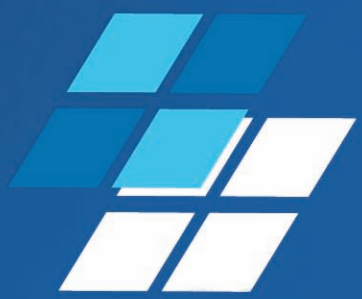
Regional Wetlands Action Plan for the Pacific Islands



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REGIONAL WETLANDS ACTION PLAN FOR THE PACIFIC ISLANDS


The Pacific Islands Region
Philippine Sea
NORTHERN MARIANA ISLANDS
SAIPAN
GUAM
WAKE ISLAND
MARSHALL ISLANDS
ENIWETAK
JOHNSTON ATOLL
HAWAII
North Pacific Ocean
PALAU
FEDERATED STATES OF MICRONESIA
CHUUK
KOSRAE
KIRIBATI
KIRIT HATI
TARAWA
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BOUGAINVILLE
PHOENIX ISLANDS
SOLOMON ISLANDS
SANTA ISABEL
MALAITA
TUVALU
FUNAFUTI
Arafura Sea
THURSDAY ISLAND
GUADALCANAL
SAN CRISTOBAL
SANTA CRUZ ISLANDS
TOKELAU
VANUATU
ESPIRITU SANTO
MALEKULA
WALLIS AND FUTUNA
SAMOA
Coral Sea
FIJI
AMERICAN SAMOA
COOK ISLANDS
KINGDOM OF TONGA
NIUE
NEW CALEDONIA AND DEPENDENCIES
LOYALTY ISLANDS
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South Pacific Ocean
NORFOLK ISLAND
KERMADEC ISLANDS
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TASMANIA

Foreword

Wetlands are among the world's most productive environments and as such, their importance cannot be overstated. Indeed their importance is expressed in how they maintain ecological processes as well as the diverse flora and fauna they protect, nurture and sustain. Aside from having cultural and traditional significance, wetlands provide tremendous economic and conservation benefits through fisheries production, maintenance of water tables, water storage and flood control, shoreline stabilisation, water purification and recreational opportunities.

The peoples of the Pacific islands region share common aspirations toward ecologically sustainable development. We have to use our resources for today but at the same time we want to make sure that there are enough for our children tomorrow. However, a number of circumstances in the region combine to restrict the opportunities for both development and conservation of wetlands and other ecosystems. These include the small land masses of islands and their widespread dispersal. In some countries, the pressures of population growth and competing resource use are major threats to ecologically sustainable development and conservation of productive mangrove areas.

This Regional Wetlands Action Plan was developed and endorsed by Pacific island governments in response to the call for greater effort and commitment to the conservation and sustainable use of wetlands in countries of the Pacific. It provides an overview of existing programmes for the conservation of wetlands in the Pacific region as well as a rationale and framework for action to increase and improve the wetlands conservation situation in the Pacific. This plan is now ready for implementation.

SPREP is committed to supporting and working with its member countries and other partners in the implementation of this Regional Wetlands Action Plan. It is a tool that will assist wetlands conservation activities in the Pacific islands region and it provides a way to help Pacific communities achieve ecologically sustainable use of wetlands and associated resources.

Tamari'i Tutangata
Director
SPREP

Contents

Acronyms

AIMS	Australian Institute of Marine Science
ASEAN	Association of South-East Asian Nations
AusAID	Australian Agency for International Development
AWB	Asian Wetland Bureau (part of Wetlands International)
CARICOMP	Caribbean Coastal Marine Productivity Programme
FSP	Foundation for the Peoples of the South Pacific
GEF	Global Environment Facility
GOOS	Global Ocean Observing System
ICLARM	International Centre for Living Aquatic Resource Management
ICRI	International Coral Reef Initiative
IOC	Intergovernmental Oceanographic Commission
ISME	International Society for Mangrove Ecosystems
IUCN	The World Conservation Union
NEMS	National Environmental Management Strategy
NGO	Non-governmental Organisation
PIANGO	Pacific Islands Association of Non-government Organisations
PIC	Pacific Island Country
PIMRIS	Pacific Island Marine Resource Information System
PNG	Papua New Guinea
RWAP	Regional Wetlands Action Plan
SPACHEE	South Pacific Action Committee for Human Ecology and Environment
SPBCP	South Pacific Biodiversity Conservation Programme
SPREP	South Pacific Regional Environment Programme
TNC	The Nature Conservancy
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPNG	University of Papua New Guinea
USP	The University of the South Pacific
WCF	Wetland Conservation Fund (Ramsar Convention)
WCMC	World Conservation Monitoring Centre
WI	Wetlands International (includes AWB)
WMO	World Meteorological Organization
WWF	World Wide Fund for Nature

1. Introduction

The area of concern for this Regional Wetlands Action Plan (RWAP) is the Pacific islands region, extending from Palau and the Northern Mariana Islands in the north-west to French Polynesia and Pitcairn in the south-east, encompassing 22 Pacific island countries and territories including large countries such as Papua New Guinea (PNG). It equates to the region of operation of the South Pacific Regional Environment Programme (SPREP).

Wetlands considered in this RWAP comprise intertidal ecosystems of mangroves and mudflats, and freshwater ecosystems of lakes, marshes, swamps and rivers. The primary focus of the RWAP is mangroves, with secondary emphasis on freshwater wetlands. It is recommended that a separate action plan be developed for seagrasses.

Mangrove forests occur on low energy, sedimentary shorelines of the tropics, generally between mean tide and high tide elevations. There are two main environmental settings for mangroves of the Pacific, deltaic and estuarine mangroves of high islands, and embayment, lagoon and reef flat mangroves of low islands. Mangrove trees have special physiological adaptations to the environmental stresses of their intertidal habitat, of high salinity, low oxygen, poor nutrient availability and substrate mobility. Mangrove ecosystems have high faunal diversity of microbes (bacteria, protozoa, fungi), invertebrate infauna (i.e crabs), fish and birds.

One of the main wetland conservation issues in the Pacific islands region today is the loss and degradation of mangroves (see Section 2) resulting from human activities. The human population in the Pacific islands region is in the order of only six million, of which more than half is in Papua New Guinea. However, rates of population increase are relatively high and land areas are small. This results in considerable pressure on natural resources, especially in the coastal zone which is where most people live.

Most Pacific island countries (PICs) have limited resources which limit opportunities for economic and social development and conservation programmes. Also whereas many local communities practice sustainable use of wetland resources, the increasing demand for material wealth is often the cause for those practices to be unsustainable.

