

# SINGAPORE

## INTRODUCTION

by Christopher J. Hails

**Area:** 620.5 sq.km.

**Population:** 2,586,200.

Singapore is an independent island republic at the southern tip of the Malay Peninsula. It is situated between latitudes 1°09'N and 1°29'N, and longitudes 103°38'E and 104°06'E, and is

135 km north of the equator. It consists of one main island (41.8 km long and 23 km wide) and approximately thirty smaller ones to the south. The annual population growth rate is 1.1%. After Hong Kong, it is the second most densely populated country in the world, with a population density of 4,122 inhabitants per sq.km. The population, 84% of which lives in public housing, is well educated and has a high standard of living. The selection of sites for this Directory has taken into account the small size and high population density of Singapore. These factors dictate that conservation priorities and amenity requirements are somewhat different from those in larger, less densely populated countries.

The equatorial climate means Singapore temperatures are high (daily average 26.6°C) with average daily maxima and minima of 30.7°C and 23°C respectively. Mean humidity is around 85%, fluctuating between 65-95% daily. The average annual rainfall is 2,373 mm with the months of November to January being slightly wetter during the northeast monsoon. Thunderstorms are frequent.

The centre of the island has a series of low hills of granite and other igneous rocks. The highest is Bukit Timah (162.5m), and only three others exceed 100m in height. In the west and southwest of the island, there is a series of low ridges running northwest to southeast formed from sedimentary rock.

The city itself is situated in the centre of the southern coast. Major industrial estates occupy the southwestern corner at Jurong and Tuas; to the southeast is the Changi Airport development. In the centre of the island, dams have been constructed between the low hills to form four water storage reservoirs. The surrounding hills are covered in secondary forest which receives the double protection of being a catchment area and Nature Reserve (1,800 ha). The hill at Bukit Timah forms part of the Nature Reserve and contains 71 ha of good forest, some of which has never been logged.

The north and northeastern areas are still mostly used for farming, but all over the island new towns have been constructed or are under construction. These form a series of satellites around the city.

### **Summary of Wetland Situation**

The island is drained by a series of small streams, most of which have now been canalised. Where the larger streams join the coast, estuaries are formed and several of the larger ones have been dammed at the mouth to form water storage reservoirs. The coastline is mostly flat and muddy, the exceptions being Labrador, where low rocky cliffs abutt the sea, and Changi peninsula, which has always been sandy. Extensive land-fill has occurred all along the southern coast. These areas inevitably form sandy beaches after the filling has occurred, although mud is later deposited in the more sheltered bays. These land-fill areas now cover 5,400 ha of what was formerly a muddy coastline.

Historically, Singapore had some freshwater wetlands and extensive mangrove formations. Freshwater wetlands comprised an area of swamp forest in the north-central part of the island and smaller amounts near Jurong and in the river valleys, in total covering about 5% of the land area (Corlett, 1987a). The Jurong patch of swamp forest was felled in 1932 and that in the north largely cleared for the construction of Seletar Reservoir in 1940 (Corner, 1978), the smaller patches being lost long before that. All that now remains is a small area to the south of Seletar Reservoir near the Nee Soon (Yishun) firing range. A recent development has been the formation of freshwater wetlands on the banks of some of the shallow coastal reservoirs. The most extensive can be found on the edge of Poyan Reservoir in the west and at Kranji Reservoir to the north. Seletar Reservoir in the east has only recently been flooded but it too seems likely to develop some interesting wetland areas around its edges in the future.

Mangroves were once very extensive along the coast of the northern and western part of the island. It has been estimated that 13% (7,800 ha) of the main island were originally covered in mangrove (Corlett, 1987a & 1987b). Mangroves were included in Singapore's forest reserves as long ago as 1884. These were opened for exploitation in 1908 for poles and firewood. The Pandan reserve was the largest, being 1,012 ha in 1884, but by 1958 it had been reduced to 336 ha. It was appropriated for industrial development in 1962. The Kranji reserve met a similar fate, shrinking from its original 306 ha in 1937 to less than one ha in 1955, before finally being flooded by a reservoir in 1973. The most recent estimate is that of Corlett (1985), who reported that about 600 ha of highly degraded mangrove remained scattered around the island, but in the last two years, as much as one half of this may have been destroyed and there may now be only 2-3% of the original mangrove cover remaining.

