



# Arboricultural Journal

The International Journal of Urban Forestry

ISSN: 0307-1375 (Print) 2168-1074 (Online) Journal homepage: <https://www.tandfonline.com/loi/tarb20>

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To cite this article: Richard Webb (1998) URBAN FORESTRY IN SINGAPORE, Arboricultural Journal, 22:3, 271-286, DOI: [10.1080/03071375.1998.9747210](https://doi.org/10.1080/03071375.1998.9747210)

To link to this article: <https://doi.org/10.1080/03071375.1998.9747210>



Published online: 27 Mar 2012.



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## URBAN FORESTRY IN SINGAPORE

*Richard Webb\**

### Summary

Through progressive landscape and urban forestry policies over the past thirty years, Singapore has achieved its aim of becoming a 'green tropical city of excellence' and is a classic example of how environmental improvements have attracted both high technology industries and financial services to the city. The history of forest conservation and tree planting in Singapore is outlined. Urban forestry co-ordination between the main agencies is also described together with the choice of tree species used in the major planting schemes which give such character to the city.

**Keywords:** development • Singapore • urban forestry

### Introduction

The Republic of Singapore is an independent city state at the southern tip of the Malay Peninsula, 137 km north of the equator. It consists of the island of Singapore, which is separated from Malaysia by shallow straits, 0.6 km wide at the narrowest point, and various smaller islands with a total area of 626 km<sup>2</sup>, of which more than 30 km<sup>2</sup> has been added by recent land reclamation. The topography of Singapore is low, with an average elevation of 15 m. In the centre of the island is a hilly region of granite and other igneous rocks, rising to 162 m at Bukit Timah Hill. To the west are low lying sedimentary rocks while to the east are relatively flat areas of sands, gravels and alluvium. Most of the soils in Singapore are acidic, sandy clay loams, except for the marine sands and clays used in reclamation schemes.

Singapore has a typical equatorial climate with a mean annual rainfall of 2375 mm and no month with a rainfall of less than 100 mm. The mean monthly temperature is 26°C. Seasonality is very limited and is a consequence of changes in the prevailing wind direction. The lack of seasonality is expressed in the tree-lined streets which are green all year round and do not show the massed flowering displays of other tropical cities (e.g. see Figure 1).

\*'Springfields', 3 Hollybrook, Bray, Co. Wicklow, Ireland.

Singapore has a population of around 2.87 million people, as at July 1994, at an average density of 4,313 people per square kilometre, and 9,000 per square kilometre in the build-up urban areas. The population growth rate is 2.0 per cent. Singapore is a major regional trading and commercial centre with one of the highest living standards in Asia, and a per capita GNP of S\$ 24,871.



FIGURE 1. A tree-lined street in Singapore

### The Protection of Forests

When the British arrived in 1819, the whole island, with the exception of coastal mangroves, was covered with tropical rain-forest—the lowland dipterocarp forest of Malaysian foresters (WHITMORE, 1984). Increased cultivation of gambier, *Uncaria gambir*, grown for export to Britain, soon led to a drastic reduction in the area of primary forest, to around 64 per cent by 1848 (THOMPSON, 1850). Gambier cultivation soon exhausted the soil and by 1859 a third of the island's land area was described as abandoned land (BURKILL, 1960). Logging and firewood collection severely damaged the remaining forest.

In 1848, concern over the possible effects on Singapore's climate led the Governor to prohibit the further destruction of forests on the hills, which seems to have been effective for Bukit Timah (CORLETT, 1988). In 1882, Cantley, superintendent of the newly established Botanic Garden, was commissioned to survey the forest resources of the Straits Settlements and

reported that a mere 7 per cent of the island was forested (CANTLEY, 1884). Cantley's recommendation for the establishment of Forest Reserves was accepted and eventually 10 per cent of the island was protected in this way. In addition to these Forest Reserves, an area around Singapore's first reservoir, what is now MacRitchie Reservoir, and covered in degraded primary forest, was protected in the 1890s. Most of the reserves were eventually worked for timber (CORLETT, 1992a).

