

TAIWAN, R.O.C.

INTRODUCTION

by Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia

Area: 36,179 sq.km.

Population: 19,500,000.

Taiwan lies in the Pacific Ocean off the southeastern coast of the Chinese mainland, between latitudes 21°45' and 25°38' North, and longitudes 119°81' and 122°06' East. It is an oblong-shaped island, approximately 394 km long and 144 km wide at its broadest point. The Tropic of Cancer crosses the south-central part of Taiwan.

The Central Mountain Range and several minor ranges run from north to south down the island and include 95 peaks above 10,000 feet (3,048m). The highest one, Mount Yushan, at 13,113 ft (3,996m) is the highest mountain in northeast Asia. The eastern mountains fall sharply to the sea, leaving little or no coastal plain. Mountains in the western part of the island fall less steeply, and there is a broad coastal plain, up to 50 km wide at its widest, interspersed with small hills. Much of the land below 100m above sea level is cultivated.

Situated on the edge of the Tropics and with a wide altitudinal range, Taiwan is able to support four major plant communities: tropical, subtropical, temperate and alpine. Both the flora and fauna are extremely rich, the island boasting approximately 4,000 species of vascular plants, 430 species of birds, 62 species of mammals, 76 species of reptiles, 30 species of amphibians, 130 species of freshwater fishes and 400 species of butterflies. The island lies on the main flyway for birds migrating between the Philippines and Japan, and is therefore of considerable importance for migrants from Japan, Mainland China and areas further north.

Taiwan is a relatively small island and has one of the highest population densities in the world. Two-thirds of the island are mountainous, and as a result, most of the population live in the narrow and now congested plains on the western side of the island. There has been great environmental stress on the land available for development because of the high population density and lack of suitable space.

Summary of Wetland Situation

The wetlands of Taiwan include tidal mudflats, mangrove swamps and salt marshes, primarily along the west coast, and a few small lakes and ponds in remote mountain areas.

Previously, there were some 80,000 ha of intertidal mudflats along the west coast of Taiwan. However, 11,000 ha of these flats have been reclaimed and there are plans to reclaim a further 15,000 ha in the near future. These tidal flats are extremely rich in invertebrates, and are major sources of sea foods such as crabs, shrimps, oysters and clams. Mangroves occur mainly in a few patches along the western coast of Taiwan, the largest stands being in the Tungshi, Tainan, Chuwei and Watzuwei areas. The most extensive salt marshes are near Guandu and at the mouth of the Lanyangchi river. The mangrove swamps and salt marshes occur in a zone of intensive human activity and are subject to reclamation and accidental modification of habitat. For example, human activity has already brought about the extinction of two species of mangrove, *Bruguiera gymnorhiza* and *Ceriops tagal*, in Taiwan. Another two species, *Rhizophora mucronata* and *Lumnitzera racemosa*, are considered to be endangered. Along the west coast, many of the tidal flats and mangrove swamps have been converted for use as fish ponds, or reclaimed for industrial estates, housing developments, power plants, harbours etc.

The major freshwater wetlands are Wuku and Luchou Swamp, Nanjen and Lungnantan Lakes in Kenting National Park, Duck Pond in Yangmingshan National Park, Yuenyang Lake and Payu Lake. Several rare and endangered species of aquatic plants occur in these ecosystems, notably *Sparganium fallax* which is known only from Yuenyang Lake, and *Isoetes taiwanensis* found only in Duck Pond.

Wetland Research

Most of the recent research on wetlands in Taiwan has been carried out by biologists from the universities or members of the bird societies, although the Taiwan Forestry Research Institute is conducting research on the succession of mangroves at Guandu. Dr Lue Kuang-Yang and Dr Wang Ying of the Department of Biology at National Taiwan Normal University have been doing research on mangroves and marsh ecosystems, and the freshwater marsh ecosystem at Nanjen Lake, respectively. Dr Chen Ming-Yih of the Department of Botany at National Chung-Hsing University is working on mangroves and estuaries; Dr Chang Kung-Hsiung, Dean of the College of Marine Science at National Sun Yat-Sen University is conducting research on marine resources; and Associate Professor Chen Ching-Hsia of the Department of Biology at Fu Jen University is working on aquatic plants.

The Taipei Wild Bird Society surveys waterbirds at many wetlands in Taiwan, and operates the bird banding program. In January 1988, the Society organized waterfowl censuses at twenty-six wetlands around the island. Over 31,000 waterbirds of 73 species were recorded during the censuses. These included 163 grebes, 67 cormorants, 3,683 herons and egrets, two spoonbills (*Platalea minor*), 9,566 ducks, 222 rails, moorhens and coots, 17,213 shorebirds and 696 gulls and terns. The Kaohsiung Bird Society surveys waterbirds in the Kaohsiung area, and the Taichung Bird Club has conducted some studies at the Tatu Estuary.

Wetland Area Legislation

Both the Ministry of the Interior and the Council of Agriculture are responsible for wetland protection in Taiwan. Under the National Park Law enacted on 13 June 1972, the Ministry of the Interior set up a National Planning Commission which is authorized to designate, alter or abolish areas set aside for national parks, and to give approval on management plans. Establishment of national parks must receive final approval from the Executive Yuan. Three wetland sanctuaries have been protected since 1984: Nanjen Lake and Lungnantan in Kenting National Park, and Duck Pond in Yangmingshan National Park.

The Ministry of the Interior is also in charge of the Taiwan Coastal Nature Reserves. These Coastal Nature Reserves are divided according to levels and types of use into "General Conservation" and "Natural Preservation" Zones. The Natural Preservation Zones are designated either as Ecological Preservation Areas or Natural Preservation Areas in accordance with the Cultural Assets Preservation Act, administered by the Council of Agriculture. Seven Coastal Nature Reserves were designated in 1983.