Wetlands still play an important role in the ecology of Singapore (Wee & Corlett, 1986). The freshwater swamp forest is of great botanical importance and is probably the last stronghold of various invertebrates in Singapore. The remaining mangrove is still important despite the fact that much of it has been so heavily disturbed that it has literally been reduced to one or two species of plants. However, the stretch between the Sungei Mandai Kechil and Sungei Mandai Besar still contains interesting plant species, some of which occur in no other locality on the island. This is, however, the last such place in Singapore.

Even those areas which have been cleared of mangroves can still form valuable wildlife habitat. Singapore is on a major migration route of shorebirds and is an over wintering site for many species. Mangroves tend to be cleared for the construction of prawn culture ponds, and the management of these ponds seems highly compatible with the existence of

shorebirds, especially if there are large mudflats nearby. The single richest location like this was the Serangoon Estuary which once ranked as one of the most important shorebird sites in the Malay Peninsula (Parish & Wells, 1984). Thirty species of shorebirds have been recorded there and the estuary once held up to 20,000 birds during the migration season. In addition, 15 species of herons and egrets (Ardeidae) have been seen there. Land-fill operations began at the site in 1984 and are still in progress. Whilst most of the bird species can still be found there, the absolute numbers have been reduced with the decline of the available mud area.

The disruption of the Serangoon system has led to attention being focused on other areas; the most promising appears to be in the northwest at the mouth of Sungei Buloh. Here a prawn-pond, mudflat and mangrove ecosystem is now attracting large numbers of birds. Lesser locations occur near Kranji Reservoir and Seletar estuary. A much visited pond system near Sembawang (Senoko) is also under land-fill operations, although numbers of birds were never high there. The sandy coastline around Changi attracts large numbers of those species only occasionally seen on muddy shores e.g. *Calidris alba*, *Charadrius peronii*, *Pluvialis squatarola* and *Arenaria interpres*.

The newly created freshwater wetlands at the edge of the reservoirs are of great ornithological interest, although botanically they are poor (R. Corlett, pers. comm.). The wetland formed at Sungei Poyan can only be seen at a distance as it is located within a military live-firing area. Much better known is the marsh at Kranji Reservoir. This contains the only nesting sites for *Ixobrychus sinensis*, *Ardea purpurea* and *A. cinerea* in Singapore. It holds the Republic's largest populations of *Gallinula chloropus* and *Porphyrio porphyrio*, and is important for *Ixobrychus cinnamomeus*, *I. eurhythmus* and a variety of warblers (Sylviidae). Various uncommon raptors such as *Aquila clanga* and *Circus aeruginosus* are also attracted to the site. As the area was flooded only fourteen years ago and the marshes are still maturing, the full potential of the site has probably not yet been realized. A similar area may well develop on the edge of the newly formed Seletar Reservoir in the future.

In Singapore there is great demand for any available land space for housing, industry, military training and other development purposes. Until recently conservation aims have taken very low priority. However, environmental awareness is increasing rapidly and there is every reason to be optimistic that one or two wetland areas may be saved for the benefit of future generations. A very interesting development which will help to arouse the public interest in wetlands is a series of projects by the Parks and Recreation Department to make wetland areas into features in public parks. Plans are in hand to incorporate mangrove stands into two new parks which are being developed. Boardwalks and interpretation facilities will be provided at one of these and possibly both. In another established park, plans are being developed to excavate a five hectare freshwater scrape adjacent to the coast, and convert the periphery to a marsh garden. The scrape will contain one or two small islands and should attract wetland birds to the site.

Although these three projects are on a small scale, it does mark a new concept in parkland design in Southeast Asia and will play an important role in heightening public awareness.

## **Wetland Research**

Almost no research has been done on the freshwater wetlands, although Corner (1978) provides documentation on the old swamp forest. Extensive work on the mangroves has been carried out at the University (formerly University of Malaya, then University of Singapore, now renamed National University of Singapore). This work has made Singapore's mangroves some of the most intensively studied in the world. Appendices I and II list current research projects and student theses at the University; a complete bibliography has never been compiled. In 1985 UNDP/UNESCO ran the Third Introductory Training Course on Mangrove Ecosystems in Singapore (UNDP/UNESCO, 1986).

## **Wetland Area Legislation and Administration**

Singapore has almost 2,000 ha of Nature Reserve. The only wetland area included in this is the remnant swamp forest at Nee Soon. There are currently no other freshwater or coastal wetlands with any protected status. The Nature Reserves Act provides adequate legislation for protected areas. In addition, the Wild Animals and Birds Act provides legislation for the protection of various categories of wildlife, including all birds with the exception of *Corvus splendens*, in every locality in the Republic. Thus, although the habitat itself is not secure, the wildlife within wetlands is protected. Establishment of wetlands protection must be made with the support of the Ministry of National Development and requires the approval of Cabinet.

