, the swamp forest and mangrove system stretching from the village of Utwe on the south coast to the village of Walung on the western tip of the island is typical of a variety of interesting and unique wetland characteristics of Kosrae. The whole of this wetland is bounded on the seaward side by a berm or barrier island averaging approximately 10 m in width. Extensive areas of open brackish water connected by narrow channels are found within the mangrove forest. All typical wetland vegetation assemblages can be found within this wetland complex. On Pohnpei, the unusual freshwater swamp, mentioned earlier and classified by Stemmermann and Proby as an open canopy phase swamp forest, and adjoining wetland areas are of significance because the swamp is a unique wetland type and harbours an endemic plant species of the genus *Liparis*, while adjoining areas display three other typical wetland types: full stature mangrove, dwarf mangrove and high canopy swamp forest. Kitti Municipality in southern Pohnpei possesses the most extensive mangrove areas within the Caroline Islands. Interest at both the community and state government levels has developed in affording the mangrove area between Dauen (river or channel) Semwei and Dauen Rakis protected status. Both these areas have been recommended for protection by Devoe (1991).

Wetland Research

Most wetland research in the FSM has been confined to basic surveys carried out by U.S. federal agencies, primarily the U.S. Forest Service. An inventory of wetland vegetation in the Caroline Islands by Stemmermann and Proby (1978), although dated, is still the most comprehensive guide to wetland areas and plants in the FSM. The U.S. Forest Service has published a variety of surveys of vegetation and timber volume (Falanruw et al., 1987a; Falanruw et al., 1987b; MacLean et al., 1986; MacLean et al., 1988; Pettys et al., 1986; Whitesell et al., 1986).

Dr Nora Devoe, a research forester with U.S. Forest Service, is currently conducting two projects: "Mangrove Areas Use Classification Study" and "Phytosocial Analysis of Pohnpei's Mangrove". This survey will assist the State Government in implementing protection measures for these areas. Fr Greg Muckenhaupt of the University of Hawaii is currently conducting research on Pohnpei into nutrient flux in the mangrove forest. Miyagi and Funimoto (1989) have investigated the geomorphology of mangroves and impact of historic sea level fluctuations on Pohnpei and Chuuk.

Lal (1989) investigated mangrove use and made management recommendations in connection with the development of a coastal resources management plan for Kosrae State. The East-West Center in Hawaii has sponsored the survey of two of the significant wetland areas in Kosrae, and made recommendations for conservation and sustainable tourism development (Wilson and Hamilton, 1992).

Wetland Area Legislation

In the FSM, with its federal system of government, the individual states have virtually exclusive jurisdiction over the management of natural resources. In Kosrae and Pohnpei States, submerged lands (those below the high tide mark) are public land and under the jurisdiction of the State Government. In Chuuk and Yap, water areas are privately or customarily owned. Little legislation exists dealing specifically with wetland areas. In Pohnpei, the 1987 Watershed Protection and Mangrove Management Act gives the State Forestry Division broad authority to manage mangrove areas. Thus far pursuant regulations have not come into effect. However, the Forestry Division instated a temporary ban on direct timber harvest by commercial saw mills which has proved difficult to enforce fully. Much of Devoe's research is directed towards the development of recommendations to be implemented through this legislation. In Kosrae, legislation exists to prevent

development along specified river drainages. Thus far this has not become a significant problem, and there has not been a real need to enforce the law.

The FSM has ratified the Convention for the Protection of the Natural Resources and Environment of the South Pacific (the SPREP Convention) and has signed but not yet ratified the Convention on Biological Diversity. It is not, however, as yet a party to the Unesco Man and the Biosphere Programme, Ramsar Convention or World Heritage Convention, nor has it signed or ratified the Convention on the Conservation of Nature in the South Pacific.

Wetland Area Administration

No protected areas exist in the FSM. Because of traditional attitudes towards land, government acquisition or control of privately held land for protection is difficult if not impossible. Because sub-tidal areas in Kosrae and Pohnpei are publicly controlled, some possibility exists for establishment of protected areas in these two states. Devoe's preliminary recommendations (1991) include the establishment of eleven mangrove reserve areas on Pohnpei. Three reserve categories are proposed: preserves where access is severely restricted; sustainable use areas allowing multiple use exclusive of timber harvest; and sustainable use areas where managed timber harvest would be allowed. In Kosrae, the State Government has expressed some interest in developing protected areas for the mangrove forests given special mention above. As noted, the East-West Center has surveyed these areas and developed management recommendations (Wilson and Hamilton, 1992).

Organizations involved with Wetlands

(a) United States Federal Agencies

- Forest Service (Department of Agriculture)
Provides technical assistance to state governments
- Soil Conservation Service (Department of Agriculture)
Currently providing technical assistance in Pohnpei State.
- Army Corps of Engineers
Published surveys and keys of Micronesian wetland vegetation;
produced atlases and inventories of coastal resources for Kosrae, Pohnpei and Yap.

(b) FSM

- FSM Department of Resources and Development
- Coordinates outside technical assistance for state agencies. Pohnpei Division of Forestry
Has management authority over mangrove and watershed areas. Kosrae Division of Agriculture and Forestry
- Chuuk Division of Agriculture and Forestry
- Yap Division of Agriculture and Forestry

(c) Academic Institutions

- College of Micronesia: Land Grant Programs
Assisting Pohnpei State Division of Forestry with mangrove management plan
- College of Micronesia: Sea Grant Extension Service
Assisting in the development of coastal resource management plans, parks and protected areas.

WETLANDS

The site descriptions for Kosrae, Pohnpei and Chuuk were compiled by Christopher R. Dahl of Sea Grant at the Community College of Micronesia, Ron Cannarella of the Division of Parks and Recreation, Pohnpei State, and Glasstine Cornelius of the Division of Agriculture and Forestry, Department of Conservation and Development, Kosrae State. No new information was received on the wetlands of Yap, and the account given below is based on the literature.

Wetland Name: Kosrae State Mangrove Forest and Freshwater Swamp Forest

Country: Federated States of Micronesia

Coordinates: 5°00'-5°23'N, 162°53'-163°03'E

Location: except for some areas on the southeast part of the island in Malem Municipality and in the northeast in Tafunsak Municipality, the island of Kosrae is entirely surrounded by mangrove forest. The mangrove is found behind a narrow sand island or cay except along the north coast. Swamp forest is found interior of mangrove forests and is best developed along the north and southeast coasts.

Area: Mangrove forest 1,562 ha; swamp forest 345 ha.

Altitude: Mangrove forest 0-2 m; swamp forest 0-10 m.

Overview: Kosrae is a volcanic island with steep sided mountains, a fairly narrow and flat coastal plain and a fringing coral reef. (This coastal plain is largely filled over lagoon and/or reef flat). Swamp forests are low wet areas just inland of the mangrove forest, especially around river mouths. The transition between the two forest types is fairly abrupt. The mangroves of Kosrae are unusual in occurring behind sandy coastal barrier islands except on the north coast. Three wetlands of outstanding importance, Okat Mangrove Forest, Utwa-Walung Mangrove Forest and Yela River Terminalia Swamp Forest, are described separately as sites la, lb and lc, respectively.

Physical features: Kosrae is one of the four constituent states of the Federated States of Micronesia. Kosrae is the only island within the State. Its administrative centre is in Tofol on the east coast and the population is mostly clustered in five villages: Tafunsak in the northeast coast, Lelu on the east coast, Malem on the southeast coast, Utwe on the south coast, and Walung on the western tip of the island.

Kosrae's coastal plains were formed by rapid erosion off steep volcanic mountain slopes and deposition on the inner portion of a fringing reef. This coastal plain is generally swampy and dominated by mangrove forest and freshwater swamp forest. Due to high wave energy, sandy barrier islands or cays, often very narrow in width, form on the seaward side of the mangrove forest except on the more protected north coast. In some areas these sand barriers are only 2-3 m wide and 1 m high. Along portions of the southeast and south coast, the distance between the inner edge of the barrier island and the outer reef margin may be less than 100 m. The hydrology of these wetlands has not been studied, but is probably complex as there is a distinct transition between adjacent fresh and brackish-water wetland types that must be mediated by the balance between freshwater influx and tidal inundation. The predominant soil type in the mangroves is Naniak-Insak. Naniak-Insak is a moderately deep and very deep, very poorly drained soil formed in alluvium derived dominantly from basic igneous rock. It is loamy and mucky. The soil types associated with swamp forest are Nansepsep-Inkosr and Ngerungor. Both are very deep poorly or somewhat poorly drained level or nearly level soils. They are loamy soils formed from alluvium derived from igneous rock. Ngerungor soils overlie coral sand. Tidal variation in Kosrae is about 3 m at maximum. The catchment area for these wetlands is the whole of Kosrae island. Major rivers include the Yela, Okat, Tofol, Malem and Finkol-Menka. The climate on Kosrae is humid tropical. The annual rainfall is very high at about 5,000 mm.

Ecological features: *Sonneratia alba* is the dominant mangrove species in most areas of Kosrae, and is the largest mangrove species occurring on the island. Some of the trees attain a height of 25-30 m and support numerous epiphytes in their branches. *Sonneratia* reaches its greatest height towards the middle of the mangrove, but is also the most seaward species, with *Rhizophora mucronata* occurring at the mouths of channels. *Rhizophora apiculata* and *Bruguiera gymnorrhiza* occur mixed with *Sonneratia* toward the middle of the mangrove, with patches of *Nypa fruticans* and stands of *Xylocarpus* found toward the landward edge (Stemmermann & Proby, 1978). Adjacent communities include coastal strand vegetation on barrier islands seaward of the mangroves around most of the island, and swamp forest or agro-forest on the landward side.