In 1984, the Council of Agriculture became directly responsible for endangered species and nature reserves under the Cultural Assets Preservation Act. This statute authorizes the Council of Agriculture to provide research funds, declare endangered species and designate nature reserves. In 1986, under the Cultural Assets Preservation Act, the Council of Agriculture established nine nature reserves, three of which are wetland ecosystems.

A draft law governing the protection of coastal areas and wetlands has been prepared by Dr T.T. Kuo in the College of Law at National Taiwan University. It contains 10 chapters with 91 articles. Subjects mentioned in the draft include definitions of terms related to the protection of coastal zones and wetlands, procedures for defining the boundary and determining the area of a protected area, the aims of protection, law enforcement, water quality and erosion control, limits for land reclamation, and budgets for management. The draft will be forwarded to the Executive Yuan for evaluation and review in the near future.

Wetland Area Administration

The Conservation and Planning Administration of the Ministry of the Interior is responsible both for the administration of National Parks, and for the planning and implementation of the National Nature Conservation Strategy and the "Taiwan Coastal Area Natural Environmental Protection Plan". The latter aims to maintain the quality of the coastal environment, to protect landscapes and biological resources, and to manage marine reserves.

The Conservation Division of the Council of Agriculture is responsible both for scientific research and for the designation of endangered species and nature reserves.

Organizations involved with Wetlands

a) Governmental Organizations

- Council of Agriculture, Executive Yuan
Responsible for designating Nature Preservation Areas and providing research funds.
- Taiwan Forestry Research Institute, Department of Agriculture and Forestry, Taiwan Provincial Government
Conducts research on mangrove succession.
- Construction and Planning Administration (Ministry of Interior)
Includes the Department of National Parks; designates Coastal Protection Areas and National Parks, and provides research funds.
- Taiwan Forestry Bureau, Taiwan Provincial Government
Responsible for some wetland management.
- National Museum of Natural Science
Involved in planning the Bird Sanctuary at the Tatu Estuary.

b) Non-governmental Organizations

- Society for Wildlife and Nature (SWAN)
Involved in campaigns for the protection of wetlands and waterbirds.
- Animal Protection Association
Campaigning for the protection of wetlands and waterfowl.
- Taipei Wild Bird Society Surveys waterbirds at many wetlands and operates the bird banding program.
- Taichung Bird Club Involved in planning the Bird Sanctuary at the Tatu Estuary.
- Kaohsiung Bird Society
Surveys waterbirds in the Kaohsiung area.
- National Taiwan University
Dr Lin Yao-Sung (Department of Zoology) is in charge of planning the Bird Sanctuary at Guandu.
- National Taiwan Normal University
The Department of Biology has conducted research on mangroves and marsh ecosystems.
- National Chung-Hsing University
The Department of Botany is involved in research on mangroves and estuaries.
- Tunghai University

Associate Professor Peter Chen (Department of Environmental Science) is in charge of the planning of a Bird Sanctuary at the Tatu Estuary, in collaboration with the National Museum and Taichung Bird Club.

- National Sun Yat-Sen University

The College of Marine Science conducts research on marine resources.

- Fu Jen University

The Department of Biology is working on aquatic plants.

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WETLANDS

Site descriptions taken from Lin *et al.* (1987), Wetlands of Taiwan (R.O.C.), a report prepared for this Directory and presented at the Conference on Wetland and Waterfowl Conservation in Asia, Malacca, Malaysia, 23-28 February 1987. Additional information has been obtained from the preliminary report of the 1988 mid-winter waterfowl censuses in Taiwan (Wild Bird Society of Taipei).

Wetland name: Wuku and Luchou Swamp

Country: Taiwan

Coordinates: 25°06'N, 121°27'E;

Location: on the west bank of the Tanshui River in Taipei County, 10 km northwest of Taipei City.

Area: 500 ha.

Altitude: 0-2m.

Biogeographical Province: 4.27.12.

Wetland type: 15 & 20.

Description of site: An area of freshwater marsh and seasonally flooded arable land, with ponds up to 2m deep; on the outskirts of Taipei City. Salinities range from 0.01-2.0 p.p.t., and pH values from 7.5-10.5.

Climatic conditions: Humid tropical climate with an average annual rainfall of about 2,000 mm, a mean annual temperature of 22°C, mean monthly temperatures in the range 15-29°C, and an average relative humidity of 80%.

Principal vegetation: *Eichhornia crassipes* is the dominant aquatic plant. 152 species of vascular plants have been recorded including species of *Polygonum*, *Ceratophyllum*, *Hydrocotyle*, *Potamogeton*, *Cyperus*, *Echinochloa*, *Paspalum*, *Phragmites*, *Sporobolus*, *Lemna*, *Salvinia*, *Azolla* and *Typha*. There are rice paddies and vegetable gardens in adjacent areas.

Land tenure: The wetland and surrounding areas are privately owned.

Conservation measures taken: The area has been classified as Flood Denuded Land.

Conservation measures proposed: The Taipei County Government has proposed that a nature park and recreational area be established at the swamp.

Land use: The flooded land is used as a rubbish dump by two villages close to the wetland, and some parts are being reclaimed for an industrial estate. There are several villages and industrial estates in the surrounding areas.

Disturbances and threats: Eutrophication caused by inflow of domestic sewage, with algal blooms occurring all year round. High concentrations of nitrates and phosphates, and biological oxygen demand values in excess of 10 p.p.m., have been reported.

Economic and social values: The swamp supports a rich fishery; over 2,000 kg of fish were caught per day in 1984.

