

F I J I

INTRODUCTION

by Alistair J. Gray

Area: 18,272 sq.km.

Population: 715,000 (1989).

Fiji is an independent island republic in the South Pacific, situated between latitudes 15° South and 21° South and straddling the 180th meridian from 177° West to 175° East. The 320 or so islands form a complex group of high islands of volcanic origin, with barrier reefs, atolls, sand cays and raised coral islands. The two largest islands, Viti Levu (10,386 sq.km) and Vanua Levu (5,535 sq.km), together comprise 87% of the total land area. Two smaller islands, Taveuni (435 sq.km) and Kadavu (408 sq.km), account for a further 4.6% of the land area, and most of the remaining islands are very small. Less than a hundred of the islands are inhabited, most of the population being concentrated in the towns, villages and lowlands of the two larger land masses. The annual population growth is 2% and the population density is 39 inhabitants per sq.km. Suva, the capital city, is located on a peninsula near the southeastern corner of Viti Levu.

Fiji has an equable maritime climate, a consequence of its high topography and prevailing winds, the Southeast Trades. The west coast of Viti Levu is in a rain shadow, and thus experiences a distinct dry season. Maxima and minima temperatures for Suva are 30°C and 20.5°C respectively. The dry season extends from May to October, and the wet season from November to April. Mean relative humidities are 80% and 75% at 0800 hrs and 1400 hrs respectively on the east coast, and about 10% lower on the west coast. Relative humidities as low as 40% can occur during the dry season.

Both Viti Levu and Vanua Levu have mountainous interiors, with peaks rising to 1,323 m and 1,032 m respectively. The uplands of both islands were formerly covered in tropical rainforest, but much of this has now been replaced with secondary forest and grassland on the lower slopes. Farm land occupies most flattish lowland, and large areas on both islands are under cultivation for sugar cane. Mangrove forest occurs widely along the coastline and at river mouths. Coral cays tend to be dominated by palms, panda -pits and casuarinas.

The large number of islands, their differing geological origins, the large size of some of the islands, the varying climates and their isolation from other islands have all contributed to provide Fiji with a large number of different ecosystems and habitat types with a very rich diversity of flora and fauna. Many species are endemic. There are about 1,500 native species of vascular plants, of which 40-50% are endemic. All 26 palm species are endemic. There are 39 species of butterfly (including seven endemics), 27 species of reptiles and amphibians (including eight endemics) and about 120 species of birds (including 22 endemics) (Dahl, 1986; Pratt *et al*, 1987). Dahl (1980 & 1986) has given a brief account of the natural ecosystems of the islands, and has reviewed their importance for nature conservation. UNEP/IUCN (1988) provide a general account of the coral reef systems and the reef resources, and also give detailed information on seven of the most important reef systems.

Summary of Wetland Situation

The wetlands of Fiji can be broadly divided into five main categories: mangrove forests, peat bogs, rivers, lakes and reservoirs.

Mangroves

The largest stands of mangroves are found in deltaic formations at the mouths of the larger rivers, notably the Ba, Rewa and Nadi Rivers on Viti Levu and the Labasa River on Vanua

Levu. Climatic conditions are important. In dry leeward areas (western shores), hypersaline mudflats characteristically occur in the mangrove areas, while these are virtually absent from the wetter, windward mangrove areas (eastern shores). It has recently been estimated that of an original 41,000 ha of mangrove forest, 38,543 ha remain, the other 2,457 ha (6%) having been reclaimed for other uses (Watling, 1985). All but about 2,000 ha of the remaining mangrove are on the two large islands of Viti Levu and Vanua Levu, with the Rewa, Ba and Labasa deltas alone supporting a combined total of 10,683 ha, or 28% of the national resource.

Only a small fraction of the mangrove forest is affected by non-sustainable exploitation, principally uncontrolled gathering of fuelwood. Consequently, the majority of the mangrove can be considered to be still in a natural condition. The total area of mangrove actively managed for fuelwood production is less than 50 ha.

The Fijian mangrove vegetation is floristically simple. Three species and a putative hybrid of the family Rhizophoraceae overwhelmingly dominate the vegetation. These are: *Bruguiera gymnorrhiza*, *Rhizophora stylosa*, *R. samoensis* and *R. x sekaa*. Less common species include: *Xylocarpus granatum*, *X. moluccensis*, *Lumnitzera littorea*, *Excoecaria agallocha* and *Heritiera littoralis*. The broad zonation consists of a seaward fringe of *R. stylosa*; *R. x selala*, or occasionally *R. samoensis*, is found along the river margins, and a mixed forest of *B. gymnorrhiza*, *X. granatum* and *Lumnitzera littorea* (with *R. samoensis* and *E. agallocha* in the Ba Delta) grows on the higher ground on the landward edge (Woodroffe, 1987). *R. stylosa* is dominant in all exposed locations and is particularly associated with sandy or coarse substrates, while *R. samoensis* is most frequently encountered bordering the depositional side of rivers and creeks over soft fine-grained substrates. Fiji's mangrove swamps have developed in their present form since the last glacial period, with the transgression of sea level to its present level.

Formerly mangroves were of major importance as a source of fuelwood. In 1952, over 50,000 cubic metres of mangrove wood were harvested and processed by the Forestry Department. However, with the increased availability of fuel oil, the demand for mangroves dropped to less than 5,000 cubic metres per year after 1967, and is now negligible. A limited amount of mangrove is used for poles and charcoal.

By far the greatest loss of mangroves in Fiji has been caused by reclamation for agriculture, *e.g.* in the Labasa River delta. However, about 300 ha of mangroves have been converted for aquaculture of penaeid prawns, and in recent years the principal threat has been reclamation of mangroves for urbanisation and industrial development. There is also some over-exploitation of mangroves to satisfy the demands for fuelwood, but this is localized.

Mangroves play an important role in Fiji's sewerage treatment programme, with most sewage disposal sites being associated with mangroves. Mangroves also provide breeding and nursery grounds for a wide variety of economically important fish and crustaceans. It has been estimated that more than 60% of Fiji's commercially important food fishes utilize the mangrove resource at some stage of their life history. In 1983, the value of Fiji's mangrove forests to the fisheries industry was estimated at over Fiji 20 million.

Peat swamps

Freshwater wetlands occupy only 0.3% of Fiji's land area. Much the most extensive freshwater wetlands are peat swamps which occur widely on the two main islands. The largest peat swamp is Bonatoa (870 ha) on Viti Levu, which provides a good example of zoned vegetation. Reclamation of swamp land has taken place on a large scale, and few freshwater wetlands now survive undisturbed. Tonuve Swamp (the only site in Fiji with Navosa reed peat) has been totally reclaimed for agriculture, while many others have suffered a smaller percentage loss to development. Much of the original swamp on Vanua Levu is likely to have been reclaimed, but information on precise areas is

unavailable.

The vegetation of the peat bogs typically consists of a continuous cover of sedges (*Scleria polycarpa*) up to 1.5 metres high with sphagnum moss (*Sphagnum cuspidatum*) in wetter areas and scrambling ferns (*Dicranopteris linearis*) in drier areas. Pandanus (*Pandanus pyriformis*) is often present and generally forms small clumps. A few dicotyledonous shrubs such as *Barringtonia aquatica* occur in association with the pandanus. On colluvium peat, the vegetation is transitional and often zoned. Sphagnum moss ceases to occur, but dense stands of the grass *Brachiara mutica* (up to 2 metres high) and various herbs and woody shrubs occur. This zone passes to medium-sized trees (5-15 metres high) and then to forest on higher ground.

On gley soils, the vegetation varies greatly according to the extent of human interference. Patches of forest are interspersed with areas of pasture land, cultivated land, abandoned cultivation and secondary scrub. Pure stands of *Metroxylon vitiense* (sago palm) are found on wet gley soils at Vunimoli on Viti Levu. Freshwater marsh typically comprises a sedge/fern community with *Athyrium* sp. On brackish soils, this is replaced by a mixed community of *Pandanus*, the fern *Acrostichum aureum* and woody shrubs and trees. The woody community passes either into a mangrove forest in coastal areas or into a taller band of trees alongside brackish creeks. Permanently flooded habitats include abandoned river channels, streams and ditches which support a relatively restricted aquatic flora of mainly floating species, such as *Lemna perpusilla*, *Nymphaea capensis* and *Spinodela punctata*, and submerged aquatics such as *Hydrilla*, *Potamogeton* and *Ceratophyllum*.

