

# AMERICAN SAMOA

## INTRODUCTION

by Richard D. Volk

**Area:** 200.47 sq.km.

**Population:** 47,600 (1990 Census, U.S. Census Bureau).

American Samoa is an unincorporated flag territory of the United States. It lies in the central South Pacific approximately 4,160 km south-southwest of Honolulu and 2,880 km northeast of Auckland. The territory consists of seven principal islands: five inhabited high islands, one inhabited atoll and one uninhabited atoll. Covering an area of 135 sq.km and with a population of over 40,000, Tutuila (14°18'S, 170°41'W) is the governmental and economic centre of American Samoa. This island and the small offshore island of Aunu'u are home for 96% of the population. Most of the remaining 4% reside on the three islands of the Manu'a group, Ta'u (44 sq.km), Ofu (8 sq.km) and Olosega (5 sq.km), situated about 130 km east-southeast of Tutuila.

Tutuila, Aunu'u and the Manu'a group are high volcanic islands of non-continental origin. They rise precipitously from the ocean, and feature narrow coastal strips of relatively flat land and rugged, mountainous interiors. Only 34% of Tutuila's land area has a slope of less than 30%. The other two principal islands are low-lying atolls: Swain's Island (2.1 sq.km), some 360 km north of Tutuila, and Rose Atoll (8 ha), 260 km east of Tutuila. Swain's Island is a raised atoll with a large enclosed lagoon. Until recently, the island was used for the production of copra and supported a population of several hundred workers. However, copra is no longer exported and only about ten inhabitants remain on the island. Rose Atoll is a typical atoll with two tiny islets, Rose Island and Sand Island, a large inner lagoon and extensive fringing reefs. This uninhabited atoll supports a large breeding colony of seabirds and is a nesting area for two species of marine turtles. The entire atoll, an area of 650 ha, was declared a National Wildlife Refuge in 1973, and is managed by the U.S. Fish and Wildlife Service (IUCN, 1991).

American Samoa's climate is warm, humid and tropical, with a mean annual rainfall of 5,080 mm and precipitation occurring on an average of 300 days per year. The rainy season is from November to March; the dry season from June to September. Air temperatures range annually between 21°C and 32°C. Southeast trade winds reach their peak between June and August, and tropical depressions with occasional cyclone development (winds of up to 240 km/hr) occur during the austral summer, usually between December and March.

### Summary of Wetland Situation

American Samoa has both saltwater and freshwater swamps and marshes, as well as cultivated and ruderal wetlands and a number of perennial streams. Much the most important wetlands are the mangrove swamps and coastal freshwater marshes.

Mangroves reach their eastern limit in the Central Pacific on Tutuila and Aunu'u, and are absent from the Manu'a Islands. American Samoa lies within a small triangle in the south-central Pacific where the oriental mangrove, *Bruguiera gymnorrhiza*, and the red mangrove, *Rhizophora mangle*, have intersecting ranges. The local form of the red mangrove, *R. m. samoensis*, is recognized by some authors as a distinct species

(Woodroffe, 1988). Undisturbed mangrove forest is comprised almost entirely of *Bruguiera gymnorrhiza*, while in disturbed mangrove stands or along their sunny margins, *Rhizophora mangle* predominates. Small stands of a third mangrove species, *Xylocarpus moluccensis*, occur in two areas (at Pala Lagoon on Tutuila and at the south end of Aunu'u). Trees typical of the littoral forest are also found along the margins of the mangrove forest, along with clumps of the fern *Acrostichum aureum* which sometimes also occurs in disturbed areas (Cole *et al.*, 1988).

The total area of mangrove on Tutuila and Aunu'u was estimated at 91 ha by Amerson *et al.* (1982) and at 52 ha by Cole *et al.* (1988). Whistler (1976) gives a figure of 127 acres (51.4 ha), and describes five main stands: at Pala Lagoon (34.4 ha), Masefau (6.1 ha), Leone (3.6 ha) and Aoa (1.6 ha) on Tutuila, and in two patches covering 4.5 ha on Aunu'u. Three other tiny patches of mangroves on Tutuila have a combined area of less than 0.5 ha.

Freshwater marshes usually occur along the coast in areas where stream outlets to the sea are blocked by sand barriers. These barriers cause the streams to spread out into low-lying areas, saturating the soils. The dominant plants are *Cyclosorus interruptus*, *Acrostichum aureum* and *Eleocharis dulcis* (Cole *et al.*, 1988). Of all the types of vegetation in American Samoa, coastal freshwater marshes have been the most affected by man. These wet areas, often in close proximity to villages, are ideal for growing taro (*Colocasia esculenta*) and have been extensively cultivated for hundreds of years. Very little undisturbed coastal marsh remains today, and the only site which appears to be relatively undisturbed is the marsh inside Aunu'u Crater (Whistler, 1976). Whistler (1976) describes eight areas of coastal marsh covering a total of 96 acres (38.9 ha): Vatia marsh (2.8 ha) and Alao marsh (1.6 ha) on Tutuila; Faimulivai Marsh (13.8 ha) and Aunu'u village marsh (8.9 ha) on Aunu'u; Luma marsh (7.3 ha) and Fusi marsh (0.8 Ha) on Ta'u; a small marsh on the west coast of Olosega (2.4 ha); and Vaoto marsh (1.6 ha) on Ofu. All of the marshes except Faimulivai Marsh on Aunu'u have been extensively modified by taro cultivation. However, this has been abandoned at the Fusi and Vaoto marshes, and these are now reverting to a more natural condition.

There are many streams on Tutuila, but virtually none on the Manu'a Islands. The wetlands associated with these streams are of very limited extent, being restricted to the margins of the streams and to channels of intermittent streams. The wetland vegetation is dominated by *Brachiaria mutica*, *Coix* sp. and *Canna* sp., as well as many other weedy species found in wetland taro patches. *Barringtonia samoensis*, a medium-sized tree closely related to the dominant coastal forest tree *Barringtonia asiatica*, is commonly found along mountain streams (Whistler, 1976). The riparian (streamside) vegetation of American Samoa is briefly summarized in the American Samoa Stream Inventory (U.S. Army Corps of Engineers, 1981).

Approximately 100 species of vascular plants have been reported from the wetlands of American Samoa. Four of these are considered to be rare in the territory. The tree *Erythrina fusca*, the mangrove *Xylocarpus moluccensis* and the sedge *Cyperus odoratus* are each known from only two sites, while the herb *Limnophila fragrans* is known from only three sites. Although all four species are common elsewhere in the Pacific, they should be considered as endangered species in this American territory (Whistler, 1976).