Fauna: The swamp supports a very rich fauna which has been well documented. This includes 11 species of molluscs, 12 species of fish (*Tilapia mossambica* being the most abundant), 6 species of amphibians, two species of freshwater turtles, and 107 species of birds (including 58 species of waterfowl). The commoner waterfowl

include *Tachybaptus ruficollis*, *Nycticorax nycticorax*, *Bubulcus ibis*, *Egretta garzetta*, *Amaurornis phoenicurus*, *Gallinula chioropus*, *Charadrius dubius*, *Actitis hypoleucos*, *Gallinago gallinago*, *Tringa nebularia*, *T. glareola* and *Sterna albifrons*. The threatened Chinese Egret *Egretta eulophotes* has been recorded. Complete lists of the molluscs and birds are given in Lin *et al.* (1987).

Waterfowl recorded during a mid-January census in 1988 included: 60 *Bubulcus ibis*

73 *Ardea cinerea*

10 *Anas poecilorhyncha*

48 *Charadrius dubius*

52 *Tringa glareola*

Special floral values: One of the most extensive and diverse freshwater plant communities in Taiwan. Complete lists of the vascular plants (152 species) and phytoplankton (29 species) are given in Lin *et al.* (1987).

Research and facilities: Lue and Tsai (1979) made an avifaunal survey of the swamp in 1977-1979, and Lue (1983) carried out an ecological survey with the support of the National Science Council.

References: Lin *et al.* (1987); Lue (1983); Lue *et al.* (1986); Lue & Tsai (1979).

Criteria for inclusion: lc, 2b.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia.

Wetland name: Guandu Marsh

Country: Taiwan

Coordinates: 25°07'N, 121°27'E;

Location: in the northwestern suburbs of Taipei City.

Area: 153 ha.

Altitude: 0-3m.

Biogeographical Province: 4.27.12.

Wetland type: 02, 06, 07, 08, 15 & 19.

Description of site: A 55 ha patch of mangroves and brackish marshes with adjacent intertidal mudflats outside a 10m wide embankment, and 98 ha of fresh to brackish ponds, marshes and rice paddies inside the embankment. The marsh is in the estuary of the Tanshui River at its confluence with the Keelung River. The maximum water depth is three metres, and salinities range from fresh to 30 p.p.t. There are two tides daily and the average tidal range is about two metres.

Climatic conditions: Humid tropical climate with an average annual rainfall of about 2,000 mm, a mean annual temperature of 22°C, monthly mean temperatures in the range 15-29°C, and an average relative humidity of 80%.

Principal vegetation: Brackish marshes with *Phragmites communis* and *Cyprus Malaccans*, and mangrove swamps dominated by *Candela candle* outside the embankment; freshwater marshes with *Paspalum repens* and *P. distichum*, and rice paddies inside the sea-wall. About 175 species of vascular plants have been recorded at the site.

Land tenure: The wetland and adjacent areas are privately owned.

Conservation measures taken: A Bird Sanctuary of 117 ha was established by the Taipei City Government in September 1983. However, this included about 60 ha of privately owned rice paddies, and few restrictions were placed on human activities in the marsh. In 1986, following a major publicity campaign for the conservation of the site, the area of mangroves and marsh (55 ha) outside the embankment was designated as a Nature Preservation Area by the Council of Agriculture, and given strict protection.

Conservation measures proposed: In October 1985, the Taipei City Government decided to establish a Nature Park incorporating 50 ha of the marshes and rice paddies inside the embankment, adjacent to the Nature Preservation Area. This Nature Park will be developed for nature protection, outdoor recreation and conservation education. A detailed management plan is being prepared; this calls for the construction of a peripheral canal and belt of trees to reduce human disturbance, the management of 43 ha as a bird sanctuary, the development of seven ha for recreational and educational purposes, and the construction of a network of nature trails and observation hides. It is anticipated that construction will commence in 1989.

Land use: None in the Nature Preservation Area. Activities in adjacent areas include the rearing of ducks and pigs, cultivation of rice and vegetables, and dumping of soil inside the embankment. The city of Taipei extends to the edge of the wetland.

Disturbances and threats: There is a considerable amount of water pollution in the marsh, and disturbance from boating activities. Parts of the marsh have been used for the dumping of soil.

Economic and social values: Situated on the outskirts of Taipei City and with a variety of wetland habitats, the reserve has tremendous potential for public recreation, conservation education and scientific research. It has long been a popular spot for bird-watchers.

Fauna: The fishes include the mudskipper *Periophthalmus* sp and *Tilapia* sp. Some 204 species of birds (45% of the total avifauna of Taiwan) have been recorded, including 74 species of waterfowl. The marsh is particularly important as a feeding area for herons and egrets, a staging area for some 40 species of migratory shorebirds, and a wintering area for several species of dabbling ducks (notably *Anas crecca*). Three threatened species of waterfowl have been recorded, *Egretta eulophotes*, *Tringa guttifer* and *Larus saundersi*. The commoner shorebirds include *Glareola maldivarum*, *Pluvialis dominica*, *Charadrius dubius*, *C. alexandrinus*, *C. mongolus*, *Tringa nebularia*, *T. glareola*, *Actitis hypoleucos*, *Phalaropus lobatus*, *Gallinago gallinago*, *Calidris ruficollis*, *C. acuminata*, *C. ferruginea* and *C. alpina* (mainly a winter visitor).

Guandu Marsh and the Tamshui River in and around Taipei City are the most important wintering area for ducks in Taiwan. Over 4,600 ducks of fourteen species were present in mid-January 1988, including:

3,500 *Anas crecca*

385 *A. poecilorhyncha*

194 *A. acuta*

575 *A. clypeata*

31 *Aythya fuligula*

Rare visitors to Taiwan included one *Tadorna ferruginea*, one *Anas formosa* and three *Aythya baeri*. Other waterfowl recorded during this census included:

300 *Bubulcus ibis*

24 *Egretta garzetta*

75 *E. alba*

190 *Charadrius alexandrinus*

940 *Calidris alpina*

142 *Larus ridibundus*

The abundant invertebrate fauna at Guandu Marsh includes ten species of crabs, notably fiddler crabs *Uca* spp, and 11 species of molluscs.