The decline in the Forest Reserves, however, coincided with an increase in the protected catchment areas as new reservoirs were built in the centre of the island. The expanded catchment area included fragments of degraded primary forests. In view of their condition, the Forest Reserves were finally abolished in 1936, but Bukit Timah and some areas of mangrove were placed under the control of the Botanic Gardens.

In 1951, Bukit Timah, the entire central catchment, and some of the mangroves and other special habitats, became Nature Reserves under the Nature Reserves Ordinance. Most of Singapore's extensive mangrove forest area survived into the twentieth century, but was heavily exploited for firewood. All but 1 per cent of the original mangrove areas have since been reclaimed for agriculture or shrimp farming, reclamation for building and the barraging of all major non-urban estuaries to create freshwater reservoirs (CORLETT, 1987). The mangrove area at Sungei Buloh is protected as a bird reserve and covers 87 ha of mangroves and former fish farms. The reserve provides basic amenities for visitors, with walkways, hides and an exhibition display.

The Nature Reserve system today, consists of 2,795 hectares in the centre of the island, of which 164 hectares is in the Bukit Timah Nature Reserve and the rest in the Public Utilities Board Catchment Area. The Nature Reserves are managed by the National Parks Board which was formed in 1990. Primary rain forest, disturbed to varying degrees, is confined to the Bukit Timah Nature Reserve, of which two-thirds is primary forest, and scattered patches totalling around 50 ha, in the neighbouring water catchment area. The Singapore Green Plan provides for 5 per cent of Singapore's land area to be set aside for protection as nature conservation areas (MINISTRY OF THE ENVIRONMENT, 1993). Nineteen sites, covering at least 3,130 ha have been identified. The considerations in selecting these areas were that they should have a natural environment in terms of landscape and wildlife, they should be ecologically stable and capable of supporting and sustaining a large variety of wildlife. Other factors considered were the potential for recreation, education and scientific research, the ability to co-exist with nearby developments and the opportunity cost of alternative uses of the land. The sites selected range from primary and secondary forests to mangroves and marshes. These areas are under government ownership and will be monitored by the National Parks Board. Flora and fauna corridors, linking up nature areas are also planned to

enhance the biodiversity of the sites by allowing greater mobility of animal and bird life. In addition, the Park Connector Network is planned to link most of the nature areas, major parks, public housing estates and transportation centres with an integrated system of green corridors, including jogging and bicycle trails, along rivers and drainage reserves. Eight kilometre of Park Connectors were completed by 1995.

### **Bukit Timah Forest**

Bukit Timah Nature Reserve consists of 164 ha of rain-forest and is a mixture of lowland and coastal hill dipterocarp forest and secondary forest on the slopes and summit of Singapore's highest hill. It is only 8 km from the city centre and a few minutes walk from three shopping centres. It has been described as the oldest small rain-forest reserve in the world, having been protected from the 1840s for climatic purposes, and the core areas of the reserve appear little different from undisturbed rain-forest in Malaysia (CORLETT, 1988). The forest at Bukit Timah has never been logged and like the other remnants of primary forest at Nee Soon and MacRitchie, are characterized by their exceptional species diversity and structural complexity and the presence of many poorly-dispersed species (CORLETT, 1992b). In terms of the number of species, five families, Rubiaceae, Euphorbiaceae, Myrtaceae, Annonaceae and Lauraceae are the most important tree families, but the Dipterocarpaceae, such as *Shorea curtisii*, account for the greatest number of large tree individuals, and is a characteristic species of coastal Malasian rain forest (WONG, 1987). The vital conservation importance of Bukit Timah becomes apparent when one realizes that within its 164 ha, the reserve contains more tree species than the whole of North America and each valley seems to have its own characteristic species (CORLETT, 1991). The rest of the central catchment area is covered in secondary forest of various ages, and is distinguished from the primary forest by its lower stature and species diversity and the complete absence of the Dipterocarpaceae (CORLETT, 1992c).