Rivers

The larger islands are well-watered, with many permanent rivers and streams. However, only Viti Levu has rivers of any considerable size. Over 70% of this island is drained by three large river systems, the Rewa, Navua and Sigatoka, which enter the sea along the south coast. The catchment area of the largest of these, the Rewa, covers nearly one third of the island. Fiji's two most economically important rivers, the Ba and the Nadi, have a combined catchment of only 15% of Viti Levu, all of which is in the dry zone. The rivers of Vanua Levu are short with only the Dreketi River being of any considerable size (55 km long). Riverine forest occurs along the lower reaches of some of the larger rivers, and is sometimes characterized by distinctive species such as the endemic palm *Neoveitchia storckii*.

Lakes

There are few freshwater lakes in Fiji, and those that do exist are small and generally limited to mountainous regions. The largest, Lake Tagimaucia on Taveuni Island, is only 2.3 ha in area. The only significant brackish and saline lakes are Ngalongalo Lake, Ngasauva Salt Lagoon and Lake Ndrano on Vanua Levu, and a small marine lake on uaqava (Vuanggava) Island in the Lau Group.

Reservoirs

Two major dams have been constructed in Fiji, both on Viti Levu. The smaller Vaturu Dam (160 ha) provides water to the dry western division of Viti Levu, and the larger Monosavu Dam (670 ha) provides hydro-electricity. A smaller dam (80 ha) has recently been built at the Wainikavika Creek near Navua to provide water for rice irrigation.

At present, the protected areas system in Fiji comprises 18 forest reserves, seven nature reserves (established within the forest reserves) and a number of forest parks and amenity reserves. There is only one National Park, established in 1988 to protect the Sigatoka sand dunes, and one Wildlife Sanctuary, established in 1981 to protect a large population of the endemic Crested

Iguana (*Brachylophus vitiensis*) on Yadua Taba Island (Anon., 1989; IUCN, 1991a). None of these protected areas contains any significant wetland habitat. However, two proposed reserves currently under consideration by the Government contain wetlands: Vaturu Forest Amenity Reserve (Vaturu Dam) and Taveuni National Park (Lake Tagimaucia). Of the many other areas which have been proposed for establishment as protected areas, the following include significant wetlands:

- Swamps in the Navua Delta, Viti Levu
- Samabula River and mangroves, Viti Levu
- Naulu-Lokia Swamps, Viti Levu
- Upper Wainimala River, Viti Levu
- Wainibuka River, Viti Levu
- Riverine forest at Waindrandra Agricultural Station, Viti Levu
- Ngalongalo Salt Lake, Vanua Levu
- Naisongothauthau Creek, Vanua Levu
- Brackish pools on Vatulele Island
- Swamp forest and bog on Moturiki Island
- Marine lake on Vuaqava Island

While the fauna of Fiji's mangroves is now well known, that of the freshwater wetlands has received very little attention. Mangrove fauna has been documented by Macrae (1968), Richmond and Ackerman (1975), Lal *et al.* (1983), Lal (1984a, 1984b), Fiji Mangrove Management Committee (1987) and others. Ryan (1980, 1984) has described the brackish and freshwater fish and the amphibians of Fiji, while Southern *et al.* (1986) have described the fauna of Lake Tagimaucia on Taveuni.

Rather few species of birds are dependent on the wetlands of Fiji. Undoubtedly the most interesting of these is the Barred-wing Rail (*Nesoclopeus poecilopterus*), a large flightless rail known only from Fiji (although a closely related form, *N. woodfordi*, occurs in the Solomon Islands). Until recently, the Barred-wing Rail was known only from about 12 specimens taken last century on Viti Levu and Ovalau. However, the species was apparently rediscovered in 1973 on the Nadrau Plateau on Viti Levu (Holyoak, 1979). The rail is believed to inhabit damp forest, swamps and thick taro gardens. The introduction of the mongoose is undoubtedly an important factor in the rail's decline (Hay, 1985). The other four species of Rallidae in Fiji, the Banded Rail (*Rallus philippensis*), White-browed Crake (*Porzana cinerea*), Spotless Crake (*P. tabuensis*) and Purple Swampphen (*Porphyrio porphyrio*), are also threatened by predation from mongooses and feral cats. Two of these, the Banded Rail and Purple Swampphen, have become extinct on Viti Levu and Vanua Levu, although they remain common on some of the outer islands which are mongoose-free. The Pacific Black Duck (*Anas superciliosa*) remains fairly common and widespread in the islands, but the Wandering Tree Duck (*Dendrocygna arcuata*), which was possibly a resident in the 19th century, is now extinct. Other resident waterbirds include the widespread Pacific Reef Heron (*Egretta sacra*) and the Little Heron (*Butorides striatus*); the latter is more or less confined to mangroves (Watling and Talbot-Kelly, 1987).

Seven species of migratory shorebirds occur regularly on passage or during the boreal winter: Pacific Golden Plover (*Pluvialis fulva*), Wandering Tattler (*Heteroscelus incanus*), Grey-tailed Tattler (*H. brevipes*), Whimbrel (*Numenius phaeopus*), Bristle-thighed Curlew (*N. tahitiensis*), Bar-tailed Godwit (*Limosa lapponica*) and Ruddy Turnstone (*Arenaria interpres*). A further nine species of shorebirds have occurred as rare stragglers (Pratt *et al.*, 1987).

Wetland Research

Relatively little research has been carried out on wetlands in Fiji. By far the most attention has been given to the mangrove ecosystems, although studies on mangroves have been piecemeal and uncoordinated. Work on the mangroves has been summarized by Nedwell (1974), Vodonaivalu (1982), Lal *et al.* (1983) and the Fiji Mangrove Management Committee (1987). Pillai (1987) has reviewed the traditional uses of mangroves in Fiji. Ash and Ash (1984) have conducted the only extensive study of freshwater wetlands in Fiji, but this was restricted to Viti Levu. Elsewhere, only Lake Tagimaucia on Taveuni Island has been well documented (Southern *et al.*, 1986). Very little information is available on the wetlands of Vanua Levu, as few ecological surveys have been undertaken on this island, and almost nothing is known about the wetlands of the outer islands.

The Institute of Marine Resources at the University of the South Pacific has two on-going programmes relevant to wetlands: (i) a study of the community structure and functional relationships between organisms and non-biotic factors; and (ii) a study of the fisheries of mangrove-related habitats. The Institute of Natural Resources at the University of the South Pacific is monitoring water quality at Monosavu Dam. This is mainly concerned with chemical analysis of the water for the Fiji Electricity Authority.

Wetland Area Legislation

There is a severe lack of environmental protection legislation in Fiji and no policy relating specifically to wetland protection. At present, only the mining industry is required by law to carry out comprehensive environmental impact assessments before new developments are started. There is little protective legislation concerning mangroves. The Government recognises that the land between the mean high water mark and the low water mark is Crown Land. In 1933, all mangroves were designated as Reserved Forest to be managed by the Forestry Department. However, in 1975 these Reserved Forests were de-notified, and all mangroves were placed under the jurisdiction of the Department of Lands and Survey as an integral part of the foreshore.

The environmental objectives of Fiji's Development Plan Nine (1986-90) were to protect and conserve unique features of Fiji's environment, and to ensure that environmental assessments are incorporated into programmes and projects. In this Development Plan, the National Trust for Fiji was given responsibility for implementing the country's National Parks and Reserves Plan. It was envisaged that during the implementation of this Plan, certain mangrove areas would be declared as National Parks or other types of reserve.

An inter-ministerial National Mangrove Management Committee was established by the Department of Lands and Survey in 1983 and produced a National Mangrove Management Plan (Phases I and II) in 1986. This plan is a comprehensive framework intended to assist decision-makers in Government, but unfortunately it still has no legal status.

At international level, Fiji has ratified the Convention on the Conservation of Nature in the South Pacific (Apia Convention) and the Convention for the Protection of the Natural Resources and Environment of the South Pacific (SPREP Convention), and has signed but not yet ratified the Convention on Biological Diversity. A Cabinet decision to accede to the World Heritage Convention has been taken (IUCN, 1991a). However, Fiji is not yet a part to either the UNESCO Man and the Biosphere Programme or the Ramsar Convention.

Wetland Area Administration

The only wetlands in Fiji which are under direct management are the reservoirs, which are controlled by the Fiji Electricity Authority and Water Department. Large portions of the catchments of these reservoirs are in native land, and are thus under no conservation obligation. There are no wetlands where there is "restricted access" specifically for conservation purposes.