The land tenure situation is also a major influence on wetland conservation in the Pacific islands region. Most land is in customary ownership, which means that consultation between owners, government and other stake holders is needed for land use planning. Inshore waters are held in customary tenure in some countries but are State owned in others.

Some conservation areas have been established in PICs but overall they are few in number and small in area. More effective however, have been the collective efforts of governments, regional and local NGOs in the recent integrated conservation and development projects (ICAD projects in PNG; South Pacific Biodiversity Conservation Programme (SPBCP) Conservation Area projects in other PICs).

A *Regional Workshop on Wetland Protection and Sustainable Use in Oceania*, organised by Asian Wetland Bureau (AWB) and SPREP, was held in Port Moresby, PNG, in June 1994 and the participants (from seven PICs) produced an *Action Plan for Wetland Conservation in the Pacific* (Jaensch 1994) containing more than 60 general action points.

Following the review of the *Action Plan for Wetland Conservation in the Pacific* by SPREP, it was decided that it should be developed further to produce a *Regional Wetlands Action Plan* (RWAP) that focused on mangroves containing actions that could be implemented by SPREP and/or collaborating organisations. SPREP appointed a team consisting of Noah Idechong (Palau Conservation Society), Joanna Ellison (Australian Institute of Marine Science) and Roger Jaensch (Oceania Program of Asian Wetland Bureau), to produce a draft RWAP in October 1995.

The purpose of the RWAP is to provide a rationale and framework for actions to improve the wetland conservation situation in the Pacific islands region, which could be readily implemented. The target readership of the RWAP therefore is primarily SPREP and collaborating organisations, notably AWB, as well as relevant national agencies and potential donor organisations. The RWAP was brought to the attention of the Pacific Regional Workshop of the International Coral Reefs Initiative (ICRI), which addressed mangroves and related ecosystems in addition to coral reefs.

The RWAP includes background on the conservation values and conservation status of mangroves and freshwater wetlands in the Pacific islands region and an overview of existing wetland conservation programmes. Regional actions for mangroves and freshwater wetlands are listed under the broad headings of Management, Capacity building, and Research and Monitoring (the list of actions reflects current knowledge, situations and priorities, and is not exhaustive; periodic review will be required to keep it a "living" action plan). Time frames, resources and partnership for implementation of the actions are proposed in the concluding section of the Regional Wetlands Action Plan.

2. Mangroves in the Pacific islands region

Mangroves of the Pacific islands occur in close association with offshore benthic communities of seagrass and coral reefs. Juxtaposition and internal character of the habitat are influenced by common physical conditions at each location, and they are closely linked through common food chains, sediment fluxes and chemical cycles.

Pacific context

In the Pacific islands, the total area of mangroves is at least 343,735 hectares (ha). The largest areas occur in Papua New Guinea, Solomon Islands, Fiji and New Caledonia (Table 1). The world mangrove area is estimated at 14,197,635 ha (Lacerda et al., 1993), hence the Pacific islands region has 2.42 per cent of the world's mangroves. Each PIC has a unique mangrove community structure, shown by the number of mangrove species present in Table 1.

Biodiversity of mangrove communities

A total of 34 species of mangroves and three hybrids (Table 1) occur in the Pacific islands region. These are of the Indo-Malayan assemblage (with one exception), and decline in diversity from the west to east across the Pacific, reaching a limit at American Samoa. The mangrove species in Hawaii are introduced, and one is thought to be introduced in French Polynesia.

Most mangroves are habitat specific, 23 of 33 mangrove tree species listed in Table 1 occur exclusively in intertidal habitats. The remaining mangrove associate species may also be found occasionally in habitats such as dry littoral forest.

In New Caledonia, Fiji, Tonga and Samoa, *Rhizophora mangle* occurs, disjunct from its extensive ranges in America. This is the only American mangrove species present in the Pacific islands, and is now known to be indigenous (Ellison, 1991). Studies in the Solomon Islands (Blaber and Milton, 1990) and New Caledonia (Thollot, 1987) have shown significant fish stocks in association with mangroves. There is an endemic subspecies of the Mangrove Monitor (*Varanus indicus spinulosus*) with limited distribution in the Solomon Islands. The only Pacific island countries with the saltwater crocodile *Crocodylus porosus* are Palau, Papua New Guinea, the Solomon Islands, and Vanuatu.

Mangrove functions and values

Mangrove ecosystems are a useful buffer between the land and the sea. They act as a sink for sediments, nutrients and other contaminants to maintain coastal water quality, and so promote coral reef and seagrass growth offshore. They also protect the land from marine inundation during storms and sea level rise.

Mangroves have been shown to be important fish habitats (Robertson and Duke, 1990), with high densities of juvenile fish, indicating their function as a fish nursery. Mangroves sustain a food chain within the mangrove habitat, and associated research has export of mangrove material (Robertson et al., 1988), and the significance of this in offshore food chains (Alongi and Christoffersen, 1992).

Mangrove utilisation

Mangrove areas in the Pacific islands are traditionally used for fishing, gathering of clams and crabs, wood for construction and handicrafts, and fuel wood (Percival and Womersley, 1975; Pillai, 1985; Devoe, 1992; Unua, 1992).

Table 1. Mangrove areas and species diversity in the Pacific islands

Pacific island countries (by Longitude)	Mangrove[1] species	Mangrove area (ha)	Source
Palau	13	4,708	Cole et al., 1987
Federated States of Micronesia	14	8,564	Scott, 1993
Papua New Guinea	33 (2)	200,000	Scott, 1993
Guam	11	70	Scott, 1993
Northern Mariana Islands	5	?	Raulerson & Rhinehart, 1991
Solomon Islands	20 (2)	64,200	Hansell & Wall, 1976
New Caledonia	14 (2)	20,250	Thollot, 1987
Vanuatu	14	?2,750	Scott, 1993
Marshall Islands	5	?	
Nauru	2	1	Scott, 1993
Kiribati	4	?	
Tuvalu	2	40	Scott, 1993
Wallis and Futuna	0	0	Scott, 1993
Fiji	8 (1)	41,000	Watling, 1985
Tonga	8	1,000	Saenger et al., 1983
Samoa	3	?700	Pearsall & Whistler, 1991
American Samoa	3	52	Whistler, 1976
Niue	1	0	Yuncker, 1943
Tokelau	0	0	
Cook Islands	0	0	
French Polynesia	1	?	Taylor, 1979
Pitcairn	0	0	
Total	**161 (7)**	**343,335**	