High canopy swamp forest on Kosrae is characterised by *Terminalia carolinensis* and *Horsfeldia nunu*. Species in the lower strata include: *Barringtonia racemosa*, *Neubergia celebica* and *Scirpodendron ghaeri*. This forest is found on low, swampy ground adjacent to the mangrove forests. At slightly higher elevations, *Camptosperma brevipetiolata* becomes a component of the high canopy wet rainforest, which is often not easily distinguished from swamp forest, as the two forest types have many species in common. The swamp forest is well developed in an area in Malem Municipality and along the Yela River (Stemmermann & Proby, 1978).

Land tenure: Mangrove areas are under the jurisdiction of the State Government. Freshwater swamp areas are privately owned.

Conservation measures taken: There are no protected areas on Kosrae.

Conservation measures proposed: Draft legislation to control harvesting of forest resources has been developed but not yet passed by the State Legislature. In July 1991, a team sponsored by the East-West Center carried out surveys in the Okat and Utwe-Walung mangrove forests to develop a protected area management plan for these areas. The State Government has committed some funding to the development of a protected area in the Utwe-Walung area.

Land use: Mangroves are primarily exploited for firewood. Mangrove timber and nipa fronds are used for house construction, but use of these traditional materials is declining. There is limited exploitation of *Xylocarpus* for handicrafts (wood carvings). There is one small portable saw mill on the island which has been used in timbering operations in the Utwe mangroves. The island experienced serious depopulation due to disease in the late 19th century. Population moved to village centres and is only now reaching pre-contact levels.

Possible changes in land use: Current changes in land use are associated with road construction (see below).

Disturbances and threats: There has been little conversion of wetland areas in Kosrae to date. Some freshwater swamps have been converted to agro-forest, mainly in Malem Municipality. During the Japanese administration, *Terminalia* forests were logged but these have apparently fully recovered as there has been no significant exploitation in the last 50 years. The principal threat to the mangrove forest and swamp forest comes from the expansion of the road network around the island. The Japanese built a simple road network on the eastern side of the island during their administration. That road was upgraded in the mid-1970s. The road network was expanded along the south coast in the mid-1980s, and is currently being expanded along the north coast. Completion of a circumferential road is a high priority in the State Government's development plans. Aside from direct impacts which include limited filling of mangrove areas and possible changes in local hydrographic patterns, the road is allowing greater access to previously inaccessible wetland areas. Clear-cutting of mangroves for firewood is most noticeable in the Okat area, where the road has most recently been completed. The road will eventually reach the Yela River swamp forest. This is privately owned and there is some interest in logging the area, once access is available.

Hydrological and biophysical values: Because of the very steep terrain of the interior and high rainfall, there is significant erosion and run-off. The freshwater swamp forests and mangrove forests doubtless intercept much of this run-off, and act as sediment traps. Because Kosrae has very rich oceanic fringing reefs, these wetlands are important in maintaining the requisite water quality that allows these coral reefs to grow in close proximity to land.

Social and cultural values: Wetlands are a source of a variety of useful products including firewood, timber, thatch and fishery products. Important fisheries products include the mangrove crab (*Scylla serrata*) and certain species of snapper (*Lutjanus* sp.). Numerous archaeological sites are also found along the interior margin of the mangrove forest, especially in the Okat and Utwe-Walung areas.

Noteworthy fauna: Vertebrates include an introduced monitor lizard (*Varanus indicus*), Marianas Fruit Bat (*Pteropus mariannus*), White-tailed Tropicbird (*Phaethon lepturus*), Pacific Reef Heron (*Egretta sacra*), White Tern (*Gygis alba*), Black Noddy (*Anous minutus*), Brown Noddy (*A. stolidus*), Micronesian Starling (*Aplonis opaca*) and Micronesian Honeyeater *Utyzomela rubrata*). Marine species include the mangrove crab (*Scylla serrata*), land crab (*Cardisoma* sp.), coconut crab (*Birgus latro*), popol clam (*Diplodonta* sp.), the snail *Littorina scabra*, the clam *Asaphis violescens*, mullets (Mugilidae), rabbit fishes *Siganus* spp., cardinal fishes (Apogonidae), Common Slipmouth (*Leiognathus equulus*), Mangrove Snapper (*Lutjanus argentimaculatus*) and Mono (*Vionodacylus argenteus*).

Noteworthy flora: Mangroves include *Sonneratia alba*, *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorrhiza*, *Barringtonia racemosa*, *Davallia solida*, *Derris trifoliata*, *Nephrolepsus acutifolia*, *Ophioglossum pendulum* and *Xylocarpus granatum*. Swamp forest species include *Terminalia carolinensis*, *Horsefieldia numu*, *Camptosperma brevipetiolata*, *Barringtonia racemosa*, *Neubergia celebica* and *Scirpodendron ghaeri*.

Scientific research and facilities: An expedition sponsored by the East-West Center (Hawaii) surveyed various wetland areas in July 1991, and made recommendations for protected area status (Wilson and Hamilton, 1992). A study entitled "Utilisation and Management of Coastal Wetland Resources" was conducted by Dr Padma Narsey Lal in 1988 in connection with development of a coastal resources management plan for Kosrae State (Lal, 1989).

Recreation and tourism: Wetland areas are not used for recreation by the local populace. The study sponsored by the East-West Center made some recommendations for the utilisation of wetland areas for tourism. A brochure was produced by Sea Grant at the Community College of Micronesia for the Kosrae State Division of Tourism describing two canoe trips that could be taken in the mangrove areas of Kosrae.

Management authority and jurisdiction: The Kosrae State Government has jurisdiction over mangrove areas, but no legislation to direct management of forest resources has yet been implemented.

References: Hosokawa (1954); Laird (1983b); Lal (1989); MacLean *et al.* (1988); Stemmermann & Proby (1978); Whitesell *et al.* (1986); U.S. Army Corps of Engineers, Pacific Ocean Division (1987, 1989a); Wilson & Hamilton (1992).

Reasons for inclusion: Swamp forest: 1a, 2b; mangrove forest 1a, 2b, 2c.

Source: Glasstine Cornelius and Christopher R. Dahl.

Wetland Name: Okat Mangrove Forest

Country: Federated States of Micronesia

Coordinates: 5°18'-5°22'N, 162°55'-162°59'E

Location: the contiguous mangrove forest along the north coast of Kosrae Island, stretching northeast from Molsron Mwot (inlet) to Tafunsak village. The mangrove forest is at its widest and most developed in the estuary of the Okat River. The mouth of the Okat River is just inland from Kosrae airport and port facilities.

Area: 453.2 ha.

Altitude: 0-2 m.

Overview: A coastal belt of mangrove forest averaging about 500 m in width except in the estuaries of the Okat and Lemwot rivers where it is somewhat wider. Unlike mangroves on the rest of the island, the Okat mangrove forest is not separated from the fringing reef by a barrier island. This area is significant because it has the largest examples of *Sonneratia alba* in the Caroline Islands.

Physical features: The coastal plains of Kosrae were formed by rapid erosion off steep volcanic mountain slopes and deposition on the inner portion of a fringing reef. This coastal plain along the north coast is narrow, generally swampy and dominated by swamp forest and mangrove. The predominant soil type in the mangroves is Naniak-Insak. Naniak-Insak is a moderately deep and very deep, very poorly drained soil formed in alluvium derived dominantly from basic igneous rock. It is loamy and mucky. The major rivers are the Yela, Okat and Lemwot. The climate is humid tropical, with an average annual rainfall of about 5,000 mm.

Ecological features: *Sonneratia alba* is the dominant mangrove species. Some of the trees attain a height of 25-30 m and support numerous epiphytes in their branches. *Sonneratia* reaches its greatest height toward the middle of the mangrove, but is also the most seaward species, with *Rhizophora mucronata* occurring at the mouths of channels. *Rhizophora apiculata* and *Bruguiera gymnorhiza* occur mixed with *Sonneratia* toward the middle of the mangrove, with patches of *Nypa fruticans* and stands of *Xylocarpus* found toward the landward edge (Stemmermann & Proby, 1978). The mangroves are bordered on their landward side by freshwater swamp forest or agro-forest.

Land tenure: The mangrove forest is under the jurisdiction of the State Government.

Conservation measures taken: None.

Conservation measures proposed: Draft legislation to control harvesting of forest resources has been developed but not passed by the State Legislature.

Land use: The mangroves are primarily exploited for firewood. Mangrove timber and nipa fronds are also used for house construction but use of these traditional materials is declining. There is limited exploitation of *Xylocarpus* for handicrafts (wood carvings). Disturbances and threats: The island's circumferential road is currently being expanded along the north coast into the Okat River drainage. Aside from direct impacts which include limited filling of mangrove areas and possible changes in local hydrographic patterns, the road is allowing greater access to previously inaccessible wetland areas.

Clear-cutting of mangroves for firewood for up to 100 m from the roadside is very noticeable in those parts of the Okat forest where the road has been located along the inner fringe of the mangroves. A major fisheries complex is under construction at the nearby port, and a cannery is proposed for this complex. Once in operation, the cannery will require substantial amounts of water and generate large amounts of waste. If treatment facilities are inadequate, local water quality will be affected.