Bukit Timah and the other reserves, are administered by the National Parks Board of Management consisting of a Chairman and nine Trustees, two appointed by the President of the Republic and the others by the Minister of National Development. The reserve was visited by 130,000 people in 1994, including walkers, joggers, nature lovers, school groups and tourists. In addition, many scientists carry out research on the reserve. There is a visitors centre with an exhibition explaining the reserve, as well as marked trails, but, as yet, there is no full-time education officer working on school-related programmes.

## Singapore Botanic Gardens

The Singapore Botanic Garden has played a key role in both the agricultural development of Malaya and the greening of the city, from its inception in 1859, and may fairly be described as the premier botanical garden of the tropics. It was from the Botanic Gardens that both rubber and oil palm were promoted to transform the economy of both Singapore and the Malay States. Upon independence, the government of Singapore looked to the Gardens for aesthetic and scientific support, and assistance was sought from the Gardens to create a pleasing environment suitable to South East Asia's emerging business centre. From a research-based institution with responsibilities for the whole region, the Garden's mission was changed to provide a botanical and horticultural service for Singapore only (TINSLEY, 1989). The ambitious tree planting projects required thousands of plants as well as advice to government departments, schools, statutory organizations and community groups. In the early 1970s a nursery was established to supply plants for both public and private projects. In 1972 the School of Ornamental Horticulture opened to meet the growing demand for technical expertise with a Diploma Course in Horticulture, and later with a Diploma in Landscape Design. The courses are for two years and are part time, with around twenty students on each course from middle level management in both the private and public sectors.

The Gardens were under the Parks and Recreation Department throughout the 1970s, but since 1988 they have been a separate division of the Ministry of National Development, charged with research, education and horticultural excellence, with the mission of once more becoming the leading international centre of tropical botany. Major work at the Gardens has included the development of orchid hybrids to form the basis of one of the country's major exports, the tissue culture of a particularly floriferous form of the ornamental tree *Lagerstromia speciosa*, and research into the health and nutrition of urban trees and shrubs. The introduction of new trees and shrubs suitable for urban Singapore is done through the Plant Introduction Unit which organizes its own plant collecting expeditions. The latest project is the rehabilitation of the 4 ha. remnant of primary rain forest within the Gardens, made possible through sponsorship from the Hong Kong and Shanghai Bank.

## The History of Tree Planting in Singapore

The history of tree Planting in Singapore has been succinctly set out by CORLETT (1992d) and the following section is quoted as follows:

'Some of the ornamental plants grown in Singapore today were cultivated in the region long before the foundation of Singapore. The well known angšana (*Pterocarpus indicus*), native in Johore, has been widely planted both there and in Malacca since the eighteenth century and was very widely

planted in Penang before being brought to Singapore soon after the establishment of the first settlement' (BURKILL, 1965). It was the most popular shade tree throughout the nineteenth century, although many other species were also planted.

The Flame of the Forest (*Delonix regia*) was introduced in around 1850 and soon became popular (JOHNSON, 1973). Saga (*Adenantha pavonina*) was a popular shade tree in the 1870s and 80s and the sea apple (*Eugenia grandis*) was planted extensively by Cantley from about 1882 as a fire-screen along roads through lalang wasteland (BURKILL, 1965). Albizia (*Albizia falcataria*), the rain tree (*Samanea saman*) and the broad-leaved mahogany (*Swietenia macrophylla*) were also introduced during this period. The native tembusu (*Fragraea fragrans*) was popular in parks and private gardens.

