

RESTORING SINGAPORE'S BIODIVERSITY: From A Garden City To A City In Nature - Laws, Policies And Environmental Governance

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This chapter provides a short history of Singapore's journey in nature conservation, from the time of its independence in 1965, to the present. It examines the efforts of the National Parks Board (NParks), guided by government policies as expressed in the Singapore Green Plans, and the laws that were passed to protect flora, fauna and the natural environment. It concludes with NParks' Biodiversity Impact Assessment Guidelines; and the aspirations expressed in the Singapore 2030 Green Plan.

Introduction

The tiny city-state of Singapore (735.2 km²) faces the constant challenge of development versus conservation. Much of its original forest cover was cleared in the early years for gambier, pepper, rubber, and coconut plantations. Mangroves were exploited for firewood, charcoal, and prawn farms. Demands on the land were exacerbated upon independence with the urgent need to urbanise and industrialise. The need for more land made necessary the reclamation of its coastline and islands, which also adversely impacted the marine environment.

Today, more than 95% of the original forest cover has been cleared, and less than 10% of what remains is primary forest.¹ The present forest reserves cover 5% of total land area and harbour over 50% of remaining native biodiversity. Singapore has also lost up to 65% of its live coral cover since 1986,² as well as 95% of its mangroves³ and 85% of its sand and mudflats.⁴

Despite these challenges, Singapore has made concerted efforts to protect and preserve its greenery and has received many accolades for its efforts, the latest being voted the cleanest and greenest city, on 13th September 2021.⁵ Many native species have adapted successfully to the urban habitat, species of plants and animals new to science continue to be discovered, and some species thought to have been extirpated have had remnant populations rediscovered. It has been a journey of learning, as Singapore moved from merely greening its environment in the most expeditious way, which unwittingly brought in some alien invasive species, to carefully considered efforts to restore habitats and populations of native species.

From Garden City to City in a Garden

The Garden City was conceived by Singapore's first Prime Minister, Mr. Lee Kuan Yew, as a strategy to woo foreign investors as well as to make the environment more pleasant, particularly to reduce the heat of the tropics.⁶ The greening of Singapore as a government policy was declared in Parliament in 1968 when, during the second reading of the Environmental Public Health Bill, the Minister stated, "The improvement in the quality of our urban environment

¹ *The Natural Heritage of Singapore* 3rd ed. 2010; Hugh Tan, Chou LM, Darren Yeo, Peter Ng. See also Peter K. L. Ng, Richard Corlett & Hugh T. W. Tan, *Singapore Biodiversity: An Encyclopaedia of the Natural Environment and Sustainable Development*, Editions Didier Millet, 2011.

² Ria Tan, "Loss of coastal ecosystems" (December 2019), wildsingapore, online: <www.wildsingapore.com/wildfacts/concepts/loss.htm>.

³ Chou Loke Ming, "Nature and Sustainability of the Marine Environment", in Wong Tai-Chee et al, ed, *Spatial planning for a sustainable Singapore* (Berlin: Springer Science & Business, 2008) 169 at 170.

⁴ Zeehan Jaafar et al, *The Singapore Blue Plan 2018* (Singapore: The Singapore Institute of Biology, 2018) at 55.

⁵ Singapore was voted the cleanest and greenest city in the world, according to Time Out survey (yahoo.com)

⁶ See Lee Kuan Yew, *From Third World to First – The Singapore Story: 1965-2000 – Singapore and the Asian Economic Boom* (Harper Collins Publishers: New York, 2000).at 176:

To achieve First World standards in a Third World region, we set out to transform Singapore into a tropical garden city...We planted millions of trees, palms and shrubs. Greening raised the morale of people and gave them pride in their surroundings. We taught them to care for and not vandalize the area. We did not differentiate between middle-class and working-class areas... Within a year, there was a distinct spruceness of public spaces.

See also Lee Sing Kong, "Concept of the Garden City" in Ooi Giok Ling, ed., *Environment and the City: Sharing Singapore's Experience and Future Challenges* (Singapore: Times Academic Press, 1995) at 133; and Lye Lin-Heng, "A Fine City in a Garden – Environmental Law and Governance in Singapore", [2008] Sing JLS 68-117.

and the transformation of Singapore into a garden city – a clean and green city – is the declared objective of the Government.”⁷ PM Lee started the first Tree Planting Day in 1967 even before it became fashionable in the developed world. An Annual Tree Planting Day was launched on the first Sunday of November 1971. “In wooing investors, even trees matter”, reaffirmed Lee on 1 August 1996, when the Economic Development Board celebrated its 35th Anniversary.⁸

Singapore’s concerted efforts to green the city have been highly successful. In 1998, NParks declared that its mission “has evolved from realising a vision for a Garden City to creating a City in a Garden where the island’s seamless green infrastructure of parks and streetscapes play an essential part of Singaporeans’ lives, homes, workplaces and playgrounds.”⁹ Today, Singapore continues to place great emphasis on its greenery. It has strengthened its laws to protect its biodiversity and eco-systems, progressing to “a City in Nature”. This paper provides a quick overview of these laws.

Nature Conservation Laws

Laws to protect Singapore’s wild flora and fauna were passed over a hundred years ago, starting with the Protection of Wild Birds Ordinance in 1884.¹⁰

The Wild Animals and Birds Act (WABA) was passed in 1965 and renamed in 2020 as the Wildlife Act (WA) 1965, commencing 31 December 2021. It is ‘An Act for the protection, preservation and management of wildlife for the purposes of maintaining a healthy ecosystem and safeguarding public safety and health, and for related matters.’ This Act and its subsidiary laws used to be administered by the Agri-Food and Veterinary Authority (AVA) but are now administered by the National Parks Board (NParks). It requires NParks to appoint a Director-General, Wildlife Management.

Today, under the Wildlife Act (2020) all wildlife (fauna) are protected in Singapore, with added protection given to highly endangered species. There are also laws protecting trees and other plants. The extent of protection depends on their location as different laws and regulations apply. The greatest protection is for nature reserves and national parks, where breaches of the law will entail a fine of up to S\$50,000 or imprisonment of up to six months, or both fine and imprisonment under the Parks and Trees Act (PTA) 2005. Flora and fauna in public parks are protected to a lesser extent under the same Act. Separate laws protect parks in Sentosa Island, and parks administered by the Jurong Town Corporation (JTC) and the Public Utilities Board (PUB). Lastly, there are laws governing particular areas in Singapore, such as tree conservation areas and a marine park.

(1) General protection for wildlife in Singapore

The Wildlife Act 2020¹¹ protects all wild animals in Singapore – defined to include “any mammal, bird, reptile, amphibian, fish or invertebrate”. It is an offence to kill, trap, take or keep any wildlife without written permission from NParks - maximum \$5,000 fine for a first offence and \$10,000 for a subsequent offence (s. 5C). These penalties are enhanced for wildlife listed in the Wildlife (Protected Species) Rules, 2020 – fine \$50,000 or imprisonment for up to 2 years or both fine and imprisonment. These Rules protect 11 categories and species of mammals (including otters,

⁷ Mr. Chua Sian Chin, Minister for the Environment, in Sing., *Parliamentary Debates*, vol. 28 at col. 396 (16 December 1968).

⁸ See Chan Chin Bock, *Heart Work – Stories of How EDB Steered the Singapore Economy from 1961 to the 21st Century* (Singapore: Economic Development Board, 2002);

⁹ See NParks, “Singapore, The Garden City – Looking Ahead”, online: http://www.nparks.gov.sg/gardencity_d.asp; see also “‘City in a Garden Plan’ set out for Singapore” *The Straits Times* (11 December 1998); “Look Up, See the Green” *The Straits Times* (24 February 2001); and “Green Piece” *The Straits Times* (5 October 2002). See Mission and History - Who We Are - National Parks Board (NParks) for a history of NParks and a timeline of its evolution and conservation efforts.