Hydrological and biophysical values: The mangrove forest probably intercepts much run-off from the mountainous interior of the island, thereby acting as a sediment trap and helping to maintain the requisite water quality that allows coral reefs to grow in close proximity to the land.

Social and cultural values: The mangrove forest is a source of a variety of useful products including firewood, timber, thatch and fishery products. Important fisheries products include the mangrove crab (*Scylla serrata*) and certain species of snapper (*Lutjanus* sp.). Numerous archaeological sites are found along the interior margin of the mangrove forest.

Noteworthy fauna: As for the wetlands of Kosrae Island in general (Site 1).

Noteworthy flora: Excellent stands of mangrove forest with *Sonneratia alba*, *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorhiza*, *Barringtonia racemosa*, *Davallia solida*, *Derris trifoliata*, *Nephrolepis acutifolia*, *Ophioglossum pendulum* and *Xylocarpus granatum*.

Scientific research and facilities: No research has been carried out specifically at this site.

Recreation and tourism: None at present. A recent survey sponsored by the East-West Center (Hawaii) developed recommendations for utilisation of wetland areas, including the Okat area, for tourism (Wilson and Hamilton, 1992).

Management authority and jurisdiction: The Kosrae State Government has jurisdiction over the mangrove forest, but no legislation to direct the management of forest resources has yet been implemented.

References: Stemmermann & Proby (1978); Whitesell *et al* (1986); Wilson & Hamilton (1992).

Reasons for inclusion: 1a, 2b, 2c.

Source: Christopher R. Dahl.

Wetland Name: Utwa-Walung Mangrove Forest

Country: Federated States of Micronesia

Coordinates: 5°16' -5°17'N, 162°54' -162°58'30"E

Location: the contiguous mangrove forest along the south coast of Kosrae Island, extending from Soaksa on the western tip of the island east to Molsron Taf, immediately to the west of Utwa village.

Area: 637.2 ha.

Altitude: 0-2 m.

Overview: A broad belt of mangrove forest on the south coast of Kosrae Island, between 500 and 1000 m in width. There are two large brackish lakes, Lulu Nefalil and Lulu Utwa, in the interior of the central portion of the mangrove. The Utwa-Walung mangrove forest is representative of mangrove physiography in Kosrae, with a narrow barrier island on the seaward margin and a typical assemblage of mangrove fauna and flora. The central and western portions of the wetland remain relatively undisturbed.

Physical features: Kosrae's coastal plains were formed by rapid erosion off steep volcanic mountain slopes and deposition on the inner portion of a fringing reef. On the south coast, the dry land aspect of this plain is very limited; the mangrove forests are for the most part adjacent to steep mountain slopes, except at the extreme eastern end around the estuary of the Finkol-Menka River and in the west at the estuary of the Falwe River. The forest overlies the inner part of the fringing coral reef. Due to high wave energy, a coastal strand or barrier island has formed between the protected waters of the mangrove forest and the open fringing reef. In some places, the distance from this narrow islet to the outer reef margin is as little as 50 m. The barrier island is bisected by a single channel (Tukunsru) near its western end. The predominant soil type in the mangroves is Naniak-Insak. Naniak-Insak is a moderately deep and very deep, very poorly drained soil formed in alluvium derived dominantly from basic igneous rock. It is loamy and mucky. Run-off from the southwestern part of the island drains into the wetland primarily through the Finkol-Menka and Falwe rivers. The climate is humid tropical with an average annual rainfall of about 5,000 mm.

Ecological features: The mangrove forest is typical of Kosrae, and has been described by Stemmermann and Proby (1978). *Sonneratia alba* is the dominant mangrove species. *Sonneratia* reaches its greatest height toward the middle of the mangrove, but is also the most seaward species with *Rhizophora mucronata* occurring at the mouths of channels. *Rhizophora apiculata* and *Bruguiera gymnorrhiza* occur mixed with *Sonneratia* toward the middle of the mangrove, with patches of *Nypa fruticans* and stands of *Xylocarpus* found toward the landward edge. Adjacent communities include coastal strand vegetation, upland forest and swamp forest.

Land tenure: The mangrove forest is under the jurisdiction of the State Government.

Conservation measures taken: None.

Conservation measures proposed: Draft legislation to control harvesting of forest resources has been developed but not yet passed by the State Legislature.

Land use: The mangroves are exploited primarily for firewood. Mangrove timber and nipa fronds also used for house construction, but use of these traditional materials is declining. There is limited exploitation

of *Xylocarpus* for handicrafts (wood carvings). The Utwa-Walung mangrove forest was inaccessible by vehicle until 1987, when a new section of the circumferential road skirting the mountain sides on the landward side of the mangrove forest was completed. This has allowed some people to move back to ancestral lands in the area. The brackish lakes (lulu) within the mangroves and Utwa harbour in the east are important to subsistence fisheries.

Possible changes in land use: The recent construction of a road along the landward side of the mangrove forest has allowed increased access to the area and renewed settlement along the south coast. Both the State Government and Utwa Municipality are interested in developing the mangrove forest for tourism as the area has great aesthetic value. No major development projects are known that will significantly alter land use or compromise the quality of the area in the near future.

Disturbances and threats: A small portable saw mill has been operating in the eastern part of the forest on an occasional basis. Logging practices are poor, and the impact has been greater than warranted by the level of exploitation. Dredging associated with road construction has led to extensive siltation in the western part of Utwa harbour (Molsron Utwa).

Hydrological and biophysical values: The mangrove forest probably intercepts much run-off from the mountainous interior of the island, thereby acting as a sediment trap and helping to maintain the requisite water quality that allows coral reefs to grow in close proximity to the land.

Social and cultural values: The mangrove forest is a source of a variety of useful products including firewood, timber, thatch and fishery products. Important fisheries products include the mangrove crab (*Scylla serrata*) and certain species of snapper (*Lutjanus* sp.).

Noteworthy fauna: As for the wetlands of Kosrae Island in general (Site 1). Noteworthy flora: Excellent stands of mangrove forest with *Sonneratia alba*, *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorrhiza*, *Barringtonia racemosa*, *Davallia solida*, *Derris tnfoliata*, *Nephrolepsus acutifolia*, *Ophioglossum pendulum*, *Xylocarpus granatum* and *Nypa fruticans*.

Scientific research and facilities: No research has been carried out specifically at this site.

Recreation and tourism: Very little at present. A brochure has been prepared for the State Division of Tourism describing canoe and hiking opportunities in the mangrove and coastal strand. A recent survey sponsored by the East-West Center (Hawaii) investigated opportunities for the development of tourism in the area (Wilson and Hamilton, 1992).

Management authority and jurisdiction: The State Government has jurisdiction over the mangrove forest, but no legislation to direct the management of forest resources has yet been implemented.

References: Stemmermann & Proby (1978); Whitesell *et al* (1986); Wilson & Hamilton (1992).

Reasons for inclusion: 1a, 2b, 2c.

Source: Christopher R. Dahl.

Wetland Name: Yela River Terminalia Swamp Forest

Country: Federated States of Micronesia

Coordinates: 5°19'N, 162°57'E

Location: located in the Yela River drainage in Tafunsak Municipality, on the north coast of Kosrae Island.

Area: 77.3 ha.

Altitude: 0-20 m.

Overview: The Yela River *Terminalia* forest is reported to be the finest example of this unique wetland type in FSM. It is situated in a flat valley floor surrounded by mountain slopes on all sides except the north, where the valley opens to the coast. Although periodically logged during the Japanese era, the forest has now been undisturbed for more than forty years.

Physical features: A large area of tall freshwater swamp forest in the lower basin of the Yela River, almost entirely surrounded by steep mountain slopes. The river drains out through a gap in the hills to the north.

Ecological features: High canopy swamp forest dominated by *Terminalia carolinensis* and *Horsfieldia nunu*. Species in the lower strata include *Barringtonia racemosa*, *Neubergia celebica* and *Scirpodendron ghaeri*. In the north, the forest is adjacent to the coastal mangrove forests. At slightly higher elevations, the forest merges into high canopy wet rainforest with *Camposperma brevipetiolata* (Stemmermann & Proby, 1978).

Land tenure: The forest is privately owned.

Conservation measures taken: None.

Conservation measures proposed: Draft legislation to control harvesting of forest resources has been developed but not yet passed by the State Legislature.

Land use: The swamp forest has been relatively inaccessible and undisturbed since the Japanese era. There is currently no human population resident in the area.

Disturbances and threats: The major threat to the wetland is associated with the construction of a new road through the area. The State Government is currently extending the island's circumferential road along the north coast. Eventually it will reach this area. The road will probably span the mouth of the valley on a filled road-bed, and this could cause a change in hydrographic patterns in the valley. Once the valley becomes readily accessible, it is likely that the forest will be logged, as the timber is of some value.

Hydrological and biophysical values: No specific information is available.

Social and cultural values: None, because of the inaccessibility of the site.

Noteworthy fauna: No information.

Noteworthy flora: Undisturbed mature stands of freshwater swamp forest dominated by *Terminalia carolinensis*, with *Horsfeldia numu*, *Camposperma brevipetiolata*, *Barringtonia racemosa*, *Neubergia celebica* and *Scirpodendron ghaeri*.