1 Sources: Ellison, in press, a. Hybrids are in parentheses

There are specialised uses developed within the region. Tannins from the Rhizophoraceae are used for protection of nets and fish traps owing to their fungicidal properties. The prop roots of *Rhizophora* are frequently used for the construction of fish traps, fuelwood, or light construction. The timber of *Lumnitzera littorea* is a good building material, being hard and durable, and resistant to marine borers. In Melanesia, sugar and vinegar can be made from the sap of *Nypa* (Percival and Womersley, 1975). Bark of *Bruguiera gymnorrhiza* is used in Polynesia to make a decorative dye for tapa (Fifita, 1992). There are a range of traditional medicines derived from mangroves. Bark from *Xylocarpus* species are used by Tongans for treatment of internal bleeding and injuries (Whistler, 1992). *Avicennia* leaves are used for boils and contraceptives in PNG, and *Bruguiera* fruits are used for diarrhoea and malaria (Percival and Womersley, 1975). Existing assessments of mangroves area conservation values among communities in the region show high levels of awareness of the ecological and traditional uses of mangroves (Eley, 1988; Prescott, 1989).

Summary of ecological importance

- Act as a buffer to sediment and nutrient rich runoff from the land, promoting healthy growth of coral reefs and seagrass beds.
- Buffer land from storm damage and sea level rise inundation.
- Breeding areas and habitats for fish and crabs.
- Habitats for rare fauna of ecotourism potential, such as birds, crocodiles.
- Many traditional use.
- Intrinsic scientific value of use for educational programmes.

There are records of losses of mangrove areas from most Pacific islands (Ellison, in press, b). Major records include loss to construction of naval facilities in Guam, to urban expansion of capital cities in New Caledonia, Vanuatu, and Tonga, the aquaculture projects in Fiji, Samoa, and Palau, and poldering (reclaiming) for agriculture in Fiji.

There are records of ongoing degradation of mangrove ecosystems from most Pacific island countries. Records exist of oil spills and hazardous wastes affecting mangroves in Guam and Palau, excessive sedimentation from upstream disturbance in New Caledonia and the Federated States of Micronesia, and rubbish dumping in Samoa, Tonga and Tuvalu. It can be expected that there are many more examples of mangrove degradation of this type in the region that remain unrecorded.

In Tuvalu mangroves are so heavily degraded by over-fishing, pollution and erosion, they are listed as a threatened ecosystem (Dahl, 1986). All significant mangrove areas of Tonga are now allocated for clearance.

Degraded mangrove areas need to be rehabilitated, replanted and cleaned up. Areas with heavy clearance may be losing sediments to affect coral and seagrass ecosystems offshore, and areas with rubbish dumping may be leaching toxic chemicals.

Manuals for rehabilitation techniques in mangroves are available from projects at the International Society for Mangrove Ecosystem (ISME) and the Australian Institute of Marine Studies (AIMS).

Mangrove swamps are likely to be a sensitive ecosystem to the effects of climate change and sea level rise (Ellison, 1994). Mangroves of low islands have been shown to be particularly vulnerable to sea level rise, owing to low accretion rates (Ellison, 1993). This has been the subject of several reviews of the literature in recent years, and resulted in activities summarised in this Action Plan.

Conclusion

Despite their many values and uses documented in the region, mangroves are increasingly degraded and under pressure from coastal development. Action is needed to promote mangrove conservation in the Pacific islands. Mangroves have had low priority in past conservation programmes and their present status reflects this neglect. This Action Plan seeks to address this imbalance.

In small island environments, mangroves are closely associated with adjacent benthic ecosystems of coral reefs and seagrasses. It makes sense to have an integrated conservation and management effort in these environments, and this Action Plan endorses this approach within the Framework for Action of ICRI.

3. Regional Actions for Mangroves

3.1 Management

Objective
To undertake regional and national actions that will enhance the management (wise use) of mangroves of the Pacific islands region.

Current situation
There are no coastal management plans for the sustainable use of mangrove areas existing in the region. This has become a necessity with increasing pressures on mangrove resources and their resultant degradation (see Kiribati National Environmental Management Strategy (NEMS) Programme Profile 3.6.3 for example). Legislation for the protection of mangroves exists in many Pacific island countries, but generally is not enforced.

Actions
Specific links are identified with the National Environmental Management Strategies.

→ *3.1.1 Regional Wetlands Management Officer*
Establish a Wetlands Management Officer position at SPREP that will oversee the implementation of the Regional Wetlands Action Plan. The interactive drafting and implementation of mangrove/wetland management plans in each country will be developmental in the Pacific islands region, and will benefit from the input from a regional coordination of experience. Many aspects of the RWAP connect with regional programmes in coastal management, protected areas, training and climate change. The Wetlands Management Officer at SPREP will ensure that the RWAP builds on and integrates with existing programmes.

This action is also recommended for Freshwater Wetlands (Section 5).

→ *3.1.2 Resource assessment*
Carry our mangrove area assessments (inventory and mapping) as a baseline for development of management plans. It is indicated in Table 1 that knowledge of the areas of mangrove in PICs is either out-dated, poorly detailed or non-existent. To a certain extent, this could be addressed at a regional level using remote sensing, with in-country ground truthing. However, many islands have small mangrove areas beyond the resolution of remote sensing techniques that are of high local importance, where interpretation of large scale aerial photography is more appropriate. Such images already exist on many islands.

Reference: Solomon Islands NEMS Programme 11.2.1, 5.1.2, 5.1.4.

→ *3.1.3 Establishment of national mangrove/wetland committees*
Establish a cross-sectorial task force (national wetland committee) in each PIC to coordinate management, research and monitoring of wetlands and their resources. This can be added to the mandate of existing committees, such as the National Environmental Management Strategy

Committee, but where there are sufficient available people and need, a separate mangrove/ wetland committee could be established. Key people to be represented would be from Departments of Environment/Lands, Fisheries/Agriculture, Marine Resources, Conservation NGOs, and would also involve community participation.

This action is also recommended for Freshwater Wetlands (Section 5).

→ *3.1.4 Preparation of management plans*

Prepare Mangrove/Wetland Management Plans for mangrove areas using trained personnel in consultation with all interested parties. The broader the input to the process, the more likely the plan will succeed. The plan should be integral and complementary to existing coastal management plans and national environmental plans.

Establish regional expertise and resources for providing technical assistance to national organisations that seek help to prepare project proposals for management of their wetlands.

Many areas have existing traditional knowledge of, or active implementation of, mangrove management strategies. These should be incorporated into the developmental process of the management plan.