Surveys of wetland fauna have recorded at least 78 species of fish and invertebrates, one amphibian (the introduced toad *Bufo marinus*), five species of reptiles, 16 species of birds and three species of mammals. The birds include Pacific Reef Heron (*Egretta sacra*), Pacific Black Duck (*Anas superciliosa*), Banded Rail (*Rallus philippensis*), Spotless Crake (*Porzana tabuensis*), Purple Swampphen (*Porphyrio porphyrio*) and seven species of migratory shorebirds, although only four of the latter, the Pacific Golden

Plover (*Pluvialis fulva*), Wandering Tattler (*Heteroscelus incanus*), Bristle-thighed Curlew (*Numenius tahitiensis*) and Ruddy Turnstone (*Arenaria interpres*) are regular.

Most wetland degradation today occurs as a result of increased pressure to convert wetland to dry land for residential or commercial purposes. Suitably flat, developable land on Tutuila is scarce, and the wetlands are often seen as "wasteland", easily converted for private use. This situation is exacerbated by the current annual rate of population increase of 3.7%.

Past wetland degradation occurred on a larger scale earlier this century through government efforts to fill in portions of the reef and mangrove swamps in Pago Pago Harbour to create land for government and U.S. naval operations. Mangroves once existed along various stretches of the harbour where today there are none. Some 10 ha of mangroves were removed and filled to create Pago Pago Park in the inner harbour in the 1960s.

The largest remaining, and most threatened, wetland in American Samoa is the mangrove forest at Nu'uuli Pala Lagoon in south-central Tutuila. This coastal mangrove swamp covers an area of 49.7 ha, and borders an important shallow lagoon extensively used for fishing and recreation. Thirty-three percent of the mangrove swamp has been converted to dry land since 1961. The lagoon's natural circulation patterns were permanently altered in the early 1960s with the construction of American Samoa's international airport. Water quality in the lagoon is of concern and the focus of an on-going toxicity study.

Taro cultivation on a commercial scale occurs in freshwater marshes on Aunu'u and Masefau on Tutuila. Production and marketing data are not available. Other commercial economic uses of wetlands, including aquaculture, are virtually non-existent, due at least in part to the limited productivity and harvest potential of the few remaining wetlands.

The American Samoa Government is working as of late 1991 to complete and implement a wetlands management plan for Tutuila and Aunu'u. Effective wetland management is faced with the general notion that wetlands are communal or private property under no regulatory control of the Government. The Submerged and Tidal Lands Act of 1974 (P.L. 93-435), however, declares that title to submerged and tidal lands in American Samoa, including "artificially made, filled in, or reclaimed lands which were formerly permanently or periodically covered by tidal waters", was conveyed to the American Samoa Government from the U.S. Government in 1974. The issue of ownership thus remains contentious, especially in the case of freshwater wetlands not influenced by tidal waters. Consequently, the American Samoa Government is exploring options for a combined regulatory and non-regulatory management programme, with full participation in the planning and implementation process by the relevant village councils.

## **Wetland Research**

Wetlands-specific research in American Samoa has been limited. Wetland vegetation (Whistler, 1976) and the fauna, flora and human uses specific to the Nu'uuli Pala (Yamasaki *et al.*, 1985) have been studied in some detail. An account of wildlife and wildlife habitat (Amerson *et al.*, 1982a, 1982b), an account of the bird fauna (Engbring & Ramsey, 1989) and a report on terrestrial vegetation (Cole *et al.*, 1988) also provide important information on wetlands. The American Samoa Stream Inventory (U.S. Army Corps of Engineers, 1981) provides information on the stream macrofauna and riparian (streamside) vegetation, while an unpublished report on non-marine aquatic resources of American Samoa (Burger and Maciolek, 1981) gives some descriptive physical data for each of the streams in the territory. The Reconnaissance Report for the Territories Development Study for American Samoa (U.S. Army Corps of Engineers, 1990) provides a

brief summary of the information available on stream and wetland resources. The wetlands management plan for Tutuila and Aunu'u prepared by Biosystems Analysis, Inc. (1991) represents the most complete synthesis to date of the wetland information available for American Samoa.

The wetlands of Tutuila and Aunu'u were delineated and mapped in 1991, and total wetland areal gains/losses calculated (Table 1). The total wetland area remaining on Tutuila in 1991 was 141.8 ha. Over a 30 year period, 1961-1991, the net loss of wetland area on Tutuila was calculated to be 23%, or a loss of 55.4 ha. This equates to an average annual rate of loss of 1.9 ha. On Aunu'u, the total remaining wetland area in 1991 was 45.2 ha, with no appreciable losses occurring since 1961. It is important to note that the calculated areas given here include certain portions of tributary stream beds, and thus may differ significantly from earlier data. Details on methodology and the current status of wetlands are available at the American Samoa Coastal Management Program in the Economic Development Planning Office in Pago Pago.

Other efforts either on-going or planned include: (1) a fish and invertebrate survey and a subsistence use survey of the Nu'uuli Pala by the Department of Marine and Wildlife Resources; (2) toxicity testing of the Nu'uuli Pala sediments and waters by the American Samoa Environmental Protection Agency; and (3) additional field surveys and wetland delineations in the Manu'a Group by the American Samoa Coastal Management Program.

### **Wetland Area Legislation**

Two principal statutes govern the protection, management and enhancement of wetlands in the Territory. These are the Coastal Management Act (ASCA 24.05), administered by the Economic Development Planning Office/American Samoa Coastal Management Program (EDPO/ASCMP), and the Environmental Quality Act (ASCA 24.02), administered by the American Samoa Environmental Protection Agency/Environmental Quality Commission. The latter Act includes the territorial Water Quality Standards. The Project Notification and Review System (PNRS), administered by EDPO/ASCMP, operates as a consolidated permitting system, and provides for interagency review of all proposed "major" developments, including those involving potential wetland impacts.

Presently lacking from territorial legislation is a specific wetland definition or delineation criteria. Thus, as alluded to earlier, regulatory control of freshwater wetlands that occur inland from tidal influence is subject to dispute. Elsewhere, the mean high waterline is commonly seen to be the "natural" delineation boundary for wetlands. Efforts to implement the wetlands management plan will include seeking a legal refinement on such issues, as well as a "no net loss" territorial policy.