In Singapore, the Nature Reserves Board is responsible for the administration of protected areas, but this does not have any full-time employees and the Parks and Recreation Department provides the work-arm.

## **Organizations involved with Wetlands**

The Nature Reserves Board and the Department of Parks and Recreation in the Ministry of National Development are the primary governmental bodies involved with wetland administration.

Few bodies outside government are concerned with wetlands. Land-fill operations are carried out by the Jurong Town Corporation, the Port of Singapore Authority and the Housing and Development Board, all Statutory Boards of the Government. Research on wetlands is carried out by the National University of Singapore, and the importance of wetlands to the Singapore avifauna has been assessed by Hails (1985 & 1987a). The Malayan Nature Society (Singapore Branch) is interested in conservation of wetlands and the bird group in particular has been actively campaigning for this.

Appendix I: Current scientific research on mangrove biology at the National University of Singapore

Murphy, D.H. (1973 and continuing). Ecological Survey of Mangroves at Sungei Mandai.

Murphy, D.H. (1980 and continuing). The systematics and ecology of Singapore Onchicliacea (Mollusca: Gastropoda).

Murphy, D.H. (1985 and continuing). Lepidoptera associated with the mangrove ecosystem.

Murphy and Polhemus. (1986 and continuing). Biology of mangrove Gerrompotpha (Insecta: Herinptua).

Harminto, S. (1986 and continuing). Taxonomy and larval development of Ocypodidae (Crustacea: Brachyura).

Ng, P. (1984 and continuing). Taxonomy and larval development of Xanthidae (Crustacea: Brachyura).

Tan Hong Kim. Reproduction and population dynamics of *Marcia japonica* and *Marcia hiantina* (Mollusca: Bivalvia).

Sigurdsson, J.B. and Moss, S. (1985-86). Colour polymorphism of *Enigmonia aemigmatica* (Mollusca: Bivalvia).

Sigurdsson, J.B. (1984 and continuing). Larval development of mangrove molluscs.

Colombera, D. & Sigurdsson J.B. (1985-86). Karyology of mangrove Ellobiacea (Mollusca: Gastropoda).

Colombera D. & Murphy, D.H. (1985-86). Karyology of mangrove Onchidiacea (Mollusca: Gastropoda).

Ding, J.L. & Ho Bo. (1985 and continuing). Use of Carcimoscopus haematocytes agglutination in antigen recognition.

Wee, Y.C. & Wah, T.T. (1985 and continuing). The ecology and taxonomy of Diatoms. Tan, T.K. & Leong, W.F. (1985 and continuing). The ecology of mangrove Fungi.

Corlett, R & Mathews, M. (1986 and continuing). Ecology and systematics of mangrove Angiosperms with special reference to *Avicennia*.

Corlett, R. (1982 and continuing). Reproductive biology of mangrove plants.

Appendix II: Undergraduate theses in the Zoology Department, National University of Singapore, which have resulted from mangrove studies

Loke Teng Chun, M. (1967/68). ZTH 63. Some studies on the local species of the genus *Onchidium*.