Planners need to quantify current and potential usage patterns of mangrove resources in both direct and indirect products (see Section 2), and in relation to other socioeconomic benefits (coastal buffer function, offshore food chain connections, ecotourism potential). Economic valuation of the mangrove resource can be developed from this, using models if it is necessary as an incentive for management (see also Action 3.3.6).

Such evaluation would allow present and future needs to be met on a sustainable-yield basis from managed mangrove ecosystems. With this basis, ecological criteria can be established for levels of use in different areas, and incorporated into the management plan.

Reference: Tonga NEMS Programme 4.9.1. This action is also recommended for Freshwater Wetlands (Section 5).

→ *3.1.5 Implementation*

Mangrove management plans may be annexed to National Environmental Management Strategies to assist their implementation. Implementation of a mangrove management plan will not occur unless there has been input to its development by all interested parties. However, it will not work unless it has been developed by trained personnel. A community education programme on mangroves and their uses will assist the implementation of a mangrove management plan.

→ *3.1.6 Review*

To meet the changing needs of population or changing condition of the mangrove resource, implemented management strategies must remain flexible within the broad limits of the overall management objectives. Periodic reviews should evaluate performance of strategies, identify applied research needs that may have arisen, and modify strategies as necessary.

→ *3.1.7 Legislation and policy*

Legislation for the protection of mangrove ecosystems exists in some PICs (reviewed by Ellison, in press, b), but needs to be strengthened and enforced. PICs without laws to protect mangrove areas should introduce these laws. The adequacy of existing legislation to implement a mangrove management plan should be considered and addressed.

Establish more mangrove protected areas in the Pacific islands region to ensure that an example of the mangrove ecosystem remains in each island nation for use by future generations.

Reference: Republic of the Marshall Islands NEMS Programme 10.4. Vanuatu NEMS Programme 4.1.2. This action is also recommended for Freshwater Wetlands (Section 5).

→ *3.1.8 Rehabilitation*

Undertake a demonstration project on rehabilitation of degraded wetlands of the Pacific islands region and prepare information on strategies for rehabilitation of degraded wetlands for distribution to regional and national organisations.

This action is also recommended for Freshwater Wetlands (Section 5).

→ *3.1.9 Environmental impact procedures*

National Governments should use existing environmental impact procedures to assess the potential impacts of proposed development projects on mangrove areas, and establish bonds or environmental levies to be applied to development projects to enable monitoring of impacts to be carried out.

Reference: Republic of the Marshall Islands NEMS Programme 10.2. This action is also recommended for Freshwater Wetlands (Section 5).

→ *3.1.10 Linkage and coordination*

Investigate and pursue opportunities for linkage and coordination between the various global and regional conventions and conservation areas (under the South Pacific Biodiversity Conservation Programme (SPBCP), Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar), Convention for the Protection of the World Cultural and Natural Heritage (World Heritage), local designation) that relate to wetland areas, so that parallel regional and local efforts become complementary and less confusing for administrators and local people in the wetland areas.

This action is also recommended for Freshwater Wetlands (Section 5).

3.2 Capacity building

Objective	Present status
Capacity building includes establishing and strengthening of human resource institutional capabilities for mangrove and wetlands management, science, training and education.	Regional and national organisations responsible for conservation and management of mangroves lack human, infrastructural and financial resources to be effective.

Actions

3.2.1 Institutional strengthening and staff training

Promote through curriculum development and special training programmes, education in wetlands ecology and management through appointment of staff with appropriate expertise to regional universities and colleges. Establish scholarships for students from the Pacific islands region to undertake courses in mangrove and wetlands ecology/management both within and outside of the region. Develop regional training courses for personnel with responsibility for management of wetlands.

This action is also recommended for Freshwater Wetlands (Section 5).

→ *3.2.2 Community education*

Develop education resource material to be used in schools and community groups for the promotion of mangrove conservation values. This could take the form of leaflets or videos, or with some training, fieldtrips to mangrove areas for educational groups could be established. Mangroves have suffered in the past from a poor popular image of dirty wastelands, and education is needed to enhance their perceived value as useful areas which will assist implementation of a management plan.

Reference: Solomon Islands NEMS Programme 11.2.3, 9.2.1. Palau NEMS Programme 8.5.7. Federated States of Micronesia NEMS Programme 4.1.1, 4.1.2, 4.1.3. Fiji NEMS projects 12, 13. Republic of the Marshall Islands NEMS Programme 2.4, 7.1. Vanuatu NEMS Programme 4.1.1.

→ *3.2.3 Community involvement*

Develop activities that empower and facilitate community involvement in the mangrove management process.

→ *3.2.4 Interpretive facilities*

There is considerable potential for use of certain mangrove forests as educational and ecotourism facilities (Hamilton and Snedaker, 1984, chapter 3). This may involve a visitor reception centre housing interpretive displays of mangrove ecology and traditional usage of the forest. A constructed boardwalk would allow access to the mangroves taking visitors through the different species zones, with interpretive signs.

→ *3.2.5 Information management*

Develop Geographical Information and Decision Support Systems that compile information relevant to management of wetland areas, and incorporate information from ongoing regional monitoring programmes (see actions 3.3.1 and 3.3.5).

Reference: Republic of the Marshall Islands NEMS Programme 6.1. This action is also recommended for Freshwater Wetlands (Section 5).

3.3 Research and monitoring

Objective	***Present status***
To collect information on mangrove ecosystems that can contribute to the management process.	Knowledge of Pacific island mangroves is poor relative to other regions (south-east Asia, Caribbean). Very few studies have been carried out that are relevant to ecology and management. There are no mangrove monitoring programmes in the Pacific region outside of Australia (AIMS).

Actions

→ *3.3.1 Regional monitoring of health of mangrove*

Develop a regional monitoring programme to assess the status of mangroves in the Pacific islands region, evaluate the success of management and conservation actions and develop more effective management practices. Mangroves inhabit a dynamic interface between terrestrial and oceanic factors and processes, and are generally less well understood than coral reefs.

Mangrove ecosystem monitoring has been recently developed in south-east Asia and the Caribbean example can be taken from these regions as to how to address the problem. In the Caribbean, the Caribbean Coastal Marine Productivity (CARICOMP) program has been developed to study and monitor the productivity of mangrove, coral and seagrass ecosystems (CARICOMP, 1992), producing a manual of standardised survey techniques and distributing field equipment packages to institutions or government departments in each island country that joined the programme. In south-east Asia, the Association of South-East Asian Nations (ASEAN)—Australia Living Coastal Resources Project produced a manual of standardised survey techniques for monitoring the status of and changes over time of coral reefs, mangroves, soft bottom communities, seagrass beds and fish stocks (English, Wilkinson and Baker, 1994). Use of standard techniques and contribution of data to a regional centre will allow results from sites to be compared for interpretation of regional and local trends and influences.