At the U.S. federal level, the U.S. Army Corps of Engineers has regulatory authority over all waters of the United States, including wetlands, through Section 404 of the Clean Water Act. Applications for a 404 permit are relayed to the U.S. Fish and Wildlife Service and the U.S. Environmental Protection Agency (USEPA) for comment before issuance. The USEPA has veto authority over issuance of 404 permits. In practice, although these agencies have regulatory jurisdiction over American Samoa's wetlands, enforcement of wetlands violations to-date has been left entirely with the American Samoan Government.

### **Wetland Area Administration**

The wetlands of Nu'uuli Pala (49.7 ha) and Leone Pala (8.4 ha) have been designated as Special Management Areas under the Coastal Management Act of 1990, in recognition of their significance to fish and wildlife habitat, recreational value and/or general importance to the community. The EDPO/ASCMP is responsible for developing

management plans specific to these two wetlands and any others that may be recommended for similar designation by the Governor. The Coastal Management Program is currently working to produce a guide to the wetlands of American Samoa.

Two candidate Special Management Areas presently under consideration include the freshwater Faimulivai Marsh (14.9 ha) in the crater lake on Aunu'u, and a pristine freshwater swamp (29.1 ha) at Malaeloa on Tutuila. Dominant vegetation within the Malaeloa swamp includes the langasat tree *Barringtonia samoensis*, the Tahitian chestnut *Inocarpus fagifer* and the beach hibiscus *Hibiscus tiliaceus*. A survey in 1991 discovered the occurrence of bucago *Elythrina fusca*, which had previously been collected only once on Tutuila in 1929.

The Department of Parks and Recreation has the legislative mandate to inventory government lands, including wetlands, and to make recommendations to the Governor for the creation of nature reserves (among other categories of parks). To date, this authority has not been exercised, although implementation of the wetlands management plan will attempt to utilize this legal authority to protect the most critical wetland areas.

### **Organizations involved with Wetlands**

The American Samoa Coastal Management Program, administered by the Economic Development Planning Office, is the primary governmental focal point for wetland management planning and implementation. Responsibilities for project review and enforcement are shared with the American Samoa Environmental Protection Agency. In addition, the Environmental Quality Commission and the Natural Resources Commission are governor-appointed entities responsible for providing direction and oversight for the maintenance of water quality and preservation of critical habitat and ecosystems. The Department of Marine and Wildlife Resources administers a fisheries research programme with special focus thus far on the Nu'uuli Pala.

The local environmental NGO, Le Vaomatua, works to enhance public awareness on environmental issues, and has been a strong advocate for increased management of the Territory's few remaining wetlands.

## **WETLANDS**

Site descriptions compiled from material provided by Carol A. Tanielu of the Economic Development Planning Office, American Samoa Government, and the literature.

**Wetland Name:** Leone Bay

**Country:** American Samoa

**Coordinates:** 170°47'W, 14°21'5

**Location:** on the southwest coast of Tutuila, 12 km southwest of Pago Pago.

**Area:** The total area of wetland was estimated at 16.2 ha in 1961, but this had been reduced to 8.4 ha by 1991. Whistler (1976) gives the area of mangrove forest as approximately 9 acres (3.6 ha).

**Altitude:** Sea level.

**Overview:** A shallow sea bay with extensive intertidal mudflats, the estuaries of two streams and an important area of mangrove forest and salt marsh.

**Physical features:** Leone Bay (Leone Pala) consists of a shallow bay separated from the ocean by a fringing reef with a generally northwest-southwest orientation. The bay is delineated by Logologo Point to the southeast and Apolima Point to the northwest. Islands in the Bay include: Nivaveve Rock, a small island with a single coconut tree; a rubble island near the centre of the fringing reef; and Papaloa Rock, a row of sandstone islets

forming a partial barrier across the northeastern shore. Two streams discharge into the bay: the Leafu and the Fuafua. The Leafu Stream is 9.9 km in length and has a catchment area of 320 ha. The upper reaches of Leafu catchment are covered in undisturbed forest; the lower estuarine reaches support mangrove forest (3.6 ha) with an adjoining salt marsh.

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The Fuafua stream is 12.8 km in length, and has a catchment area of 400 ha, most of which is now highly disturbed.

No tidal data are available, but tides in Leone Bay are apparently close in timing and range to those at Apia, Western Samoa. The tide in Apia is mixed semi-diurnal with a spring range of 1.1 metres and a neap range of 0.4 metres. Water circulation in the bay is driven predominantly by waves breaking over the reef flat (particularly to the north), by the tides and by freshwater flow from Leafu Stream. Circulation from the fringing reef is sluggish, flowing generally to the northwest parallel to the reef. The bay inside of the fringing reef has a maximum depth of about one metre at mean lower low water (MLLW). The reef crest is shallow (10-30 cm deep at the northern and southern ends) except for a channel about 1-2 metres deep just south of the rubble island which carries the flow of water exiting the lagoon.

The climate is warm and humid with an average temperature of 26°C and an average humidity of 80%. The mean annual rainfall is 3,200 mm at Pago Pago airport, with the heaviest rains from November to March. Trade winds blow generally from the southeast from May to November, and are variable for the rest of the year. The hurricane season is during the austral winter, with tropical storms sufficient to cause damage occurring about every 3-5 years. Leone Bay is somewhat protected from the trade winds by the hills to the east and by Logologo Point.

**Ecological features:** The mangrove forest is dominated by *Bruguiera gymnorrhiza*, with a considerable amount of *Rhizophora mangle* mixed in. The forest is dense and mostly less than 5 m in height. Behind the mangrove swamp, there is a small salt marsh consisting of two patches of the marsh grass *Paspalum vaginatum* with some candlebush (*Cassia alata*) and a stand of *Hibiscus tiliaceus* trees. The extensive intertidal mudflats in the bay are largely devoid of macrophytes.

**Land tenure:** Most land surrounding Leone Bay is communal land. Communal land is land set aside for an extended family (Aiga) and governed by a Matai (High Chief). Conservation measures taken: The U.S. Fish and Wildlife Service, in accordance with its Mitigation Policy, has designated the mangrove swamps at the mouth of Leafu Stream as "Resource Category 1", meaning that there should be no loss of existing habitat values. Conservation of Leone Bay was identified as a national priority in the SPREP/IUCN Action Strategy for Nature Conservation in the South Pacific (SPREP/IUCN, 1989). The wetland area (8.4 ha) was designated as a Special Management Area under the Coastal Management Act of 1990 in recognition of its significance to fish and wildlife habitat, recreational value and general importance to the community. The Coastal Management Program in the Economic Development Planning Office is responsible for developing a management plan for the site.

**Land use:** Subsistence fishing in the bay. The mangrove forest is utilized as a source of firewood. As of the 1980 census, Leone village was the fourth largest village in American Samoa and the largest in Western District.