Organizations involved with Wetlands

There is no single body concerned specifically with wetland protection or management in Fiji. There are, however, a number of organizations and government departments who indirectly have a responsibility to ensure the preservation of the environment in general. Most are members of the National Environmental Management Committee which includes representatives of the following:

- Ministry of Primary Industries (land use, drainage, irrigation and fisheries)
- Ministry of Forestry
- Ministry of Lands and Mineral Resources
- Ministry of Health
- Native Land Trust Board (NLTB)
- University of the South Pacific
- Bureau of Meteorology
- National Trust for Fiji
- National Museum

An Environmental Management Unit was created in 1982, but this did not become fully operational until 1989. The role of the Environmental Management Unit is to develop a national environmental policy, to co-ordinate environmental impact assessments, and to develop environmental awareness programmes.

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WETLANDS

Site descriptions based on a report prepared by Alistair J. Gray of the National Trust for Fiji, information provided by Birandra Singh, also of the National Trust for Fiji, and the literature.

Wetland Name: Mangroves of the Rewa Delta

Country: Fiji

Coordinates: 17°58'-18°10'S, 178°30'-178°43'E

Location: at the southeast corner of Viti Levu, east of Suva.

Area: 5,130 ha.

Altitude: Sea level.

Overview: A large area of rich and diverse mangrove forest in the delta of the Rewa River.

Physical features: The Rewa River is the largest river in Fiji, draining approximately 2,980 sq.km or about one third of Viti Levu and discharging an estimated 7,897 million cubic metres of water per year. It has been estimated that about 1,600 tonnes of suspended sediment are transported to

the mouth of the river each year. This alluvium has formed Fiji's most fertile and productive delta with over 5,100 ha of mangrove forest. The mangrove communities are the most diverse in Fiji. The high, regular rainfall prevents the formation of bare, hypersaline mudflats which are a feature of mangrove formations on dry, leeward coasts. Situated on the windward side of Viti Levu, the delta is exposed to the full force of the Southeast Trades, and as a consequence much of the mangrove is in backwater locations. The mean tidal range is about 0.9 m during neap tides and 1.3 m during spring tides. The delta has a Wet Eastern climate with a dry season rainfall of 1,200-1,600 mm and a wet season rainfall of 2,000-2,400 mm.

Ecological features: Watling (1985) recognizes six main vegetation zones.

- (1) A mixed fringing forest, found predominantly on the more exposed seaward banks but extending up some of the larger creeks (4.9% of the total area). Somewhat stunted *Rhizophora stylosa* often forms a single belt on the seaward edge with taller trees abruptly behind mixed with *Rhizophora x selala*, *Bruguiera gymnorrhiza* and *Rhizophora samoensis*. Levees in these situations support in addition *Xylocarpus granatum* and *Excoecaria agallocha* as well as other landward species such as *Cocos nucifera*.
- (2) An extensive formation in the northern part of the delta consisting of shrub forest dominated by *Rhizophora samoensis* (14.5% of the total area). Stunted *B. gymnorrhiza*, *X granatum* and *R. stylosa* are commonly present.
- (3) A uniform closed forest of *B. gymnorrhiza*, with well-developed stands exceeding 18 m in height (35.6% of the total area). Within the forest, occasional *R. x selala* occur with *X granatum* and *Lumnitzera littorea*.
- (4) A heterogenous open forest of variable and mixed composition with an uneven canopy (29.1% of the total area). *B. gymnorrhiza* and *R. x selala* are the dominant species, sometimes forming small discrete stands. *R. samoensis* occurs commonly and also forms limited pure stands, occasionally stunted. The presence of *X. granatum*, *L. littorea*, *E. agallocha* and landward vegetation varies greatly with location.
- (5) A heterogenous closed forest of mixed composition, found only in the least exposed situations (12.6% of the total area). The most common tree species are *X. granatum*, *B. gymnorrhiza* and *E. agallocha*. *R. samoensis* and *R x selala* occur more rarely and on creek banks. Other common trees include *Tenninalia littoralis*, *Heritiera littoralis*, *Inocarpus fragiferus*, *Ficus obliqua*, *Hibiscus tiliaceus*, *Pandanus pyroformis* and *Cocos nucifera*. The presence of an extensive epiphytic and climbing flora indicates that this community is stable, well drained and well protected from storm damage.
- (6) Large areas of poorly drained flats supporting a dense growth of the fern *Acrostichum aureum* (3.6 % of the total area).

Land tenure: State (Crown Land).

Conservation measures taken: All mangroves in Fiji were designated as Reserved Forests and managed by the Forest Department from 1933 to 1975. These Reserved Forests were denotified in 1975, and the mangroves have since been under the jurisdiction of the Department of Lands and Survey as an integral part of the foreshore. There are some restrictions on cutting, but traditional exploitation is still permitted.

Conservation measures proposed: Watling (1985) has made some recommendations for management.

Land use: The mangrove flora and fauna provide a variety of products and services to the local people including: firewood, construction material, household items, fishing devices, dyes, clothing, fish poison, food and medicine (Pillai, 1987). Seventy-two of 87 fish species caught in the mangroves are considered edible, as well as several species of molluscs and crustaceans. Formerly the Rewa Delta was an important source of mangrove for industrial and domestic fuelwood. In 1945, the "Suva area" produced 20,089 tons of fuelwood, most of this presumably coming from the Rewa Delta. In recent years, approximately 5,000 cubic metres of fuelwood have been extracted annually for domestic needs (Wading, 1985).

Possible changes in land use: The high population density and anticipated community development in the Rewa Delta will increase pressure on the mangroves, with traditional uses

evolving into non-sustainable activities (Watling, 1985).

Disturbances and threats: The major long-term threat to the mangrove forests is reclamation for agriculture. A reclamation project in the early 1980s resulted in the loss of over 200 ha of mangroves in the Waidamu River area (Lal, 1984b). The construction of new sea walls in recent years has also resulted in the loss of some mangrove. Illegal felling of timber is a serious problem locally, and may become more widespread as access to the area is improved.

Hydrological and biophysical values: The delta supports an important artisanal fishery which supplies not only the delta communities but much of the needs of greater Suva.

Social and cultural values: In pre-European contact times, the Rewa Delta is believed to have supported one of the densest human populations in the Pacific. The population has declined since then, but in 1976 there were still nearly 5,000 Fijians living in over 100 village communities dispersed through the delta. This is by far the largest community closely associated with mangroves in Fiji.

Noteworthy fauna: No information.

Noteworthy flora: The mangrove forests of the Rewa Delta are floristically the most diverse mangrove communities in Fiji.

Management authority and jurisdiction: Department of Lands and Survey.

References: Lal (1984b); Pillai (1987); Watling (1985).

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

Source: Birandra Singh and references.

Wetland Name: Bonatoa Swamp

Country: Fiji

Coordinates: 18°04'S, 178°33'E

Location: in the Rewa Delta, approximately 4 km south of Nausori, Viti Levu.

Area: 870 ha.

Altitude: Sea level.

Overview: A peat swamp.

Physical features: Bonatoa Swamp is the largest peat swamp in Fiji and provides a good example of zoned vegetation due to soil differences. The wetland is bordered by low hills and the levees of the Rewa and its anabranch in the west, by the Toga River to the north and east, and by beach ridges to the south. The soils are well-drained sandy loams, poorly drained gley clay loams and peat.

The region has a Wet Eastern climate with a dry season rainfall of 1,200-1,600 mm and a wet season rainfall of 2,000-2,400 mm.

Ecological features: Where the peat is more than one metre deep, *Pandanus pynformis*, ferns and patches of *Sphagnum cuspidatum* are common. The inner colluvium peat zone is herbaceous with sedges, grasses and dicotyledonous herbs. This passes abruptly into a zone of trees, shrubs and grasses.

Land tenure: Native land.

Conservation measures taken: None.

Land use: Grazing by domestic livestock.

Disturbances and threats: Approximately 11% of the swamp has been drained for agriculture. The swamp vegetation is occasionally burned to improve the grazing for domestic livestock.

Hydrological and biophysical values: No information.

Social and cultural values: There are several interesting examples of ring ditch fortifications on raised areas around the swamp, and one site, Nakasi, on an island within the limits of the swamp (Parry, 1977).

Noteworthy fauna: Unknown.