Special floral values: None known.

Research and facilities: The Taipei City Government has supported several studies on the fauna and flora of the reserve by the universities. Lin *et al.* (1987) give complete lists of the birds, crabs, molluscs and plants recorded at Guandu.

References: Chou (1985); Karpowicz (1985); Lin *et al.* (1984); Lin *et al.* (1987); Wang (1984).

Criteria for inclusion: 1b, 2b.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia.

Wetland name: Chuwei Mangrove Swamp

Country: Taiwan

Coordinates: 25°10'N, 121°26'E;

Location: in the estuary of the Tanshui River, 15 km NNW of Taipei City.

Area: 60 ha.

Altitude: 0-5m.

Biogeographical Province: 4.27.12.

Wetland type: 02 & 07.

Description of site: An area of mature mangrove swamp on the east bank of the Tanshui River approximately five km upstream from the river mouth, with rice paddies and duck farms on the landward side. Salinities range from 0-30 p.p.t., and pH values from 7.3-8.3.

Climatic conditions: Humid tropical climate with an average annual rainfall of about 2,000 mm, a mean annual temperature of 22°C, and mean monthly temperatures in the range 15-29°C.

Principal vegetation: Mangrove swamp dominated by *Kandelia candel*, with some *Phragmites communis* in the high tide zone. The density of *K. candel* exceeds 2.5 individuals per sq.m. About 58 species of plants have been recorded in the area immediately above the high tide limit.

Land tenure: The mangrove swamp is owned by the Taiwan Forestry Bureau. Adjacent land is privately owned or owned by the Railroad Bureau.

Conservation measures taken: The mangrove swamp was designated as an Ecological Protection Area in 1986. It is administered by the Taiwan Forestry Bureau.

Land use: None in the mangrove swamp. It is being maintained in its natural state. There are some small rice paddies adjacent to the reserve, two aquaculture ponds for clams *Meretrix lusoria* to the east, and a duck farm to the northeast.

Possible changes in land use: There is a possibility that the aquaculture ponds will be extended and will encroach upon the reserve.

Disturbances and threats: Water pollution from the Tanshui River, over harvesting of crabs *Scylla serrata*, and consumption of aquatic vegetation by domestic ducks reared on the nearby duck farms.

Economic and social values: The swamp is an important breeding ground for several species of crabs with high economic value such as *Scylla serrata*, and for bivalves, notably *Meretrix lusoria*.

Fauna: The mangrove swamp supports a breeding colony of over 5,000 herons and egrets, mainly *Nycticorax nycticorax*, *Bubulcus ibis* and *Egretta garzetta*, and a wide variety of ducks and shorebirds occur during the migrating season. The mudskipper *Periophthalmus cantonensis* is common, and there are at least three species of amphibians and three species of reptiles in the swamp and surrounding areas. Other fauna includes 12 species of crabs and 11 species of molluscs. The snail *Neritina turrita* has recently been found in this area, a new species for Taiwan. Polychaetes are abundant in the mud. Lin *et al.* (1987) give full lists of the molluscs, crabs, amphibians and reptiles recorded at the site.

Special floral values: Chuwei Swamp contains the largest mature stand of *Kandelia candel* in Taiwan.

Research and facilities: An investigation of the crab fauna and some basic ecological surveys including productivity studies have been carried out by staff and students of National Taiwan Normal University.

References: Lin *et al.* (1987); Lue (1982).

Criteria for inclusion: 2b, 2c.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia.

Wetland name: Watzuwei Mangrove Swamp

Country: Taiwan

Coordinates: 25°10'N, 121°24'E;

Location: on the south bank of the Tanshui river near its mouth, 15 km northwest of Taipei City.

Area: 20 ha.

Altitude: Sea level.

Biogeographical Province: 4.27.12.

Wetland type: 02, 06, 07 & 08.

Description of site: An area of mangrove swamp, salt marshes and intertidal mudflats near the mouth of the Tanshui River. Salinities range from 5-30 p.p.t. There are two tides daily, with an average tidal range of approximately 3m. Climatic conditions: Humid tropical climate with an average annual rainfall of about 2,000 mm, a mean annual temperature of 22 °C, and mean monthly temperatures in the range 15-29°C.

Principal vegetation: A pure stand of *Kandelia candel*; the vine *Ipomoea pescaprae* grows on the sandy beach to the west of the mangroves.

Land tenure: The wetland is owned by the Taiwan Forestry Bureau. Adjacent areas are privately owned.

Conservation measures taken: The wetland was designated as a Coastal Ecological Protection Area in 1985.

Land use: None.

Possible changes in land use: There is a proposal to build a water treatment plant nearby.

Disturbances and threats: Pollution from the metropolitan area of Taipei and possible future pollution from a proposed water treatment plant. **Economic and social values:** Because of its proximity to Taipei City, the area is a popular bird-watching spot.

Fauna: Over 150 species of birds have been recorded in the area including 99 species of waterfowl. The mangroves and mudflats are particularly important as a staging area for migratory shorebirds (42 species recorded), and this is one of the few breeding localities for *Charadrius dubius* in Taiwan. The endangered Chinese Egret *Egretta eulophotes* occurs in winter, and *Grus monacha* and *Numenius minutus* have been observed. Fifteen species of crabs belonging to four families (Protunidae, Ocypodidae, Grapsidae and Mictyridae) occur, including the rare endemic *Uca formosensis*. Other fauna includes seven species of molluscs, six amphibians and nine reptiles. Full lists of the birds, reptiles, amphibians, crabs and molluscs are given by Lin *et al.* (1987).