**Possible changes in land use:** A commercial boat harbour facility was proposed for Leone Bay by the previous administration. A comprehensive feasibility study was conducted by Energy Resources International, Inc. (1989) outlining the positive and negative impacts of the proposed project. The project was shelved during the transition to

the new administration and has not been resurrected.

**Disturbances and threats:** The mangrove forest is slowly losing ground to encroaching settlement. The dumping of litter, illegal landfill and pollution from pig farming are major problems in the area. Problems with groundwater quality have resulted both from infiltration of polluted surface water and from the encroachment of saline water. A recent study of groundwater in the Leone area revealed that during and after heavy rainfall, several well fields exhibited unacceptably high turbidity and total and faecal coliform levels. All active wells in this area have had at least one water sample exceeding the maximum contaminant standards for turbidity and/or coliform levels, and several well-fields have exceeded these standards consistently during rainy periods. Leone village is experiencing pressure as residents seek to expand into inland areas which have traditionally been reserved for agricultural uses. New development, which would potentially draw new businesses and residents to the village, would increase the pressures on environmentally sensitive areas including the reef communities and the wetlands.

**Hydrological and biophysical values:** No information.

**Social and cultural values:** Water supply, fishing, agriculture and light tourism. Leone village is rich in archaeological and cultural properties.

**Noteworthy fauna:** The wetlands support a variety of both native and migratory waterbirds. Resident species include the Pacific Reef Heron (*Egretta sacra*), Banded Rail (*Rallus philippensis*) and Collared Kingfisher (*Halcyon chloris*); migratory species include the Pacific Golden Plover (*Pluvialis fulva*), Ruddy Turnstone (*Arenaria interpres*), Bristlethighed Curlew (*Numenius tahitiensis*), Bar-tailed Godwit (*Limosa lapponica*), Wandering Tattler (*Heteroscelus incanus*) and Sanderling (*Calidris alba*). Five species of geckoes and seven species of skinks are found in the area, along with one introduced amphibian, the Marine Toad (*Bulb marinus*). Mammals include the Polynesian Rat (*Rattus exulans*), House Mouse (*Mus musculus*) and feral pig (*Sus scrofa*). Mudflats throughout the bay support a dense population of fiddler crabs (*Uca* sp.), while the estuarine sandflats are habitat for a dense population of *Calianassa* mud shrimps. Mangrove crabs (*Scylla serrata*) and freshwater prawns (*Macrobrachium* sp.) are also present.

**Noteworthy flora:** The mangrove swamp is one of the few important mangrove forests remaining on Tutuila. It is believed that the first specimen of the shrub *Erythrina fusca* from American Samoa (collected in 1929) came from the marsh behind the mangroves. Scientific research and facilities: A report prepared for the Environmental Quality Commission of the territory by Energy Resources International, Inc. (1989) explored many of the current concerns surrounding Leone Bay, as well as the positive and negative impacts of a proposed commercial boat harbour.

**Recreation and tourism:** Tourism occurs on only a small scale, although there are several historical sights in Leone Bay of interest to tourists. The proposed boat harbour would provide more recreational and tourist attractions but at great sacrifice to the natural environment.

**Management authority and jurisdiction:** American Samoa Coastal Management Program and Environmental Protection Agency.

**References:** Amerson *et al* (1982a, 1982b); Energy Resources International, Inc. (1989); Kennedy, Jenks & Chilton (1987); Noda & Associates (1987); SPREP/IUCN (1989); U.S. Army Corps of Engineers (1981); Whistler (1976).

**Reasons for inclusion:** 1a, 2b, 2c. One of the most important mangrove swamps in American Samoa, with a rich and diverse flora and fauna and noteworthy socio-economic and cultural values.

**Source:** Carol A. Tanielu.

**Wetland Name:** Pala Lagoon (Nu'uuli Pala)

**Wetland ID:** 2

**Country:** American Samoa

**Coordinates:** 170°42'W, 14°19'S

**Location:** on the south coast of Tutuila, 5 km south-southwest of Pago Pago.

**Area:** Bay area 300 ha. The total area of wetland was estimated at 74.7 ha in 1961, but

this had been reduced to 49.7 ha by 1991.

**Altitude:** Sea level.

**Overview:** A shallow sea bay with extensive fringing mangrove swamps and rocky wooded promontories. The lagoon is an important nursery and spawning ground for fish and invertebrates.

**Physical features:** Pala Lagoon is a shallow sea bay with a relatively narrow exit to the open sea. Estuarine conditions are created by the influx of fresh water from two principal streams, the Vaitele and the Papa, and seven springs near the western and northern shores. The lagoon is roughly circular in shape. Approximately two thirds of the inner lagoon area is very flat and shallow, with a depth ranging from 0.3 to 1.5 metres depending upon tide. The bottom is muddy, coral sand to silty mud, and the overlying water is usually turbid. The mean residence time for water in the lagoon is about 30 hours. The mean total volume of the lagoon is about two million cubic metres; a volume equal to about forty percent of this is exchanged during a semidiurnal tidal cycle. There are approximately 49.7 ha of mangrove forest which extends in a broad fringe around much of the lagoon. The largest stands are found along the north and east shores and at Coconut Point, north of the entrance to the lagoon.

**Ecological features:** The algal flora is dominated by the red algae *Acanthophora spicifera*, which covers much of the muddy and sandy bottom of the lagoon. Other algae include the green algae *Caulerpa* sp. and the brown algae *Dictyota* sp. and *Padina* sp. The calcareous green algae *Halimeda* sp. and the sea grass *Halophila minor* occur on the sandflats bordering Coconut Point. Small springs along the rocky western shore of the lagoon support dense mats of the filamentous algae *Enteromorpha* sp. (Yamasaki *et al.*, 1985). Most of the mangrove vegetation consists of well-developed stands of large *Bruguiera gymnorrhiza* trees forming a continuous canopy 8-16 m high. Ground cover is absent except for *Bruguiera* seedlings. *Rhizophora mangle* occurs in small stands along the seaward margin of the *Bruguiera* forest, and also as a band of vegetation along the western edge of Nu'uuli peninsula between the village and the lagoon. This is the only large stand of red mangrove in American Samoa. A few "puzzlenut" trees (*Xylocarpus moluccensis*) have been found growing along the seaward margin of the swamp at Coconut Point and on the rocky western shore of the lagoon (Whistler, 1976). Yamasaki *et al.* (1985) failed to find any *Xylocarpus* on the western shore, and suspected that the trees had been cut during one or more of the landfill projects in the early 1980s. The uncommon shrub *Sophora tomentosa* occurs at Coconut Point (Yamasaki *et al.*, 1985). Land tenure: Areas surrounding the lagoon are generally communally owned land, L e. land set aside for an extended family and governed by a Matai/high chief.