Noteworthy flora: Unknown.

Management authority and jurisdiction: Customary owners. The National Trust for Fiji is involved in the management of the site as an area of outstanding natural beauty and cultural significance.

References: Ash & Ash (1984); Parry (1977).

Reasons for inclusion: 1a. An area of outstanding natural beauty and cultural significance.

Source: Alistair J. Gray.

Wetland Name: Melimeli Swamp

Country: Fiji

Coordinates: 18°12'S, 178°11'E

Location: on the eastern margins of the Navua Delta, 3 km northeast of Navua, Viti Levu.

Area: 507 ha.

Altitude: Sea level.

Overview: A peat swamp.

Physical features: A large area of peat swamp bounded by hills to the northwest, by coastal and estuarine mangroves to the east, and by levees of a former distributary of the Navua River to the southeast. The wetland soils and those beneath the peat are fine textured alluvium to the north and west and coarser coastal deposits to the southeast. Brackish salt water extends 50-150 metres inland from the mangroves and there is a gradual transition from freshwater to saline wetlands. The peat has a maximum depth of two metres deep in the inland section of the swamp and becomes shallower towards the margins. Parts of the abandoned distributary channel to the west of the swamp contain peat and standing water.

The region has a Moist Coastal climate with a dry season rainfall of 1,200-1,600 mm and a wet season rainfall of 2,000-2,400 mm.

Ecological features: The vegetation is extremely varied. On the peat, the most abundant species are the fern *Dicranopteris linearis* and the sedges *Scleria polycarpa* and *Eleocharis dukis*. There are extensive patches of *Pandanus pyriformis* on the deeper peat and occasional small trees and shrubs such as *Fagraea berteriana*, *Glochidion cordatum*, *Psidium guajava* and *Melastoma denticulatum*. The transition from the peat to the saline gley soils is zoned with the following sequence of species: *Eleocharis dulcis* and *E. ochrostachys* - *Nephrolepis biserrata* - *Sphaerostephanos unitus* - *Acrostichum aureum* - *Pandanus pyriformis* and *P. whitmeanus* - *Lumnitzera littorea*, *Bruguiera gymnorhiza* - *Rhizophora samoensis*. Where the peat is bounded by brackish streams, there is a zone of shrubs and trees including *Annona glabra*, *Barringtonia racemosa*, *Fagraea berteriana*, *Glochidion cordatum* and *Hibiscus tiliaceus*. The wet gley pastures and abandoned cultivation are usually dominated by *Rhynchospora corymbosa*, whereas slightly better drained areas support a variety of dominants including *Fimbristylis dichotoma*. A few patches of shrubs and trees remain, and these have the typical woody flora of wet gley soils with abundant *Hibiscus tiliaceus*, *Annona glabra* and *Barringtonia racemosa*.

Land tenure: Freehold land (Ross Estate).

Conservation measures taken: None.

Conservation measures proposed: Peat swamps in the Navua Delta have been identified as sites of conservation interest meriting special protection (Dahl, 1980 & 1968; TCSP, 1990).

Land use: The alluvial soils are now mostly drained, and are used as pastures or for cultivation of rice, taro and maize.

Disturbances and threats: The principal threat is reclamation for agriculture. An estimated 12% of the swamp has already been drained.

Hydrological and biophysical values: No information.

Social and cultural values: There are areas of abandoned reticulated drainage gardens and ring ditch fortifications on the wet gley soils southwest of the peat swamp, and also several ring ditch fortifications near the Vatuloa River.

Noteworthy fauna: No information.

Noteworthy flora: No information.

Management authority and jurisdiction: No information.

References: Ash & Ash (1984); Dahl (1980, 1986); TCSP (1990).

Reasons for inclusion: 1a, 2b.

Source: Alistair J. Gray.

Wetland Name: Vunimoli Swamp

Country: Fiji

Coordinates:

Location: 18°14'S, 178°05'E; in the delta of the Navua River, about 6 km west of Navua, Viti Levu.

Area: 461 ha.

Altitude: 100 m.

Overview: A peat swamp.

Physical features: A large area of peat swamp and swamp forest on fine-textured alluvium brought down by the Qaraniqio River, and on sandy coastal deposits from the Navua Delta to the east. The river and its eastern tributaries have been diverted westwards along the inner margin of the coastal plain, and this forms the northern boundary of the swamp. Most of the wetland comprises peat bog, with peat depths of up to two metres. The region has a Moist Coastal climate with a dry season rainfall of 1,200-1,600 mm and a wet season rainfall of 1,800-2,200 mm.

Ecological features: The wet gley soils of the colluvium and the alluvium in the valleys upstream of the coastal plain support nearly pure stands of *Metroxylon vitiense* (sago palm). This also occurs on adjacent hill sides in association with a variety of trees. This is the only extensive swamp forest (262 ha) in Fiji, and includes most of the *Metroxylon* population. The least disturbed eastern part of the swamp supports a typical peat swamp flora of ferns, sedges, *Sphagnum* mosses and *Pandanus*. A waterlogged, peat-filled channel supports a flora of *Eleocharis ochrostachys*, *E. dulcis* and *Lepironia articulata* in submerged areas, and *Sphagnum* hummocks colonized by ferns and bryophytes on the better drained patches of peat.

Land tenure: Native land.

Conservation measures taken: None.

Conservation measures proposed: Peat swamps in the Navua Delta have been identified as sites of conservation interest meriting special protection (Dahl, 1980 & 1968; TCSP, 1990).

Land use: The peat swamp is scarcely utilised.

Disturbances and threats: The principal threat is drainage for agriculture and residential development. An estimated 60% of the swamp has already been drained. The western part of the peat swamp (270 ha) has been developed as a resort and housing complex. Southeastern parts have been partially drained, and ferns and grasses are more abundant in these areas. The swamp vegetation is occasionally burned, and this apparently destroys the *Sphagnum* and favours sedges, grasses and *Pandanus* rather than ferns e.g. *Dicranopteris linearis*.

Hydrological and biophysical values: No information.

Social and cultural values: There are a few ring ditch fortifications along the southern margins of the swamp, including one site within a raised area of the bog, but this region seems to have been less intensively settled than the central part of the delta around the Navua and Deuba river levees.

Noteworthy fauna: No information.

Noteworthy flora: No information.

Management authority and jurisdiction: No information.

References: Ash & Ash (1984); Dahl (1980, 1986); TCSP (1990).

Reasons for inclusion: 1a, 2b.

Source: Alistair J. Gray.

Wetland Name: Mangroves of Nadi Bay

Country: Fiji

Coordinates: 17°31'-17°41'S, 177°20'-177°29'E

Location: between Yako and Nacilau Point on the west coast of Viti Levu.

Area: Formerly 3,614 ha; 3,068 ha in 1986.

Altitude: Sea level.

Overview: Extensive mangrove formations in the deltas of the Nadi, Sabeto and Vitogos rivers, and stands of fringing mangroves along the intervening coasts.

Physical features: The Nadi Bay mangroves, as described by Watling (1986), extend for about 70 km along the coast from the headland north of Yako village in the south to Nacilau Point in the north. The small offshore islands of Yakuilau (20 ha), Via (2 ha), Bekana (20 ha) and Yawalau (2 ha) are included. Three substantial rivers flow into the sea at the site, the Nadi, Sabeto and Vitogo. The protected situation of the coastline has resulted in the retention of alluvial sediments allowing the formation of extensive mangrove-dominated deltas at the mouths of all three rivers and the formation of extensive fringing mangroves, especially along the coast between Vuda Point and Lautoka. Hypersaline flats are a characteristic feature of the site; they are formed as a consequence of the very high evaporation rates during the severe dry season. The hinterland is an extensive alluvial plain.

The site lies in Viti Levu's dry climatic zone and experiences strongly seasonal annual rainfall averaging 1,650 mm. Situated in a protected bay on Viti Levu's leeward coast, the site *is* sheltered from the Southeast Trades. However, it is exposed to cyclones which normally arrive from the northwest.