→ *3.3.2 Traditional knowledge*

Catalogue the knowledge in Pacific island cultures of traditional mangrove taxonomy, ecosystem understanding, management and human uses. This could contribute appropriate management practices.

References: Republic of the Marshall Islands NEMS Programme 9.5, Solomon Islands NEMS Programme 9.2.1. This action is also recommended for Freshwater Wetlands (Section 5).

→ *3.3.3 Ecological research*

There are many gaps in knowledge about Pacific island mangrove ecosystems relative to other regions such as south-east Asia and the Caribbean. The Wetlands Management Officer and SPREP's Library and Information Centre should compile the material published, to contribute to the knowledge base for development of management plans and identify unknown areas.

Mangrove species are morphologically similar, and errors of identifications have occurred to confuse the distribution records summarised in Table 1. Many herbarium collections are sporadic or incomplete, and poorly catalogued and maintained. Information needs to be

compiled on the existing herbarium collections held in the Pacific and elsewhere, and the descriptions published.

Reference: Solomon Islands NEMS Programme 5.1.2.

Little is known about the ecology of habitat preferences of mangrove fauna in the Pacific islands. Research is needed on occurrences of species in mangroves, ecology, food chains and their connections with adjacent coastal habitats.

→ *3.3.4 Endangered species*

Mangroves of the Pacific islands are habitats to a number of internationally endangered species such as dugong, marine turtles, flying foxes (fruit bats) and saltwater crocodiles. Very little is known about the population ecology of these species in the Pacific islands, hence their status is difficult to assess and improve.

→ *3.3.5 Mangrove response to sea-level rise predictions*

Mangrove swamps, particularly those of low islands, are likely to be sensitive to rise in sea level. PICs should promote the development of a Global Mangrove Monitoring Network under the Coastal Zone Module of the Global Ocean Observing System. This could be combined with a regional effort for monitoring on mangrove ecosystem health (Action 3.3.1).

Reference: Western Samoa NEMS Programme Profile 11. The Kingdom of Tonga NEMS Programme 4.4.1. Republic of the Marshall Islands NEMS Programme 1.1, 1.2.

→ *3.3.6 Economic values*

Conduct or sponsor research on the economic values of wetland ecosystems and species of the Pacific islands region, and direct results to national land-use planning/management plans and conservation organisations.

This action is also recommended for Freshwater Wetlands (Section 5).

4. Freshwater Wetlands in the Pacific islands region

Lakes

Types of lakes that occur in the Pacific island countries include crater lakes, lakes in highland valleys or basins, freshwater lakes in the coastal zone of high islands, and lakes (both freshwater and saline) on coralline limestone islands. Large floodplain lakes occur in PNG.

Most crater lakes do not support rich biodiversity and some lack any native fish species, essentially due to their isolation from the sea and relatively recent formation, through some support distinctive wetland flora. Many highland lakes are similarly depauperate but some support suites of endemic fish species or have been stocked with exotic fishes that sustain subsistence fisheries. Some coastal lakes of high islands have the potential function of water supply for growing urban centres, although ecological roles such as support for threatened fauna (e.g. crocodiles, endemic taxa) may be at risk. Most lakes in the Pacific islands region, especially those on limestone islands, have high aesthetic values and this offers potential ecotourism opportunities. The large floodplain lakes of PNG support populations of waterbirds and fishes, and are essential to the subsistence and commercial livelihood of local communities.

Threats to lakes in the Pacific islands region include introduced species (fish, weeds), exploitation and pollution resulting from support to urban growth (coastal lakes) and poorly planned eco-tourism, and downstream effects of changes to catchments (mining, agriculture, logging).

Examples

- Crater lakes: Lake Letas, Vanuatu (1900 ha).
- Highland lakes: Lake Kutubu, PNG (4924 ha).
- Freshwater lakes in the coastal zone: Ngardok Lake, Palau (~15 ha).
- Freshwater lakes on limestone islands: Lake Te-Nggano, Solomon Islands (15,500 ha).
- Lowland floodplain lakes: Lake Murray, PNG (64,700 ha).

Marshes

The Pacific islands region has examples of freshwater wetlands that are covered with dense low vegetation: the main types are marshes or swamps dominated by aquatic grasses, reeds and/or herbs (usually in lowlands: large areas on PNG floodplains) and marshes on peaty substrate (usually in highlands). The main conservation value of the smaller isolated marshes is the diversity of aquatic plants, some (perhaps many) of which are endemic to island or countries. Small coastal marshes on small islands are often converted to taro cultivation. The PNG floodplain marshes support large populations of fauna, including many species that migrate to other world regions and some others that are harvested, as well as diverse plant assemblages. Threats to these wetlands include over-exploitation for cultivation, destruction or pollution due to urban landfill, and (especially for floodplains) downstream effects of changes to catchments (mining, agriculture, logging).

Examples:

- Lowland marshes: Emaotfer Swamp, Vanuatu (60 ha).
- Highland marshes: Mount Silisili Bog, Samoa.

Freshwater swamp forests

Closed forests occur on lowland floodplains and in some cases highland swampy situations in many of the larger PICs. Diversity of tree species varies from high (mixed swamp forest) to low (dominated by one species, e.g. *Campnosperma, Melaleuca,* or *Casuarina).* Diversity of fauna is often low. Some of these wetlands, such as the *Terminalia* swamp forests of the Solomon Islands, are managed for commercial logging. Others, such as the sago palm *Metroxylon sagu* wooded swamps of PNG, are important for subsistence livelihoods.

Threats to swamp forests include unsustainable logging and excessive burning.

Examples:

- Lowland swamp forest: Jordan River Floodplains, Vanuatu (~1000 ha).
- Highland swamp forest: Vaipu Swamp Forest, Samoa (520 ha).

Rivers

Only the larger islands have rivers of substantial length and discharge, with the largest PNG rivers having among the world's highest river discharges per catchment area. Some of these rivers have been dammed to provide water supply and electricity. PICs comprising mainly atolls (e.g. Kiribati) have no rivers and consequently have limited water supplies. Threats to rivers include damming (of all rivers on an island) and pollution.

Examples:

- Large rivers: Fly-Strickland River system, PNG (more than 1000 km).
- Rivers on smaller islands: Ngermeskang River, Palau.

5. Regional Actions for Freshwater wetlands

5.1 Management

Objective

To undertake regional actions that will enhance the management (wise use) of freshwater wetlands of the Pacific islands region.