**Conservation measures taken:** Various authors have recommended that Pala Lagoon be afforded protected status, e.g. Dahl (1980), UNEP/IUCN (1988) and Engbring and Ramsey (1989). Conservation of Nu'uuli Pala Lagoon was identified as a national priority in the SPREP/IUCN Action Strategy for Nature Conservation in the South Pacific (SPREP/IUCN, 1989). Pala Lagoon has subsequently been declared a Special Management Area under the Coastal Management Act of 1990, in recognition of its significance to fish and wildlife habitat, recreational value and general importance to the community. The Coastal Management Program in the Economic Development Planning Office is responsible for developing a management plan for the area. The following activities are prohibited in the Special Management Area: dumping or discharge of solid or industrial waste materials; construction of animal pens over or adjacent to the shoreline; dredging and filling activities, except when in compliance with applicable permits and water quality standards; discharge of hazardous and radio-active waste; and discharge of oil sludge, oil refuse, fuel oil or bilge water from any vessel or shoreside facility. The support and propagation of marine resources and mariculture development are encouraged. A public sewerage system has been connected to surrounding areas, thereby eliminating pollution by raw sewage.

The Nu'uuli village council is apparently becoming more aware of the need to protect the lagoon, and has been very cooperative regarding land use regulations.

**Conservation measures proposed:** Yamasaki *et al.* (1985) have provided a series of recommendations for the management of the mangrove and lagoon areas of Pala Lagoon.

**Land use:** Subsistence fishing and the harvesting of crabs are permitted in the bay. The large mangrove crab *Scylla serrata* is a favourite local food item, and is trapped with nets and wire-mesh traps. Some mangrove is cut for firewood. The village of Nu'uuli, which borders on the lagoon, is a residential and business area.

**Disturbances and threats:** In recent years, there has been some use of dynamite and poisons for fishing, but this is now prohibited. The northern edge of the wetland is slowly being encroached upon by landfills from Nu'uuli village. Mangroves have been cut and filled to provide land for home sites. At several sites, rubbish has been used as the initial fill material, over which layers of cinders have been packed (Yamasaki *et al.*, 1985). Landfill violations are now subject to litigation, and two such cases are pending. The dumping of rubbish continues to be a problem, especially in one area, where the illegal dumping of solid waste, including old automobiles, creates pollution of the surrounding water. In 1971, a study on the expected impact of a dredging project in the lagoon revealed that coliform and faecal coliform counts were 6,000 per 100 ml and 57 per 100 ml, respectively. Bacterial contamination appeared to be the cause of an outbreak of hepatitis in people eating clams from the lagoon. Following the installation of the public sewerage system, microbial contamination has decreased.

**Hydrological and biophysical values:** The mangroves are valuable for land-building, protection against erosion and storm damage, and as breeding and nursery grounds for many species of offshore and coastal fish and invertebrates.

**Social and cultural values:** Subsistence fishing is still the major social function of the lagoon. The high levels of pollution are a deterrent to swimming and other recreational activities.

**Noteworthy fauna:** The lagoon supports an abundance of fish and invertebrates. Yamasaki *et al.* (1985) found a surprisingly high diversity of fish species in the inner lagoon and a great abundance of mullet (Mugilidae). These authors also found an abundance of small predatory fish, notably juvenile *Sphyraena barracuda* and *Caranx ignobilis*. Common invertebrates include the scyphozoan *Cassiopeia* sp., the holothurians *Stichopus* sp. and *Actinopyga* sp., the gastropods *Littorina* sp. and *Nerita plicata*, the mangrove oyster *Isogamon* sp., the edible clam *Gafrarium tumidum*, mantis shrimps *Lysiosquilla* sp., fiddler crabs *Uca* sp., land crabs *Cardisoma* sp., and the mangrove crab *Scylla serrata* (Yamasaki *et al.*, 1985). Due to the low salinity and high turbidity of the lagoon water, corals are virtually non-existent within the lagoon, although there is some live coral in and around the entrance channel. Marine turtles are occasionally reported in the lagoon, probably Hawksbill (*Eretmochelys imbricata*).

The wetlands formerly provided habitat for the Pacific Black Duck (*Anas superciliosa*), which still occurred in the area as recently as 1975 (Amerson *et al.*, 1982), but this species is now probably extinct in American Samoa. The tidal mudflats are of considerable importance for migratory shorebirds, mainly Pacific Golden Plover *Pluvialis fulva*, Wandering Tattler *Heteroscelus incanus* and Ruddy Turnstone *Arenaria interpres* (Engbring & Ramsey, 1989). The Bar-tailed Godwit (*Limosa lapponica*) has also been recorded. Birds occurring in the mangrove forest include Banded Rail (*Rallus philippensis*), Collared Kingfisher (*Halcyon chloris*), Wattled Honeyeater (*Foulehaio carunculata*) and Cardinal Honeyeater (*Myzomela cardinalis*) (Amerson *et al.*, 1982). The Sheath-tailed Bat (*Emballonura semicaudata*) forages in the mangroves.

**Noteworthy flora:** Pala Lagoon contains by far the largest stands of mangrove forest in American Samoa, as well as the only large stand of red mangrove (*Rhizophora mangle*) and one of only two stands of the puzzlenut tree (*Xylocarpus moluccensis*), a potentially threatened species in American Samoa.

**Scientific research and facilities:** Various general floral and faunal surveys have been carried out, and Yamasaki, Itano and Davis (1985) conducted a detailed study of the mangrove and lagoon areas. There are no research facilities at the present time.

**Conservation education:** Various public awareness programmes have been undertaken in conjunction with the American Samoa Coastal Management Program, the Department of Education, Marine and Wildlife Resources and the Environmental Protection Agency. These public awareness activities have focused on the preservation and restoration of the lagoon, and have been met with mixed reactions from local residents.

**Recreation and tourism:** There is very little recreation or tourism in the area at present. A small boat harbour was proposed, but the idea was shelved as it would have meant the destruction of much of the "naturalness" of the bay.

**Management authority and jurisdiction:** The American Samoa Coastal Management Program, under the aegis of the Economic Development Planning Office. References: Amerson *et al* (1982); Dahl (1980); Engbring & Ramsey (1989); Helfrich (1975); Preston (1988); Shleser & May (1977); SPREP/IUCN (1989); Takata (1986); UNEP/IUCN (1988); U.S. Army Corps of Engineers (1980, 1986); U.S. Department of Commerce (1980); Whistler (1976); Yamasaki *et al.* (1985).