¹⁰ See Lye Lin Heng, “Wildlife Protection Laws in Singapore”, (1991) *SJLS* 287–319; Lye Lin Heng, “Legal Protection of the Natural Environment”, *State of the Natural Environment in Singapore*, Clive Briffett and Ho Hua Chew eds., Nature Society, Singapore, June 1999; Joseph Chun, “Wildlife Law in Singapore: Protecting Wildlife in the ‘Garden City’” in *Wildlife Law: A Global Perspective* (ABA Publishing, 2008); Joseph Chun “Enhancing the Garden City: Towards a Deeper Shade of Green” (2006) *Singapore Academy of Law Journal*, Melissa B.N. Tan and Hugh T.W. Tan, *The Laws relating to Biodiversity in Singapore*, Raffles Museum of Biodiversity Research, NUS (2013).

¹¹ Singapore’s statutory laws can be found on this site - Home - Singapore Statutes Online (agc.gov.sg)

Sunda pangolin, Masked palm civet, Large Indian civet, Sunda slow loris, the Raffles' banded langur, fruit bats and flying foxes); 6 categories and species of birds; 9 categories and species of reptiles; 3 categories of fishes (rays, saw fishes and seahorses) and 8 categories and species of invertebrates (the Common birdwing butterfly, Giant clams and six categories of corals).

However, some wildlife species are not protected. These are listed in the Wildlife (Exemption) Order - 4 species of mammals (rats and mice), 4 species of birds, 5 species of lizards, and all invertebrates other than those that are specially protected under the Wildlife (Protected Species) Rules, 2020.

The Act also prohibits the "intentional" feeding of wildlife without permission from NParks – fine \$5,000 for a first offence, \$10,000 fine for subsequent offences (s. 5A). It is also an offence to release any wildlife "in any place" unless with written approval – fine \$5,000 (s. 5B). It is an offence to set up any spring gun, trap or device for the purpose of hunting or trapping a wild animal, if that device is likely to endanger human life – fine \$20,000 or imprisonment up to 12 months or both fine and imprisonment (s. 7). The sale or export of any wildlife (whether alive or dead) is an offence – fine \$10,000 or 12 months imprisonment or both; but if the animal is a protected species, the fine is \$50,000 or imprisonment up to 2 years or both (s. 8). It is also an offence to import any "living" wildlife without permission – fine \$10,000 or imprisonment up to 12 months or both (s. 9). These penalties are enhanced if the offence is committed in the course of an "animal-related business" (defined in the Act) - fine up to \$20,000 or imprisonment up to 12 months or both (s.5C (3)(b)).

Authorised officers and the police are given wide powers - they may remove wildlife traps on any private property, search, seize and arrest without a warrant (s.11A, 11B, 12). The court has power to order forfeiture of a conveyance seized in the commission of the offence (s.12C-E), and power to authorize repayment of expenses incurred in storage, housing, maintenance, transport, repatriation or disposal of any seized item (s. 12F). The court may also direct that any fine or part thereof be paid to the informer as a reward (s.13).

However, section 6 allows the occupier or person in charge of any land to "kill, trap or take any wildlife found damaging or destroying the crops or any other property thereon." This provision should be removed, particularly for protected species of wildlife, as they are extremely precious in urbanised Singapore. If it remains, the law should place the onus on the owner of property that was allegedly damaged by wildlife, to prove that he had taken all reasonable steps to protect his property and prevent any access by wildlife.

(2) Enhanced Protection for flora and fauna in Nature Reserves and National Parks

Singapore has four nature reserves (Bukit Timah Nature Reserve, Central Catchment Nature Reserve, Labrador Nature Reserve and the Sungei Buloh Wetland Reserve)¹² and two national parks (the Singapore Botanic Gardens and Fort Canning Park). All are protected under the Parks and Trees Act (PTA), 2005.¹³

Various activities are prohibited in a national park or nature reserve (s. 9 PTA). It is an offence to capture, displace or feed any animal; disturb or take its nest; use or possess any net, trap or hunting device for its capture, or carry out any activity which may injure or kill any animal. It is also an offence to release any animal into a nature reserve or to allow a domestic animal to stray into a nature reserve. The penalty is a fine up to \$50,000, or imprisonment up to six months or both fine and imprisonment, and a daily fine of \$500. The term 'animal' is given a very wide definition in section 2, to mean 'any mammal (other than man), bird, reptile, amphibian, fish (including shellfish), insect or any other living creature, vertebrate or invertebrate, and includes any egg or young thereof'.

¹² Sungei Buloh and the Bukit Timah Nature Reserve are also ASEAN Heritage Parks, declared on 18 December 2003 and 19 October 2011 respectively. See Joseph Chun, "The Protection of Nature Reserves under the Parks and Trees Act – A Deep Dive," APCEL Working Paper series 1905 (Dec 2019).

¹³ Act 4 of 2005.

For plants, it is an offence to carry out any activity within any national park or nature reserve which causes alteration, damage or destruction to any property, tree or plant within the park. The same penalties apply. Smoking is prohibited (fine up to \$2,000).¹⁴

(3) *Protection of flora and fauna in Public Parks*

A 'public park' is defined under the PTA (section 2) as 'any State land, any land belonging to the NParks or any other land, which is:

- (a) utilised as a public park, marine park, recreation ground, playground, garden, public open space, walk, park connector or green verge; and
- (b) managed or maintained by the Board.

The same prohibitions apply except the penalties are reduced to a maximum fine of \$5,000 (see Parks & Trees Regulations). There are also restrictions on the bringing of animals (other than a pet or guide dog) into a national park or public park or allowing the animal to enter any water body. For plants, it is an offence to cut, collect or displace any tree or plant or clear, break up, dig or cultivate any land. In both cases, the penalty is a maximum fine of \$2,000.

(4) *Protection of flora and fauna in other parks in Singapore*

Specific laws protect flora and fauna in the parks managed by the Jurong Town Corporation (JTC), Sentosa Development Corporation, and the Public Utilities Board (PUB).

The JTC manages several parks that used to include the Chinese Garden and Japanese Garden (today managed by the National Parks Board as the Jurong Lake Gardens). Various offences are listed under the JTC (Parks) Regulations¹⁵, particularly Regulation 4 that relate to the protection of animals, fish and waterfowl, birds, reptiles, insects as well as trees and plants. There are also restrictions on the bringing in of dogs and other animals to JTC parks. The maximum fine is \$500 for each offence.

Sentosa Development Corporation Parks

The Sentosa Development Corporation Regulations¹⁶ apply to Sentosa Island as well as eleven other smaller islands, namely St John's Island; Kusu Island; Pulau Hantu; Terembu Retan Laut; Sisters' Islands; Pulau Renggit; Lazarus Island; Pulau Seletar; Pulau Sudong; Pulau Jong; and Pulau Biola. Regulation 7 lists various acts that are prohibited on these islands. They are quite similar to the offences under the JTC (Parks) Regulations, including the prohibition on collection of any bird's egg or nest and the removal of any plant or tree. The penalty is a fine of up to \$2,000.¹⁷

Catchment Area Parks (under the Public Utilities Board (PUB))

The Public Utilities (Reservoirs, Catchment Areas and Waterway) Regulations were passed in 2006.¹⁸ "Catchment Area Parks are defined in the First Schedule to include a long list of reservoirs as well as some lakes. The Second Schedule specifies boundaries of the "Central Water Catchment Area", and the Third Schedule relates to parts of the Kallang River as a "waterway".

Regulation 6 lists various prohibited activities in Catchment Area Parks. These are quite similar to JTC and Sentosa Island parks, prohibiting the damage of any flora and the killing, hunting, shooting or trapping of any animal or the doing of any act which causes injury to the fauna. Regulation 7 lists activities that require prior approval – these include

¹⁴ Regulation 23 above.

¹⁵ Rg.2, GN.No. S 285/1988.