Current situation

At present, freshwater wetlands of the Pacific islands region are under increasing pressure from conversion for cultivation, diversion or modification for water supply or power generation, commercial logging, catchment alteration, pollution, and introduction of exotic species. Regional and national organisations often lack knowledge and/or strategies relevant to the Pacific islands region for management (wise use) of freshwater wetlands. Local communities are often unaware of the likely consequences of proposed changes to these wetlands.

Actions

The following actions described under Section 3 "Regional Actions for Mangroves", also apply to freshwater wetlands of the Pacific islands region:

→ 3.1.1 Wetlands and Mangroves officer at SPREP.

→ 3.1.3 Wetland communities.

→ 3.1.4 Management plans and preparation of project proposals.

→ 3.1.7 Legislation and policies.

→ 3.1.8 Rehabilitation of degraded wetlands.

→ 3.1.9 Environmental impact.

→ 3.1.10 Linkage and coordination of Conventions and Conservation Areas.

Additional Actions

The following additional actions for freshwater wetlands are recommended.

→ ***5.1.1*** Awareness materials - biodiversity conservation

Prepare awareness materials (posters, information sheets, other) that illustrate the importance of freshwater wetlands of the Pacific islands region for conservation of biodiversity (especially fishes and plants) and for existing and potential sustainable human uses, for distribution to regional and national organisations.

→ ***5.1.2*** Awareness materials - introduced species

Prepare and distribute awareness materials on the potential negative impacts of introducing exotic flora and fauna to freshwater wetlands of the Pacific islands region.

→ ***5.1.3*** Awareness materials - river modification

Prepare and distribute awareness materials on the potential negative impacts of river modification projects (damming, diversion, dredging, re-aligning), with special reference to probable changes to fish populations.

→ ***5.1.4*** *Pilot studies - sustainable fishery*

Undertake pilot studies on sustainable freshwater fishery in the Pacific islands region and distribute information on the results and applicability.

→ ***5.1.5*** *Pilot studies - ecotourism in lakes*

Undertake pilot studies on appropriate ecotourism in freshwater lakes of the Pacific islands region and distribute information on the results and applicability.

5.2 Capacity Building

Objective	***Current situation***
To undertake regional actions that will enhance the capacity of regional, national government and non-governmental organisations to oversee wise use of freshwater wetlands of the Pacific islands region, including provision of resources to Pacific island countries to facilitate national actions.	In general, regional and national organisations responsible for conservation of wetlands of the Pacific islands region lack adequate human, infrastructural and financial resources to enable them to be highly effective. In addition, they have focused their attention on coastal (tidal) wetlands and thus have little experience or capacity to deal with freshwater wetlands.

Actions

The following actions described under Section 3, "Regional Actions for Mangroves", also apply to freshwater wetlands of the Pacific islands region:

→3.2.1: Institutions and training

No additional actions are recommended for Freshwater Wetlands.

5.3 Research and Monitoring

Objective	***Current situation***
To conduct regional research and monitoring of freshwater wetlands of the Pacific islands region, which can contribute to the management (wise use) of these wetlands at regional and national levels.	To date, the regional research and monitoring of Pacific wetlands has focused on coastal (tidal) wetlands and little if any work has been done on freshwater wetlands. Regional and national organisations responsible for wetlands conservation could benefit from regionally organised resource inventory and research, and monitoring of threatening processes.

Actions

The following actions described under Section 3, "Regional Actions for Mangroves", also apply to freshwater wetlands of the Pacific islands region.

→3.3.2: Traditional knowledge of wetland species

→3.3.6: Economic values of wetland species

Additional Actions

The following additional actions for freshwater wetlands are recommended.

→ ***5.3.1*** *Map and classify the freshwater wetland estate*

Assist PICs to identify, map and classify their freshwater wetland estate as an aid (baseline data) for conservation planning, by facilitating access to remote sensing information and other appropriate technical resources.

→ ***5.3.2*** *Inventories of flora and fauna*

Conduct regional inventories of the flora and fauna of freshwater wetlands, especially lakes on small isolated islands where endemic species have been recorded or are likely to be discovered, and involving indigenous persons who, where necessary, are assisted (and trained) by regional or external experts.

→ ***5.3.3*** *Populations and threats to freshwater fauna*

Conduct assessments of the populations and threats of freshwater fauna, especially species that are endemic to an island, island group or sub-region within the Pacific islands region.

→ ***5.3.4*** *Ecology of freshwater species*

Encourage and assist regional and national institutions and organisations to conduct basic research on the ecology of freshwater wetland species, especially endemic fauna (e.g. freshwater fishes.

6. Overview of existing wetland and conservation programmes

Ramsar Convention

The Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention) is the global convention that focuses solely on wetlands. Established in 1971, it now has nearly 90 Contracting Parties, 18 of them in Asia-Pacific. Though only one (PNG) of the 18 is a Pacific island country, several other countries in Melanesia and Micronesia have been closely considering the accession process.

The Ramsar Convention brings international attention to sites that member countries designate to the List of Wetlands of International Importance ("Ramsar sites") and funds for enhanced management of these sites may be accessed through the Convention's Wetlands Conservation Fund (WCF: Davis 1994). PNG has received WCF grants for a 1994 regional workshop/and promotion of the Convention in the Pacific islands region. These projects were executed in conjunction with AWB and funds were secured by AWB from Australia to continue Ramsar promotion and support work in the Pacific islands region during 1995-1998. Recently, a package of WCF funds was awarded to five PICs to prepare for Ramsar accession. The Ramsar Convention also was a co-sponsor of the Directory (Scott 1993).

Other Conventions

Other global and regional conventions, notably the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD), are relevant to wetlands though they do not address wetlands in detail.

Global Marine Conservation Programmes

The Intergovernmental Oceanographic Commission (IOC), World Meteorological Organization (WMO), United Nations Environment Programme (UNEP) Global Ocean Observing System (IOC-WMO-UNEP GOOS) is intended to provide a coordinated approach to monitoring of physical, biological and chemical parameters in the ocean. The Coastal Module (IOC, 1990) includes development of a long-term global monitoring system of mangroves and coral reefs with respect to changes expected from climate change (IOC, 1991). Key parameters for measurements have been selected, sites have been suggested, (including within the Pacific islands region), and a manual of techniques is under development. This will involve a more detailed and rigorous analysis of sites that can be expected to show different climate change signals.

There was a UNEP/UNESCO Global Task Team on Climate Change Effects on Mangroves, which produced a literature review (UNEP, 1994), and recommended a research programme (UNEP/UNESCO, 1993) owing to the relative lack of knowledge on climate change effects on mangroves.