**Reasons for inclusion:** 1a, 2b, 2c. The site contains the largest stands of mangroves in American Samoa, and supports a rich and diverse estuarine flora and fauna. Source: Carol A. Tanielu.

**Wetland Name:** Wetlands of Aunu'u

**Country:** American Samoa

**Coordinates:** 14°17'30"S, 170°33'E

**Location:** on the island of Aunu'u, 1.6 km off the southeastern tip of Tutuila.

**Area:** 45 ha.

**Altitude:** Sea level to 6 m.

**Overview:** A freshwater marsh in a dormant volcanic crater; a unique "mud" lake with fringing mangrove forest; a large area of taro fields in a former freshwater marsh; and a small area of mixed mangrove forest. These wetlands include the largest and least disturbed freshwater marsh in American Samoa and one of only two stands of the "puzzlenut" tree *Xylocarpus moluccensis*.

**Physical features:** Aunu'u Island is a small volcanic island (2.6 sq.km) with a 61 metre cone. There are four significant wetlands on the island: a large freshwater marsh (Faimulivai Marsh) in Aunu'u Crater; an area of taro fields in a former marsh near Aunu'u village; a mud lake (Pala Lake) with fringing mangroves near the north end of the island; and a small patch of mixed mangrove forest on poor rocky soils on the south coast of the island. With an area of 14.9 ha, Faimulivai Marsh is the largest freshwater wetland in American Samoa. The wetland is about six metres above sea level, and consists of several open-water ponds surrounded by extensive marshes. It is drained by a stream that flows out of the eastern end of the crater. Faimulivai Marsh is somewhat anomalous in that it was formed not by sedimentation in a lagoon but from poor drainage in a low-lying crater. The Aunu'u taro fields, covering about 11.0 ha, are situated in a large depression between the western slope of the crater and the village of Aunu'u. This area was formerly an extensive coastal marsh, but little of the original marsh vegetation remains. Pala Lake is an area of "quicksand" inland from the north coast of the island. It is slightly above sea level, and consists of reddish-brown mud covering an area of about 1.2 ha. The mud is totally devoid of vegetation, and is completely surrounded by a narrow strip of tall mangrove trees. The mangrove forest extends in a northwesterly direction, and becomes mixed with trees of the coastal and lowland forests. The whole wetland covers an area of about 18.1 ha.

**Ecological features:** Faimulivai Marsh has two main zones of vegetation. The western half is composed almost entirely of two species, *Eleocharis dulcis* and *Cyclosorus interruptus*, which form a dense vegetation 1.0-1.5 m high. On the eastern side and around the margins of the central pond, the vegetation is dominated by large clumps of *Acrostichum aureum* up to 3 m in height. Along the edges of the marsh, there is a dense thicket of *Hibiscus tiliaceus* trees which

separates the marsh from the coconut groves and secondary forest on the inside slopes of the crater. *Ludwigia octovalvis* and *Rhynchospora corymbosa* appear in disturbed portions of the marsh. The marshy depression near Aunu'u village is largely under cultivation for taro (*Colocasia esculenta*). Some *Acrostichum*, *Cyclosorus*, *Eleocharis*, *Rhynchospora* and *Ludwigia* persist, along with a number of weeds that have invaded the area, such as *Canna indica*, *Alternanthera sessilis*, *Paspalum conjugatum*, *Mikania micrantha* and *Commelina diffusa*. The fringe of mangrove around Pala Lake consists of tall *Bruguiera gymnorrhiza* trees (up to 15 m high) with small *Rhizophora mangle* trees around the edge. The mixed mangrove forest on the south coast consists of *B. gymnorrhiza* mixed with a few *Xylocarpus moluccensis* trees and several species of the littoral forest. The surrounding open forests contain typical littoral species such as *Hernandia sonora*, *Pisonia grandis* and *Barringtonia asiatica*, as well as a coastal ridge species, *Planchonella costata*.

**Land tenure:** No information.

**Conservation measures taken:** Part of Aunu'u Island (123 ha), including Faimulivai Marsh, was designated a National Natural Landmark in 1972 (Amerson *et al.*, 1982; IUCN, 1991).

**Conservation measures proposed:** Whistler (1976) considered the marsh inside Aunu'u Crater to be a unique type of wetland vegetation, and recommended that any proposal for nature reserves in American Samoa should give this site priority. He also identified the mud lake as a unique type of wetland worthy of special protection. Dahl (1980), Amerson *et al.* (1982) and Engbring and Ramsey (1989) recommended the establishment of a reserve at Faimulivai Marsh, and the conservation of this wetland was identified as a national priority in the SPREP/IUCN Action Strategy for Nature Conservation in the South Pacific (SPREP/IUCN, 1989). Faimulivai Marsh (14.9 ha) is currently being considered for designation as a Special Management Area under the Coastal Management Act of 1990.

**Land use:** There is one small village on the island. The marshy depression near Aunu'u village is intensively cultivated for taro. These taro patches are probably the best in Samoa, with extensive canals and a paved walkway crossing the area (Whistler, 1976). Disturbances and threats: The mixed mangrove forest on the south coast of the island has been degraded by severe cutting for firewood by local villagers. The disappearance of the Pacific Black Duck has been attributed to hunting, rat predation and human disturbance in the marshes (Amerson *et al.*, 1982). Purple Swamphens are both hunted for food and killed as pests on crops.

**Hydrological and biophysical values:** No information.

**Social and cultural values:** No information.

**Noteworthy fauna:** The Pacific Black Duck (*Antis superciliosa*) formerly occurred as a breeding species in the wetlands. Seven were observed in Faimulivai Marsh in November 1976 (Amerson *et al.*, 1982), but there do not appear to have been any records on the island since about 1980, and the species may now be extinct as a breeding bird in American Samoa (Engbring & Ramsey, 1989). The Purple Swamphen (*Porphyrio porphyrio*) remains fairly common despite some persecution. Engbring and Ramsey (1989) observed seven at one time in Faimulivai Marsh in 1985. These birds belong to the subspecies *P. p. samoensis*, endemic to the high islands of American Samoa and Western Samoa. Other waterfowl recorded on Aunu'u include Pacific Reef Heron (*Egretta sacra*), Banded Rail (*Rallus philippensis*) and three species of migratory shorebirds: Pacific Golden Plover (*Pluvialis fulva*), Wandering Tattler (*Heteroscelus incanus*) and Ruddy Turnstone (*Arenaria interpres*) (Amerson *et al.*, 1982; Engbring & Ramsey, 1989). Collared Kingfishers (*Halcyon chloris*) and Wattled Honeyeaters (*Foulehaio carunculata*) frequently forage in the mangrove areas.