Special floral values: None known.

Research and facilities: The crabs and molluscs have been investigated by Lue Kuang-Yang and Hung Jen-Su. A bird banding programme is currently being undertaken by the Taipei Wild Bird Society, as a pilot study for an International Bird Banding Programme to be conducted in the near future.

References: Lin *et al.* (1987); Wu (1986).

Criteria for inclusion: 1b, 2a, 2b.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia.

Wetland name: Duck Pond (Dream Lake)

Country: Taiwan

Coordinates: 25°10'N, 121°33'E;

Location: in Yan gmingshan National Park, 15 km north of Taipei City.

Area: 0.09 ha.

Altitude: 850m.

Biogeographical Province: 4.27.12.

Wetland type: 15.

Description of site: A tiny freshwater lake, only nine hundred square metres in extent, fed by local rainfall; on the forested southeastern slopes of Chihshingshan volcano (1,120m). The lake reaches a maximum depth of 4m during periods of heavy rainfall, but dries out almost completely during dry periods.

Climatic conditions: Humid subtropical climate, with average temperatures ranging from 15-19°C. For most of the year the lake is enveloped in fog.

Principal vegetation: *Isoetes taiwanensis* is the dominant aquatic plant. Other species include *Eriocaulon chishingsanensis*, *Schoenoplectus mucroxatus subsp. robustus*, *Eleocharis dulcis*, *Nymphoides indica*, *Sphaerocaryum malaccense*,

Eleocharis congesta var. *japonica*, *Juncus effusus*, *J. leschenaultii* and *Isachne globosa*. Grassland, mixed coniferous forest and broadleaf forest occur in surrounding areas.

Land tenure: The lake and surrounding areas are owned by the Ministry of Interior.

Conservation measures taken: The pond is protected in Yangmingshan National Park (10,000 ha), established in 1982 and administered by the Ministry of Interior.

Land use: Outdoor recreation in the National Park.

Disturbances and threats: Disturbance from visitors to the Park and some collection of botanical specimens.

Economic and social values: A popular scenic spot with mythological associations, and a very valuable site for scientific research and educational purposes.

Fauna: The fish *Channa asiatica* and the frog *Rana longicrus* occur in the lake.

Special floral values: The lake is the only known locality for the endangered aquatic plant *Isoetes taiwanensis*. Fifty-one species of plants have been recorded, and these are listed by Lin *et al.* (1987).

Research and facilities: Huang (1984) has conducted a floral survey of the lake and its surroundings.

References: Lin *et al.* (1987); Huang (1984); Huang *et al.* (1984).

Criteria for inclusion: 1a, 2d.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia.

Wetland name: Lanyangchi Estuary

Country: Taiwan

Coordinates: 24°43'N, 121°49'E;

Location: on the east coast of Taiwan near Han City, 45 km southeast of Taipei.

Area: Several hundred ha.

Altitude: 0-5m.

Biogeographical Province: 4.27.12.

Wetland type: 02, 05, 06 & 11.

Description of site: The estuary of the Lanyangchi River, with some brackish marshes, intertidal mudflats, sandy beaches and several sandy islets. The river has a maximum depth of 3m, and salinities in the marshes range from 0-10 p.p.t. There are two tides daily with a tidal variation of approximately 3m. The extensive brackish marshes which once existed in this area have been replaced with fish ponds.

Climatic conditions: Humid tropical climate.

Principal vegetation: Brackish marshes with *Phragmites communis*; rice fields in adjacent areas.

Land tenure: The wetland is owned by the Water Board; adjacent areas are privately owned.

Conservation measures taken: A Bird Sanctuary was established by the Bureau of Tourism in 1977, and the estuary was designated as a Coastal Protection Area by the Department of National Parks, Ministry of the Interior, in 1985.

Land use: None at the wetland; cultivation of rice and aquaculture in adjacent areas.

Disturbances and threats: Water pollution from Ilan City, and the spread of water hyacinth *Eiehornia easipes* in the river. Increased human disturbance, especially

disturbance from illegal hunting, has caused a decrease in the number of migratory ducks and shorebirds visiting the area in recent years.

Economic and social values: The estuary is an important area for the study of waterfowl migration.

Fauna: 159 species of birds have been recorded including 91 species of waterfowl (Lin *et al.*, 1987). The area is particularly important as a staging and wintering area for herons and egrets (13 species), geese (4 species), ducks (12 species), shorebirds (42 species) and terns (11 species). *Cygnus cygnus*, *C. columbianus*, *Grus japonensis* and *G. vipio* have occurred, and *Pandion haliaetus* and *Falco peregrinus* are regular on passage.

Reptiles and amphibians include *Natrix stolata*, *Bufo melanosticus*, *Rana limnocharis* and *R. guntheri*.

Special floral values: None known.

References: Lin *et al.* (1987); Wu (1986).

Criteria for inclusion: lb. 2b.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia.

Wetland name: Yuenyang Lake

Country: Taiwan

Coordinates: 24°35'N, 121°24'E;

Location: in Sinchu County, 50 km SSW of Taipei.

Area: 5.8 ha (lake 3.6 ha; surrounding marsh 2.2 ha).

Altitude: 1,670m.

Biogeographical Province: 4.27.12.

Wetland type: 15.

Description of site: A small freshwater lake with fringing marshes in a mountain valley, with nearby peaks rising to 2,178m. Fed by local rainfall, and up to 15m deep.

Climatic conditions: Humid temperate montane climate.

Principal vegetation: *Potamogeton octandra*, *Sparganium fallax*, *Schoenoplectus mucronatus* in the lake; *Miscanthus transmorrisonensis*, *S. mucronatus*, *Scirpus morrisonensis*, *Rhododendron mariesii*, *Rhamnus crenata* in the marshes. *Chamaecyperis formosensis* and *C. taiwanensis* in adjacent areas.