¹⁶ Rg.1 GN No.S 454/1997

¹⁷ Regulation 57.

entering or fishing in any reservoir or stream; collecting any bird's egg or nest; releasing any animal or allowing any animal to stray into a catchment area park; or removing or cut any plant, shrub or tree. Additional offences (unless with a permit) include using any part of the Central Water Catchment Area or Catchment Area Park as a location for the shooting of a film or the setting of a play; using live bait for fishing; drawing water from any reservoir or stream; releasing any animal into the waters or feeding marine animals. The penalty is a maximum fine of \$3,000.

(5) General Protection of Flora

Tree Conservation Areas

The Parks and Trees (Preservation of Trees) Order 1991, designated two areas of Singapore as tree conservation areas.¹⁹ It is an offence to cut down a tree with a girth that exceeds 1 metre, measured half a metre from the ground, if it is growing on vacant land or in a tree conservation area. Such trees can only be felled with permission of the Commissioner of Parks and Recreation. The penalty is a fine of up to S\$50,000 (s. 13-15 PTA). The PTA also empowers the Commissioner to order any person to maintain or preserve a tree in a tree conservation area.

The Commissioner may protect a large tree or group of large trees (girth of at least one metre) by serving a Tree Conservation Notice, (s. 15, PTA). However, this can be done only if the tree is either in a tree conservation area or is growing on vacant land. This Notice can be revoked at any time. In 2002, a real estate corporation was fined \$8,000 (the maximum fine then was \$10,000) for cutting down the last Changi tree (*Hopea sangal*) in a tree conservation area, taking into account that it was a first-time offender. The company was also ordered to pay S\$76,035 as compensation to the state for loss of the tree.²⁰

Heritage Road Green Buffers

Trees and plants along the verges of roads with mature trees and greenery may be protected, by designation as Heritage Road Green Buffers (s. 16, PTA). Five roads have been so gazetted – they are Mount Pleasant Road, South Buona Vista Road, Lim Chu Kang Road, Arcadia Road, and Mandai Road.²¹ It is the duty of the Board to manage and maintain these areas (s. 17). No tree or plant within these buffers can be cut or damaged without the permission of the Board (s. 18). The penalty of a maximum fine of \$50,000 applies.

Heritage Trees

In 2001, NParks established a Heritage Tree Scheme for the conservation of Singapore's mature trees. The public may nominate these trees via an online Heritage Tree nomination form. The list of nominated trees will be inspected by arborists from NParks before being submitted to the Heritage Tree Panel for approval. The criteria for endorsement of a Heritage Tree include (dependent on species) a girth (trunk circumference) of more than 5 metres and /or botanical, social, historical, cultural and/or aesthetical value. However, it does not appear that trees designated as "Heritage Trees" have legal protection per se. To date, there are some 260 heritage trees, located all over the island, each specifically mentioned in "Singapore's Heritage Trees Register", kept by NParks.²²

¹⁸ S 401/2006, formerly Public Utilities (Catchment Area Parks) Regulations (S 48/89). Amended by S 235/2010, S 70/2015 and S 155/2018.

¹⁹ The two tree conservation areas are: (1) The area bounded by Dunearn Road, Whitley Road, Mt. Pleasant Road, Thomson Road, Lornie Road, Pan Island Expressway, Clementi Road, Pasir Panjang Road, Telok Blangah Road, Lower Delta Road, Ayer Rajah Expressway, Alexandra Road, River Valley Road, Fort Canning Road and Selegie Road; (2) The area bounded by Netheravon Road, Cranwell Road, Loyang Avenue, Loyang Way, Upper Changi Road North and Changi Village Road.

²⁰ See Felling of the Chengal Pasir tree | Infopedia (nlb.gov.sg).

²¹ Section 15, PTA, Parks and Trees (Heritage Road Green Buffers) Order, 1 June 2006.

²² <https://www.nparks.gov.sg/gardens-parks-and-nature/heritage-trees>

Planting Areas and Streetscapes

The PTA enables the Commissioner of Building Control, where building works are being carried out, to require that the area be surrounded by a 'planting area' of certain dimensions (s. 22-27). It is an offence to carry out building works within these planting areas or to interfere with these planting areas (s. 24 - fine \$30,000 and a daily fine of \$500 for a continuing offence). The occupier of the premises has a duty to maintain the planting area (s. 25). The Commissioner is also empowered under s. 27 to require that the occupier of any premises "fronting, adjoining or abutting any public street", plant or replant any tree or plant within the green margin as well as maintain it, and even clear the area of weeds or cut the grass.

(6) *The Protection of Marine Life and Eco-systems*

Although four coral reefs were identified for conservation under the Singapore Green Plan in 1992, only one marine park exists – the Sisters' Islands Marine Park, established in 2014. This is a 40 hectare area around Sisters' Islands and along the western reefs of both St John's Island and Pulau Tekong.²³ In 2017 the definition of a 'public park' under the Parks & Trees Act was amended to include 'land utilised as a marine park'; and "marine park" is defined to mean "any area of the sea or seabed that is set aside for conservation of marine organisms and is designated in Part III of the Schedule."²⁴

It would appear that with the 2017 amendment to the PTA, the responsibility for marine conservation and protection of marine parks falls on NParks. Indeed, NParks is assuming increasing responsibility for surveys and data collection on marine life, protection and rehabilitation projects. The Singapore Land Authority (SLA) is responsible for the issuing of licences for removal of the substrate (sand, rock, coral) under the State Lands Encroachment Act (1883), but not for living organisms on the substrate or in the water column.

The Singapore Food Agency is responsible for the Fisheries Act²⁵ and its regulations. These laws require persons who use fishing gear to obtain a licence. Fishing vessels plying at any port in Singapore also require a licence. The trapping of fish by explosives or poisons, and the use of trawl nets are prohibited. Penalties include a fine of up to \$10,000 and/or imprisonment of up to 12 months. It is an offence to keep dangerous fish such as the piranha, and the penalty is a fine of up to \$50,000 and/or imprisonment up to 12 months.²⁶

Trade in Endangered Species - CITES

Singapore acceded to the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) in 1986 and passed the Endangered Species (Import and Export) Act (ESA) in implementation, in 1989. This was repealed and replaced with a new ESA in 2006²⁷ and this again was substantially amended in 2022, with effect from 1 November 2022. Each amendment increased penalties and tightened loopholes. NParks is now the authority that enforces the ESA, taking over from the Agri-Food and Veterinary Authority (AVA) which no longer exists as from 2019. NParks has appointed a Director, Wildlife Trade Control to implement the ESA.

CITES has three appendices – Appendix I is a list of animals and plants on the verge of extinction (no trade is allowed except for non-commercial purposes e.g. scientific research); Appendix II lists species which are not now threatened with extinction but may become so unless trade is carefully controlled; Appendix III lists species that need

²³ <https://www.straitstimes.com/singapore/environment/5-things-about-the-sisters-islands-singapores-first-marine-park> (15 July 2014)

²⁴ Act 4 of 2005, Cap 216, amended by Act 9 of 2017.

²⁵ Cap. 111, 2002 Rev. Ed. 1st January 1969, Amended by Act 11 of 2019 and Act 2015 of 2019.

²⁶ Animals and Birds (Piranha) Rules 2019, S 210/19.

special control in specific countries that list them. In all three cases, permits are required from various authorities and monitored by the CITES Secretariat in Geneva, Switzerland.

Singapore's ESA prohibits trade in endangered animals, plants and their by-products, unless with a permit from the National Parks Board. The subsidiary laws prohibit the sale of parts and derivatives of tigers, rhinoceros (horns) and elephants (tusks and teeth). Artificially propagated plants with proper permits may be brought into Singapore. As from 1 November 2022, ivory is prohibited from display except for educational or religious purposes.

Under the ESA, the penalty for trade in Appendix I species is a maximum fine of \$100,000 (up from \$50,000 previously) for each specimen of that scheduled species (but not to exceed \$500,000 or the market value of all the specimens of that species at the time of the offence, whichever is higher) or imprisonment for up to 6 years or both fine and imprisonment. For specimens in Appendix II or III, the maximum fine is \$50,000 for each specimen of that species (but not exceeding \$500,000 or the market value at the time of the offence, whichever is higher) or imprisonment up to 4 years or both fine and imprisonment. This new law makes it clear that the ESA applies to specimens on transit – proper permits must be issued by the country of export at least 14 days before its arrival in Singapore, and by the country of import or the final destination.²⁸ The same penalties for breach apply.