As early as 1860, Governor Cavenagh reported that nurseries had been established at police and convict stations 'for the propagation of useful and ornamental trees and shrubs' and that convict labour was used for planting and maintenance. The following year he wrote that 'considerable progress has been made in planting avenues of trees along the most frequented roads'. In 1876, however, Henry James Murton, the Superintendent of the Botanic Gardens, called for the planting of useful timber trees along roads 'instead of the worthless *Erythrinas* etc. now used' (MURTON, 1877). His proposal that a nursery for valuable trees be set up within the Gardens was adopted, and the Botanic Gardens has had an important influence on ornamental planting in Singapore ever since.

In 1914 an angšana disease, of unknown cause, arrived from the north and gradually spread inland, killing most of the trees by about 1928 (FURTADO, 1935). For the next forty years this species was little planted. In many places the dead angšana were replaced by rain trees. The broad-leaved mahogany was planted widely in the 1920s and 1930s along with a variety of old favourites and new introductions such as the hop tree (*Arfeuillea arborescens*). An unpublished census of street trees in 1924 revealed 5,626 trees of 38 different species on 63 roads. The Botanic Gardens played a major role in plant introductions as well as advising, supervising and inspecting municipal planting schemes (CORNER, 1938).

In the immediate post-war period, Government involvement in tree planting and landscaping increased. The newly-formed Parks Department of the City Council was responsible for much planting within city limits while the Public Works Department was responsible for rural roads. According to the Botanic Gardens Annual Reports, favoured species at this time included acacia (*Acacia auriculaeformis*), broad-leaved mahogany, brown heart (*Andira inermis*), flame of the forest, hop tree, madras thorn (*Pithocellobium dulce*), purple milletia (*Milletia atropurpurea*), rain tree, royal palm (*Roystonea regia*), sea almond (*Terminalia catappa*), sea apple, and yellow flame (*Peltophorum pterocarpum*) (BURKILL, 1956; 1957). The angšana was

still in disgrace. By the end of the 1950s most residential areas of Singapore were well planted but much of the business area of the city was bare of trees (BURKILL, 1960).

The desire to create a more pleasant environment for healthy living led the government, in 1963, under Prime Minister Lee Kwan Yew, to launch a tree planting campaign with the intention of planting 10,000 trees annually (BURKILL, 1964). This campaign was specifically launched to improve the image of Singapore, as the Prime Minister, 'did not want Singapore to be like Hong Kong'. The campaign was reactivated with the 'Keep Singapore Clean and Beautiful Campaign' in 1967. The Parks and Trees Unit was formed in the Public Works Department in June 1967. To promote public awareness of the importance of greening the city and to encourage public involvement, the first Tree Planting Day was inaugurated in November 1971. 1973 saw the formation of the 'Garden City Action Committee' to direct and oversee the future course of the garden city programme. This paved the way for the establishment of the Parks and Recreation Department (PRD) in 1976, which merged the Parks and Trees Unit with the Botanic Gardens. The Botanic Gardens was later placed under the National Parks Board.

The initial emphasis was on quantity, so ease of propagation and establishment became the critical factors in the choice of tree species. Saplings of free-seeding species such as acacia, sea apple, rain tree and pong pong (*Cerbera odollam*), were widely used, but were slow to make an impact on the landscape. Emphasis then shifted to 'instant trees', propagated from stem cuttings two metres tall, and transplanted as semi-mature trees. Trees are grown to 'semi-mature' size in tree banks established on any available vacant land, including the edges of parks. The angšana was found to make an ideal 'instant tree' and its tolerance of poor soils led to its becoming the mainstay of the expanded planting programme. Other species which could tolerate the stress of being transplanted as semi-mature trees were the sea apple, broad-leaved mahogany, rain tree, pong pong and coral tree (*Erythrina variegata*). By about 1980 the initial greening of the city had been achieved and the emphasis then changed to quality of colour and scent.

### **Institutional Issues**

Section 14 of the Parks and Trees Act requires the provision of tree planting and open space in all developments. In the construction of new roads, development of residential, industrial and commercial areas such as shopping centres, hotels and offices, tree planting and landscaping must be included. In some cases, existing trees may be retained and incorporated into the schemes under section 5 of the Act. The Singapore Institute of Architects produces guidelines on landscaping and the retention of mature trees.