- Sih Gek Huang, A. (1967/68). ZTH 64. A preliminary study on the morphological changes of the sipunculoid *Phascolosoma lurco* with age. Tan Wee Hin. (1968/69). The Teredinidae of Singapore.
- Chan Yueh Tarn. (1974/75). ZTH 139. A preliminary study of the biology of the bivalve *Glaucanome straminea* Reeve (Family Glaucomyidae) with observations on an associated bivalve *Coecela horsfieldi* Gray (Family Mesodesmatidae).
- Chin Mui Sim, M. (1974/75). ZTH 140. Thermal effects on some intertidal molluscs.
- Law Ting Ting, L. (1975/76). ZTH 146. Some reproductive and gut content studies on the bivalve molluscs *Glaucanome straminea* Reeve and *Coecella horsfieldi* Gray.
- Fernando, A-A. (1976/77). ZTH 156. A preliminary study on the effect of calcium on *Glaucanome straminea*, *Coecella horsfieldi horsfieldi* and *Mytilus viridis* (Molluscs: Bivalvia).
- Tan Hong Kim, (1983/84). ZTH 220. Some studies on reproduction and larval culture of the bivalve molluscs *Paphia marmorata* (Lamarck), *Anomia (anomia) caelata* Reeve & *Enigmonia cf. Aenigmatica* (Sowerby).
- Yap Soh Mooi. (1984/85). ZTH 250. Histology of the ureter of *Onchidium aberrans* (Semper).
- Yip Wal Kuan. (1985/86). ZTH 291. Studies on the reproductive habits and larva development of some Ellobiidae (Gastropoda: Pulmonata).
- Lal Hoi-Chew. (1964/65). ZTF 1a. A brief survey of plankton of brackish water in Singapore with relation to its environments.
- Charles, S. (1965/66). ZTH 4. A preliminary study on fouling organisms of Johore Strait.
- Yap Tung Buan. (1967/68). ZTFI 17. A preliminary investigation of the occurrence and characteristics of marine bacteria in Singapore and Johore Straits.
- Lee Hoe Beng. (1971/72). ZTF 34. A preliminary study on the tolerance of the brackish water Mysid *Mesopodopsis orientalis* Tattersall (Crustacea, Mysidae) to some environment factors.
- Nah Seang Chew. (1972/73). ZTF 38. A preliminary investigation of the benthic diatoms occurring in the littoral zone at Johore Straits.
- Suhaimi, A. (1965). ZTM 12. Systematic and biological studies of the barnacles (Cirripedia: Thoracica) of Singapore with special reference to the *Balanus amphitrite* complex.
- Khoo Hong Woo. (1966). ZTM 13. A preliminary study of the physical, chemical and biological characteristics of Johore Straits.
- Soo Cheng Lam. (1969). ZTM 24. Studies on some biological aspects of Sesarma (Decapoda, Brachyura) of Singapore.
- Lim Al Poo. (1983/84). ZTH 213. Some studies on sexual dimorphism, reproduction and larval development of *Isognornon ephippium* (Linnaeus).

## WETLANDS

Site descriptions compiled by Christopher J. Hails in collaboration with R. Corlett and D.H. Murphy of the National University of Singapore.

**Wetland name:** Sungei Poyan Reservoir

**Country:** Singapore

**Coordinates:** 1°23'N, 103°40'E;

**Location:** on the west coast of Singapore Island.

**Area:** c.60 ha.

**Altitude:** Sea level.

**Biogeographical province:** 4.7.1.

**Wetland type:** 11, 15 & 17.

**Description of site:** A large water storage reservoir with fringing freshwater marshes, formed by the damming of the estuary of the Sungei Berih and Sungei Poyan rivers. The shallow edges of the reservoir and the slow moving rivers support a rich growth of aquatic vegetation. The reservoir is fed by the Berih and the Poyan, perennial rivers rising in the interior of the island.

**Climatic conditions:** Humid tropical climate with an average annual rainfall of 2,373 mm, an average relative humidity of 85%, and temperatures in the range 23.7-30.7°C.

**Principal vegetation:** Flooded grassland and scrub, with some *Achrostichum* fern; old rubber plantations and secondary growth in adjacent areas.

**Land tenure:** The wetland and surrounding areas are state owned.

**Conservation measures taken:** None. The whole site lies in the centre of a military live-firing area and the public are denied access. Wildlife can be viewed through telescopes from a nearby hill-top.

**Conservation measures proposed:** None

**Land use:** Public water supply and Military live-firing range; some wasteland and cemeteries nearby.

**Disturbances and threats:** Constant movement of vehicles, troops and large calibre shells through the area.

**Economic and social values:** None other than water supply. The area was a popular bird-watching and fishing spot before being closed off to the public.

**Fauna:** Despite the disturbance, the area is rich in marshland birds. Of particular interest in that it is the only Singapore locality for *Nettapus coromandelianus*, *Anas acuta* and *Fulica atra* (a great rarity in Southeast Asia). It also holds *Ardea cinerea*, *Dendrocygna javanica*, *Gallinula chloropus* and *Porphyrio porphyrio* in numbers which are significant by Singapore standards. For several years it provided an overwintering site for Greater Spotted Eagles *Aquila clanga*, and is one of the regular haunts of harriers (*Circus* spp) in winter.