However, in the case of an offence by a corporation, unincorporated association or partnership, the fines are doubled – for Appendix I species, a maximum fine of \$200,000 for each specimen of that scheduled species (but not exceeding \$1,000,000 or the market value of all the specimens of that species at the time of the offence, whichever is higher), or imprisonment up to 8 years or both; and for Appendix II and III specimens, the maximum fine is \$100,000 for each specimen of that scheduled species (but not to exceed \$1,000,000 or the market value at the time of the offence, whichever is higher) or to imprisonment for a term not exceeding 6 years or both.

Officers from NParks have wide powers of enforcement including powers to investigate and powers of entry, search and seizure. Persons may be arrested without a warrant, and items used in connection with the offence including any conveyance such as vehicles, aircraft or ships or may be seized and forfeited, with some exceptions.

Protection of Biological Diversity

Singapore signed the Convention on Biological Diversity (CBD) in 1993 and ratified it on 21 December 1995. Many steps have been taken towards implementing this framework Convention. Surveys have been done of the biodiversity resources in Singapore. Under Article 15 (Access to Genetic Resources), States have sovereign rights over their natural resources; and access to genetic resources is to be determined by national laws. NParks has devised an application form which requires all persons conducting taxonomic/ecological research to seek prior written permission from the Board, but only for research on organisms within areas under the control or management of the Board.²⁹ The form requires the applicant to state the purpose for this research, the methodology (including duration and frequency of intended field survey or schedule of field trips); the logistic and field requirements (equipment, manpower, field survey locations, permanent traps/plots, marking, etc.). It also requests details on the collection of specimens – the applicant is to indicate the type/number/amount/ collection frequency required, specimen collection type (e.g., whether whole plant, animal, or part), the field or locality of research. The application requires a minimum of two weeks' processing time. As for marine species, the application must be made to the Land Office for permission. There does not appear to be any prescribed form.

²⁷ 2020 Rev. ed.

²⁸ See PP v Wong Wee Keong, [2019] SGCA 21; Burton Ong, Lye Lin Heng & Joseph Chun, "Regulating International Trade in Endangered Species – Transshipments of CITES-listed Species in Singapore" [2016] SingJLS 277-306.

²⁹ See Lye Lin-Heng & Rose-Liza Eisma-Osorio, "Regulatory Measures on Access & Benefit Sharing for Biological and Genetic Resources—National & Regional Perspectives from the Philippines, Singapore & ASEAN," chapter 13, Charles M McManis & Burton Ong (2017) *Routledge Handbook of Biodiversity and the Law*.

The Research Permit devised by NParks contains various conditions. These include the following: (1) the researcher must give prior notice to NParks before he proceeds to the field; (2) he must take into account the delicate ecosystem of the field venue, observing minimum clearance and disturbance to surroundings; and (3) he must keep the team small and not schedule trips during high-peak hours such as during school.

NParks initiated the Cities Biodiversity Index, which was adopted at the Convention on Biodiversity's Conference of the Parties in Nagoya in 2010.³⁰ The Singapore Index comprises three components;

- (a) Biodiversity in the City,
- (b) Ecosystem Services provided by the Native Biodiversity in the City, and
- (c) Governance and Management of Biodiversity in the City.

In this form, it would function as a monitoring tool.³¹ It is being tested now by other cities.

Beyond the Garden City to a City in Nature - Land Stewardship

The Garden City concept has been criticized as being "more successful in 'taming and manicuring' the urban environment with greenery and less so with protecting the ecological integrity of the natural heritage of Singapore."³² Environmental lawyers have also expressed disquiet that notwithstanding laws to protect wildlife habitats and ecosystems, "these laws are powerless against state encroachment."³³ Examples include the cutting of a 50 meter swathe separating the Bukit Timah Nature Reserve from the Central Catchment Nature Reserve in 1985 and the removal of part of the Kranji Reservoir Marshes in 2004 to make way for Singapore's 20th golf course, the Kranji Sanctuary Golf Course. Indeed, a major controversy started in 1992, soon after Singapore shared its 1992 Green Plan at the UNCED meeting in Rio, as this was soon followed by a proposal to take part of the Lower Peirce Reservoir (legally protected as part of a nature reserve) for a golf course. Thereafter came the proposed reclamation of Chek Jawa, a rich inter-tidal eco-system. The Nature Society objected strongly to both these proposed projects, producing its own Environmental Impact Assessment (EIA) as the authorities refused to disclose theirs.³⁴ Recent controversies include the Cross-Island mass rapid transit line which will cut beneath one of the country's largest nature reserves; the Bukit Brown cemetery, the Mandai Nature project, the Dover Forest and the Clementi Forest.

These issues are exacerbated as Singapore's laws do not provide for mandatory EIAs for projects that may have an adverse impact on the environment. The essence of the EIA is to "Look before you Leap", and it is a very important tool in planning for development projects. The nearest statutory equivalents to the EIA are sections 26 and 36 of the Environmental Protection and Management Act (EPMA³⁵), both of which relate to environmental pollution and hazardous installations. They focus only on industries or projects with high polluting capacity, whereas EIAs require a comprehensive, integrated and detailed study of all potential impacts on the environment, including ecological and sociological impacts. It is also a hallmark of EIA laws that they allow public participation and access to information, whereas sections 26 and 36 do not involve any third parties.

Many multilateral environmental instruments have called for states to implement EIAs, including the Rio Declaration on Environment and Development, 1992; the Convention on Biological Diversity (CBD), Agenda 21 (Earth's Action Plan)

³⁰ <https://www.nparks.gov.sg/biodiversity/urban-biodiversity/the-singapore-index-on-cities-biodiversity>

³¹ <https://www.nparks.gov.sg/-/media/nparks-real-content/biodiversity/singapore-index/handbook-on-the-singapore-index-on-cities-biodiversity-cbd-ts98.ashx>

³² Joseph Chun, "Enhancing the Garden City: Towards a Deeper Shade of Green" (2006) 18 Sing. Ac. L.J. 248 at 250.

³³ See Joseph Chun, "Wildlife Law in Singapore: Protecting Wildlife in the 'Garden City'", chapter 5 pp 201-256 in *Wildlife Law – A Global Perspective*, Raj Panwani, ed. (2008), American Bar Association at p. 213. See also J Chun "The Protection of Nature Reserves under the Parks and Trees Act – A Deep Dive", APCEL working paper 2019.

³⁴ See Goh Hong Yi, "The Nature Society, Endangered Species and Conservation in Singapore", chapter 8 in *Nature Contained – Environmental Histories of Singapore*, Timothy P Barnard (ed.), NUS Press, 2014, pp 245-275.

³⁵ Cap. 94A, 2002 Rev. ed; Act

and the 1985 ASEAN Agreement on the Conservation of Nature and Natural Resources.³⁶ The EIA process is also promoted by the United Nations Environment Program (UNEP).³⁷

Today, EIAs continue to be done in Singapore on an ad hoc basis, but increasingly, access to EIAs has been given to non-government organisations such as the Nature Society. It would appear that the authorities and responsible NGOs have started to work at achieving a workable partnership in caring for the environment. Announcements have been made on the Government Gazette informing readers that the EIA report can be viewed.³⁸ However, as there is no legislation mandating environmental impact studies, there is no system in place for the proper facilitation of such studies. There is no spelling out of the roles of the different parties, the right of the public to be informed and to be allowed to participate in the process of deliberation. This is a glaring inadequacy in our laws.