There are two main co-ordination groups concerned with trees in



Singapore. The Garden City Action Committee was established in the early seventies to oversee and coordinate government efforts in greening the city. The committee comprises representatives from the Urban Redevelopment Authority, the Public Works Department, PRD, the National Parks Board and the Housing and Development Board, and is chaired by the Permanent Secretary to the Ministry of National Development and meets every two months. One initial course of action by the GCAC was the identification of important roads, for example the road from the airport to the city centre, for tree planting and landscaping. The GCAC carried out inspection tours of these important roads during which sites to be beautified were identified and coordinated plans of action were drawn up.

The PWD Coordination Committee on Road Openings includes officers from the Telecommunications Authority, Public Utilities Board, Drainage and Sewerage Departments of the Ministry of the Environment, PWD, Mass Rapid Transit Corporation, Jurong Town Corporation and the Traffic police. This committee coordinates the excavation of roads and footpaths for the laying and maintenance of utility services in order to minimize public inconvenience. Utility services are laid in specific sub-surface locations within utility reserves which are separate from the roadside tree reserves (Figure 2). Besides its main function, the committee deals with any conflict of interest arising from the protection of tree roots and the need to maintain and protect utilities.



FIGURE 2. Example of a planned street tree reservation, with a separate area for utilities running alongside.

Both government and private sector projects must be approved by the PRD's Regulatory Section which ensures that developments have adequate provision for landscape treatment. Tree felling and landscape plans are submitted to PRD for approval. The planting requirements (as well as those of other authorities eg Sewerage Department) have to be implemented before the development is cleared by the Building Control Division of the PWD for occupation. In the early years of the garden city programme, developers were required to deposit with PWD a refundable financial deposit to ensure implementation of their planned planting proposals.

### *Parks and Recreation Department*

The Parks and Recreation Department (PRD) is a department within the Ministry of National Development. The department is organized into three divisions; planning and development, maintenance and corporate services divisions.

The lush greenery achieved over the past three decades has become one of the hall-marks of the city state. The PRD now maintains (in 1994) 4,716 ha of parks, open spaces, vacant government lands and roadside green verges, including around 803,000 trees (including palms) and some 6.3 million shrubs. 964 ha of the total area maintained comprises 52 major parks and open spaces. The green open spaces presently provided stands at about 0.6 ha for every 1,000 people, the target being 0.8 ha. PRD intends to develop another 435 ha of park land in the next five years. PRD is an active participant in the planning for the provision of parks and open spaces which is carried out in the preparation of development guide plans (DGP's) by the planning authority, the URA.

The PRD does not actively seek out the involvement of NGO's and has no educational role, although it organized the annual Tree Planting Day (from 1979 till 1992) at which Members of Parliament, schools, community groups and the general public took part. The department initially provided horticultural maintenance services to government premises such as schools and police stations but it has since assisted them to obtain these services by contract. PRD, however, continues to landscape new government premises and provides them with advice on landscape matters.

The PRD has a continuing programme of park construction and has, since 1992, commenced development of 'green corridors' to form a Park Connector Network to link major parks, nature areas and public housing estates. In its park developments, natural areas of native grasses and other plants are retained and trees and shrubs are planted for their wildlife value. The PRD has also focused on providing shade for footpaths, at road junctions and at bus stops, as increasing restrictions are being placed on private motoring and the use of public transport is being encouraged.

The horticultural estate of 4,716 ha. on the island is divided into 20 units within the Maintenance Division of the Department. Each unit is headed by a graduate officer with at least a Bachelor of Science with Honours degree. A number of these officers were further trained overseas in arboriculture. Tree maintenance works include transplanting, tree pruning and felling are fully contracted out. At present, tree wastes are dumped at city dumps. The annual maintenance budget is in the region of S\$20M per year. The Department keeps a record of all trees and shrubs planted as well as all horticultural operations carried out on them in a customised Computerised Horticultural Information System. These records are updated each time a plant receives maintenance. The records are used for budgeting purposes and management schedules. Trees with girth size of 1m and more are inspected at least once in eighteen months. The Department also plants fruit trees in parks as well as on institutional grounds. The PRD has a central nursery producing 400,000 plants a year. The department recently received an award from the Singapore Tourism Promotion Board for its work on greening the city.