Scientific research and facilities: This swamp forest was first described in 1952 by Hosokawa (1954), and may have been visited in connection with a U.S. Forest Service survey of timber volumes (McLean *et al.*, 1988).

Management authority and jurisdiction: No information.

References: Hosokawa (1954); MacLean *et al.* (1988); Stemmermann & Proby (1978); Whitesell *et al.* (1986).

Reasons for inclusion: 1d, 2b.

Source: Christopher R. Dahl.

Wetland Name: The Wetlands of Pohnpei State

Country: Federated States of Micronesia

Coordinates: 6°57'N, 158°12'E

Location: the wetlands of Pohnpei State, primarily mangrove forests surrounding the main island of Pohnpei.

Area: 5,525 ha.

Altitude: 0-772 m.

Overview: Pohnpei State consists of the main island of Pohnpei, and the atolls Ngatik, Mokil, Oroluk, And, Kapingamarangi, Nukuoro, Pingalap and Pakin. There are extensive mangrove and freshwater swamp forests on Pohnpei island along with freshwater marshes, ivory nut palm forests (*Metroxylon amicarum*) and upland swamps. Taro swamps (*Colocasia esculenta* and *Cyrtosperma chamissonis*) are found on both Pohnpei and the outer island atolls. Limited stands of dwarf *Rhizophora* and *Lumnitzera* are found on some of the atolls. Two wetlands of outstanding importance, Enipein Mangroves and Palikir Freshwater Marsh, are described separately as sites 2a and 2b, respectively.

Physical features: Pohnpei is a volcanic island with both fringing and barrier reefs. Wetland areas are most extensive along the flat coastal plain and adjacent inner reef flat, although wet areas are encountered at all altitudes due to high rainfall (recorded at about 5,000 mm/yr on the coast and estimated to exceed 10,000 mm/yr in upland areas). Mangroves are found on the lower portions of rivers and on tidal mudflats built over inner fringing reef flat. They also surround small coral islets on the barrier reef. Freshwater swamp forest is common adjacent and inland to mangroves. Marshes and taro swamps are considered to be variations of the swamp forest community. The soil types in wetlands (United States Department of Agriculture soil series taxonomy) are Inkosr series silty clay loam in swamp forests, Mesei Variant mucky peat in marshland and

Naniak series mucky silt loam in mangrove areas (Laird, 1982). Water quality is variable around Pohnpei but generally good. There is some localised sewage contamination of rivers and rather serious pollution from sewage, oil products and other contaminants in estuarine areas around the urban centre of Kolonia. Freshwater wetlands have little standing water, generally no more than 0.5 metre, while the soil is constantly saturated and mucky. In mangroves, water depths vary from a few centimetres to 2 metres in channels. Tidal fluctuation on Pohnpei has a 0.7 m mean and 1.0 m diurnal range. Because of high rainfall, there are many significant perennial river systems on Pohnpei. The Nanpil, in the north, and the Lehn Mesi, in the south, are the two largest drainages. Total dry land area, or drainage, is 335.5 sq.km. The climate is wet tropical with recorded rainfall exceeding 5,000 mm/yr, and a fairly constant year-round temperature averaging 27°C.

Ecological features: Mangrove forest is well developed and in some areas extends more than two km from the shore. The forests are characterised by channels bordered by large trees with a canopy height of up to 30 metres. Away from the channels, canopy height decreases markedly, reaching only two metres in some areas (Stemmermann & Proby, 1978), and creating dwarf forest. Mangrove species are not uniformly distributed throughout the forests of Pohnpei. Along the channels and toward the leeward edge of the mangrove forest, *Rhizophora mucronata* and *Sonneratia alba* tend to dominate. Other common tree species are *R. apiculata*, *Xylocarpus granatum*, *Lumnitzera littorea* and occasionally *Bruguiera gymnorrhiza* (Stemmermann & Proby, 1978). Marine crocodiles are not found on Pohnpei. As elsewhere in Micronesia, the mangroves of Pohnpei do not support abundant bird life, although the seaward margins are used by roosting seabirds. Freshwater swamp forest is usually found in flat coastal areas adjacent to the inside of the mangroves. It is characterised by *Terminalia carolinensis*, *Campnosperma brevipedunculata* and *Pandanus comminsii*. *Metroxylon amicarum* may be found as an emergent species in the high canopy phase, but is more typically associated with the low canopy phase (Stemmermann & Proby, 1978). The low canopy phase is characterised by *Phragmites kark a*, *Hibiscus tiliaceus*, *Barringtonia racemosa*, *Macaranga* spp. and *Glochidion* sp. Four lowland marsh areas were identified by Stemmermann and Proby; they are adjacent to, or in one case, surrounded by mangrove forest. They are characterised by sedges (*Eleocharis* spp.) with dwarf tree species (*Lumnitzera* or *Rhizophora*) sparsely interspersed. Cultivated taro swamps are another common type of wetland.

Land tenure: Land below the high tide mark is under the jurisdiction of Pohnpei State Government. Most of the land adjoining the mangroves is owned privately by deed.

Conservation measures taken: The Pohnpei State Government passed a Watershed and Mangrove Protection Act in 1987 giving management jurisdiction over mangrove areas to the State Division of Forestry. The Division has instituted a state-wide mangrove logging ban until adequate management measures can be implemented. This same act also protects publicly owned watershed areas in the interior of the island as a Watershed Reserve. However, effective implementation of watershed protection has not yet occurred.

Conservation measures proposed: In connection with the above mentioned legislation, Devoe (1991) has proposed 11 reserve areas in the mangroves. Protection would vary from strict habitat protection to sustainable harvest managed by the State Division of Forestry.

Land use: According to recent population estimates, there are about 30,000 people on Pohnpei island. Of these, approximately 7,000 are concentrated in the urban centre of Kolonia. The majority of the population are subsistence farmers and fishermen. Freshwater swamp is occasionally converted for taro production. The mangrove forests of Pohnpei have been logged on both a commercial and subsistence basis. Many marine products are harvested in the mangrove, including the mangrove crab (*Scylla serrata*), other shellfish and various species of fish.

Possible changes in land use: Most significant development is currently concentrated in the urban centre of Kolonia. Population growth and urbanisation has led to localised impacts on wetlands from conversion and pollution. Extension of infrastructure, including a circumferential road and electrical transmission lines, may increase rural development and consequent environmental impacts. Secondary road construction may affect wetlands by increasing erosion rates. A few proposals for major resort development have been mooted, but none are currently under construction. Such resorts would include golf courses; their construction and maintenance could have downstream impacts on wetlands and estuarine areas. The State Government has considered two sites either in or adjacent to wetlands for the development of a new, larger airport. As of this writing, no decision has been taken on this matter.

Disturbances and threats: Aside from the problems mentioned above, the main threat to forested wetlands, particularly mangroves, is unmanaged timber harvest, both subsistence and commercial. Devastation of the upland forest is affecting downstream water quality and sediment loads, and this in turn is threatening the mangrove and lagoon systems. As noted above, the State Government is trying to establish a viable management regime for mangrove and watershed areas.

Hydrological and biophysical values: Mangroves are important for shore protection. They also serve as a natural filtering and buffering system which settles silt and provides for a slow release of nutrients into the lagoon (MacLean *et al.*, 1986). The hydrology of adjacent freshwater swamps and mangroves is no doubt complex and has not been studied. Social and cultural values: The principal social values of the wetlands include timber, marine products, traditional medicines, tourism and recreation, and scientific research. There is also a strong cultural attachment to mangrove areas (as there is to all areas of Pohnpei). Numerous legends exist that relate to specific name locations in the mangroves. The mangroves also play an important role in the origin myth of Pohnpei.

Noteworthy fauna: Wetland areas provide habitat for a variety of seabirds, waterbirds and forest birds, some endemic and others threatened. Notable seabirds and waterbirds include the Great Frigatebird (*Fregata minor*), Pacific Reef Heron (*Egretta sacra*), terns (*Sterna* spp.), noddies (*Anous* spp.) and the Micronesian Kingfisher (Pohnpei subspecies: *Halcyon cinnamomina reichenbachii*). There are a number of endemic birds on Pohnpei. While these are generally inhabitants of the mountain forests, they may be encountered in and around wetlands. They include the Pohnpei Lory (*Trichoglossus rubiginosus*), Pohnpei Flycatcher (*Myiagra pluto*), Pohnpei Fantail (*Rhipidura kubagi*), Long-billed White-eye (*Rukia longirostra*), the Pohnpei subspecies of Cicadabird (*Coracina tenuirostris insperatum*) and Pohnpei Mountain Starling (*Aplonis pelzelni*), although the latter may now be extinct. The Caroline Islands Ground Dove (*Gallicolumba kubaryi*) is endemic to Pohnpei and Chuuk. The only indigenous mammal in the mangrove and swamp forests is the Marianas Fruit Bat (*Pteropus mariannus*). There are a number of endemic freshwater gobies (Gobiidae) in the rivers and streams of Pohnpei.

Noteworthy flora: Typical mangrove species include *Rhizophora mucronata* var. *sylosa*, *R. apiculata*, *Sonneratia alba*, *Bruguiera gymnorrhiza*, *Xylocarpus granatum*, *Lumnitzera littorea* and *Nypa fruticans*. Characteristic tree species in freshwater swamp forest are *Terminalia carolinensis*, *Camptosperma brevipetiolata*, *Pandanus comminsii* and *Metroxylon amicarum* and in the low canopy phase *Phragmites karka*, *Hibiscus tiliaceus*, *Barringtonia racemosa*, *Macaranga* spp. and *Glochidion* sp.