**Special floral values:** None known.

**Research and facilities:** None

**References:** None

**Criteria for inclusion:** 2b.

**Source:** Christopher J. Hails.

**Wetland name:** Sungei Buloh Prawn Ponds and Mangrove

**Country:** Singapore

**Coordinates:** 1°27'N, 103°43'E;

**Location:** at the northwest corner of Singapore Island, to the west of the Sg. Buloh Besar.

**Area:** c.20 ha.

**Altitude:** 0-5m.

**Biogeographical province:** 4.7.1.

**Wetland type:** 02, 03, 06, 07 & 10.

**Description of site:** An area of much degraded mangrove which has been almost entirely cleared for the construction of prawn culture ponds, and some better stands of mangrove on the small offshore island of Pulau Buloh. The whole system is adjacent to farmland where fruit and vegetables are grown and chickens raised. The ponds are fed by tidal inflow and run-off from nearby farmland, and vary in depth from 0-2m. The tidal range is 3.2m.

**Climatic conditions:** Humid tropical climate with an average annual rainfall of 2,373 mm, an average relative humidity of 85%, and temperatures ranging from 23.7° to 30.7°C.

**Principal vegetation:** Mangroves; farmland and wasteland in adjacent areas.

**Land tenure:** The land tenure of the site is not known. Ownership of the surrounding land probably reverts to the State as the farms are cleared.

**Conservation measures taken:** None.

**Conservation measures proposed:** A formal proposal for protection of the site has been submitted to the Government.

**Land use:** Aquaculture for prawns; agriculture in adjacent areas.

**Possible changes in Land use:** Many of the farms have been resettled by the Government, and there are plans to develop the area for agro-technology.

**Disturbances and threats:** Possible future development.

**Economic and social values:** The wetland has potential recreational value as a bird-watching area.

**Fauna:** Forty-four species of water birds have been recorded, and concentrations of over 5,000 shorebirds have been observed. The site seems to be assuming greater importance as other locations on the island suitable for shorebirds are being lost. About 125 species of birds have been recorded at the site; this is 41% of the Singapore avifauna.

**Special floral values:** The mangroves on Pulau Buloh seem to be unusually mature for Singapore.

**Research and facilities:** None

**References:** None

**Criteria for inclusion:** 2b.

**Source:** Christopher J. Hails.

**Wetland name:** Kranji Reservoir and Estuary

**Country:** Singapore

**Coordinates:** 1°25'N, 103°43'E;

**Location:** at the northwest corner of Singapore Island.

**Area:** c.80 ha.

**Altitude:** 0-5m.

**Biogeographical province:** 4.7.1.

**Wetland type:** 02, 06, 07 & 17.

**Description of site:** A former river which has been dammed at its mouth to form a freshwater storage reservoir. There is still a small estuary with mudflats and very degraded mangroves below the dam. The most important area is the flooded edge of the reservoir which forms a freshwater marsh, a fairly rare type of habitat in Singapore and Peninsular Malaysia. The reservoir is fed by run-off from the catchment area, and probably does not exceed 10m in depth. The maximum tidal range on the mudflats is 3.2m.

**Climatic conditions:** Humid tropical climate with an average annual rainfall of 2,373 mm, an average relative humidity of 85%, and temperatures ranging from 23.7 to 30.7°C.

**Principal vegetation:** Coastal mangroves with species of *Avicennia* and *Rhizophora* in the estuary; grassland with *Imperata cylindrica* and *Panicum maximum*, remnants of *Achrostichum* and some Acacia trees on the edge of the reservoir; extensive growths of *Eichhornia crassipes* at certain times. Urban areas, old coconut estates, vegetable farms and secondary growth nearby.

**Land tenure:** Most of the area is owned by the Public Utilities Board (Water Department); the surrounding areas are Government land.

**Conservation measures taken:** The reservoir is covered under the legislation which prevents pollution of a public water supply.

**Conservation measures proposed:** A recent proposal by the Malayan Nature Society (Singapore Branch) that steps be taken to re-establish the freshwater marshes as a Nature Reserve, replacing the one which was degazetted some years ago, has been rejected by the Public Utilities Board on the grounds that the existence of any marshy areas at the reservoir conflicts with their aim of having a "neat" reservoir. The Malayan Nature Society has subsequently proposed that the mangrove belt and muddy foreshore on the seaward side of the dam be developed as a Nature Reserve.

**Land use:** Public water supply; industry, farming and parkland in the surrounding areas.

Possible changes in **Land use:** In the future the marshland area may be reclaimed to prevent the development of the *Eichhornia* beds. The surrounding areas will undoubtedly be used for industry or housing purposes, although this will not be allowed to reduce water quality as it is a public water supply.

**Disturbances and threats:** Possible land-fill, and possible "neatening" of the edges of the reservoir in an attempt to improve water quality.