The Polynesian Rat (*Rattus exulans*) and Brown Rat (*R. rattus*) are common on the island and both occur in the freshwater marshes. Other mammals include the flying fox *Pteropus samoensis* and the Sheath-tailed Bat (*Emballonura semicaudata*), the latter frequently foraging in the mangroves.

The Marine Toad (*Bufo marinus*) was introduced in 1953 by the U.S. Department of Agriculture as a general control on insect pests, and is now common in the wetlands

(Amerson *et al.*, 1982).

**Noteworthy flora:** Faimulivai Marsh is the only site in American Samoa with an intact *Eleocharis dulcis* marsh community. The mangroves of Aunu'u are at the extreme eastern limit of natural mangrove distribution in the Central Pacific. The *Xylocarpus moluccensis* trees at the south end of the island comprise one of only two stands of this rare species in American Samoa.

**Scientific research and facilities:** The wetland flora has been surveyed by Whistler (1976) and Cole *et al.* (1988). The wildlife has been investigated by Amerson *et al.* (1982), and detailed surveys of the bird fauna have been conducted by Engbring and Ramsey (1989).

**Management authority and jurisdiction:** No information.

**References:** Amerson *et al.* (1982); Cole *et al.* (1988); Dahl (1980); Engbring & Ramsey (1989); IUCN (1991); SPREP/IUCN (1989); Whistler (1976).

**Reasons for inclusion:** la, ld, 2b. Faimulivai Marsh is the largest area of freshwater marsh in American Samoa, and the only one which remains in a relatively undisturbed condition. Pala "Mud" Lake is a unique type of wetland. The mangroves are of interest as the easternmost stands in the Central Pacific.

**Source:** See references.

**Wetland Name:** Lake Namo

**Country:** American Samoa

**Coordinates:** 11°03'S, 171°05'E

**Location:** in the centre of Swain's Island, 360 km NNW of Tutuila. Area: Approximately 100 ha.

**Altitude:** Sea level.

**Overview:** A enclosed brackish lagoon with a small area of salt marsh in the centre of a raised coral atoll.

**Physical features:** Swain's Island is a raised, ring-shaped atoll with a total area of 326.34 ha, a maximum elevation of 9.1 m and a shoreline of 6.2 km. Geographically and floristically, the island is closely related to the Tokelau Islands, 160 km to the northwest. The entire central portion of the island is occupied by a large brackish lagoon, Lake Namo, which has apparently been isolated from the sea only in recent times. The lagoon is approximately 1.5 km long and 1.0 km wide. There is a small patch of marsh on the north side of the lagoon. The annual rainfall is about 2,500 mm.

**Ecological features:** The salt marsh on the north side of the lagoon is dominated by *Paspalum distichum* and *Eleocharis geniculata*. Swain's Island was originally covered with littoral forest dominated by species of *Pisonia*, *Hernandia*, *Pandanus*, *Neisosperma*, *Calophyllum* and possibly *Barringtonia* and *Cordia*. This original vegetation was almost totally removed and replaced with coconut plantations for the production of copra. Most of the plantations have recently been abandoned, and the coconut trees are slowly being replaced by littoral forest, chiefly *Hernandia* and *Pandanus* (Amerson *et al.*, 1982). *Scaevola* is the dominant plant in the littoral scrub vegetation.

**Land tenure:** The customary owners of Swain's Island were the Tokelauans of Fakaofu. The island came into private ownership in 1856, when the coconut plantations were established, and remains a private estate owned by the Jennings family. The island is a sovereign (flag) possession of the U.S.A.

**Conservation measures taken:** None.

**Conservation measures proposed:** Swain's Island was recommended for protected area status by UNEP/IUCN (1988).

**Land use:** Until recently, the production and exportation of copra were major activities on the island, and several hundred Tokelau Islanders were employed for this purpose (Amerson *et al.*, 1982). Copra production has now apparently ceased. By 1987, the population had declined to 18-20, and there are now only about ten people living on the island.

**Disturbances and threats:** None known at the lagoon. A severe storm in early 1987 caused devastating damage to the coral reefs, and destroyed all buildings at Taulaga, the only village on

the island (UNEP/IUCN, 1988). The paucity of breeding birds has been attributed to disturbance from the human inhabitants (Amerson *et al.*, 1982). The harvesting of turtles and turtle eggs in the early 1980s may have been responsible for the disappearance of *Chelonia (mydas) agassizi* as a breeding species on the island.

**Hydrological and biophysical values:** No information.

**Social and cultural values:** No information.

**Noteworthy fauna:** Seven species of reptiles occur on the island, including three species of gecko, three species of skink and the Black Turtle *Chelonia (mydas) agassizi*. The turtle formerly nested on the island, but now occurs only as a visitor to inshore waters. Swain's Island is the only known locality for the Micronesian Skink (*Emoia adspersa*) in American Samoa. The Pacific Reef Heron (*Egretta sacra*) breeds in the coconut plantations and feeds in shallow portions of the lagoon. The Pacific Black Duck (*Arras superciliosa*) has been reported in the past, and could still occur as a visitor. Five species of migratory shorebirds have been recorded: the Pacific Golden Plover *Pluvialis fulva*, Wandering Tattler *Heteroscelus incanus*, Bristle-thighed Curlew *Numenius tahitiensis*, Ruddy Turnstone *Arenaria interpres* and Sanderling *Calidris alba* (rare). Four species of seabird breed: White-tailed Tropicbird *Phaethon lepturus*, Brown Noddy *Anous stolidus*, Black Noddy *A. minutes* and White Tern *Gygis alba*, but numbers are relatively low. The Polynesian Rat *Rattus exulans* is common, and feral pigs are found in the coconut plantations.

**Noteworthy flora:** Lake Namo is the only known locality for *Eleocharis geniculata* in Samoa.

**Scientific research and facilities:** The fauna and flora of Swain's Island have been surveyed by Amerson *et al.* (1982). Work on the coral reefs has been summarized in UNEP/IUCN (1988).

**Management authority and jurisdiction:** No information.

**References:** Amerson *et al.* (1982); UNEP/IUCN (1988).

**Reasons for inclusion:** 1a, 2a, 2b. A good example of an enclosed brackish lagoon; habitat for shorebirds including *Numenius tenuirostris*.