Ecological features: Two principal mangrove communities have been identified: a closed shrub forest overwhelmingly dominated by *Rhizophora stylosa* (29% of the mangroves), and an open forest dominated by the hybrid *Rhizophora x selala* (71% of the mangroves). In the closed shrub forest, the canopy height varies from 2-4 m at the seaward edge to 5-7 m in the most vigorous stands. In poorly drained areas, stunted stands of *R. stylosa* down to 1 m in height occur alongside hypersaline mudflats. *Rhizophora samoensis* is associated with fine, soft sediments and fresh water, and is dominant along some creeks. In the open forest dominated by *R. x selala*, the canopy is uneven, varying between 4 m and 12 m. *R. samoensis* occurs commonly in these forests, and there is also some *Bruguiera gymnorrhiza*. In the more elevated areas, species such as *Xylocarpus granatum*, *Excoecaria agallocha*, *Scaevola taccada* and *Hibiscus tiliaceus* appear. In the Nadi and Sabeto deltas, extensive levees have been formed. Some of these are of considerable size and have been cultivated; others have a typically terrestrial flora with *Cocos nucifera*, *Leucaena leucocephala*, *Morinda citrifolia*, *Tamarindus indica*, *Cordia subcordata*, *Thespesia populnea*, *Calophyllum inophyllum*, *Samanea saman* and *Xylocarpus moluccensis* (Watling, 1986).

Land tenure: State (Crown Land).

Conservation measures taken: All mangroves in Fiji were designated as Reserved Forests and managed by the Forest Department from 1933 to 1975. These Reserved Forests were denotified in 1975, and the mangroves have since been under the jurisdiction of the Department of Lands and Survey as an integral part of the foreshore. There are some restrictions on cutting, but traditional exploitation is still permitted.

Conservation measures proposed: Watling (1986) has prepared a management plan for the mangroves of Nadi Bay. He recommends that the mangroves north of the Waibitu Creek and in the Vitogo mangrove complex be protected as a Resource Reserve to help sustain the fisheries of Nadi Bay. The mangrove overwash island of Yawalevu should also be included in the reserve. Elsewhere, the majority of the mangroves should be zoned for traditional uses. Small areas of mangrove which help to protect the FSC railway line in exposed situations should be retained and managed for this purpose. Watling (1986) does not consider the mangroves of this area to be suitable for the large-scale production of fuelwood.

Land use: Formerly the mangroves were used for fuelwood by light industry and bakeries in Nadi and Lautoka, and especially by the Cane Crushing Mill at Lautoka. This practice declined in the 1950s, and today there are no mangrove fuelwood concessions for industrial purposes. However, the mangroves continue to be heavily utilised for domestic fuelwood. Between 1983 and 1986, 23 Mangrove Cutting Licenses were issued by the Divisional Forestry Office Western for domestic fuelwood. All licensed sites were in remnant mangroves behind recently rehabilitated sea walls (Watling, 1986). The mangroves of Nadi Bay border on a dense rural population of small-holder cane farmers and lie in close proximity to two major urban centres; Lautoka City (population 29,000) in the north, and Nadi/Nadi Airport (population 13,000) in the south.

Possible changes in land use: Further areas of mangrove are likely to be cleared for tourist and industrial development. Watling (1986) has identified several small development zones.

Disturbances and threats: The major threats are land-fill for industrial and tourist development, and reclamation for agriculture. There is also some illegal cutting of timber. In some areas the demand for fuelwood is exceeding the sustainable yield, and mangroves are being completely removed. At the turn of the century, the Colonial Sugar Refining Company constructed sea walls at several places in the bay, but most extensively north of Lautoka on the Lovu-Drasa-Vitogo flats. Some mangrove was lost (perhaps as much as 100 ha), but the sea walls eventually fell into disrepair and mangrove recolonized the original areas. Between 1976 and 1983, the old sea walls were rehabilitated and some new sea walls were constructed. This resulted in the loss of 233 ha of mangroves. A further 366 ha of mangrove had been lost by 1986 as a result of other reclamation projects: 234 ha for four tourist developments, 109 ha for three industrial developments, 10 ha for an urban sewerage system, 6 ha for a rubbish dump, 4 ha for urban development and 3 ha for agriculture (Watling, 1986). By 1986, reclamation (either developed or approved) had accounted for approximately 600 ha of mangroves or about 15% of the original resource. According to Lal (1984b), nine reclamation projects involving 813 ha of mangroves were approved between 1980 and 1984. Most were for agricultural purposes, although the largest (493 ha) was for tourist development and fiscal industries at Sawena Beach.

Hydrological and biophysical values: The mangroves help sustain the inshore fisheries of Nadi Bay which is very intensively fished. They also play an important role in coastal protection, particularly by dampening the effects of cyclones and storm surges.

Social and cultural values: No information is available specifically for this site.

Noteworthy fauna: No information.

Noteworthy flora: No information.

Recreation and tourism: Nadi Bay is an important focus of the tourist industry. **Management authority and jurisdiction:** The coastline from the north of Lautoka to the south of Vuda Point lies within the Port of Lautoka-Vuda and is under the jurisdiction of the Ports Authority of Fiji. Mangroves elsewhere are under the jurisdiction of the Department of Lands and Survey.

References: Gangaiya *et al.* (1988); Lal (1984b); Watling (1986).

Reasons for inclusion: la, lc, 2c.

Source: See references.

Wetland Name: Mangroves of the Ba Delta

Country: Fiji

Coordinates: 1726'-17°31'S, 177°35'-177°45'E

Location: in the delta of the Ba River near Ba, on the northwest coast of Viti Levu.

Area: 3,995 ha including 3,714 ha of mangroves and 281 ha of mudflats.

Altitude: Sea level.

Overview: A large area of deltaic mangrove forest and hypersaline mudflats in the delta of the Ba River.

Physical features: The delta of the Ba River contains the largest contiguous stand of mangroves in Fiji. The more elevated and less well-drained portions of the delta are hypersaline because of the high evaporation rates and low rainfall. These areas are either bare mudflats or covered in stunted mangrove forest. The water catchment of the Ba River is approximately 940 sq.km or about 10% of the area of Viti Levu, all of it in the dry, leeward zone. The total volume of water discharged is estimated at 1,636 million cubic metres per year.

The delta receives an average annual rainfall of 1,905 mm and experiences a pronounced dry season.

Ecological features: Watling (1985) recognizes two main mangrove communities; one dominated by *Rhizophora stylosa* and *R. samoensis* (62% of the total), and the other dominated by the hybrid *Rhizophora x selala* (31% of the total). In the first community, *R. stylosa* forms an almost pure closed shrub forest on the extensive less well-drained flats behind the banks of the rivers and

creeks. The least well-drained areas, often surrounding or adjacent to hypersaline mudflats, are stunted with a canopy height of less than 2 m. Elsewhere, the canopy height increases to 5 m. In some localities, *R. sylosa* is mixed with and occasionally replaced by *R. samoensis*, while in other localities, *R. x selala* appears and can dominate. Along or near the main river bank in upstream locations, *R. samoensis* dominates, occasionally forming pure stands with a canopy height of 5-7 m, but more frequently occurring in mixed open forest with some *R. sylosa* and *R. x selala*. Landward species such as *Excoecaria agallocha* and *Heritiera littoralis* appear as the mangrove merges into terrestrial forest dominated by the Rain Tree *Samanea saman* on poorly drained soils. The second community comprises an open forest dominated by the *selala* hybrid. This is found to varying extents along almost all banks of rivers and streams and on associated levees. *Bruguiera gymnorrhiza* and *Xylocarpus granatum* occur infrequently with either *R. sylosa* or *R. samoensis*. The canopy is very uneven and varies between 6 and 12 m in height.

Land tenure: State (Crown Land).

Conservation measures taken: All mangroves in Fiji were designated as Reserved Forests and managed by the Forest Department from 1933 to 1975. These Reserved Forests were denotified in 1975, and the mangroves have since been under the jurisdiction of the Department of Lands and Survey as an integral part of the foreshore. There are some restrictions on cutting, but traditional exploitation is still permitted.

Conservation measures proposed: Watling (1985) makes some recommendations for management.

Land use: The principal activity in the delta is fishing. The customary fishing rights for the entire delta are held by the residents of Votua village. Inhabitants of other villages in the area make extensive use of a variety of forest products. There is, however, no legal commercial wood production in the delta (Watling, 1985).

Possible changes in land use: The Ba Delta has long been identified as a site for large-scale reclamation for agriculture. In 1973, the Lands Department identified 2,367.5 ha (or 55% of the gross delta area) as being potentially suitable for reclamation. Although only small areas of mangrove have been reclaimed since 1980, there remains the possibility that proposals for large-scale reclamation will re-surface.