Land tenure: The lake and surrounding areas are owned by the Taiwan Forestry Bureau.

Conservation measures taken: The lake is protected in the Yuenyang Lake Nature Reserve (374 ha), established in 1986 and administered by the Taiwan Forestry Bureau.

Land use: None; a Nature Reserve.

Disturbances and threats: There is some disturbance from the occasional hunter and other visitors to the Reserve.

Economic and social values: The Nature Reserve provides excellent opportunities for research on aquatic plants, liverworts, mosses and cypress forest.

Fauna: Only two species of waterfowl, *Tachybaptus ruficollis* and *Anas querquedula*, have been recorded at the lake, but the surrounding shrubbery and woodland are rich in terrestrial species including many endemic birds.

Special floral values: The rich flora of the lake and surrounding areas includes 208 species of vascular plants, 28 of which are ferns and four of which are known only from this locality, viz. *Sparganium fallax*, *Galium taiwanense*, *Carex capillacea* and *Rhynchospora alba*. Lin *et al.* (1987) give a complete list of the plants recorded.

Research and facilities: Basic faunal and floral surveys have been conducted by the Taiwan Forestry Research Institute.

References: Lin *et al.* (1987); Liu & Hsu (1973).

Criteria for inclusion: 1a, 2d.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia.

Wetland name: Tatu Estuary

Country: Taiwan

Coordinates: 24°11'N, 120°29'E;

Location: in northwestern Changhua County, 20 km WNW of Taichung. **Area:** c.7,000 ha including c.150 ha of marshes inside the sea-wall.

Altitude: 0-5m.

Biogeographical Province: 4.27.12.

Wetland type: 02, 06, 08 & 10.

Description of site: The lower estuary of the Tatu River, with extensive intertidal mudflats, up to five km wide at low tide, and an adjacent area of brackish marshes, wet grassland and abandoned fish ponds between an old and a new seawall.

Climatic conditions: Humid tropical climate with an average annual rainfall of about 2,000 mm.

Principal vegetation: The aquatic vegetation is dominated by *Phragmites communis* and *Paspalum vaginatum*. Lin *et al.* (1987) give a list of 58 species of plants recorded at the site.

Land tenure: The wetland and adjacent areas are owned by the Ministry of Economic Affairs.

Conservation measures taken: The Council of Agriculture has recently declared the area as a Waterfowl Sanctuary. A management plan for the sanctuary is being developed by the Department of Environmental Science at Tunghai University in collaboration with the National Museum of Natural Science and the Taichung Bird Club.

Land use: None at the wetland; abandoned fish ponds in the surrounding areas.

Possible changes in land use: The Taiwan Power Company plans to utilize the marsh for dumping coal ash, and proposals have been made to use the site for industrial development.

Disturbances and threats: There is a considerable amount of air and water pollution from nearby industrial developments. Although the wetland has been declared a sanctuary, there is no active protection, and fish ponds have been constructed illegally in the marsh.

Economic and social values: The wetland is a popular spot for bird-watching and other forms of outdoor recreation.

Fauna: The very diverse fauna includes eight species of mammals, 168 species of birds, nine species of reptiles, seven species of amphibians, 36 species of fishes and

25 species of butterflies (Lin *et al.*, 1987). The marshes inside the seawall provide breeding habitat for *Tachybaptus ruficollis*, *Amaurornis phoenicurus*, *Gallinula chioropus* and *Rostratula benghalensis*. The estuary is a very important feeding area for hundreds of *Nycticorax nycticorax*, *Bubulcus ibis* and *Egretta garzetta* from the three surviving egrettries in the Taichung area. Up to 70 *Ardea cinerea* and many *Egretta intermedia* and *E. alba* occur in winter. The area is particularly important as a staging and wintering area for migratory shorebirds. Some 40 species have been recorded, the commonest being *Charadrius alexandrinus* (which also breeds), *Limosa limosa*, *Tringa stagnatilis*, *T. nebularia*, *T. glareola*, *Xenus cinereus*, *Phalaropus lobatus*, *Calidris rut icollis*, *C. acuminata*, *C. alpina*, *C. ferruginea* and *Limicola falcinellus*. Some 2,000-4,000 *Calidris alpina* winter in the area, along with over 300 *Numenius arquata*. Approximately 120 *Calidris canutus* were present in early May 1986. Regular shorebird censuses in spring 1987 gave maximum counts of 1,708 in April and 1,015 in May. The marshes are also of considerable importance for passage and wintering ducks; 13 species have been observed, and concentrations of over 3,000 birds have been recorded. Three Scaled Mergansers *Mergus squamatus* in November 1987 were the first record of this endangered species in Taiwan. Waterfowl recorded during a mid-January census in 1988 included:

20 *Egretta garzetta*

1,000 *Anas acuta*

400 *Pluvialis squatarola*

500 *Charadrius alexandrinus*

380 *Numenius arquata*

50 *Tringa nebularia*

1,500 *Calidris alpina*

30 Saunders' Gulls *Larus saundersi*

Special floral values: Two rare species, *Myoporum bontioides* and *Gymnodinium aeruginosum*, occur in the marsh.

Research and facilities: Basic faunal and floral surveys have been conducted by biologists from National Taiwan University and Tunghai University. References: Karpowicz (1985); Lin *et al.* (1987).

Criteria for inclusion: lb. 2b, 3b.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih, Chen Ching-Hsia and Peter Chen.

Wetland name: Tungshih (Ton-Shou) Mangroves

Country: Taiwan

Coordinates: 23°27'N, 120°09'E;

Location: on the west coast of Chiayih County, 50 km north of Tainan.

Area: c.30 ha.

Altitude: Sea level.