In 2020, NParks released its *Biodiversity Impact Guidelines*³⁹, stating that it is the biodiversity component of a full EIA and that “Development projects that are in or near to sensitive areas such as Nature Reserves, Nature Areas and areas of biodiversity interest, and all coastal and marine development projects, will be subject to greater scrutiny on their impacts to biodiversity.” However, this still falls short of an EIA as it only focuses on the impacts on biodiversity of a proposed development project whereas an EIA examines all the potential impacts of a proposed project including issues relating to pollution and contamination of natural resources as well as social impacts. The Guidelines are also not mandatory as they are not laws.

In February 2021, the government announced its Green Plan 2030, a “whole-of-nation movement” to advance the national agenda on sustainable development.⁴⁰ The plan, which is spearheaded by five ministries, charts Singapore’s green targets over the next 10 years, mindful of the challenges of climate change. In the context of nature, it aims to build “A City in Nature” with specific and laudable targets including the addition of new parks, more green spaces, and the planting of one million more trees.

Conclusion

While Singapore has indeed become the clean and green city state that its first Prime Minister strived for, it can do better. This calls for ethical public land stewardship using the concept of the public trust, wherein the government is viewed as trustee of all publicly-owned lands, for present and future generations of citizens and is under an obligation to give due consideration to ecological concerns and involve the public in its deliberations on land-use.⁴¹ It is essential that Singapore’s laws require the conduct of full EIAs before any development project is allowed to proceed. This is especially critical as climate change is a reality, and decisions on land use must be very carefully considered with the fullest possible information. There is therefore a need for public participation in environmental decision-making, as a true measure of the partnership between the state and the people.

Finally, this chapter calls for environmental education, which should include an understanding of ecology as well as ethics. This should be the way forward, in the spirit of Agenda 21, towards attaining the Sustainable Development Goals (SDGs), with government and citizens as co-stewards of the land for future generations of Singaporeans.⁴²

³⁶ See Article 14 of the ASEAN Agreement; Article 14 of the CBD; and Section III of the Agenda 21.

³⁷ See <http://www.unep.fr/pc/pc/tools/eia.htm>

³⁸ See the EIA commissioned by Jurong Town Corporation, relating to the reclamation of Pulau Ular. This appeared in the Government Gazette on 13 July 2006, informing the public that the EIA can be viewed at their office; see online <http://www.egazette.com.sg/Document/gg/2006/065016.pdf> Re the Cross Island MRT line, the Land Transport Authority has released its EIA online. See LTA | Environmental Impact Assessment (Phase 2) Report

³⁹ [bia-guidelines.pdf](https://www.nparks.gov.sg/bia-guidelines.pdf) (nparks.gov.sg)

⁴⁰ Home (greenplan.gov.sg)

⁴¹ See Joseph Chun, “Reclaiming the Public Trust in Singapore”, (2005) SAclJ 717-746; Lye Lin Heng, “Land Law and the Environment - Re-examining the Concept of Ownership and Forging New Rights and Obligations in a Changed World”, (2010) SAclJ 189-229.

⁴² For a comprehensive text on Singapore’s environmental laws, see Joseph Chun and Lye Lin Heng, *Environmental Law in Singapore* (2019), Singapore Academy of Law, 759 pp.

ALGAE

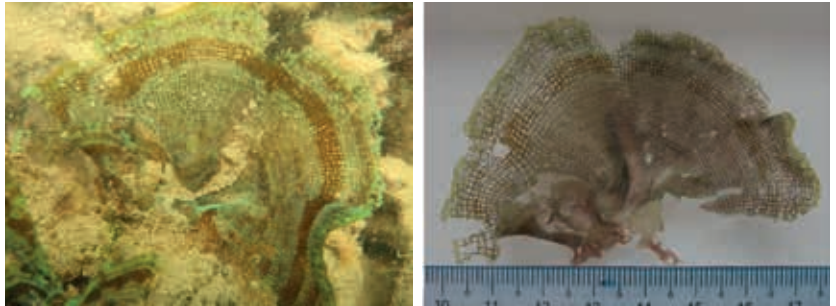
MICHELLE LEE AI CHIN, JENNY FONG, YIP ZHI TING,
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Algae were a taxon not assessed in the 2nd edition of the Singapore Red Data Book. For this 3rd edition, a total of 1107 species of algae were considered for assessment of which 932 were Not Evaluated (NE), 159 were Data Deficient (DD) and 16 were given a category of threat status of Least Concern (LC). While none of the algae species have been assessed as threatened, there is much work that remains to be done for anyone who is interested to study this fascinating taxon. A brief overview of some of the algae found in Singapore is provided in the following pages in the hope that some readers may choose to take an interest in this taxon with such a large number of species that are as yet awaiting detailed study in Singapore.

Phylum:
Rhodophyta

Family:
Delesseriaceae

Genus:
***Martensia* K.Hering,**
1841



Left image: field image, Pulau Hantu reef flat 14 Jan 2013; Right image: laboratory image

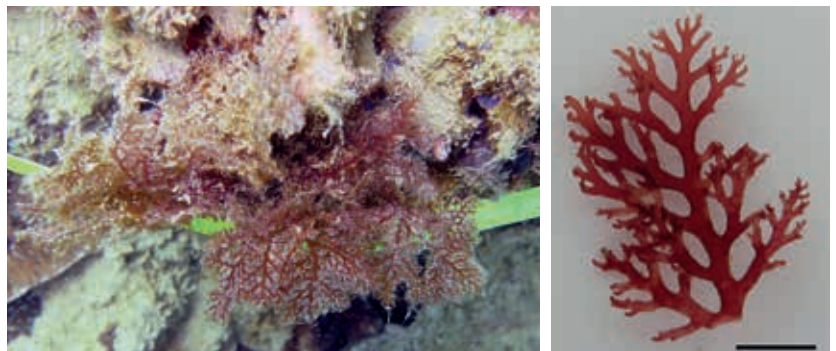
Martensia is a red alga that has thin membranous blades when young, mature thallus becoming net-like in appearance towards the edges. Generally sparsely distributed, most often found in sandy environments.

Phylum:
Rhodophyta

Family:
Rhizophyllidaceae

Genus:
Portieria

Species:
Portieria hornemannii
(Lyngbye) P.C.Silva 1987



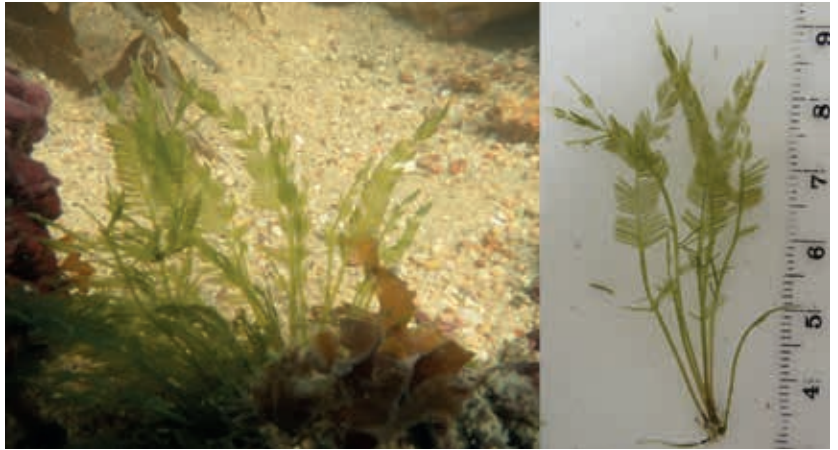
Left image: field photo Pulau Subar Laut, 28 Feb 2012; Right image: close up, scale bar = 5 mm

Portieria hornemannii is a small red alga, up to 50 mm tall. It is easily distinguishable by the in-curved tips of the thallus. This red algae is often found in areas of higher wave exposure, particularly on rocks and rubble in subtidal environments.