Low island sites were particularly recommended owing to their sensitivity to sea-level rise problems, and the Folaha mangrove forest in Tonga has been selected as a possible site, subject to it being protected from clearance.

Pacific islands region programmes of other global organisations

In August 1994, the Asian Wetland Bureau established a regional programme for Oceania with a focus on the Pacific islands region. To date, activities have included Ramsar promotion and technical support, building of linkages with regional and PIC agencies and NGOs, preliminary development of a regional project on mangrove conservation, and support to the PNG wetland conservation programme. From January 1995, AWB became part of Wetlands International (WI), a global alliance with greater resources available to support specific wetland conservation actions in the Pacific islands region.

Other Organisations

Other global and regional organisations have conservation programmes or projects on the Pacific islands region and some of these contain components that include or are relevant to wetlands. Examples include: the World Conservation Union (IUCN) undertook a study of the Fly river basin in PNG; World Wide Fund for Nature (WWF) partnership with local communities in conservation at Marovo Lagoon, Solomon Islands; and SPREP and The Nature Conservancy (TNC) support to the conservation area project at Arnavon Islands in the Solomon Islands.

7. Implementation of the Action Plan

Priority, duration, agencies and resources needed for each action proposed for Mangroves and Freshwater Wetlands are given in Table 2. Categories and other information in the table are indicative rather that prescriptive.

Table 2. Implementation of the Regional Wetlands Action Plan for the Pacific islands

Action	Priority	Duration	Lead Agency	Partners	Personnel	Funding
3 Mangroves						
3.1 Management						
3.1.1 wetland officer **	P	L	SPREP		C	2
3.1.2 resource assessment	P	M	SPREP	National governments, AWB, WWF, IUCN	C+L+E	3
3.1.3 wetland committees **	P	M	national governments	SPREP, AWB	L+E	1
3.1.4 management plans **	P	M	SPREP	National governments, AWB, WWF, TNC	C+L+E	2
3.1.5 implementation	S	M	national governments	SPREP	L	2
3.1.6 review	S	S	national governments	SPREP	L	1
3.1.7 legislation & policy **	P	M	national governments	SPREP	L+E	2
3.1.8 rehabilitation	P-S	M	SPREP	ISME, SPC	C+L+E	2
3.1.9 environmental impact **	P	L	national governments	SPREP	L+E	1
3.1.10 linkage & coordination	S	M	SPREP	Convention secretariats, AWB, IUCN	C	1
3.2 Capacity building						
3.2.1 institutions, training **	S	L	Pacific academic institutions	SPREP External academic institutions	E	2
3.2.2 community education	P	M	SPREP	PIANGO, FSP, UNESCO, local NGOs	C+L+E	2
3.2.3 community involvement	P	L	national governments	SPREP, PIANGO, FSP, local NGOs	L+E	2
3.2.4 interpretive facilities	S	L	national governments	international aid agencies, SPREP	L+E	3
3.2.5 information management	S	L	SPREP	national governments, PIMRIS, WCMC	C+L+E	2
3.3 Research and Monitoring						
3.3.1 regional monitoring	P	L	SPREP	research institutions, international aid agencies	C+L+E	3
3.3.2 traditional knowledge **	P	M	national governments	SPREP	L+E	2
3.3.3 ecological knowledge	S	L	SPREP	research institutions, AWB, WWF	C+L+E	2
3.3.4 endangered species	P	L	SPREP	research institutions, AWB, WWF, IUCN	C+L+E	3
3.3.5 sea-level rise	P	L	SPREP	GOOS	C+L+E	3
3.3.6 economic values **	S	M	SPREP	GEF (incremental costs projects) regional experts	C+L+E	2

Key to codes used

Priority: P=primary (highest); S=secondary.
Duration: S=short-term (<1 year): M=medium-term (1–2 years); L=longer-term (2–5 years).
Lead/partner agency: refer to list of acronyms.
Personnel required: C=coordinator; L=local officers; E=regional or external experts.
Funding required per year (US$ 000s): 1=a few; 2=tens; 3=hundreds.
**=This action is also recommended for freshwater wetlands.

Table 3. Regional Actions for Freshwater Wetlands

Action	Priority	Duration	Lead Agency	Partners	Personnel	Funding
5 Freshwater Wetlands						
5.1 Management						
5.1.1 biodiversity conservation	S	S	SPREP	AWF, WWF	C+L+E	1
5.1.2 introduced flora/fauna	P	S	SPREP	national governments	C+L+E	1
5.1.3 river modification	P	S	SPREP	national governments (water, public works)	C+L+E	1-2
5.1.4 sustainable fishery	S	M	national governments	SPC/FFA, SPREP	L+E	2
5.1.5 lake ecotourism	S	M	national governments	international aid agencies, SPREP	L+E	2
5.3 Research and Monitoring						
5.3.1 map and classify	S	M	national governments	SPREP, AWB		2
5.3.2 introduced flora/fauna	P	M	national governments	SPREP, AWB, WWF, research institutions		2
5.3.3 river modification	P	L	SPREP	AWB, WWF, research institutions		2
5.3.4 sustainable fishery	S	L	SPREP	AWB, WWF, research institutions		2

8. References

Alongi, D. M. and Christoffersen, P., 1992. Benthic infauna and organism-sediment relations in a shallow, tropical coastal area: influence of outwelled mangrove detritus and physical disturbance. *Marine Ecology Progress Series*, 81, 229–245.

Blaber, J.M. and Milton, D.A. 1990. Species composition, community structure and zoogeography of fishes of mangrove estuaries in the Solomon Islands. *Marine Biology* 105:259–267.

CARICOMP, 1992. *Manual of methods for mapping and monitoring of physical and biological parameters in the coastal zone of the Carribean*. University of Florida: Carribean Coastal Marine Productivity Programme.

Cole, G.C. Falanruw, C.F., McLean, C.D., Whitesell, C.D.and Ambacher, A.H. 1987. *Vegetation survey of the Republic of Palau*. U.S. Department of Agriculture, Forest Service Resource Bulletin PSW-22.

Dahl, A.L.1986. *Review of the Protected Areas Systems in Oceania*. Gland: UNEP and IUCN Commission on National Parks and Protected Areas.

Davis, T. 1994. *The Ramsar Convention Manual.* Ramsar Convention Bureau, Gland, Switzerland.

Devoe, N. N.1992. Country Report Mangrove Forests in the Federated States of Micronesia. In *Proceedings Seminar and Workshop on Integrated Research on Mangrove Ecosystems in Pacific Islands Region.* Ed. T. Nakamura, 79–89. Tokyo: Japan International Association for Mangroves.