### *Housing and Development Board*

Public housing began in Singapore in the 1960s after a fire in a squatter area, similar to the situation which occurred in Hong Kong in 1953. However, unlike in Hong Kong, the resulting apartments are owner occupied. The HDB was founded in 1959 to continue the work of the Singapore Improvement Trust and to tackle the pressing problem of housing.

In the 1960s and 1970s, tree planting was introduced into the public housing landscape to emphasize the provision of shade and greenery to the environment. Initially, fast growing trees with wide, dense spreading crowns were used. Typical examples were Angsana, Rain Tree, Yellow Flame and Brown Heart. In the 1980s, the emphasis was changed to planting trees with colourful or fragrant flowers and edible fruits. In new housing estates palms are added to selected areas to reflect a tropical effect as depicted by the national theme of 'Towards a Tropical City of Excellence'. The HDB consider the planting of trees as the most important aspect of landscape works. Trees change the micro-climate and provide shade and greenery to soften the concrete structure of apartment blocks. Residents appear to value tree planting and landscaping within public housing schemes and regard the greenery as important for their living environment (HDB, pers. comm.).

The first landscape architect in the HDB was appointed in 1979. There are now three landscape architects and three horticulturalists in the Landscape Unit in the Architectural Department, employed to design and implement the landscape planting programme. They are professionally qualified and are supported by horticultural staff, who have Diplomas or Certificates of Ornamental Horticulture from Singapore Botanic Gardens, to assist in the

design and to supervise contractors in the implementation of the programme. The HDB does not run any in-house arboricultural staff training. Neither is the HDB involved with tree education programmes for the housing residents, nor community tree planting projects.

The landscape team has worked out a set of landscape design guidelines to bring out the features of the precinct concept used in the housing designs. The precinct boundaries and entrances, green walkways and the various focal points, such as courtyards and play areas, are all specially landscaped with trees, palms, flowering and foliage shrubs and groundcover. Each precinct has its own planting theme. Shade trees are planted along roads, paths and in courtyards. The natural flora and existing trees are preserved wherever possible.

Within the housing areas fruit trees are required to be planted as a strategic food reserve, at the rate of one fruit tree for every five ornamentals. They are planted on the periphery of the housing developments because of the perceived need for spraying. Fruit trees are planted where site and soil conditions permit, alongside access roads, along river banks and in larger open spaces such as neighbourhood parks. The Jackfruit, *Artocarpus heterophyllus*, is commonly planted along roads and footpaths in housing areas, together with mango, starfruit, dwarf coconut and other species. The fruit tree planting programme involves the residents' committee of the housing estates, as members of the RC are supposed to look after the trees, check vandalism and theft and raise funds for regular fertilization, as regular maintenance is required for the trees to fruit eventually. In return, the RC members have the right to harvest and distribute the fruits, which are usually given to families in need. If the fruit is picked illegally, there is a \$2000 fine, but police apparently treat this leniently (WALKER, pers. comm.). There are still issues to be resolved, but the HDB recommend that other cities carry out a similar programme and share their experience with them.

Neighbourhood parks of around 1.5 ha. within the housing areas are designed by the HDB. The cost is around \$120–140/m<sup>2</sup> for both hard and soft elements. Based on the past 10 years planting record, HDB has planted around 23,000 trees and palms each year. The budget provided for tree and landscape planting is set at S\$150.00 per dwelling unit for new development. All planting work is done by HDB contractors. Until December 1994, sewage sludge was used as a soil conditioner, but this is no longer approved as it contains toxic elements. Shredded coconut husks are to be used instead. After a six month maintenance period, the planting is handed to the Town Councils for subsequent maintenance, which includes cleaning, refuse collection and tree and turf maintenance carried out by contractor. The budgets for tree management are drawn up by the individual Town Councils. Parks of more than 10 ha. are designed by the PRD.