**Economic and social values:** The site is a public water supply. The reservoir supports a freshwater fishery which is exploited on a limited and controlled scale. Sport fishing is allowed along one stretch of the bank (one of the few such sites in Singapore). Public recreation areas are provided along the dam and people collect shellfish on the mudflats, although the latter is mainly for pleasure rather than commercial purposes. The Singapore Science Centre has used part of the dam area for school science projects. There is a very good potential for converting the marsh area into a public recreation area to provide education facilities on freshwater systems and especially on the birdlife found there.

**Fauna:** Several species of fish occur, including the Climbing Perch. It is unlikely that there are any rare species, although there has not been any serious study of the area.

The area is noted for its waterfowl. It has the only breeding colonies of *Ardea purpurea* (over 100 individuals) and *A. cinerea* in Singapore. These are the only known breeding colonies of

these species south of Selangor in Peninsular Malaysia. The marshes are particularly rich in Rallidae; *Rallus striatus*, *Porzana fusca*, *P. cinerea* and *Amaurornis phoenicurus* are common, and there are large numbers of *Gallicrex cinerea* (100+), *Gallinula chloropus* (200+) and *Porphyrio porphyrio* (200+), species seldom seen elsewhere in Singapore. *Ixobrychus sinensis* is a very common winter visitor, and has recently begun to breed. *I. eurhythmus* and *Hydrophasianus chirurgus* are rare visitors. The grasslands hold probably the largest Singapore population of *Ixobrychus cinnamomeus*, and are important wintering areas for *Acrocephalus orientalis*, *A. bistrigiceps* and other small passerines. The largest congregations of the weaver *Ploceus philippinus* in Singapore nest in the nearby coconuts and feed on the grass seeds.

The offshore mudflats can provide low-tide feeding for up to 2,000 shorebirds, adding greatly to the overall diversity of the site. The most numerous species are *Pluvialis dominica*, *Charadrius mongolus*, *Tringa totanus*, *T. nebularia* and *Calidris ferruginea*. *Chlidonias leucoptera* and *Sterna albifrons* feed over the sea and the reservoir in large numbers (500+ of each).

Some of the largest Water Monitors *Varanus salvator* in Singapore are to be found here.

**Special floral values:** None known.

**Research and facilities:** None

**References:** Hails (1985 & 1987b); Hails & Jarvis (1987).

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

**Source:** Christopher J. Hails.

**Wetland name:** Mandai Mangroves

**Country:** Singapore

**Coordinates:** 1°28'N, 103°46'E;

**Location:** on the north coast of Singapore Island, adjacent to the causeway to Malaysia.

**Area:** 10 ha.

**Altitude:** Sea level.

**Biogeographical province:** 4.7.1.

**Wetland type:** 02, 06, 07 & 11.

**Description of site:** A narrow coastal strip between a railway line and the sea, with mangroves, intertidal mudflats, and the estuarine systems of two small rivers. The site has been disturbed in parts by the construction of a stilted village, but parts are relatively undisturbed, although all the timber has been cut over at least once. The site contains the last significant stand of mixed mangrove forest in Singapore. The maximum tidal range is 3.2m.

**Climatic conditions:** Humid tropical climate with an average annual rainfall of 2,373 mm, an average relative humidity of 85%, and temperatures ranging from 23.7 to 30.7°C.

**Principal vegetation:** Mangrove forest with species of *Rhizophora*, *Avicennia*, *Bruguiera* and *Sonneratia*. Urban ornamental plantings in adjacent areas.

**Land tenure:** Formerly occupied by a small village (kampong) which has now been rehoused; tenure has probably reverted to the State. Adjacent areas are partly owned by the Malayan Railways and are partly private.

**Conservation measures taken:** None.

**Conservation measures proposed:** The Nature Reserves Board has recently proposed designating this as a nature reserve; the outcome is yet to be decided.

**Land use:** Some subsistence shell fishing. There is an abandoned village at the site, and a railway line, a main road and several factories nearby.

Possible changes In **Land use:** Possible further industrial development in the water catchment area.

**Disturbances and threats:** Possible landfill.

**Economic and social values:** Some subsistence shell fishing occurs at the site. The main potential lies in the amenity value for recreation and environmental education.

**Fauna:** A large number of organisms are on record from this site as a result of several years of study by biologists from the National University of Singapore. The invertebrates include 20 Protozoa, 10 Platyhelminthes, three Nemertina, 12 Aschelminthes, 109 Mollusca, 13 Annelida, nine Myriapoda, 486 Insecta, 120 Crustacea, 37 Arachnida and two Merastomata. Vertebrates include 178 species of fish, two amphibians, 15 reptiles, 130 birds and nine mammals.