Eley, T. J. 1988. *Hunters of the reefs: The marine geography of the Kiwai, Papua New Guinea*. PhD dissertation, University of California, Berkeley.

Ellison, J. C. 1991. The Pacific palaeogeography of *Rhizophora mangle* L. (Rhizophoraceae). *Botanical Journal of the Linnaean Society* 105: 271–284.

Ellison, J. C. 1993. Mangrove retreat with rising sea level, Bermuda. *Estuarine Coastal and Shelf Science* 37: 75–87.

Ellison, J. C. 1994. Climate change and sea-level rise impacts on mangrove ecosystems. In J. Pernetta, R. Leemans, D. Elder & S. Humphreys, Eds., *Impacts of Climate Change on Ecosystems and Species: Marine and Coastal Ecosystems*. IUCN, Gland, pp. 11–30.

Ellison, J.C. In press, a. Systematics and taxonomy of Pacific island mangroves. In *Marine and Coastal Biodiversity in Tropical Island Pacific Report: I. Species Systematics and Information Management Priorities*, ed. J. E. Maragos, M.N.A. Petersen, L.G. Eldredge and J.E. Bardach. Honolulu: East-West Center.

Ellison, J.C. In press, b. Present status of Pacific island mangroves. In *Marine/Coastal Biodiversity in the Tropical Island Pacific Region: II. Population, Development and Conservation Priorities*. Eds, L.G. Eldredge, J.E. Maragos and P.L. Holthus, Pacific Science Association/East-West Center, Honolulu.

English, S., Wilkinson, C. and Baker, V. 1994. *Survey manual for tropical marine resources*. Townsville: Australian Institute of Marine Science.

Fifita, N.P., 1992. Tonga Country Report. In *Proceedings Seminar and Workshop on Integrated Research on Mangrove Ecosystems in Pacific Islands Region*. Ed. T. Nakamura, 79–89. Tokyo: Japan International Association for Mangroves.

Hamilton, L.S. and Snedaker, S.C., Eds. 1984. *Handbook for Mangrove Area Management.* IUCN and UNESCO, Honolulu, East-West Center, 123 pp.

Hansell, J.R.F. and Wall, J.R.D. 1976. *Land resources of the Solomon Islands. Volume 1: Introduction and Recommendations*. Land Resources Study 18, Land Resources Division. London Ministry: Ministry of Overseas Development.

Intergovernmental Oceanographic Commission 1990. UNEP-IOC-WMO-IUCN Meeting of Experts on a Long-Term Global Monitoring System of Coastal and Near Shore Phenomena Related to Climate Change. *Intergovernmental Oceanographic Commission Report of Meetings of Experts and Equivalent Bodies 69*.

Jaensch, R.P. (ed.) 1994. *An Action Plan for Wetland Conservation in the South Pacific*. Asian Wetland Bureau, Darwin, Australia. 35 pp.

Lacerda, L. D., et al. 1993. Mangrove Ecosystems of Latin America and the Caribbean: A Summary. In *Conservation and SustainableUtilization of Mangrove Forests in Latin America and African Regions*. Ed. L. D. Lacerda, 1–42. Okinawa: International Tropical Timber Organization and International Society for Mangrove Ecosystems.

Pearsall, S.H and Whistler, W. A. 1991. *Terrestrial ecosystem mapping for Western Samoa*. Report for the Government of Western Samoa. SPREP, Noumea, and East-West Center, Honolulu.

Percival, M. and Womersley, J. S. 1975. *Floristics and ecology of the mangroce vegetation of Papua New Guinea*. Papua New Guinea National Herbarium Botanu Bulletin 8, Lae.

Pillai, G. 1985. Mangrove of Fiji their uses and management. In *Mangrove Ecosystems of Asia and the Pacific*. Eds E. D. Field and A. J. Dartnall, 150–160. Townsville: Australian Institute of Marine Science.

Prescott, F. 1989. *The management of mangrove resources in Tonga*. MSc. Thesis, University of Sydney, Australia.

Raulerson, L. and Rinehart, A. 1991. *Trees and shrubs of the Northern Mariana Islands*. Saipan, Office of the Governor.

Robertson, A. I. and Duke, N. C. 1990. Recruitment, growth and residence time of fishes in a tropical Australian mangrove system. *Estuarine, Coastal and Shelf Science*, 31, 725–745.

Robertson, A. I., et. al. 1988. How much mangrove detritus enters the Great Narrier Reef lagoon? *Proceedings of the Sixth International Coral Reef Symposium*, 2, 601–606.

Saenger, P., Hegerl, E. J. and Davie, J. D. S. 1983. *Global status of mangrove ecosystems*. IUCN Commission on Ecology Papers No. 3, Gland.

Scott, D. A. (ed.) 1993. *A Directory of Wetlands in Oceania* Asian Wetland Bureau, Kuala Lumpur, Malaysia, and International Waterfowl and Wetlands Research Bureau, Slimbridge, UK. 444 pp.

Taylor, F. J. 1979. *Rhizophora* in the Society Islands. *Pacific Science* 33: 173–176.

Thollot, P. 1987. *Importance de la mangrove pour l'ichthifaune du lagon de Novelle-Caledonie*. Diplome d'etude affronfondie en Oceanologie. Centre d'Oceanologie de Marseille. ORSTOM, Noumea, New Caledonia.

UNEP. 1994. *Assessment and Monitoring of Climatic Change and Impacts on Mangrove Ecosystems*. UNEP Regional Seas Reports and Studies No. 154, 62 pp.

UNEP/UNESCO. 1993. Impact of expected climate change on mangroves. *UNESCO Report in Marine Science* 61.

Unua, W. B. O. 1992. Papua New Guinea. In T. Nakamura ed. *Proceedings Seminar and Workshop on Integrated Research on Mangrove Ecosystems in the Pacific Islands Region*. Japan International Association for Mangroves Workshop. 15–17 January 1992. USP, pp. 34–45.

Watling, D. 1985. *A mangrove management plan for Fiji.* Phase 1. Suva: Government Press.

Whistler, W. A. 1976. *Inventory and Mapping of Wetland Vegetation in the Territory of American Samoa*. Report for the US Army Corps of Engineers.

Whistler W. A. 1992. *Flowers of the Pacific Island Seashore*. Hawaii: Isle Botanica.

Yuncker, T. G. 1943. The flora of Niue Island. *Bernice P. Bishop Museum Bulletin* 178: 1–126.