Tree and shrub planting is from the HDB nursery at Kai Sang. The HDB

nursery covers 7.5 ha. and is efficiently run. It has its own irrigation pond and mist propagating system. The cost of running the nursery is reputedly 20 per cent higher than in Malaysia and the nursery is on a valuable site and the intention is to close the nursery. In future it is envisioned that most of the plants used in Singapore will come from Malaysia, because of the differential in land prices, a position similar to that regarding Hong Kong and mainland China.

### Choice of Tree Species

The choice of tree species is somewhat limited by the urban environment. One potential problem is the effect of air pollution. The highest concentrations of both sulphur dioxide and ozone recorded in industrial areas in Singapore are within the range where damage to sensitive species might be expected. However, no damage has yet been recorded (ANTI-POLLUTION UNIT, 1984). Of more significance are the soil types in which planting is attempted. Most tree planting in Singapore is into degraded soils which have usually had the topsoil removed and have been compacted by construction, aggravating problems of drainage and aeration. Reclaimed land presents the greatest problems for tree planting (CHUA and LEE, 1985). Land reclamation has added more than six per cent to the area of Singapore and much of this has been scheduled for use as parks. Reclamation material includes marine sand and clay subsoil from other construction projects. Sand fill has a low water-retention capacity and nutrient content. A problem with younger reclamation schemes, which also occurs in Hong Kong, is that through hydrostatic pressure a saline water-table, which rises and falls with the tides, persists beneath reclamation schemes for many years and can restrict rooting depth of some species. Native coastal species are adapted to such conditions and can also tolerate the higher wind speeds and light intensity of coastal reclaimed areas.

Species include the sea apple, sea almond, sea hibiscus (*Hibiscus tiliaceus*), penaga laut (*Calophyllum inophyllum*), and the african tulip (*Spathodea campanulata*), and casuarina. Clay fill is commonly used for reclamation schemes on the main island and the material is compacted as much as possible to ensure stability. As a result the soil becomes structureless, poorly aerated and drained and very low in fertility. Few species can thrive under such conditions. CHUA and LEE (1985) give details of 60 tree species tested on both types of fill. Favoured species on clay fill include: brown heart, casuarina, yellow flame, angšana, rain tree, sea almond, pink poui (*Tabebuia rosea*), *Erythrina* spp., *Eucalyptus* spp., *Eugenia* spp., *Ficus* spp., and *Khaya* spp.

Another problem in Singapore is the non-seasonal climate. Attempts to produce the mass flowering avenues of trees seen in other tropical cities have not been successful. Species which flower spectacularly in areas with more

seasonal rainfall or a distinct cooler period, flower erratically in Singapore (CORLETT, 1992c). *Angsana* is an example. In Penang, during the dry season in the early part of the year, the trees lose their leaves and flower on new growth before the new leaves open. Each tree becomes a sheet of gold and fills the air with scent. By contrast it rarely flowers in Singapore. Other trees which flower erratically in Singapore include yellow flame, flower of the forest, pink poui, golden shower (*Cassia fistula*), and pride of india (*Lagerstroemia speciosa*). However, one tree which does flower regularly and spectacularly in Singapore is the native tembusu, which produces a profusion of creamy-white perfumed flowers in May, followed by bunches of red berries in September. There is often a less dramatic flowering in October.