Scientific research and facilities: The College of Micronesia has limited research facilities at the Community College and Land Grant facility in Kolonia. Current research on mangrove use is being carried out by Dr Nora Devoe, a research forester with the USDA Forest Service. Fr Greg Muckenhaupt of the University of Hawaii is currently conducting research on nutrient flux within the mangrove forest (pers. comm.).

Conservation education: While Pohnpei wetlands have high potential as a site for educational activities, no facilities or programmes utilising wetland areas currently exist. Recreation and tourism: Nipein Marine Park, Inc. has begun giving mangrove channel tours on an irregular basis employing traditional dugout canoes. There appears to be significant potential for expansion of this activity as the mangrove forest is of high scenic value, adjacent reefs are in excellent condition and the mangrove forests do not harbour dangerous animals (e.g. crocodiles) or large numbers of biting insects. A private entrepreneur is building a boardwalk through mangrove forest adjacent to the village of Pwudoi (Kitti) on the southwest coast of Pohnpei.

Management authority and jurisdiction: Division of Forestry, Kolonia, Pohnpei.

References: Devoe (1991); Holthus (1987); Laird (1982); MacLean *et al.* (1986, 1988); Miyagi & Kiyoshi (1989); Pettys *et al.* (1986); Stemmermann & Proby (1978); U.S. Army Corps of Engineers, Pacific Ocean Division (1985, 1986).

Reasons for inclusion: la, lc, ld, 2a, 2b, 2c, 2d.

Source: Christopher R. Dahl and Ron Cannarella.

Wetland Name: Enipein Mangroves

Country: Federated States of Micronesia

Coordinates: 6°51'N, 158°13'E

Location: the Enipein mangrove forest is on the south-southeast side of Pohnpei island in the municipality of Kitti. It is approximately 18 km from the urban centre of Kolonia. This forest is part of contiguous mangrove forest that surrounds virtually all of Pohnpei. The Enipein forest is defined as the area bounded by Dauen (channel) Rakis on the west and Dauen Semwei on the east.

Area: 755 ha.

Altitude: Sea level

Overview: This mangrove forest is one of the most extensive on Pohnpei, approximately 2 km wide (from inner to outer boundaries) at its widest point. The forest is well developed with excellent examples of *Sonneratia alba*, *Lumnitzera littorea* and *Xylocarpus granatum*. This area is being considered for protected status by Pohnpei State.

Physical features: The Enipein mangrove forest has formed on the inner reef flat by the gradual deposition of eroded material. Pohnpei is a volcanic island that experiences high rates of rainfall (approximately 5,000 mm/year) and thus high erosion rates. Stratigraphy analyzed by Miyagi and Fujimoto (1989) from the Enipein area indicates that about 1.7 metres of mangrove peat overlies the original coralline reef flat. The soil type in mangroves (United States Department of Agriculture soil series taxonomy) is Naniak series mucky silt loam (fine loamy mixed non-acid, isohyperthermic, Typic sulfaquents). Water quality is generally typical of mangrove areas (tea-coloured due to tannins) with little pollution caused by humans. Coastal waters around the island are bearing heavier sediment loads due to land clearance, construction and agriculture. This is no doubt the case in Enipein as well. Water depths vary from a few centimetres to two metres in mangrove channels. Tidal fluctuation on Pohnpei has a 0.7 m mean and 1.0 m diurnal range. Five rivers flow into this mangrove area. The catchment area for the Enipein mangroves is very roughly estimated at 22 sq.km. The climate on Pohnpei is wet tropical, with an annual rainfall approaching or exceeding 5,000 mm. Temperature varies little throughout the year, averaging 27°C. Humidity is high, especially from May to October when the trade winds cease to blow.

Ecological feature: Enipein is a wide dense mangrove area forming part of an extensive and contiguous mangrove fringe that surrounds Pohnpei island. It is bisected by a system of channels except in the central parts of the widest areas where poor water circulation has resulted in dwarf forest. *Rhizophora mucronata* is found on the outer margin. Well developed groves of *Xylocarpus granatum* and *Lumnitzera littorea* are found towards the landward margin of the forest. Large *Sonneratia alba* are also found in the middle and landward zones. In estuarine areas around river mouths or bays, *Rhizophora mucronata* and *R. apiculata* occur as pure stands or mixed with some *S. alba* and *Bruguiera gymnorrhiza*. Upstream the *Rhizophora* component drops out. *Nypa fruticans* can become dominant in narrow bands along riverine portions of the inner mangrove.

Land tenure: Land below the high tide mark is under the jurisdiction of Pohnpei State Government.

Conservation measures taken: The Pohnpei State Government passed a Watershed and Mangrove Protection Act in 1987 giving management jurisdiction over mangrove areas to the State Division of Forestry. The Division has instituted a state-wide mangrove logging ban until adequate management measures can be implemented.

Conservation measures proposed: Devoe (1991) has proposed Enipein as a reserve area. 76 ha would be classified as strict preserve for wildlife habitat with limited access; 163 ha as park area where timber is not harvested, and hunting and fishing are allowed by permit only; and 365 ha for managed timber harvest under the direction of the State Division of Forestry. The village of Enipein Pah has established a corporation, Enipein Marine Park, Inc., that wishes to utilise this area for tourism. The village supports park status for the area.

Land use: The Enipein mangrove forest has been logged on both a commercial and subsistence basis. However, most of this has had low impact except for an 8 ha clear-cut in the western section of the tract (Devoe, 1991). Many marine products are harvested in the mangrove including the mangrove crab (*Scylla serrata*), other shellfish and various species of fish. Adjacent lands are mostly settled agro-forest. There are extensive freshwater wetlands adjacent to the inner margin of the mangroves. These include swamp forest, freshwater swamp and *Metroxylon amicarum* palm forest. Much of the freshwater swamp was turned over to the

production of taro in a state agricultural development project. Population densities are relatively low. The most recent census (1985) enumerated a population of 4,572 for all of Kitti Municipality. Most residents engage in subsistence activities while some commute to Kolonia for wage employment (primarily in the government sector) on a daily basis.

Possible changes in land use: The State Government has considered development of a new airport along the inner margin of this mangrove area. As of this writing, no decision has been taken on this matter.

Disturbances and threats: No major threats currently exist. Unmanaged subsistence and commercial logging has probably had the greatest impact, but this is still modest.

Hydrological and biophysical values: Mangroves are recognised for their value in shore protection and stabilisation. The lagoonal and barrier coral reefs adjacent to Enipein are of high quality; mangroves intercept silt run-off which might otherwise degrade these reefs.

Social and cultural values: The mangroves are of subsistence value for a variety of products including timber, shellfish and fish. Timber has also been harvested on a semi-commercial basis. This area of mangroves is also being used in a tourism venture and *as a* research site. Areas within the mangroves are named and often have legends associated with them. Particular resources or areas may be associated with certain clans. According to legend, *Xylocarpus granatum* originated from a particular grove in Enipein and then spread to the rest of the island.

Noteworthy fauna: Mangroves provide habitat for various seabirds and waterbirds. However, it is not primary habitat for any of the endemic, rare or threatened species on Pohnpei. The mangrove crab (*Scylla serrata*) is common and an important subsistence and commercial species. Two bivalves of subsistence importance that are abundant in the Enipein mangroves are the "lipwei" clam (*Anadara* sp.) and "kopil" clam (*Pitar* spp.). A number of economically important fish are transient in the mangroves; these include *Lutjanus argentimaculatus*, *Lutjanus fulvus* (groupers), *Lethrinus harak* (snapper), *Liza vaigiensis*, *Valamugil seheli* (both mullets), *Siganus* spp. (rabbitfish) and *Parupeneus barberinus* (goatfish).

Noteworthy flora: Characteristic trees are *Rhizophora* spp., *Bruguiera gymnorrhiza*, *Lumnitzera littorea*, *Nypa fruticans* and *Sonneratia alba*. The Enipein area encompasses some fine examples of undisturbed high stature mangrove forest with groves of *Lumnitzera* and *Xylocarpus* and quite large *Sonneratia* trees. *Asplenium* spp., *Nephrolepis acutifolia* and species of Orchidaceae are characteristic epiphytes; *Nephrolepis* is particularly associated with *Sonneratia*.

Scientific research and facilities: No research facilities exist in the area. Devoe (1991) has a study site here for her research on mangrove forest utilisation. Fr Greg Muckenhaupt of the University of Hawaii is currently conducting research on Pohnpei into nutrient flux in the mangrove forest (pers. comm.) and has a study site at Enipein.

Conservation education: There are no conservation education programmes at Enipein. Potential for basic educational activities here is high given the nascent interpretive potential of the Enipein Marine Park Corporation.

Recreation and tourism: Enipein Marine Park Corporation has begun giving tours on an irregular basis employing traditional dugout canoes. There appears to be significant potential for expansion of this activity *as* the mangrove forest is of high scenic value, adjacent reefs are in excellent condition and the mangrove forests do not harbour dangerous animals (e.g. crocodiles) or large numbers of biting insects.

Management authority and Jurisdiction: Division of Forestry, Kolonia, Pohnpei. References: Devoe (1991); Holthus (1987); Laird (1982); MacLean *et al.* (1986, 1988); Miyagi & Kiyoshi (1989); Pettys *et al.* (1986); U.S. Army Corps of Engineers, Pacific Ocean Division (1985, 1986).