Disturbances and threats: The major threats are reclamation for agriculture and aquaculture. In the early 1970s, some 308 ha of mangroves were cleared and polderized at Raviravi, and half of this was intended for aquaculture, especially the culture of penaeid prawns. According to Lal (1984b), two reclamation projects for agriculture, involving 95 ha of mangroves, were approved between 1980 and 1984. In all, an estimated 541 ha of mangroves have been reclaimed for agriculture and aquaculture and a further two ha for industrial development. Illegal cutting of timber takes place, and in some areas this illegal felling is causing severe damage to the forest (Watling, 1985).

Hydrological and biophysical values: The Ba Delta mangroves sustain one of the most important offshore fisheries in Fiji.

Social and cultural values: No information is available specifically for this site.

Noteworthy fauna: No information.

Noteworthy flora: The Ba Delta supports the largest contiguous stand of mangroves in Fiji.

Management authority and jurisdiction: Department of Lands and Survey.

References: Lal (1984b); Watling (1985).

Reasons for inclusion: la, lc, 2c.

Source: Birandra Singh and references.

Wetland Name: Vaturu Dam

Country: Fiji

Coordinates: 17°44'S, 177°40'E

Location: in the valley of the Nadi River, 25 km southeast of Lautoka and 25 km north-northeast of Nadi, Viti Levu.

Area: 160 ha.

Altitude: 510 m.

Overview: Freshwater reservoir.

Physical features: A water storage reservoir approximately 5 km long and up to 1.5 km wide on the edge of a plateau in the upper drainage of the Nadi River. The catchment area rises to about 800 metres above sea level. The dam has a maximum depth of 37 metres and a total storage volume of 27 million cubic metres. The average water flow into the reservoir is 2.4 cubic metres per second. Access is very difficult except along the ridge routes, the plateau falling away steeply on all sides.

The region has a Dry Western climate with an average annual rainfall of about 3,600 mm and a mean temperature of 19.7°C. Sunshine hours total 157, and a wind speed of 2.6 knots is average. Most of the precipitation falls during storms and cyclones.

Ecological features: The water catchment is covered in dense closed montane tropical rainforest. No detailed botanical description of the forest is available.

Land tenure: The reservoir and its catchment are on Native land, ownership being shared by the Mataqali, Qoqa and Nasaucoke from Nagado, and the Naivua and Navunito from Yaloku.

Conservation measures taken: None.

Conservation measures proposed: The reservoir and forests of its catchment area were proposed as an Amenity Reserve (Vaturu Forest) in the Ninth Development Plan (Anon, 1989).

Land use: Vaturu Dam supplies water to Nadi and Lautoka. There is some fishing by local people.

Disturbances and threats: None known.

Hydrological and biophysical values: The reservoir supplies Nadi and Lautoka with water and is thus of considerable economic importance.

Social and cultural values: No information.

Noteworthy fauna: At least 42 species of birds have been recorded in the vicinity of the reservoir, including the Long-tailed Cuckoo (*Eudynamis taitensis*), a non-breeding migrant from New Zealand. Giant geckoes and skinks are found in the area as well as the Pacific Boa (*Camdoia bibronii*). Amphibians such as the cane toad (*Bufo marinus*) are present, as well as the Pacific Fruit Bat (*Pteropus tonganus*). The Indian Mongoose (*Herpestes semipunctatus*), mice, rats and the domestic pig are present.

Noteworthy flora: No information.

Recreation and tourism: Recreational-based activities have potential on the reservoir, but at present there is insufficient local utilisation to make it financially viable. It is in both the landowners' interest and the government's interest to make Vaturu a viable tourist attraction.

Management authority and jurisdiction: The Native Lands Trust Board and the Public Works Department are the authorities concerned with development.

References: Anon (1989); Fawcett, Wilton and Bell Ltd (1983).

Reasons for inclusion: 2b.

Source: Alistair J. Gray.

Wetland Name: Nadrau Swamp

Country: Fiji

Coordinates: 17°42'S, 177°58'E

Location: in the upper drainage of the Rewa River, close to the watershed of the Sigatoka River, central highlands of Viti Levu.

Area: 114 ha.

Altitude: 2,500 m.

Overview: Peat bog.

Physical features: A montane peat bog in a side valley of the Nanuku Creek in the headwaters of the Rewa River. The Nanuku Creek passes along the downstream edge of the swamp, which receives water from several short streams and also by flooding from the creek. In the deeper

parts of the valley, the peat is several metres deep. Colluvium is found along the valley sides, and there is a major alluvial levee along Nanuku Creek. A small pond is located at the western end of the swamp within 50 metres of the Sigatoka River catchment. It appears- that the Sigatoka River has captured the headwaters of the valley in which the swamp is situated, but the drainage patterns including the direction of flow are complicated by tectonic tilting.

The region has a Wet Eastern climate with a dry season rainfall of 800-1,200 mm and a wet season rainfall of 2,000-2,400 mm.

Ecological features: The wetland vegetation is herbaceous and differs in several respects from that of lowland peat swamps. The dominant upland peat species are *Urena lobata*, *Adenostemma lavenia*, *Cuphea carthagensis*, *Desmodium heterophyllum* and *Polygala paniculata*. Typical lowland species such as *Pandanus pyriformis*, *Sphagnum cuspidatum* and *Eleocharis ochrostachys* are absent. The pond contains aquatic plants notably *Limnanthemum indicum*, *Eleocharis dulcis* and *Nymphaea capensis*.

Land tenure: Native land.

Conservation measures taken: None.

Land use: Cattle graze the margins of the swamp, but avoid those areas dominated by sedges and ferns.

Disturbances and threats: The slopes around the swamp are being cleared and used as pastures.

Hydrological and biophysical values: No information.

Social and cultural values: No information.

Noteworthy fauna: There is an unconfirmed report of the endangered Barred-wing Rail (*Nesoclopeus poecilopterus*) in swamps on the Nadrau Plateau in 1973 (Holyoak, 1979).

Noteworthy flora: No information.

Management authority and jurisdiction: No information.

References: Ash & Ash (1984); Holyoak (1979).

Reasons for inclusion: 1d, 2b.

Source: Alistair J. Gray.

Wetland Name: Monosavu Dam

Country: Fiji

Coordinates: 17°45'S, 178°02'E

Location: 60 km northwest of Suva, in the headwaters of the Rewa River on the Nadrau Plateau, central highlands of Viti Levu.

Area: 670 ha.

Altitude: 750 m.

Overview: A water storage reservoir.

Physical features: The reservoir lies immediately upstream of the original Monosavu Falls where the Nanuku Creek drops off the edge of the Nadrau Plateau. The sides of the valley are very steep and hence the reservoir is long and narrow (18 km long but no more than one km wide). The reservoir has a volume of 142 million cubic metres, with a 625 metre head of water. The area receives approximately 3,600 mm of rainfall per year, distributed unevenly. The reservoir is on the wet side of the Monosavu catchment area.

Ecological features: The catchment is covered by tropical rainforest, although most of this is commercial forest. Dominant emergents are *Endospermum macrophyllum*, *Canarium* sp., *Parinari* sp. and *Agathis vitiensis*. The exposed pebbly shores of the reservoir are scantily covered with a native shrub, *Acalypha rivularis*, and a variety of reeds and sedges, notably *Cyperus brevifolius*. There is, however, no *Miscanthus*. Where the shore is muddy, the grass *Brachiaria mutica* is abundant.

Land tenure: Native land and Fiji Electricity Authority.

Conservation measures taken: None.

Land use: Generation of hydro-electric power, fishing and some recreation.

Disturbances and threats: None known.

Hydrological and biophysical values: The dam provides an important input into the electricity grid, with a generating capacity of 80 MW.

Social and cultural values: The reservoir supplies the local population with fish (tilapia), and is a popular recreation area.

Noteworthy fauna: No information is available on the wetland fauna. The forests of the catchment area support a varied bird life.

Noteworthy flora: No information.

Management authority and jurisdiction: Native land owners and the Fiji Electricity Board.

References: Brodie (1984); Brodie & Gibbons (1986); Brodie *et al.* (1987); Gibbons (1985); Institute of Natural Resources (undated); Raj *et al.* (1977).

Reasons for inclusion: 2b.

Source: Alistair J. Gray.

Wetland Name: Mangroves of the Labasa Delta

Country: Fiji

Coordinates: 16°21'-16°26'S, 179°14'-179°25'E

Location: in the delta of the Labasa River near Labasa, on the north coast of Vanua Levu.

Area: 1,473 ha.