Phylum:
Chlorophyta

Family:
Bryopsidaceae

Genus:
Bryopsis J.V.Lamouroux,
1809



Left image: field photo, St. John's Island reef flat 12 Jan 2013

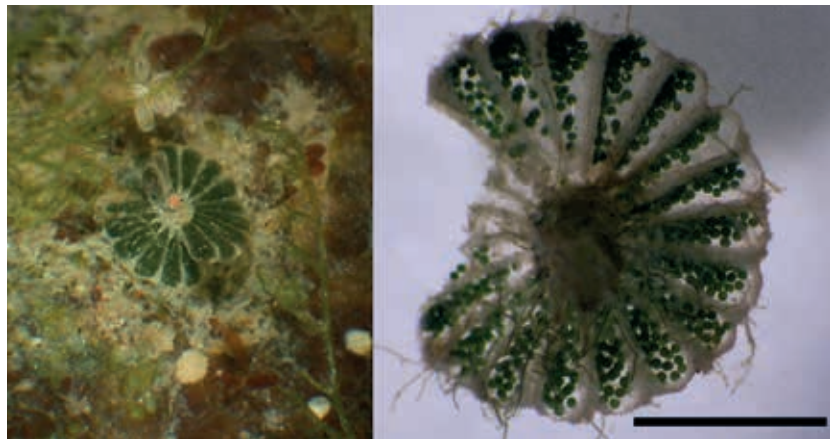
Bryopsis is a common green alga with feather-like fronds, growing on hard substratum such as rock, rubble and dead corals. Some species can form large seasonal blooms which persists for several months. Widely distributed in Singapore, found in many different habitats.

Phylum:
Chlorophyta

Family:
Polyphysaceae

Genus:
Parvocaulis

Species:
Parvocaulis parvulus
(Solms-Laubach)
S.Berger, Fettweiss,
Gleissberg, Liddle,
U.Richter, Sawitzky &
Zuccarello, 2003



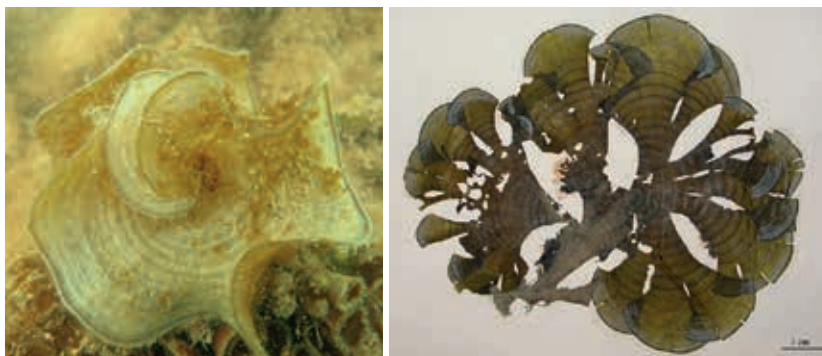
Left image: field photo, St. John's Island reef flat 12 Jan 2013; Right image: close up of cap, scale bar = 1 mm

Parvocaulis parvulus is a small green alga that is usually less than 2.5mm in diameter, resembling a daisy in appearance, consisting of a cap on a stalk. Often overlooked due to its small size. Can be found growing on rocks and rubble in the intertidal and subtidal.

Phylum:
Ochrophyta

Family:
Dictyotaceae

Genus:
Padina Adanson, 1763,
nom. cons.



Left image: Field photo of *Padina* sp, Pulau Hantu 14 Jan 2013; Right image: Pressed *Padina* sp. algae (herbarium specimen)

Padina is a fan-shaped brown alga, commonly found in both intertidal and subtidal environments, growing on rocks and rubble. Found in many areas in Singapore, in low to moderate cover.

Phylum:
Ochrophyta

Family:
Dictyotaceae

Genus:
Dictyota J.V.Lamouroux,
1809



Left image: field photo Pulau Satumu 21-08-2008; Right image: laboratory photo of cleaned algae, scale bar = 5 mm

Dictyota is a brown alga that is characterized by flattened blades that are dichotomously branched. Found in many areas in Singapore, in low to moderate cover.

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FLORA

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Included in this account are the bryophytes (liverworts, mosses and hornworts), lycophytes, ferns, gymnosperms and flowering plants. The classification systems we use here are the same as used in the *Flora of Singapore* (Middleton et al., 2019b) and are explained in more detail there. We do not include the algae and fungi which are classified separately.

The starting point to assess the conservation status of the plants of Singapore is the exploration of Singapore's forest and other habitats, the identification of the species found, and a comprehensive and accurate list of the taxa that occur in the country (Er et al., 2022). The greater the number of collections made in a country, coupled with the resources to properly study those collections, the better the chance that a country's plant diversity has been accurately recorded. Singapore has the highest collection density of any country in Southeast Asia, and possibly in the world (Middleton et al., 2019a).

There have been several checklists over time, the most recent and most detailed of which is the checklist and bibliography published by Lindsay et al. (2022). That list also included the most recent published national conservation assessment applied to each of Singapore's plant taxa or, when there was no previous published assessment or when the authors of the checklist and bibliography knew the previous assessment to be inaccurate, a new assessment was given. Lindsay et al. (2022) made clear, however, that they were not comprehensively reassessing all of the species known from Singapore as this was something to be done for the *Singapore Red Data Book* instead. Nevertheless, almost 1200 new or updated assessments were published in Lindsay et al. (2022). All the taxa recorded as Not Evaluated in Lindsay et al. (2022) have now been evaluated. The total number of native species and the number of species in each IUCN category is presented in Table 1.

The reassessment of the conservation status of all native plant taxa in Singapore has now been completed and is presented here. Since Lindsay et al. (2022), three species new to science and 16 new records of native species have been published. Moreover, about 28 species recorded by Lindsay et al. (2022) as Nationally Extinct have been rediscovered and their conservation assessments are updated here. In addition, further research has clarified the native status or otherwise of several species. As research on Singapore's plant diversity continues and as we progress with our work on the *Flora of Singapore*, we shall have an ever-more accurate list of the species that occur, whether they are native or not, where they can be found, what their ecological niches are, and what their conservation needs are. Research in the wider region and internationally will lead to the publication of papers which challenge our established norms. For example, since the publication of Lindsay et al. (2022), a paper has been published which has made some fundamental changes to the genus *Shorea* in the iconic plant family Dipterocarpaceae (Ashton & Heckenbauer, 2022). These changes and others are incorporated here and will be reflected in forthcoming *Flora of Singapore* accounts, meaning that a few species now have names different from those presented in Lindsay et al. (2022).

As a consequence of the substantial reassessments that already appeared in Lindsay et al. (2022), rather fewer taxa than one might expect, given the greater scrutiny applied in this work, have updated or new assessments, around 301 in all. The changes in some of the threat categories between the data presented in Lindsay et al. (2022) and the data

presented in Table 1, particularly for the bryophytes, is primarily due to the assessment of species previously listed as Not Evaluated rather than due to material differences in the fortunes of species in Singapore.

It should be borne in mind that this new review of the threatened statuses of Singapore's plants relies upon and builds upon the work published in Lindsay et al. (2022) which was compiled by over 100 authors. The authorship of this new review of the plants for the *Red Data Book* does not include the entire authorship of Lindsay et al. (2022) but rather only those who were actively involved in the reassessments and updating of the data presented here.

In the second edition of the *Singapore Red Data Book*, Tan (2008) presented a mixed picture of the prospects for plant diversity conservation in Singapore, emphasising both the huge deforestation in Singapore but also that the rate of deforestation has not been matched by a proportionate rate of species loss. This latter point, that Singapore has experienced a much lower rate of species loss than one would expect based on the amount of forest loss, has also been highlighted by Turner et al. (1994) and Neo et al. (2024). Nevertheless, 78% of Singapore's extant native plant taxa are assessed in one of the threat categories. Many plant species in Singapore are known from extremely few populations, sometimes even extremely few individuals, and NParks aims to ensure that these are protected in situ and are studied to assess their reproductive potential. When possible, these species are also brought into cultivation and Singapore Botanic Gardens' Seed Bank in order to protect against population loss or declines. They are sometimes also brought into tissue culture to increase the number of individuals. Plants cultivated from native stock, including those incorporated into NParks' Species Recovery Programme, can eventually be planted out in the nature reserves, nature parks, streetscapes, parks and gardens to ensure these species persist and eventually thrive again in Singapore. These initiatives complement ongoing work to better understand the ecology of Singapore's primary and secondary forests which could lead to informed forest restoration programmes using native stock.