Reasons for inclusion: 1a, 2a, 2b, 2c.

Source: Christopher R. Dahl.

Wetland Name: Palikir Freshwater Marsh

Country: Federated States of Micronesia

Coordinates: 6°55'N, 158°07'E

Location: this marsh is located on the most westerly tip of Pohnpei Island in Sokehs Municipality. It is approximately 10 km southwest of Kolonia, the main population centre on the island, and 4 km west of the site of the national capital. The freshwater swamp is bounded on three sides by mangrove forest and on its inland side

by freshwater swamp forest.

Area: Stemmermann and Proby (1978) give the area at "roughly 11 ha". According to the Pohnpei vegetation survey (MacLean *et al*, 1986), the area of open sedge is only 2 ha. If the surrounding unit they classify as freshwater swamp forest is included then the total area is 19 ha.

Altitude: 0.5-2.0 m.

Overview: Stemmermann and Proby (1978), who categorised this wetland type as a phase of lowland swamp forest, state that this was "one of the most intriguing wetlands (type) encountered." It is open marshland bordered on three sides by mangrove and by freshwater swamp forest on its interior border. This wetland type is unusual; Stemmermann and Proby (1978) identify four sites on Pohnpei, although two of the others are close to one another and found in the centre of an extensive mangrove forest and may have somewhat different physical and ecological characteristics. In addition, they collected an endemic orchid (*Liparis* sp.) that is apparently specific to this site. (On a recent visit to this site, this orchid was not observed).

Physical features: The hydrology of the area is undoubtedly unusual given that it is a freshwater area bounded on all but one side by mangrove swamp. The landward boundary does have a steep bank about seven metres high. It may be that laterally flowing ground water reaches the surface in this area. Brackish water circulation in the adjacent mangroves is also poor as evidenced by nearby stands of dwarf trees. The hydrology may be similar to the other site discussed by Stemmermann and Proby, at Mutok, Kitti Municipality. This is in the centre of a relatively extensive mangrove forest and may have such poor water circulation that a freshwater environment can be maintained by rainfall. In both cases land elevation, even if slight, may play a role. Vegetation zonation in this wetland may indicate a higher elevation at its centre where dense stands of *Pandanus* grow with an understorey of *Melastoma malabathricum* and a few other woody species such as *Ficus tinctoria*, *Camposperma brevipetiolata* and even one fairly large *Albizia lebbek*. It appears, however, to be occasionally inundated by brackish water around its borders. In the vegetation zone adjacent to the mangrove forest (in this case primarily *Lumnitzera*), the soil is wetter and much dead wood is found. Stemmermann and Proby speculated that this was evidence that the area had been previously forested. However, it appears to be arrayed as if it had settled on a receding water. In addition, bits of flotsam such as an empty plastic bottle of suntan lotion were observed. Since the area is isolated and infrequently visited, it seems unlikely that such flotsam was brought there by a visitor. Thus an alternative explanation may be that unusual spring tides inundate the borders of the wetland and deposit deadfall and flotsam from the mangrove forest. It may be that with rising sea level, the wetland is slowly shrinking in size. This border area is populated by more salt tolerant species: stunted *Pandanus*, *Lumnitzera littorea* and one sedge, *Scirpodendron ghaeri*. While a series of ponds are shown within this wetland on the USGS topographic map and were noted by Stemmermann and Proby, they were not observed during a recent trip. This trip was undertaken during a relatively dry period, and it may be that these ponds are ephemeral. The soil in this area is classified as Inkosr gravelly sandy clay loam (Laird, 1982).

The wetland is natural in origin. Stemmermann and Proby state that: "in openings in adjacent high closed canopy *Camposperma* swamp forests, a large sedge can be seen from the air (near the site at Mutok, Kitti). This may imply that, if undisturbed, the open canopy swamp forest may mature to high closed canopy swamp forest. This would then be the climax of the lowland freshwater marsh. If this succession does occur, then the high canopy swamp forest could be considered the climax of lowland freshwater marsh. However, any succession such as this must be very slow, since there has been no apparent change in the area between 1945 and 1976 as shown on aerial photographs" (Stemmermann & Proby, 1978: pp 61-62). Recent observations suggest that another alternative, at least at this site, is a slow invasion by mangrove forest. As noted, the margin of the wetland on its north and south sides is mucky with standing water and fairly barren. Stranded deadfall and flotsam suggest it is occasionally inundated on high tides. Along its western border, clumps of *Lumnitzera* suggest that this low salinity mangrove species is slowly invading. Detailed examination of aerial photographs from 1945, 1975 and 1984 would be necessary to determine what changes, if any, are occurring at this wetland.

Ecological features: Three vegetation zones can be observed within the wetland. Around most of its border, the soil is mucky with standing water and vegetation is scarce, primarily clumps of the large sedge *Scirpodendron ghaeri*, *Pandanus* c.f. *odoratissimus* and stunted (1-2 m) *Lumnitzera littorea*. Roughly in the centre of the wetland, *Pandanus* grows fairly densely as an overstorey. *Melastoma malabathricum* grows as a shrub understorey. *Melastoma* is a facultative wetland plant also found in upland areas. In open areas,

sedges, notably *Eleocharis ochrostachys*, the fern *Cyclosorus gongylodes* and *Lycopodium cernuum* grow as ground cover. Occasional tree species were observed, most notably *Camptosperma brevipetiolata*. To the west of the Pandanus area is a large open area of low sedges, primarily *Eleocharis ochrostachys*, with *E. geniculata* dominating more towards the southern part of this area. The soil here is quite firm in comparison to the border zone. This zonation is probably due to variations in elevation and hydrology. The wetland is bordered to the south and west by almost pure stands of *Lumnitzera* which are perhaps 100 m wide, beyond that taller mangrove species such as *Sonneratia alba* could be observed. To the north mangrove, primarily *Rhizophora* sp., borders directly on the wetland. The inland margin borders on lowland swamp forest.

Land tenure: This land is most probably privately owned but the details of ownership are not known.

Conservation measures taken: None.

Conservation measures proposed: Devoe (1991) proposes adjacent mangrove areas as a reserve. Because this wetland is above the high tide mark, it is not directly under the jurisdiction of the State so no proposals have been made for its protection.

Land use: The wetland is in a relatively remote and lightly populated area. There is some taro (*Cyrtosperma*) cultivation along the inland margin of the wetland. Numerous signs of deer were observed at the wetland; it may be a popular hunting spot.

Possible changes in land use: None are being contemplated although the nearest road, which is about one km distant, is to be improved at some future date. This may induce more settlement in the area.

Disturbances and threats: None known.

Hydrological and biophysical values: Because of its small size and location, the wetland probably does not have great hydrological or biophysical significance.

Social and cultural values: None known, although, as noted, it may be a good area for deer hunting.

Noteworthy fauna: This is probably a popular site for various seabirds, shorebirds and migrants. The Pacific Golden Plover (*Pluvialis fulva*) Brown and Black Noddies (*Anous stolidus* and *A. minutus*), Whimbrel (*Numenius phaeopus*) and Wandering Tattler (*Heteroscelus incanus*) were observed at the wetland during a short visit. Numerous deer trails and footprints were also seen suggesting that this is good habitat for the introduced Asian and European deer.

Noteworthy flora: Notable flora include *Cyclosorus gongylodes*, *Eleocharis geniculata*, *E. ochrostachys*, *Lumnitzera littorea*, *Lycopodium cernuum*, *Melastoma malabathricum*, *Pandanus* c.f. *odoratissimus* and *Scirpodendron ghaeri*. Of special interest is a species of orchid of the genus *Liparis* which is apparently endemic to this site. The orchid was first observed and collected by Stemmermann and Proby (1978), who state that: "this may be an undescribed taxon. A single specimen of this terrestrial orchid was found (at this wetland). It is certainly rare, and because of its limited distribution should be considered endangered".

Scientific research and facilities: Stemmermann and Proby (1978) are the only scientists known to have visited the site, and the account of their findings is the only published source of information on the site.

Conservation education: No education programmes directed specifically to this wetland or wetland type exist. Because it is an unusual and probably unique site, it should have significant interpretive value.

Management authority and jurisdiction: Division of Forestry, Department of Conservation and Resource Surveillance, Pohnpei State Government.

References: Devoe (1991); Laird (1982); MacLean *et al.* (1986); Stemmermann & Proby (1978); U.S. Army Corps of Engineers, Pacific Ocean Division (1985).

Reasons for inclusion: 1d, 2d.

Source: Christopher R. Dahl.

Wetland Name: Wetlands of Chuuk State

Country: Federated States of Micronesia

Coordinates: 151°45'E, 7°30'N

Location: the wetlands of Chuuk State, primarily mangrove forests surrounding the volcanic islands within Chuuk Lagoon.

Area: 1,592 ha (based on the total area of wetland soil types). This total can be subdivided into 1,143 ha of mangrove forest and 449 ha of freshwater wetland.

Altitude: Sea level.

Overview: *Rhizophora mucronata* dominant mangrove forest forms a narrow broken band around the ten major islands (over one ha in size) of Chuuk Lagoon. The other major wetland type is freshwater swamp dedicated to the cultivation of taro.