Altitude: Sea level.

Overview: A large area of deltaic mangrove swamps on the north coast of Vanua Levu. Physical features: The Labasa Delta is the combined alluvial fans of three rivers, the Labasa, Qawa and Wailevu, which drain the fertile Labasa plains and adjacent foothills. The combined annual discharge of the rivers is estimated at about 1,063 million cubic metres. Mangrove forest covers much of the delta. The seasonal dry climate has resulted in the formation of hypersaline mudflats with adjacent stunted mangroves in the less well-drained areas.

The Labasa Delta lies in the leeward dry zone of Vanua Levu, receiving a mean annual rainfall of 2,309 mm and experiencing a distinct dry season.

Ecological features: Watling (1985) recognizes two main mangrove communities. A closed shrub forest occurs well behind the river banks and seaward edge, generally with hypersaline mudflats at its centre. *Rhizophora samoensis* dominates the association, forming pure stands towards the centre. *Bruguiera gymnorrhiza* and the hybrid *Rhizophora x selala* become increasingly common towards the outer edge. The canopy height declines from 5-8 m at the periphery to 1-2.5 m near the mudflats. This mangrove community comprises approximately 25.9% of the mangroves in the delta. The other community (comprising about 68.6%) is dominated by *Bruguiera gymnorrhiza* which in many areas forms pure stands with a canopy at 10-15 m. *R. x selala* and *R. samoensis*, either separately or combined, form a distinct, vigorous association of limited extent along the banks of rivers and creeks. *Rhizophora stylosa* forms a fringing belt along many parts of the seaward edge, but is occasionally displaced by pure *R. samoensis*. Conversely, *R. stylosa* occasionally replaces *R. samoensis* in its more usual riverbank locations. The more landward species *Xylocarpus granatum*, *Lumnitzera littorea* and *Excoecaria agallocha* are locally common, especially at the head of the delta where there are some small pockets of typically terrestrial vegetation (Watling, 1985).

Land tenure: State (Crown Land).

Conservation measures taken: All mangroves in Fiji were designated as Reserved Forests and managed by the Forest Department from 1933 to 1975. These Reserved Forests were denotified in 1975, and the mangroves have since been under the jurisdiction of the Department of Lands and Survey as an integral part of the foreshore. There are some restrictions on cutting, but traditional exploitation is still permitted.

Conservation measures proposed: Watling (1985) has made some recommendations for management.

Land use: Formerly the mangroves were used for fuelwood by a cane crushing mill and bakeries in Labasa. This practice declined in the 1950s, and there is no longer any commercial extraction of fuelwood. The principal activity in the delta at present is fishing. The customary fishing rights east of the Wailevu River are owned by the Vanua of Labasa, while those

west of the Wailevu are owned by the Vanua of Wailevu. Labasa Town is a major fish supply centre, with much of the produce from the Labasa Delta being retailed in Viti Levu (Watling, 1985).

Possible changes in land use: Labasa Town is the rapidly growing capital of Vanua Levu. As there is a shortage of land suitable for development, it is inevitable that there will be further proposals for reclamation of mangroves for urban and industrial expansion.

Disturbances and threats: Major reclamation has occurred in the Labasa mangroves. Large areas of mangrove were lost as a result of the construction of three sea walls by the Colonial Sugar Refining Company between 1896 and 1904. Watling has estimated that about 650 ha of mangroves were lost at this time, but Lal (1990) puts the figure at 2,334 ha, while Baines (1979) gives a figure of 2,713 ha. In recent years, 145 ha of mangroves have been reclaimed for agricultural development, 30 ha for industrial development, and 0.2 ha for a rubbish dump. Twenty-four ha of mangroves have been converted into sewerage oxidation ponds. Pollution is also a problem in the delta, as effluents from Labasa Town and the Fiji Sugar Company Mill are discharged into the rivers at the head of the delta. Fish kills as a result of mill discharge are of almost annual occurrence (Watling, 1985).

Hydrological and biophysical values: The mangroves of the Labasa Delta form an important productive unit which contributes greatly to the rapidly growing fisheries industry centred at Labasa.

Social and cultural values: No information is available specifically for this site.

Noteworthy fauna: No information.

Noteworthy flora: No information.

Management authority and jurisdiction: The mangrove areas are under the jurisdiction of the Department of Lands and Survey.

References: Baines (1979); Lal (1990); Watling (1985).

Reasons for inclusion: la, lc, 2c.

Source: Birandra Singh and references.

Wetland Name: Lake Tagimaucia

Country: Fiji

Coordinates: 16°49'S, 179°56'W

Location: in the highlands of Taveuni Island, 6 km southeast of Somosomo.

Area: 213 ha.

Altitude: 820 m.

Overview: A freshwater crater lake, mostly covered with a floating mat of sedges and reeds.

Physical features: Lake Tagimaucia is the largest natural freshwater lake in Fiji. It is a crater lake with extensive floating mats of aquatic vegetation and only about 16 ha of open water. The lake is situated on the eastern side of the central mountain ridge of Taveuni Island, and overflows into the Wainisairi Creek. The catchment has a total area of 619 ha, of which 35% is swamp and open water, and the remainder is forested. Sedge peat swamp is gradually filling the lake basin. The floating mats of peat are dissected by fissures to form a number of interlocking islands. The lake is about 2.5-5.5 metres deep. The climate is very wet, with an average annual rainfall of over 6,800 mm. The climate is strongly influenced by the prevailing humid southeasterly winds which rise over the centre of the island and produce abundant rainfall. The mean daily temperature is 15-21°C in July and 18-24°C in January. Relative humidity remains in the range 94%-98% throughout the year. Annual evapo-transpiration rarely exceeds 900 mm.

Ecological features: The swamp vegetation is dominated by *Lepironia articulata* and algae which form floating sedge-peat islands, and *Pandanus taveuniensis* and other small trees where alluvium and colluvium are infilling the margins of the crater. The surrounding slopes are forested.

Land tenure: Native Land.

Conservation measures taken: None.

Conservation measures proposed: Various recommendations have been made for the establishment of some form of protected area on the island of Taveuni (Anon., 1989; Dahl, 1980 & 1986; TCSP, 1990), and the entire island has been proposed for listing under the World

Heritage Convention. A proposal to establish a national park on the island is currently being considered by the government (Lenoa *et al.*, 1989). In all cases, the proposed protected areas have included Lake Tagimaucia.

Land use: None. The lake is a six hour walk from the nearest village and is seldom visited.

Disturbances and threats: None known.

Hydrological and biophysical values: No information.

Social and cultural values: None known.

Noteworthy fauna: The fauna of the lake and swamp is low both in species diversity and in abundance. The only aquatic vertebrates which have been observed at the lake are eels (*Anguilla* sp.) and the introduced cane toad (*Bufo marinus*). The Swamp Harrier (*Circus approximans*) occurs in the area, but no true waterbirds have been recorded. A variety of aquatic insects are present, but crustaceans and other invertebrate taxa are poorly represented.

Noteworthy flora: A rare endemic flowering plant, the Tagimauthea Flower *Medinella waterhousei* (Melastomataceae), is known only from the vicinity of the lake and Mt Seatura on Vanua Levu. Other interesting plants include *Freycinetia storkii*.

Research and facilities: The lake has been the subject of extensive limnological studies (Southern *et al.*, 1986).

Management authority and jurisdiction: No information.

References: Anon. (1989); Dahl (1980, 1986); Lenoa *et al.* (1989); Southern *et al.* (1986); TCSP (1990).

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

Source: Alistair J. Gray.

Other Wetlands

Insufficient information is available on the following wetlands to provide more than a very sketchy account, and in most cases their national and international significance is uncertain. Some of the sites have been identified as being of conservation interest by workers such as Dahl (1980, 1986), Dunlap and Singh (1980) and the Tourism Council of the South Pacific (TCSP, 1990), while most of those on Vanua Levu have been identified from the 1:50,000 maps published by the Directorate of Overseas Survey in 1961. It can be assumed that many of the Vanua Levu wetlands are now much reduced in size as a result of reclamation activities.

Wetland Name: Waindrandra Palms

Country: Fiji

Coordinates: Coordinates unknown

Location: at the Waindrandra Agricultural Research Station at Nanggali on Viti Levu.

Area: Unknown.

Altitude: Unknown.