Biogeographical Province: 4.27.12.

Wetland type: 06 & 07.

Description of site: Several small patches of mangroves with adjacent intertidal mudflats, remnants of once much more extensive coastal swamps and flats. Salinities range from 20-35 p.p.t.

Climatic conditions: Humid tropical climate with an average annual rainfall of about 2,000 mm.

Principal vegetation: Mangrove forest with a mixture of *Avicennia marina*, *Kandelia candel* and *Rhizophora mucronata*. Strand communities with *Atriplex nummularia* and *Myoporum bontioides* in adjacent areas.

Land tenure: The wetland is Public Land (state owned); adjacent areas are privately owned.

Conservation measures taken: The patches of mangrove forest have recently been protected under the Coastal Area Natural Environmental Protection Plan.

Land use: There are extensive culture beds for oysters (*Crassostrea gigas*) and clams (*Meretrix lusoria*) adjacent to the mangroves, and other types of aquaculture ponds inland.

Possible changes in land use: A project for the reclamation and development of the intertidal mudflats in the area is currently under consideration.

Disturbances and threats: Destruction of mangroves for shellfish culture, water pollution, increased sedimentation and proposed development of the intertidal mudflats.

Economic and social values: The mangrove swamps play an important role in supporting the culture of oysters and clams in adjacent areas, and provide valuable opportunities for research and education.

Fauna: The rich fish fauna includes a variety of species of economic importance. 102 species of birds have been recorded, including 60 species of waterfowl (Lin *et al.*, 1987). The site is particularly important as a feeding and nesting area for Ardeidae. There are two breeding colonies of herons and egrets, one in the Wen-Kiang mangroves (4.3 ha) and the other in a 1.1 ha stand of bamboo and casuarina at Lie-Tzu-Lun. The latter colony held 4,500 birds in 1975 and 5,300 birds in 1976, with the three common species, *Nycticorax nycticorax*, *Bubulcus ibis* and *Egretta garzetta*, present in roughly equal numbers. The intertidal mudflats are also important for migratory shorebirds (39 species recorded), and the rare cranes (*Grus japonensis*, *G. vipio*) have been observed. *Pandion haliaetus* and *Falco peregrinus* occur on passage. Waterfowl recorded in the general area during a mid-January waterfowl census in 1988 included:

480 *Bubulcus ibis*

410 *Egretta garzetta*

130 *E. alba*

25 *Ardea cinerea*

220 *Pluvialis dominica*

35 *Charadrius dubius*

60 *C. alexandrinus*

50 *Tringa nebularia*

260 *T. glareola*

50 *Gallinago gallinago*

120 *Calidris ruficollis*

30 *C. subminuta*

1 *Larus saundersi*

17 *Gelochelidon nilotica*

Other fauna includes 16 species of molluscs and 18 species of crabs (Lin *et al.*, 1987).

Special floral values:The mixed mangrove stands contain *Rhizophora mucronata*, an endangered species in Taiwan.

Research and facilities:Detailed faunal and floral studies have been carried out by biologists from National Chung-Hsing University, and changes in the mangrove ecosystem have been monitored for the past thirty years.

References: Chen & Lee (1978); Lin *et al.* (1987); Wu (1986).

Criteria for inclusion: 1b, 2b, 2c, 3 b.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia.

Wetland name: Payu Lake

Country: Taiwan

Coordinates: 22°44'N, 120°53'E;

Location: on the boundary of Pingtung and Taitung Counties, in the southern highlands 40 km east of Pingtung.

Area: 5.13 ha.

Altitude: 2,040m.

Biogeographical Province: 4.27.12.

Wetland type: 15.

Description of site: A small freshwater lake high in the mountains of southern Taiwan, with a peak rising to 2,377m nearby. The lake is fed by local rainfall and drains west. The maximum depth is 1.5m, and the pH value 7.0.

Climatic conditions: Humid subtropical montane climate.

Principal vegetation: A species of *Chara* is the only large aquatic plant. There is virgin *Taiwania* forest to the northeast of the lake.

Land tenure: The lake and surrounding areas are owned by the Taiwan Forestry Bureau.

Conservation measures taken: None.

Conservation measures proposed: A protected area is in the planning stage.

Land use: Carp are reared in the lake by the Pingtung County Government, and there is occasional hunting in the surrounding areas.

Disturbances and threats: Disturbance from carp rearing activities and hunting.

Economic and social values: As one of the very few natural high mountain lakes in Taiwan, the site has considerable value for research and educational purposes.

Fauna: No information is available on the lake fauna. Forty-seven species of birds have been recorded from the surrounding forests, including many of Taiwan's endemic species (Lin *et al.*, 1987).

Special floral values: No information.

Research and facilities: Basic limnological studies have been conducted by Otsu *et al.* (1984), who give a list of the phytoplankton and zooplankton.

References: Lin *et al.* (1987); Otsu *et al.* (1984).

Criteria for inclusion: 1a.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia.

Wetland name: Nanjen Lake

Country: Taiwan

Coordinates: 22°05'N, 120°51'E;

Location: in the northeastern part of Kenting National Park on the Hengchun Peninsula, at the southern tip of Taiwan.

Area: 150 ha.

Altitude: 319m.

Biogeographical Province: 4.27.12.

Wetland type: 14 & 19.

Description of site: A freshwater lake with deeply indented shoreline and associated marshes surrounded by grassland and abandoned rice paddies; in the forested hills of the Hengchun Peninsula. The depth of the lake varies from 0.5-1.5m according to the local rainfall, and reaches its lowest at the end of the dry season (November to May). Salinities are in the range 0-0.4 p.p.t., and pH values in the range 5-7.