Species of trees are also sought which will grow to a height which will complement high-rise buildings. Unfortunately, among potentially tall trees there seems to be a trade-off between rate of growth and wood strength. *Albizia* is perhaps the tallest and fastest growing tree in Singapore but it has weak wood. *Tembusu*, on the other hand has very hard wood but grows slowly. On many housing estates the tallest trees are African mahogany, (*Khaya grandifolia*), but it is too irregular in its growth habit for roadside planting. Palms are becoming increasingly common in Singapore as they are grown for their ultimate height and striking shape as they do not provide shade, colour or scent. Magnificent formal avenues, which can be seen in the Botanic Gardens, are comprised of alexandra palm (*Archontophoenix alexandriae*) and royal palm (*Roystonea regia*) (Figure 3).



FIGURE 3. Royal palms (*Roystonea regia*) in the Singapore Botanic Gardens.

The plant species grown in Singapore are constantly changing as a result of new introductions and advances in propagation methods. The Plant Introduction Units of the PRD and Singapore Botanic Gardens are responsible for testing and introducing new species, which are obtained by exchange with overseas botanical gardens, purchased from commercial nurseries or found on special plant collecting expeditions. Among the most successful introductions have been the African Mahoganies, which are now widely planted. Others include the Yellow Terminalia (*Terminalia ivorensis*) from Africa, East Indian Rosewood (*Dalbergia latifolia*), and Firebush (*Hamelia patens*) from tropical America. There is also an increased interest in planting native trees. There is a 'cultivated forest' at Marina City Park and bird refuges have been built at East Coast Park and elsewhere to attract native bird life. The single most attractive trees for birds are the figs, especially *Ficus microcarpa* and *Ficus benjamina* which produce prolific crops of highly edible fruit for birds several times a year and also harbour a rich insect fauna (CORLETT, 1985).

The use of a range of tree species over a long period has enabled an assessment to be made of their long-term qualities as urban trees. As a result, some species have fallen into disfavour. The rain tree, yellow flame and sea apple are still widely planted, and one introduction, the ordeal tree (*Erythrophleum guineense*) has also become popular. However, Albizia has proved dangerous because of its superficial rooting and weak branches. A similar problem has been found with the african tulip, which also has vigorous roots that obstruct drains and damage foundations. The pong pong not only has roots which damage drains, pavements and roads, but also produces large fruits which can break car windscreens and leave dirty red blotches on the pavement. The madras thorn seems to generate plagues of migrating caterpillars which become a nuisance in neighbouring houses. Acacia and Saga become untidy with age and drop large amounts of leaf litter. The ubiquitous Angsana has also shown a tendency to instability when propagated vegetatively. Its branches snap and its requires frequent pruning. It is rarely planted long roadsides today from cuttings but is still planted as standards raised from seed (CORLETT, 1992d).

### Acknowledgments

Thanks are due to Ms. Susan Braatz of the Forest Resources Division of the FAO and to Dr. Richard Corlett of the Department of Ecology and Biodiversity in the University of Hong Kong. I also wish to acknowledge the help of Mdm. Boey Yut Mei, senior architect with the Housing and Development Board, and Mr. Yong Kong, horticulturalist with the HDB, Mr. Ho Kee Yan, deputy director, Corporate Services Division, Parks and Recreation Department, Ms Jennifer Ng-Lim Cheo Tee, assistant director (education) with the Singapore Botanic Gardens, and to Dr. Lee Sing Kong,

Head of the Biology Division, School of Science, Nanyang Technological University National Institute of Education.

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## Résumé

Grâce aux stratégies progressives s'appliquant au paysage et à la foresterie urbaine, mises en oeuvre ces trente dernières années, Singapour a atteint le but qu'elle s'était fixé de devenir une cité tropicale verte "d'excellence" et est devenue un exemple classique par la façon dont les améliorations apportées à l'environnement ont attiré l'implantation d'industries de haute technologie et de services financiers dans la cité. L'historique de la conservation des forêts et de la plantation des arbres à Singapour y est donné dans les grandes lignes. La coordination de la foresterie urbaine entre les agences principales est aussi décrite en même temps que le choix des trois essences d'arbres utilisées dans les principaux systèmes de plantation qui donnent tant de caractère à la ville.