Overview: A unique stand of riverine forest with the only known population of the endemic palm *Neoveitchia storckii* (an endemic genus). This population numbered less than 200 trees in 1972, and continues to decline as a result of clearing (Gorman & Siwatibau, 1975; Dahl, 1980). Recommended for protection in the 1980 Parks and Reserves Plan (Dunlap & Singh, 1980) and by Dahl (1980, 1986)

Land tenure: No information.

Wetland Name: Vatulele Pools

Country: Fiji

Coordinates: 18°32'S, 177°38'E

Location: on Vatulele Island, 33 km off the south coast of Viti Levu, almost due south of Korolevu.

Area: Unknown.

Altitude: Sea level.

Overview: Two brackish tidal ponds on rocky shores, with an endemic red prawn (Crustacea). The prawn is strictly protected by traditional taboos. The site was recommended for protection in the 1980 Parks Plan (Dahl, 1986; TCSP, 1990).

Land tenure: Native land.

Wetland Name: Moturiki Swamp

Country: Fiji

Coordinates: 17°46'S, 178°45'E

Location: on the small island of Moturiki, off the southwest coast of Ovalau Island in the Lomaiviti Group.

Area: Unknown.

Altitude: Near sea level.

Overview: An area of freshwater swamp forest and bog on the small volcanic high island of Moturiki (10 sq.km). Identified as an ecosystem of conservation interest and recommended for protection by Dahl (1980 & 1986) and TCSP (1990).

Land tenure: No information.

Wetland Name: Lake Rovurovu

Country: Fiji

Coordinates: 16°44'S, 178°40'E

Location: near the west end of Vanua Levu.

Area: Length: 400 metres, Width: 50 metres.

Altitude: 50 metres.

Overview: Freshwater lake.

Land tenure: Native Reserve.

Wetland Name: Pond at the source of the Ndranoumbamba River

Country: Fiji

Coordinates: 16°38'S, 178°56'E

Location: in the interior of western Vanua Levu, 6 km southeast of Nabavatu.

Area: 2.5 ha (500 m long, 50 m wide).

Altitude: 400 m.

Overview: Freshwater swamp.

Land tenure: Native land.

Wetland Name: Nairirileka Swamp

Country: Fiji

Coordinates: 16°34'S, 178°52'-178°53'E

Location: near the mouth of the Ndreketi River on the north coast of Vanua Levu.

Area: 250 ha.

Altitude: Sea level.

Overview: A brackish swamp.

Land tenure: Freehold land.

Wetland Name: Ndrano Yalewa and Ndrano Tangane

Country: Fiji

Coordinates: 16°31'S, 178°56'E

Location: in the hills near Navidamu on the north coast of Vanua Levu.

Area: 5 ha (1 km long, 50 m wide).

Altitude: 100 metres.

Overview: Two small freshwater lakes.

Land tenure: Native land.

Wetland Name: Ndoindoi Swamp

Country: Fiji

Coordinates: 16°30'S, 178°57'E

Location: northeast of Navidamu on the north coast of Vanua Levu.

Area: 100 ha.

Altitude: 50 m.

Overview: Freshwater swamp.

Land tenure: Native land, plus 10% freehold.

Wetland Name: Swamps of the upper Ndreketi River

Country: Fiji

Coordinates: Within a large triangle with co-ordinates: 16°30'S, 179°03'E; 16°32'S, 179°04'E; and 16°31'S, 179°05'E

Location: In the upper drainage of the Ndreketi River in the north-central hills of Vanua Levu, 15 km east of Navidamu.

Area: 500 ha.

Altitude: 100 m.

Overview: Six freshwater swamps: Korowaiwai Swamp, Nduriwailevu Swamp, Ndranowakalevu Swamp, Narualango Swamp, Vunimolau Swamp and Ndangau Swamp.

Land tenure: Native land.

Wetland Name: Taketakelo Pond

Country: Fiji

Coordinates: 16°35'S, 179°06'E

Location: near Naravuka in the north-central interior of Vanua Levu.

Area: 20 ha.

Altitude: 50 m.

Overview: Freshwater pond.

Land tenure: Native land.

Wetland Name: Ponds along the Ndreketi River

Country: Fiji

Coordinates:

Location: 16°31'S, 179°07'E; 16°31'S, 179°08'E; and 16°30'S, 179°09'E; in the upper drainage of the Ndreketi River in north-central Vanua Levu, southwest of Naduri.

Area: Total of all ponds approximately 20 ha.

Altitude: 100 m.

Overview: A series of freshwater ponds along creeks close to the Ndreketi River.

Land tenure: Native land.

Wetland Name: Mbalawa Swamp

Country: Fiji

Coordinates: 16°14'S, 179°46'E

Location: near the mouth of the Nasuvu River, on the northeast coast of Vanua Levu.

Area: 100 ha.

Altitude: Sea level.

Overview: Brackish swamp.

Land tenure: Native reserve.

Wetland Name: Ngasauva Salt Lagoon

Country: Fiji

Coordinates: 16°10'S, 179°59'E

Location: near the extreme northeastern tip of Vanua Levu.

Area: 150 ha.

Altitude: Sea level.

Overview: Salt water lake.

Land tenure: Native reserve.

Wetland Name: Lake Ndrano

Country: Fiji

Coordinates: 16°09'S, 180°00'E/W

Location: near the extreme northeastern tip of Vanua Levu.

Area: 5 ha.

Altitude: Sea level.

Overview: Brackish lake.

Land tenure: Native reserve.

Wetland Name: Lake Navesiwaka

Country: Fiji

Coordinates: 16°25'S, 179°40'E

Location: in the upper drainage of the Nasuvu River in the interior of eastern Vanua Levu.

Area: 10 ha.

Altitude: 500 m.

Overview: Freshwater lake.

Land tenure: Native land.

Wetland Name: Ngalongalo Salt Lake

Country: Fiji

Coordinates: 16°46'S, 179°31'E

Location: in the narrow isthmus south of Natewa Bay, 19 km east of Savusavu, Vanua Levu.

Area: 150 ha.

Altitude: Sea level.

Overview: Salt lake. Recommended for protection (Dahl, 1986; TCSP, 1990).

Land tenure: Surrounded by freehold land.

Wetland Name: Lake on the Songatiri River

Country: Fiji

Coordinates: 16°42'S, 179°16'E

Location: near the mouth of the Songatiri River, east of Wailevu on the south coast of Vanua Levu.

Area: 20 ha (1 km long, 200 m wide).

Altitude: Sea level.

Overview: Freshwater pond.

Land tenure: Bordering native reserve and freehold land.

Wetland Name: Un-named wetland

Country: Fiji

Coordinates: 16°53'S, 179°00'E

Location: near Nadivakarua, on the south coast of Vanua Levu.

Area: Length: 1.5 km, Width: 150 metres.

Altitude: 50 m.

Overview: A freshwater pond.

Land tenure: Native reserve.

Wetland Name: Muanithula Marsh

Country: Fiji

Coordinates:

Location: 16°53'S, 178°55'E; at the mouth of the Wainunu River southeast of Dada, on the south coast of Vanua Levu.

Area: 500 sq.m.

Altitude: Sea level.

Overview: Saltmarsh.

Land tenure: Freehold land.

Wetland Name: Delaimoala Lake

Country: Fiji

Coordinates: 18°36'S, 179°54'E

Location: on the island of Moala, in the Moala Group.

Area: Unknown.

Altitude: Unknown.

Overview: A small freshwater lake on Delaimoala Peak, with matted sedges and a reed fringe (Dahl, 1986).

Land tenure: No information.

Wetland Name: Tuvuca Lakes

Country: Fiji

Coordinates: 17°41'S, 178°49'W

Location: on the island on Tuvuca in the Lau Group.

Area: Unknown.

Altitude: Unknown.

Overview: A group of four or five small brackish lakes in a depression in the interior of Tuvuca Island, a raised coral island with an area of 13 sq.km (Dahl, 1986).

Land tenure: No information.

Wetland Name: Vuaqava Salt Lake

Country: Fiji

Coordinates: 18°52'S, 178°54'W

Location: on the island of Vuaqava (Vuanggava) in the Lau Group.

Area: Unknown.

Altitude: Sea level.

Overview: A tidal saltwater lagoon (marine lake) in the central basin of Vuaqava Island, a raised coral atoll with an area of 7.7 sq.km. The lagoon is used as a turtle pen by Kambara Islanders. The site was recommended for protection in the 1980 Parks Plan (Dahl, 1980 & 1986).

Land tenure: No information.

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