Climatic conditions: Humid tropical climate with an annual rainfall of 1,700-2,000 mm, about 80% of which falls during a rainy season from June to September. The mean annual temperature is 23°C (maximum 30°C, minimum 15°C), and the relative humidity in the range 72%-84%.

Principal vegetation: 110 species of aquatic plants have been recorded (Lin *et al.*, 1987). The dominant submergents are *Najas minor*, *Spirogyra arcta* and *Riccia fluitans*; the dominant floating species are *Nymphoides cristata*, *Nymphaea rubra* and *Azolla pinnata*; and the dominant emergents are *Eleocharis dulcis*, *Schoenoplectus juncooides*, *Leersia hexandra* and *Sagittaria trifolia*. The dominant vegetation in surrounding areas is tropical monsoon forest with some open areas of grassland.

Land tenure: The lake is privately owned, and the surrounding areas are Public Land. Some 66.62% of the National Park is Public Land and 33.38% is private.

Conservation measures taken: The lake is included within the Kenting National Park (32,631 ha), established in 1982. Hunting is strictly prohibited by the Park Authority, but only 30% of the habitat is under strict protection. The lake and adjacent areas were designated as the Nanjen Ecological Preservation Area in 1984.

Conservation measures proposed: It has been proposed that the lake be made into a Bird Sanctuary.

Land use: The lake is used for water supply. Rice paddies around the lake have been abandoned and the virgin forests in surrounding areas are protected.

Possible changes in land use: There is a proposal to build a check dam to maintain water levels in the lake.

Disturbances and threats: *Leersia hexandra* is spreading rapidly in the lake, and will have a significant effect on the lake's ecology.

Economic and social values: The lake is of considerable value for scientific research.

Fauna: The diverse fauna includes nine species of molluscs, seven species of crustaceans, 21 species of fishes (with an introduced *Tilapia* hybrid as the most abundant), 14 species of amphibians and 24 species of reptiles (Lin *et al.*, 1987).

Eighty species of birds have been recorded in the area, including 27 species of waterfowl, mainly herons and egrets, dabbling ducks (*Anas* spp) and shorebirds.

Special floral values: Four rare species of aquatic plant occur, namely *Rotala wallichii* (recently recorded for the first time in Taiwan), *Floscopa scandens*, *Isachne niliaceae* and *Monochoria korsakowii*.

Research and facilities: The fauna and flora of the lake have been well documented, and a limnological study has been carried out by Lue *et al.* (1985). A permanent Ecological Station was established in 1987. A considerable amount of information is available on the National Park as a whole. There are extensive facilities for visitors and for the large permanent staff, and numerous programmes of conservation education, interpretation and scientific research are now being carried out or are planned for the future.

References: Chen & Wang (1985); Huang *et al.* (1984); IUCN (in prep); Karpowicz (1985); Lin *et al.* (1987); Lue *et al.* (1985); Wang (1985).

Criteria for inclusion: lb. 2a, 2b.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia.

Wetland name: Lungnantan Lake

Country: Taiwan

Coordinates: 21°59'N, 120°44'E;

Location: 3 km southeast of Hengchun, in the southwestern part of Kenting National Park, at the southern tip of Taiwan.

Area: c.175 ha.

Altitude: Less than 50m.

Biogeographical Province: 4.27.12.

Wetland type: 14.

Description of site: A freshwater lake with surrounding marshes, fed by local rainfall. The maximum depth is 3.5m but the lake level fluctuates greatly with the seasons, reaching its lowest at the end of the dry season (November to May).

Climatic conditions: Humid tropical climate with an annual rainfall of 1,700-2,000 mm, about 80% of which falls during a rainy season from June to September. The mean annual temperature is 23°C (maximum 30°C, minimum 15°C), and the relative humidity in the range 72%-84%.

Principal vegetation: No information is available on the aquatic vegetation. Rice paddies, onion fields and *Leucaena* plantations in adjacent areas.

Land tenure: The lake is Public Land; surrounding areas are privately owned.

Conservation measures taken: The lake is included within the Kenting National Park (32,631 ha), established in 1982. The lake was designated as a Scenic Area in 1984.

Conservation measures proposed: There is a proposal to make the lake into a Bird Sanctuary.

Land use: The lake is used for water supply and for the culture of fish and clams. Rice and sisal (*Agave rigida* var. *sisalana*) are farmed in the surrounding areas.

Disturbances and threats: None known.

Economic and social values: The lake provides water for irrigation and is a public water supply for the Hengchun area. It is one of the most popular spots for bird-watching in Taiwan.

Fauna: Thirteen species of freshwater fishes occur in the lake, a species of *Tilapia* being the most abundant. Over 70 species of waterfowl have been recorded, mainly herons, egrets, ducks, rails and shorebirds. The lake is particularly important during the autumn migration season when large numbers of Ardeidae, ducks and shorebirds stop over briefly on their way to the Philippines and beyond.

Waterfowl recorded during a mid-January census in 1988 included three *Podiceps nigricollis* (a rare winter visitor to Taiwan) and:

92 *Anas acuta*

48 *A. clypeata*

1,352 *Aythya fuligula*

50 *Fulica atra*

along with small numbers of *Tachybaptus ruficollis*, *Phalacrocorax carbo*, five species of herons and egrets, and five other species of ducks.

Special floral values: None known.

Research and facilities: Numerous avifaunal surveys have been conducted at the lake. A considerable amount of information is available on the National Park as a whole. There are extensive facilities for visitors and for the large permanent staff, and numerous programmes of conservation education, interpretation and scientific research are now being carried out or are planned for the future.

References: Huang *et al.* (1984); IUCN (in prep); Lin (1985); Lin *et al.* (1987).

Criteria for inclusion: 1b, 2b, 3 b.

Source: Lin Yao-Sung, Lue Kuang-Yang, Chen Ming-Yih and Chen Ching-Hsia.

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