**Special floral values:** The last reasonably rich stand of mangroves in Singapore, with a number of species of plants which are not found in any other location in the country, e.g. *Avicennia lanata*, *Browniowia tersa* and *Finlaysonia obovata*. Twenty-five species of fungi, 49 algae, five mosses (Bryophyta), 24 ferns (Pteridophyta), 88 dicotyledons, one gymnosperm and 33 monocotyledons have been recorded.

**Research and facilities:** There are no facilities for conducting research at the site but it has featured prominently in the research work of staff and students at the National University of Singapore. Projects and unpublished theses emanating from this work are listed in the Introduction.

**References:** None

**Criteria for inclusion:** lb. 2b.

**Source:** Christopher J. Hails.

**Wetland name:** Serangoon Estuary

**Country:** Singapore

**Coordinates:** 1°23'N, 103°56'E;

**Location:** in east-central Singapore at the mouth of the Serangoon River.

**Area:** c. 15 ha.

**Altitude:** Sea level.

**Biogeographical province:** 4.7.1.

**Wetland type:** 02, 06, 07, 08 & 10.

**Description of site:** A river estuary with extensive mudflats and prawn ponds adjacent to the Serangoon Sewage Works. The area formerly had extensive mangroves but much was destroyed by a sanitary landfill which began about 15 years ago. The wetland is saline and intertidal, with a tidal range of 3.2m.

**Climatic conditions:** Humid tropical climate with an average annual rainfall of 2,373 mm, an average relative humidity of 85%, and temperatures ranging from 23.7 to 30.7°C.

**Principal vegetation:** Remnants of mangrove forest, mainly *Avicennia* sp; wasteland, urban development and landfill desert which may be planted with ornamentals, in the surrounding areas.

**Land tenure:** The wetland and the adjacent areas are State Land.

**Conservation measures taken:** None.

**Conservation measures proposed:** A proposal made in 1984 to preserve the area was rejected.

**Land use:** The site is currently undergoing landfill for development purposes. Housing construction, sewage works and a rubbish dump in adjacent areas.

Possible changes in **Land use:** The whole of the wetland is slated for landfill coverage in the next few years.

**Disturbances and threats:** The present landfill operations are only half complete so the area is still able to attract large numbers of shorebirds for which it was formerly famous. However, the landfill is likely to destroy the area completely.

**Economic and social values:** The area formerly supported a prawn fishery, but fishing activities were discontinued prior to the onset of landfill. For many years it has been an extremely popular bird-watching and bird ringing site.

**Fauna:** Large numbers of waterfowl, especially shorebirds, once occurred at the site including at least three threatened species, Chinese Egret *Egretta eulophotes* (average maximum 15), Nordmann's Greenshank *Tringa guttifer* and Asian Dowitcher *Limnodromus semipalmatus*. It has been estimated that the estuary as a whole held up to 20,000 shorebirds during the migration seasons in the early 1980s. During the period 1977-1982, over 120 species of birds were recorded, including 54 species of waterfowl. Average maximum counts included:

200 *Pluvialis squatarola*

5,000 *P. dominica*

100 *Cliaradrius dubius*

50 *C. alexandrinus*

3,000 *C. mongolus*

200 *Numenius phaeopus*

500 *Tringa totanus*

250 *T. nebularia*

2,000 *T. glareola*

500 *Xenus cinereus*

500 *Actitis hypoleucos*

100 *Gallinago stenura*

1,000 *Calidris ruficollis*

50 *C. subminuta*

2,500 *C. ferruginea*

200 *Limicola falcinellus*

200 *Chlidonias leucoptera*

100 *Sterna albifrons*

*Pandion haliaetus* and *Falco peregrinus* are regular passage migrants and winter visitors, and unusual visitors have included a party of 11 Glossy Ibis *Plegadis falcinellus* in June 1984. Concentrations of over 500 *Motacilla flava* are common during the migration seasons. A large number of invertebrates have been recorded in the mudflats and remnants of mangroves.

**Special floral values:** None known.

**Research and facilities:** Studies of the shorebirds have been carried out by the Malayan Nature Society Bird Study Group, and regular bird counts were made during the period 1977-1982 by D. Bradford, H. Buck and R. Ollington.