Physical features: Mangrove forests have formed in sheltered areas along the shores of the volcanic islands of Chuuk Lagoon. Wetlands typically form by silt deposition on inner reef flats. In Chuuk, the islands are small with a narrow fringing reef limiting mangrove forest development. Insufficient silt deposition also limits mangrove growth. Because the islands are subjected to significant wave action (especially during typhoons) mangrove forest development is further limited. Soil types of wetlands (United States Department of Agriculture soil series taxonomy) are Chia mucky peat, Insak Variant sandy peat, Ngerungor peaty much and Naniak mucky silt loam. Insiak Variant soil has a shallow rooting depth (25-50 cm) and thus affords poor growth. Sewage and silt are the major threats to water quality. Around urbanised areas and on heavily populated islands, large amounts of untreated sewage enter coastal waters. Siltation may be caused by run-off of sediments or from coastal dredging activities. Water depth within the mangroves varies from a few centimetres to two metres in the channels. Tidal fluctuation in Chuuk is moderate; mean diurnal tidal range is 1.5 feet (0.46 m) and the maximum is 2.0 feet (0.61 m). Total dry land area in Chuuk Lagoon is 100.26 sq.km giving a rough indication of total catchment area for wetlands.

Ecological features: In mangrove areas, *Rhizophora mucronata* is dominant with *R. apiculata* found behind the seaward fringe in areas where the forest is fairly wide. *Bruguiera gymnorrhiza* is present but not extensive in the inner mangrove. Swamp forest typically adjoins mangrove areas in Chuuk, but most freshwater wetlands have been turned over to the cultivation of taro (*Colocasia esculenta* and *Cyrtosperma chamissonis*). *Phragmites* spp., *Hibiscus tiliaceus*, *Barringtonia racemosa*, *Macaranga* spp., *Glochidion* sp. and *Metroxylon amicarum* are typical of freshwater swamp that has been converted but is not being actively cultivated.

Land tenure: Wetland and reef areas are owned by matrilineal clans or individuals.

Conservation measures taken: None.

Land use: The islands of Chuuk Lagoon are densely populated (approximately 1,200/sq.mile). Most terrestrial wetlands have been converted to agricultural use. Mangrove areas are also occasionally impounded and slowly turned over to taro cultivation once the salinity has fallen. Mangrove poles and nipa thatch (*Nypa fruticans*) are used in house construction. Mangrove forests are also important fishing areas for certain marine species.

Disturbances and threats: Due to high population density and a rapidly expanding population, there is much demand for usable land. As noted, freshwater wetlands have been mostly converted for agricultural use and mangrove areas are marginally threatened by agricultural conversion. Mangroves are also occasionally filled to create usable land for building construction. Construction of roads with few drainage culverts causes impoundment of mangroves on a localised basis. The municipal dump for the urban centre island of Weno (Moen) is located in the mangroves.

Hydrological and biophysical values: Mangroves are important for shore protection. Chuuk is in the most typhoon prone region of the world. Mangrove forests can protect against storm wave inundation. They may also be important in stabilising the shoreline against erosion.

Social and cultural values: None known.

Noteworthy fauna: No information.

Noteworthy flora: Characteristic mangrove species are *Rhizophora mucronata*, *R. apiculata* and *Bruguiera gymnorrhiza*; freshwater species include two species of taro, *Colocasia esculenta* and *Cyrtosperma chamissonis*, and *Phragmites* spp., *Hibiscus tiliaceus*, *Barringtonia racemosa* and *Metroxylon amicarum*.

Scientific research and facilities: There are no research facilities in Chuuk nor any ongoing wetland research there.

Management authority and jurisdiction: Division of Agriculture and Forestry, Chuuk State.

References: Falanruw *et al.* (1987a); Kogo *et al.* (1985); Laird (1983a); MacLean *et al.* (1988); Miyagi & Kiyoshi (1989).

Reasons for inclusion: la, 2b, 2c.

Source: Christopher R. Dahl.

Wetland Name: Wetlands of Yap State

Country: Federated States of Micronesia

Coordinates: 9°33'N, 138°09'E

Location: the wetlands of Yap State, chiefly mangrove forests surrounding the four main islands of Yap, Gagil-Tamil, Maap and Rumung. Area: 1,592 ha; including 1,171 ha of mangroves (26 ha of which is classed as scrub), 155 ha of freshwater swamp forest, 165 ha of freshwater marsh, 6 ha of saline marsh and 38 ha of ponds and other water bodies.

Altitude: 0-10 m.

Overview: Mangrove forest dominated by *Rhizophora mucronata* occurs in a broken band of variable width around all four of the main islands of Yap State and forms extensive stands in sheltered embayments. Other wetland types include freshwater swamp forest, saline marsh, freshwater marsh and ponds, but these are very limited in extent.

Physical features: Yap State comprises four metamorphic, old volcanic high islands, 15 outlying atolls and low coral islets, and the raised coral island of Fais. The four high islands, Rumung (4.3 sq.km), Maap (10.6 sq.km), Gagil-Tamil (28.8 sq.km) and Yap Proper (56.0 sq.km), lie within a broad fringing reef system and are separated by narrow channels. Only these four islands possess significant wetlands, although there are some unusual stands of mangrove in the interior lagoons of some of the outer atolls. Much the most extensive wetland type is mangrove forest, which covers about 1,171 ha or approximately 32.2% of the total forested area of Yap. Mangrove forest occurs widely around the coasts of all four of the main islands, and is especially well developed on mudflats at the mouths of drainage systems. Sheltered coasts and embayments support broad continuous belts of mangrove 150-450 m wide, but along exposed shorelines, the mangrove stands become much narrower and discontinuous. The largest stands are found in Munguuy Bay and Yunearaway Passage between Maap and Tamil-Gagil, near Gachpar on the southeast coast of Tamil-Gagil, around the inner margin of Qatlirow Embayment and in the northern portion of the Tagireeng Canal between Tamil-Gagil and Yap Proper, along the east coast of Yap Proper from Peelaek Channel south to Dechumur village, and along the west coast of Yap Proper between the villages of Qokaaw and Raeng. A continuous belt of mangroves, on average about 450 m wide, lines almost the entire coastline of southeastern Yap Proper, and is most extensive between the villages of Yinuuf and Luweech, where it penetrates 1.5 km inland. The mean tidal variation in Yap is 0.9 m.

Other types of wetland are very limited in extent. There are a few small saline marshes, generally along the coast adjacent to mangroves. Small stands of swamp forest occur in low wet areas just inland of mangroves (above tidal influence), in low areas along streams and in areas of impeded drainage. Many areas which probably once supported swamp forest have been converted into taro patches, and the remaining forests are now heavily disturbed, with about 85% of the forest containing secondary vegetation or agro-forest inclusions. There are also a number of small freshwater marshes in water-logged areas slightly above sea level landward of the mangroves and in depressions in upland areas. Other wetlands include a number of streams, most of which are intermittent, several small ponds, a small water storage reservoir near the capital, Colonia, and numerous small taro patches. Only one of the ponds, Machbaab Pond near the old airport in southern Yap, is permanent.

The climate is humid tropical with an average annual rainfall of 3,087 mm and a mean annual temperature of 27°C. A season of trade winds and drought extends from December to April. The wet season, between July and October, accounts for about half of the annual rainfall. Typhoons are especially prevalent in May June and November.

Ecological features: The mangrove forests of Yap are more diverse than those of Chuuk, Pohnpei and Kosrae, and include three species which are not known to occur on the other islands: *Schypiphora hydrophyllacea*, *Ceriops tagal* and *Dolichandrone spathacea*. The most conspicuous species in the mangrove forests are *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorrhiza* and *Sonneratia alba*. *Rhizophora mucronata* is dominant along the seaward fringe, with *R. apiculata* occurring behind this fringe in areas where the forest is fairly wide. *Sonneratia alba* becomes common along channels and towards the leeward edge of the mangrove forest, while *Bruguiera gymnorrhiza* and *Xylocarpus granatum* tend to dominate along the landward edge of the mangrove. Other species which generally occur along the landward edge of the mangrove forests are *Lumnitzera littorea*, *Ceriops tagal* and *Dolichandrone spathacea*. *Nypa fruticans* is generally found in the more brackish areas, in narrow bands along the margins of channels (Falanruw *et al.*, 1987b).

Species characteristic of swamp forest adjacent to mangrove forest include *Dolichandrone spathacea*, *Heritiera littoralis*, *Pongamia pinnata*, *Cynometra ramiflora*, *Dalbergia candenatensis*, *Derris trifoliata* and *Acrostichum aureum*. A few almost pure stands of *Dolichandrone spathacea* can be found, and *Barringtonia racemosa* is common in wetter areas. In the of swamp forests along streams and in wet inland depressions, characteristic tree species include *Barringtonia racemosa*, *Hibiscus tiliaceus*, *Semecarpus venenosus*, *Inocarpus fagifer*, *Ficus tinctoria*, *Pandanus jenkinsii*, *Cerbera manghas*, *Ixorea casei* and *Derris elliptica* (Falanruw *et al.* 1987b).