	Total Species	Globally Extinct	Nationally Extinct (NEEx)	CR/D	EN/D	VU/D	LC	DD
Liverworts	122	1	37	37	22	5	15	5
Mosses	156	0	42	27	25	14	27	21
Hornworts	3	0	0	0	0	2	0	1
Lycophytes	12	0	4	1	2	2	3	0
Ferns	163	0	47	29	26	14	40	7
Gymnosperms	8	0	0	6	2	0	0	0
Angiosperms	2199	3	514	910	255	190	294	33
Totals	2663	4	644	1010	332	227	379	67

Table 1. Number of native species in each of the major plant groups and disposition of these species in the IUCN categories.

Liverworts

Scientific Name:

Gaolejeunea hoi W.Ye & Y.M.Wei

Common Name:

–

Family:

Lejeuneaceae

National Status: Endangered (EN)

Habitat and Ecology: This tiny, leafy liverwort is restricted to exposed tree roots and tree bases in shade under the canopy of mature forest.

Distribution: In the Bukit Timah and Central Catchment Nature Reserves but in small and scattered populations. Endemic to Singapore.

Threats: Degradation of habitat.

Photo: Wen Ye



Gaolejeunea hoi colony. Inset: close up.

Scientific Interest and Potential Value: It was recognised as a new species in 2021 and named after a local botanist who was the first to collect specimens. The Lejeuneaceae, the largest liverwort family, includes about half of all reported liverwort species in Singapore.

Conservation Measures: Its known localities are in nature reserves.

Scientific Name:

Podomitrium malaccense (Steph.) Campb.

Common Name:

–

Family:

Pallaviciniaceae

National Status: Endangered (EN)

Habitat and Ecology: This thalloid liverwort is restricted to soil banks, rotten logs and boulders in moist and shady gullies in mature forest.

Distribution: In Singapore, known in the Bukit Timah and Central Catchment Nature Reserves but in small and scattered populations confined to shady moist microhabitats. Also known from southern Thailand, Cambodia, Peninsular Malaysia, Sumatra, Borneo, Moluccas, Philippines, New Guinea and the Pacific Islands.

Photo: Ho Boon Chuan



Podomitrium malaccense colony.

Threats: Degradation of habitat and small population size.

Scientific Interest and Potential Value: First described from a specimen collected by H.N. Ridley on Bukit Timah. This liverwort belongs to a small genus of three species which is characterised by having sex organs that develop on the ventral surface of the thallus.

Conservation Measures: Its known localities are in nature reserves.

Mosses

Scientific Name:

Syrrhopodon ciliatus (Hook.) Schwägr.

Common Name:

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Family:

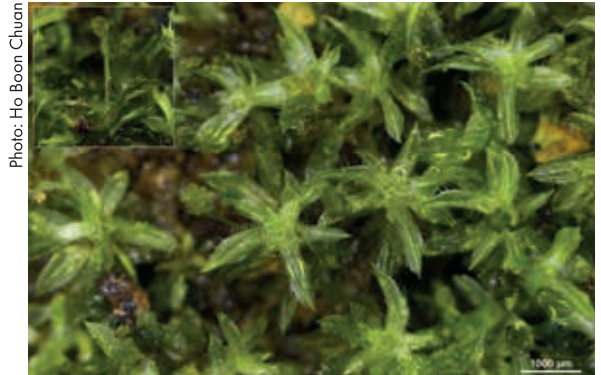
Calymperaceae

National Status: Endangered (EN)

Habitat and Ecology: This moss grows on tree trunks and, occasionally, also on humus in light shade in mature secondary lowland forest. In Borneo, it has been found above 1000 m on humus overlying limestone.

Distribution: In Singapore, sporadic and currently known only from very small populations in the Singapore Botanic Gardens and on Pulau Semakau. It is widespread throughout Malesia, northern Australia and across Oceania.

Threats: Degradation of habitat.



Syrrhopodon ciliatus colony.

Scientific Interest and Potential Value: With long delicate cilia along the leaf margins, this is one of the most distinctive species in this large pantropical genus of over a hundred species. Some of its leaves are strongly modified into a tube-like structures bearing fusiform gemmae (asexual reproductive structures).

Conservation Measures: The population in Singapore Botanic Gardens is protected under the Parks and Trees Act.

Scientific Name:

Ectropothecium singaporense Dixon

Common Name:

–

Family:

Hypnaceae

National Status: Endangered (EN)

Habitat and Ecology: Tree bases and exposed tree roots.

Distribution: Endemic to Singapore. Specimens have been collected from Singapore Botanic Gardens and a few parks and gardens.



Ectropothecium singaporense colony.

Threats: Staff in parks may routinely clear bryophytes from tree bases and exposed roots unaware that they are removing threatened plants.

Scientific Interest and Potential Value: This prostrate moss species was first described from a specimen collected in 1913 from Singapore Botanic Gardens where it persists today.

Conservation Measures: The populations in Singapore Botanic Gardens are protected under the Parks and Trees Act. There has been some success in the propagation of this species in the Evolution Garden of Singapore Botanic Gardens.

Hornworts

Scientific Name:
Notothylas javanica (Sande Lac.) Gottsche

Common Name:
–

Family:
Notothyladaceae

National Status: Vulnerable (VU)

Habitat and Ecology: This thalloid species is a colonist found on the surface of disturbed soils including those in flowerpots. However, populations are short-lived and occur sporadically then disappear after a few months.

Distribution: In Singapore, it has been collected fewer than 10 times in the last 30 years. It is, however, likely to be more common. Also known from other tropical and subtropical parts of Asia (Sri Lanka, China, Japan, Thailand, Sumatra and Java), Australasia (Australia), America (Mexico, Panama, Brazil), and Africa (Ivory Coast, Ghana and DR Congo).

Threats: Availability of suitable wild habitats, sporadic distribution and small population size.

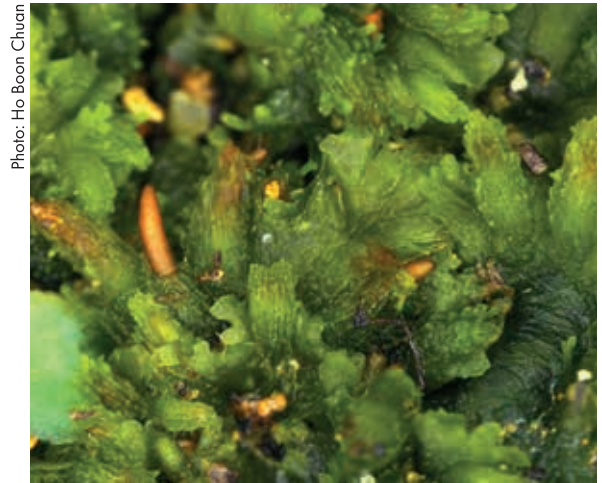


Photo: Ho Boon Chuan

Notothylas javanica colony.

Scientific Interest and Potential Value: Unlike other hornworts with typical erect sporangia, those in the genus *Notothylas* are short, finger-like and horizontal. In *Notothylas javanica*, the sporangia do not have any sutures and thus rupture irregularly to release their spores. The species is also distinguished by the absence of pseudoelaters.

Conservation Measures: Mostly collected from plant nurseries and gardens (horticultural settings) and more research is needed to assess its conservation needs in the wild.

Lycophytes

Scientific Name:

Phlegmariurus carinatus (Desv.) Ching

Common Name:

Keeled tassel-fern, Shoelace tassel-fern,
Paku tali kasut

Family:

Lycopodiaceae

National Status: Critically Endangered (CR)

Habitat and Ecology: In Singapore, a pendulous epiphyte in the crowns of tall trees. Elsewhere, also on mossy rocks in forests below 400 m.