**Source:** See references.

## REFERENCES

- Amerson, A.B., Jr., Whistler, W.A. & Schwaner, T.D. (1982).** Wildlife and Wildlife Habitat of American Samoa. Vol.I: Environment and Ecology. Vol.II: Accounts of Flora and Fauna. U.S. Department of the Interior, Fish and Wildlife Service. Washington, D.C. 119 pp & 151 pp.
- Anon. (1989).** American Samoa Country Review. Report presented by the American Samoa Government to the Fourth South Pacific Conference on Nature Conservation and Protected Areas, Port Vila, Vanuatu, September 1989. SPREP/IUCN.
- Biosystems Analysis, Inc. (1991).** A comprehensive wetlands management plan for the islands of Tutuila and Aunu'u, American Samoa. Tiburon, California. 212 pp.
- Burger, I.L. & Maciolek, J.A. (1981).** Map Inventory of nonmarine aquatic resources of American Samoa, with on-site biological annotations. U.S. Fish and Wildlife Service, National Fishery Research Center. Seattle, Washington. 133 pp.
- Cole, T.G., Whitesell, C.D., Whistler, W.A., McKay, N. & Ambacher, A.H. (1988).** Vegetation survey and forest inventory, American Samoa. PSW-25. Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture. Berkeley, California. 14 pp.
- Dahl, A.L. (1980).** Regional Ecosystems Survey of the South Pacific Area. SPC Technical Paper No. 179. South Pacific Commission, Noumea, New Caledonia.
- Dahl, A.L. (1986).** Review of the Protected Areas System in Oceania. UNEP & IUCN Commission on National Parks and Protected Areas, Gland, Switzerland.
- Engbring, J. & Ramsey, F.L. (1989).** A 1986 Survey of the Forest Birds of American

- Samoa. U.S. Fish & Wildlife Service, Honolulu, Hawaii. 145 pp.
- Energy Resources International, Inc. (1989).** Future Directions for Leone Village, American Samoa. An Analysis of Two Choices. Energy Resources International, Sausalito, California, U.S.A.
- Helfrich, P. (1975).** An assessment of the expected impact of a dredging project for Pala Lagoon. American Samoa.
- IUCN (1991).** IUCN Directory of Protected Areas in Oceania. Prepared by the World Conservation Monitoring Centre. IUCN, Gland, Switzerland and Cambridge, U.K.
- Kennedy, Jenks & Chilton (1987).** Final Report Groundwater Contamination Study, Tafuna-Leone Plain, Tutuila Island.
- Noda & Associates (1987).** Environmental Assessment, Leone Harbour, Tutuila, American Samoa. Report prepared for the Department of Public Works, American Samoa Government.
- Preston, G.L. (1988).** Development of Pala Lagoon, American Samoa.
- Shleser, R. & May, R. (1977).** Evaluation of the potential for aquaculture in American Samoa.
- SPREP/IUCN (1989).** Action Strategy for Nature Conservation in the South Pacific Region. South Pacific Commission, Noumea, New Caledonia.
- Stemmermann, L. (1981).** A Guide to Pacific Wetland Plants. U.S. Army Corps of Engineers, Honolulu District, Hawaii, U.S.A.
- Takata, H.A. (1986).** Aquaculture site visit/survey on Tutuila, Aunu'u, and Manu'a Islands. Unpublished report.
- UNEP/IUCN (1988).** Coral Reefs of the World. Volume 3: Central and Western Pacific. UNEP Regional Seas Directories and Bibliographies. IUCN, Gland, Switzerland and Cambridge, U.K./UNEP, Nairobi, Kenya.
- U.S. Army Corps of Engineers (1980).** American Samoa, Coral Reef Inventory.(Pala Lagoon Section only). U.S. Army Corps of Engineers. Fort Shafter, Hawaii.
- U.S. Army Corps of Engineers (1981).** American Samoa Stream Inventory, Island of Tutuila. American Samoa Water Resources Study. U.S. Army Corps of Engineers. Fort Shafter, Hawaii.
- U.S. Army Corps of Engineers (1986).** Initial appraisal report for Pala Lagoon harbour, Territory of American Samoa.
- U.S. Army Corps of Engineers (1990).** Territories Development Study: American Samoa. Reconnaissance Report. U.S. Army Corps of Engineers. Fort Shafter, Hawaii. 117 pp.
- U.S. Department of Commerce (1980).** American Samoa Coastal Management Program and Final Environmental Impact Statement.
- Whistler, A.W. (1976).** Inventory and Mapping of Wetland Vegetation in the Territory of American Samoa. U.S. Army Corps of Engineers. Fort Shafter, Hawaii. 94 pp.
- Woodroffe, C.D. 1987.** Pacific Island Mangroves: Distribution and Environmental Settings. Pacific Science 41(1-4): 166-185.
- Yamasaki, G., Itano, D. & Davis, R. (1985).** A study of and recommendations for the management of the mangrove and lagoon areas of Nu'uuli and Tafuna, American Samoa. American Samoa Coastal Management Program. Pago Pago, American Samoa. 99 pp.

Table 1:

Summary of the change in total wetland acreage for the wetland areas of Tutuila and Aunu'u Islands.

Wetland	1961 Wetlands (acres)	1991 Wetlands (acres)	Loss (Gain) (acres)	Percent change (%)	Rate of change (acre/yr)
<u>Tutuila Island</u>	488.12	350.93	37.19	28%	4.57
Nu'uuli Pala	184.49	122.90	61.59	33%	2.05
Leone Pala	40.10	20.74	19.36	48%	0.64
Malaeloa	92.20	72.06	20.14	22%	0.67
Aua	11.63	9.18	2.45	21%	0.08
Masefau	48.48	43.06	5.42	11%	0.18
Vatia	33.60	34.05	(0.45)	+1.3%	+0.01
Alofau	3.17	2.03	1.14	36%	0.04
Aoa	36.60	23.45	13.15	36%	0.44
Alao	18.66	15.47	3.19	17%	0.11
Tula	19.19	7.99	11.20	58%	0.37
<u>Aunu'u Island</u>	111.76	111.93	(0.17)	+0.1%	Insignificant
Pala Lake	44.76	44.76	No change	0	No change
Taro Fields	27.30	27.30	No change	0	No change
Crater Lake	36.84	36.84	No change	0	No change
School Swamp	2.86	3.03	(0.17)	+0.1%	Insignificant
<b>TOTAL</b>	599.88	462.86	137.02	23%	4.57

Source: Biosystems Analysis, Inc. (1991).