The plant community of the saline marshes includes *Acrostichum aureum*, *Cyperus javanicus*, *Eleocharis geniculata*, *Fimbristylis cymosa*, *Paspalum distichum*, *Ipomoea pescaprae*, *Excoecaria agallocha*, *Derris trifoliata* and *Clerodendron inerme* (Stemmermann & Proby, 1978). The vegetation of the freshwater marshes may consist of tall reeds, especially *Phragmites karka*, sedges, and herbaceous species such as *Ludwigia hyssopifolia*, *L. octovalvis* and *Hanguana malayana* (Falanruw *et al.*, 1987b). Most of the ponds are in open savannah and support considerable rooted vegetation, including emergent species, such as *Eleocharis ochrostachys*, *Eriocaulon sexangulare* and *Ischaemum polystachum*, and the submerged species *Blyxa sp. I. polystachum* dominates the stream flora in open areas and mosses are common in cascades, but rooted vegetation is very restricted (Lobban *et al.*, 1990). Lobban *et al.* (1990) collected periphyton and other visible algae from the streams and ponds, and found 12 blue-green algae, two red algae, two charophytes, seven genera of filamentous green algae and five flagellates. No endemic species were found, and it was concluded that the freshwater algal flora of the Yap Islands did not show characteristics of the biota of "oceanic" islands. These authors also summarized the physico-chemical characteristics of Yap's ponds and streams.

The four main islands of Yap have long been densely populated, and most natural terrestrial ecosystems have been extensively modified, with reduction in species diversity and degradation of forests to savanna grasslands or conversion to agro-forests.

Land tenure: Almost all of Yap's land and nearshore waters are privately owned (customary ownership).

Conservation measures taken: No conventional protected areas have been established on Yap. However, in the past, the use of land and marine resources, including mangroves, was traditionally subject to many regulations and restrictions. A complex system of ownership and rights of usage established limitations and helped to prevent over-exploitation (Yinug *et al.*, 1989). There has been some replanting of mangroves in Nimpal Embayment on the west coast of Yap Proper to protect fishing grounds from siltation caused by construction work.

Conservation measures proposed: Yap State Marine Resources Management Division is working on a Marine Resources and Coastal Management Plan incorporating traditional customs and laws (IUCN, 1991). This is likely to include recommendations for the protection of specific areas.

Land use: The four main islands are densely populated, with the 10,000 inhabitants living in over 100 villages. A subsistence lifestyle dominates; fishing is important and tourism is still a relatively minor industry. The mangrove forests are widely utilised for construction materials, wood for handicrafts, firewood and fishing, and land crabs and mangrove crabs are harvested in large numbers in some areas. In most areas, the cutting of mangrove for local building projects continues on a small scale as it has done for

centuries, but in one area south of Peelaek Channel, there has been some commercial logging. Many of the freshwater swamp forests and marshes have been converted to taro fields (*Colocasia esculenta* and *Cyrtosperma chamissonis*), and in recent years, shallow ponds have also been used for the cultivation of the introduced aquatic plant *Ipomoea aquatica* (Nelson, 1989).

Disturbances and threats: Freshwater wetlands have been extensively modified for agricultural use, and some mangrove areas are threatened by uncontrolled harvesting of timber, filling to create land for houses and other development, and the dumping of rubbish and toxic materials. Some mangroves were destroyed by siltation during the construction of a new airport, but there has been some recovery since then. The construction of roads with too few drainage culverts has resulted in localised impoundment of mangroves, and the building of a solid causeway between Gagil-Tamil and Maap islands has resulted in the death of mangroves along part of the Yuneeraway Passage. A small amount of commercial logging has been reported, but a proposal (with Taiwanese backing) to undertake commercial logging in the mangroves on a large scale has been rejected. At least two proposals to clear mangroves for aquaculture and a proposal to utilise mangrove wood as fuel to smoke fish have also been rejected, but a proposal to use mangrove areas as rubbish dumps is still under discussion. Oil spills and pesticides have had localised impact, although Mowbray (1988) has reported a leakage of endrin and sodium arsenite into a freshwater stream and coastal lagoon which caused a large-scale kill of fish, wildlife and domestic animals. The greatest threat to the sustainable use of mangrove forests and other natural resources in Yap is the removal of traditional limitations on their exploitation, generally as a result of new technologies, outside inputs and commercialized exploitation (Yinug *et al*, 1989).

Hydrological and biophysical values: Mangroves serve as natural filtering and nutrient buffering systems between the islands and the adjacent fringing reefs, protecting the reefs from sedimentation and providing for a slow sustained release of nutrients. The mangrove forests afford some protection against storm damage, and may also be important in stabilising the shoreline against erosion. They play a critical role as nursery habitat for larval and juvenile fishes and thereby help to maintain the coastal fishery.

Social and cultural values: Many of Yap's inhabitants are dependent on the mangrove forests as a source of timber for house posts, wood for handicrafts and firewood, and make extensive use of the inshore fishery which these forests support.

Noteworthy fauna: The mangrove forests provide habitat for a wide variety of marine organisms as well as many birds and fruit bats. They provide shelter and feeding habitat for reef fish, the most conspicuous families being Chaetodontidae (butterfly fish), Lutjanidae (snappers), Apogonidae (cardinal fish), Acanthuridae (surgeon fish), Siganidae (rabbit fish), Pomacentridae (damselfish), Gobidae (gobies) and Gerreidae (mojarra). Gastropods such as the periwinkle *Littorina scabra*, the cerithiid *Clypeomorus pellucida* and the muricid snails *Naquetia capucina* and *Thais aculeata* are common, as are land crabs (*Cardisoma* sp.) and mangrove crabs (*Scylla serrata*) (U.S. Army Corps of Engineers, Pacific Ocean Division, 1989b).

The pond and stream fauna includes at least 50 species of aquatic insects, eight species of decapod crustacean, and 14 species of gastropods (Nelson, 1989). The most abundant fishes in the stream environments are the eleotrids *Eleotris fuscus* and *Ophieleotris aporos*, and the freshwater eel *Anguilla marmorata*. Other stream fishes include the mudskipper *Periophthalmus vulgaris*, the flagtail perch *Kuhlia rupestris* and the spotted scat *Scatophagus argus*. The introduced tilapia *Oreochromis mossambicus*, which escaped from an aquaculture project in the 1970s, is now well established and is abundant in some of the freshwater ponds, streams and estuarine habitats (Nelson & Hopper, in Nelson, 1989).

There are only three resident species of waterbirds on Yap; the Yellow Bittern (*Ixobrychus sinensis*), Pacific Reef Heron (*Egretta sacra*) and White-browed Crake (*Porzana cinerea*). The Yellow Bittern is particularly common, occurring in a wide variety of wet habitats. Situated only 1,300 km east of Mindanao in the Philippines and only 1,250 km north of western Irian Jaya, Yap lies sufficiently close to the continental island systems of eastern Asia to serve as a staging area for significant numbers of migratory shorebirds using the East Asian/Australasian flyway. Twenty-six species of shorebirds have been recorded, and at least 12 of these are fairly common on migration and/or in winter. These are: Pacific Golden Plover (*Pluvialis fulva*), Mongolian Plover (*Charadrius mongolus*), Greenshank (*Tringa nebularia*), Wood Sandpiper (*T. glareola*), Wandering Tattler (*Heteroscelus incanus*), Grey-tailed Tattler (*H. brevipes*), Common Sandpiper (*Actitis hypoleucos*), Whimbrel (*Numenius phaeopus*), Ruddy Turnstone (*Arenaria interpres*), Sanderling (*Calidris alba*), Rufous-necked Stint (*C. ruficollis*) and Sharp-tailed

Sandpiper (*C. acuminata*) (Pratt *et al.*, 1987). At least 175 shorebirds of 17 species were recorded during a brief survey of two islands in early September 1990 (D.A. Scott, unpublished). Other migratory waterbirds from eastern Asia which have been recorded on the islands include four species of herons and egrets, two ducks and the Whiskered Tern (*Chlidonias hybrida*).

The only indigenous mammal is the Marianas Fruit Bat (*Pteropus mariannus*), which frequently forages in the mangrove and swamp forests. Two endemic subspecies occur in Yap: *P. m. yapensis* on the main islands and *P. m. ulithiensis* on Ulithi atoll.

Noteworthy flora: Most of the mangrove forests are still in relatively pristine condition. Mangrove species include seven species shared with the other islands of FSM: *Rhizophora mucronata*, *R. apiculata*, *Bruguiera gymnorhiza*, *Xylocarpus granatum*, *Lumnitzera littorea*, *Nypa fruticans* and *Sonneratia alba*, and three species of more westerly distribution: *Schypiphora hydrophyllacea*, *Ceriops tagal* and *Dolichandrone spathacea*.

Scientific research and facilities: The U.S. Forest Service has carried out a vegetation survey of Yap in cooperation with the State Government (Falanruw *et al.*, 1987b). Detailed studies of Yap's inland aquatic habitats were carried out by a team of aquatic biologists from the University of Guam Marine Laboratory, Yap State Department of Natural Resources and the College of Micronesia in 1988. The limnological characteristics of the streams and ponds, the vegetation and the freshwater fishes, aquatic insects, decapod crustaceans and freshwater gastropods were investigated (Nelson, 1989). Lobban *et al.* (1990) have described the periphyton of Yap, excluding the diatoms and desmids.

Management authority and jurisdiction: No information.

References: Falanruw *et al.* (1987b); IUCN (1991); Lobban *et al.* (1990); MacLean *et al.* (1988); Mowbray (1988); Nelson (1989); Pratt *et al.* (1987); Stemmermann & Proby (1978); U.S. Army Corps of Engineers, Pacific Ocean Division (1988, 1989b); Yinug *et al.* (1989).

Reasons for inclusion: la, lc, 2b, 2c.

Source: See references.

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