Distribution: In Singapore, now only known from one locality in the Central Catchment Nature Reserve and from one rain tree close to the Central Catchment Nature Reserve. It is native to India (Andaman & Nicobar Islands) through to China and Japan and throughout continental Southeast Asia and Malesia to Australia (Queensland) and the Pacific Islands.

Threats: Degradation of habitat and loss of small populations. Most of the known plants are on a single rain tree in a semi-urban area that may be subject to overzealous pruning or even removal.

Photo: Ng Xin Yi



Pendent plant of *Phlegmariurus carinatus*.

Scientific Interest and Potential Value: Nowadays, one of only two species of native tassel-ferns; three others are presumed Nationally Extinct (NEx). A very attractive plant widely used in horticulture.

Conservation Measures: A small ex-situ conservation collection has recently been established at NParks' Native Plant Centre with the goal of preserving and propagating native stock. The fate of the rain tree that is home to most of the remaining plants must be closely monitored and, if necessary, its survival championed.

Ferns

Scientific Name:

Dipteris conjugata Reinw.

Common Name:

Broad-leaf fern, Bua cek, Paku payung

Family:

Dipteridaceae

Photo: Ng Xin Yi



A stand of *Dipteris conjugata*.

National Status: Critically Endangered (CR)

Habitat and Ecology: Large, terrestrial, sun-loving and stand-forming fern. In Singapore, it grows more-or-less at sea-level on coastal cliffs and steep earth embankments. Elsewhere, it grows in open montane forest and on exposed high-altitude ridges.

Distribution: In Singapore, now only known to occur naturally at a few coastal localities in the Western Catchment, including Pulau Sarimbun. It is native to China and Japan, through continental Southeast Asia and Malesia to Australia (Queensland) and the Pacific Islands.

Threats: Degradation of habitat and loss of small populations. Susceptible to being shaded-out by encroaching vegetation and to being wiped-out by cliff falls and landslides.

Scientific Interest and Potential Value: The populations in Singapore, which are more-or-less at sea level, are unusual for the species as a whole which is mostly known as being a species of higher altitudes up to 1700 m.

Conservation Measures: The remaining populations are within a military training area which affords some protection, and the species has also been included in NParks' Species Recovery Programme. The most accessible populations are regularly monitored and encroaching vegetation cleared. Propagation by rhizome division and by spores is proving difficult but one small clump has been successfully translocated from the Western Catchment to Labrador Park (a former locality) and a few sporelings have been raised from soil samples. Unverified reports of a population on Pulau Tekong warrant investigation.

Scientific Name:

Lindsaea parasitica (Roxb.) Wall. ex Hieron.

Common Name:

–

Family:

Lindsaeaceae

National Status: Endangered (EN)

Habitat and Ecology: A climbing fern (reaching heights of 2–3 m) which, in Singapore, grows only on trees and only in shady places with permanently wet soil and very high humidity such as by streams in primary forest and in intact freshwater swamp forest. Elsewhere in its range it is not restricted to stream banks and swamp forest; it also climbs rocks and occurs at altitudes up to 1100 m.

Distribution: In Singapore, now only known from one locality in Bukit Timah Nature Reserve and two localities in the Central Catchment Nature Reserve, including Nee Soon freshwater swamp forest. It is also found in Peninsular Thailand, Peninsular Malaysia, Sumatra and Borneo.

Photo: Stuart Lindsay



Lindsaea parasitica climbing a tree.

Threats: Degradation of habitat and loss of small populations. In Singapore, this species is vulnerable to any event or activity that could alter the normal levels of the water table and changes that reduce humidity or shade.

Scientific Interest and Potential Value: The behaviour of this species requires further study. While currently believed to always be a ground-rooted

climber in Singapore, published descriptions claiming the species is 'epiphytic', may mean that it sometimes loses its connection to the ground.

Conservation Measures: The remaining populations are in protected areas. Preservation of its stream and swamp habitats is the only way to ensure the survival of this species in Singapore.

Scientific Name:

Nephrolepis acutifolia (Desv.) Christ

Common Name:

Sword fern, Fish-bone fern

Family:

Nephrolepidaceae

National Status: Endangered (EN)

Habitat and Ecology: Nowadays in Singapore, only known as a low hanging (but very long) epiphyte on a range of tree species in secondary forest and parks in full or dappled sunlight. Formerly an epiphyte of trees near the sea, including in mangroves, and once reported as being 'common on ground in humus on rocky sea cliffs'. Elsewhere in its range is also epiphytic in swamp and riverine forests, on oil palms, and terrestrial in heath forest.

Distribution: Currently uncertain in Singapore but the distribution and habitats of the known plants suggests that more individuals may be widely scattered in secondary forests, parks and on street trees all over the island. It is native to tropical Africa and the Mascarene Islands through continental Southeast Asia and Malesia to parts of Australia and the Pacific Islands.

Threats: Degradation of habitat and loss of small populations. None of the known plants are in protected areas. Most are on trees that may be subject to overzealous pruning or even removal.

Scientific Interest and Potential Value: This is the only species of *Nephrolepis* with linear marginal sori, a characteristic that led to its misclassification in the wrong



Photo: Stuart Lindsay

Curtain of *Nephrolepis acutifolia*.

family for many years. Capable of forming a curtain of pendulous fronds up to 4 m long, this can be a strikingly beautiful fern whose horticultural potential may not yet be fully realised.

Conservation Measures: Although no plants are in protected areas, a few plants are epiphytic on at least one Heritage Tree which affords them some protection. Plants salvaged from a rain tree before it was cut down are being propagated in NParks' Native Plant Centre nursery for introduction to suitable sites. The fate of the other trees that are home to this fern must be closely monitored and, if necessary, their survival championed.

Gymnosperms

Scientific Name:
Cycas edentata de Laub.

Common Name:
Paku raja

Family:
Cycadaceae

National Status: Critically Endangered (CR)

Habitat and Ecology: In Singapore, in coastal forests along shorelines..

Distribution: Found on Pulau Tekong and in the Western Catchment. Also in Myanmar, Thailand, Vietnam, Malaysia, western Indonesia and the Philippines.

Threats: Loss of coastal habitats and loss of very small populations.

Scientific Interest and Potential Value: The only native cycad species in Singapore. It is extremely hardy and makes a striking ornamental plant, even at non-coastal locations. It is also the host plant of the native Cycad blue butterfly.

Conservation Measures: Individuals have been successfully propagated via manual pollination of female plants. Viable seeds have been collected from successful pollination and germinated in NParks' Native Plant Centre nursery. Established plants have been planted out to suitable coastal sites such as Kranji Marshes and Pulau Ubin.



Female cone of *Cycas edentata* bearing young seeds.



Cycas edentata in the wild.

Scientific Name:*Podocarpus polystachyus* R.Br. ex Endl.**Common Name:**

Sea teak

Family:

Podocarpaceae

National Status: Endangered (EN)**Habitat and Ecology:** In Singapore, mostly in coastal forest, beach vegetation and coastal cliffs but also found in lowland forest..**Distribution:** Found on several of the southern islands, on Pulau Ubin, in Labrador Nature Reserve and in the Western Catchment. There are a few trees in the Central Catchment Nature Reserve but it is likely that these were planted.**Threats:** Loss of habitat and loss of very small populations.**Scientific Interest and Potential Value:** One of only two native conifer species in Singapore. The trees are attractive and are sometimes used as ornamental and roadside trees.**Conservation Measures:** Some of the populations are in the Central Catchment and Labrador Nature Reserves and some are in the Sisters' Islands Marine Park. Other populations are not in protected areas. The provenance of many cultivated trees is unknown. Seeds and wildings have been collected from native localities and grown in NParks' Native Plant Centre nursery. Established plants have been planted out to suitable coastal sites such as Sungei Buloh Wetland Reserve and Labrador Nature Reserve.

Photo: Zaki Jamil

Male cones of *Podocarpus polystachyus*.