**References:** Hails (1987b); Karpowicz (1985); Parish & Wells (1984); Ng (1977).

**Criteria for inclusion:** 2a, 3a.

**Source:** Christopher J. Hails.

**Wetland name:** Pulau Tekong Mangroves

**Country:** Singapore

**Coordinates:** 1°25'N, 104°03'E;

**Location:** on the north shore of a small island, Pulau Tekong, to the northeast of Singapore Island.

**Area:** c.20 ha.

**Altitude:** 0-5m.

**Biogeographical province:** 4.7.1.

**Wetland type:** 06 & 07.

**Description of site:** An area of mangroves and intertidal mudflats adjacent to an abandoned kampong (village). The site is mostly mangrove with some secondary vegetation on the landward side and some small mudflats offshore.

**Climatic conditions:** Humid tropical climate with an average annual rainfall of 2,373 mm, an average relative humidity of 85%, and temperatures ranging from 23.7 to 30.7°C.

**Principal vegetation:** Mangroves; agriculture, rubber plantations and secondary scrub in adjacent areas.

**Land tenure:** The wetland and adjacent areas are State land.

**Conservation measures taken:** None.

**Conservation measures proposed:** None

**Land use:** The whole island has been acquired by the military for training purposes, and public access is no longer allowed.

**Disturbances and threats:** No information.

**Economic and social values:** Formerly a popular spot for local naturalists and bird-watchers.

**Fauna:** The mangrove forest is the only site in Singapore for the Ruddy Kingfisher *Halcyon coromanda*, Mangrove Pitta *Pitta megarhyncha* and Mangrove Blue Flycatcher *Cyornis rufigastra*. Breeding has been proven for both the kingfisher and the flycatcher, and is assumed for the pitta.

**Special floral values:** None known.

**Research and facilities:** None

**References:** None

**Criteria for inclusion:** 2b.

**Source:** Christopher J. Hails.

**Wetland name:** Nee Soon (Yishun) Swamp Forest

**Country:** Singapore

**Coordinates:** 1°24'N, 103°48'E;

**Location:** in the northern part of the Nature Reserve southeast of Seletar Reservoir.

**Area:** c.15 ha.

**Altitude:** 5m.

**Biogeographical province:** 4.7.1.

**Wetland type:** 21.

**Description of site:** An area of permanently flooded peat swamp forest, the last remnant of a more extensive area which was cleared for the formation of Seletar Reservoir. It forms part of the catchment area for the public reservoir system in the centre of the island. The swamp is fed by local rainfall and drainage from the nearby hills; there is a slight drying out during periods of no rainfall.

**Climatic conditions:** Humid tropical climate with an average annual rainfall of 2,373 mm, an average relative humidity of 85%, and temperatures ranging from 23.7 to 30.7°C.

**Principal vegetation:** Peat swamp forest. There is an area of secondary rainforest with small patches of primary forest to the west, and an urban area to the east.

**Land tenure:** The wetland and forested areas to the west are State Land; land to the east is partly State Land and partly privately owned.

**Conservation measures taken:** Protected in a Nature Reserve under the Nature Reserves Act, and administered by the Nature Reserves Board. Part of the area has been declared a Protected Area by the Military for training purposes. Public access is restricted as it is adjacent to a military live-firing range.

**Conservation measures proposed:** None

**Land use:** Water catchment and Nature Reserve with no visitor facilities. Firing range, water catchment area and urban development in surrounding areas.

**Disturbances and threats:** Possible future excision from the Nature Reserve for a housing project.

**Economic and social values:** Amenity value for recreation and environmental education.

**Fauna:** There are no longer any specific swamp forest birds at the site, and most of the species still occurring are typical of secondary forest. It is, however, one of the few sites in Singapore where the Blue-eared Kingfisher *Alcedo meninting* is seen.

There is a small group of Banded Leaf Monkeys *Presbytis femoralis* resident in the area. The taxonomy of colobine leaf monkeys is controversial, but the group at Nee Soon are the last of what may be a distinct subspecies, *P. f. femoralis*, known only from Singapore (Lucas *et al.*, in prep).

**Special floral values:** This is the only location in Singapore where peat swamp forest is found, and thus it is the only locality for a large number of plant species.

**Research and facilities:** Corner (1978) has described the flora of the original swamp forest at this site (known to him as the swamp forest at Mandai Road). There is no recent listing of plants found in the forest patch that remains, but collections have been made in recent years by J. Maxwell and these materials are in the Herbarium of the Botanical Gardens, Singapore.

**References:** Corner (1978); Lucas *et al.* (in prep).

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

**Source:** Christopher J. Hails.

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