

## **NATURE RESERVE PARKS, GARDENS AND STREETSCAPES: TODAY SINGAPORE, TOMORROW THE WORLD**

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### **SUMMARY**

A proposal is made for Singaporeans to cultivate native plant species propagated from plants growing in Singapore's wild areas (native plants from Singapore stock — NPSS) for parks, gardens, streetscapes and any other plantings in urban areas, instead of utilizing exotic (non-native) ornamental species or even native species of non-Singaporean stock.

There is a growing trend for to utilize native plants for gardens and landscapes especially in the more developed countries such as the USA and the EU, so this is not a new idea. Use of native species has many advantages.

However, for land-scarce countries like Singapore, where development covers about 90.2% of the land area of the country, whatever nature reserves there are, may already be viewed as a luxury of space. To expand the area covered by nature reserves,

without utilizing more expensive land, NPSS instead of exotic species can be planted in urban areas. Planting exotic species conserves the genetic resources of foreign countries and runs counter to the commonsensical principle that every nation must be responsible and conserve its own genetic resources in order that the whole world's genetic resources are ultimately protected. Planting NPSS in several localities will also spread out the risk of any one rare species dying out as not all eggs will be in one genetic basket.

Nature reserve parks, gardens and streetscapes are theoretically easy to conceive, but will require great political will and some funding. It is convenient but risk-averse to purchase ornamental plants off-the-shelf from commercial nurseries which stock mainly exotic species and utilize these exotics well-known for their performance. Efforts must be made to collect and propagate all native species from Singapore's wild areas in very large quantities, develop the know-how to propagate these threatened species, curate the collections to ensure that the inventory of genetic resources is well documented, be willing to try out the species in various urban settings through designs and plantings, be willing to accept failure in some cases, be willing to sell the propagated materials to commercial landscape companies to plant these in Singapore, and lastly, the public must be willing to accept this.

Some progress has been made in these aspects, but with different degrees of success. Native plant propagation from local provenance has been initiated by the National Parks Board (NParks) under the Plant Conservation Strategy with 102 threatened species successfully propagated (Foo, 2006). The Plant Systematics Laboratory, Department of Biological Sciences, National University of Singapore (NUS) and the Natural Sciences and Science Education Division, National Institute of Education, Nanyang Technological University (NTU) have also propagated several threatened native plants, with the permission of NParks. However, much more can be done, especially in the collection of planting materials and in the propagation.

Some of these materials have been planted in nature reserves, parks and along streets but is highly dependant of supply. NPSS so far are a very small percentage of the plants cultivated by NParks.

As NParks controls the four nature reserves in which almost all the threatened plant species grow, it is imperative that NParks through its National Biodiversity Reference Centre (NBRC) participates with or takes the lead and initiates partnerships or collaborations with other institutions or commercial enterprises to implement this most useful landscape design concept, as well as administrate the whole programme.

Through Singapore's success in implementing this, other nations in a similar situation can follow our model and methodology to conserve their own genetic resources and optimise land use.

## **INTRODUCTION**

The Republic of Singapore or Singapore is a country of 699.4 square kilometres (Singapore Department of Statistics, 2006) found at the southern tip of Peninsular Malaysia. It consists of Singapore Island and some 60-odd smaller islands which are separate or merged together by reclamation. It lies between the latitudes 1° 09' N and 1° 29' N, at about 137 kilometres north of the Equator and between longitudes 103° 36' E and 104° 25' E (Foo, 2001). As at 2005, it had a population of 4,351,400 residents and non-residents, or 3,553,500 residents alone (citizens and permanent residents), giving a population density of 6,222 per square kilometre (Singapore Department of Statistics, 2006), the second highest in the world, after Monaco (Wikipedia, 2006). Space is thus a premium on such a crowded nation. It was founded

by Sir Stamford Raffles in 1819 to become firstly a trading station, then a British colony in 1826, and subsequently became an independent and sovereign nation on 9 August 1965 (Foo, 2001). Through prudent economic policies, strong leadership, hard work and sacrifice over the decades, it developed into “one of the world's most prosperous countries with strong international trading links (its port is one of the world’s busiest in terms of tonnage handled) and with per capita GDP equal to that of the leading nations of Western Europe.” — CIA the World Factbook (2006).

Primeval Singapore Island was virtually covered in forest: Mangrove forest covered about 13% of the area, freshwater swamp forest perhaps covered 5%, and almost all of the remainder was covered by tropical lowland evergreen rain forest with a very small percentage consisting of herbaceous vegetation along the sandy beaches found mainly from Tanjong Rhu to Changi (Corlett, 1991). From the most recent figures available for land use in Singapore today, forest now occupies only 4.2% of Singapore’s land area, with the rest mostly built-up areas (47.5%) and managed urban habitats (42.7%) (Foo, 2001). Of those forests, only 279 ha are primary forests (the best quality forest) with the rest being secondary forest of various grades (Corlett, 1997). Forests are where most of the threatened plant species are found, with the rarer species and higher diversity in the primary forests.

The plants in any country may be categorized as follows:

1. Wild species
  - a. Native (indigenous) — Plants that occur in the country where they evolved over thousands or millions of years and not introduced there by humans.
    - i. Extinct species — Species previously recorded to occur in the country, but now no longer growing there.
    - ii. Threatened species — Rarer species which are under some degree of threat of extinction.
    - iii. Common species — Species frequently encountered in many areas.
  - b. Exotic (non-native) plants — Species deliberately or accidentally introduced by humans into the country.
    - i. Alien species — Exotic species which have adapted so well to the country that they are reproducing and spreading to many areas on their own.
    - ii. Escapes from cultivation — Exotic species which have not adapted well to the country that they are restricted to the sites they were introduced by accident.
2. Cultivated species — Species deliberately planted by humans in managed habitats.

Based on Tan (1995), the native vascular plants of Singapore are categorized as below. (Vascular plants are the spike and club mosses, horsetails, ferns, gymnosperms and flowering plants — the dominant plants of most localities.)

S/No.	Local Status	No. of Species	Percentage
1.	Extinct	584	25.6
2.	Threatened	1,457	63.8
3.	Common	241	10.6
	<b>Totals</b>	<b>2,282</b>	<b>100.0</b>

With about 26% of the Singapore vascular plant flora already extinct, and about 64% under threat of extinction, something must be done to prevent further attrition of the remaining species. Human intervention is welcome for the collection of planting materials (fruits, seeds, seedlings, saplings, cuttings), growing them in nurseries and planting them at appropriate sites all over Singapore. Reafforestation can be done, but there is limited space since most of the best forests are in the nature reserves. Based on the Schedule of the Parks and Trees Act 2005, the nature reserves are as follows:

S/No.	Park/Nature Reserve	Area (ha)
1.	Bukit Timah Nature Reserve	162.6442
2.	Central Catchment Nature Reserve	3,043.1482
3.	Labrador Nature Reserve	9.9878
4.	Sungei Buloh Wetland Reserve	131.3705
	<b>Total</b>	<b>3,347.1507</b>

It must be noted that the approximately 33.5 square kilometers of nature reserves also include the areas covered by the water in the Upper Seletar, Upper Peirce, Lower Peirce and MacRitchie Reservoirs in the Central Catchment Nature Reserve, so the available area for growing threatened species is even less.

#### **ADVANTAGES OF NATIVE PLANTS FOR USE IN LANDSCAPING**

The plants or vegetation in Singapore have many useful functions (Corlett, 1991):

- Aesthetics — To beautify locations, as a kind of ‘green wallpaper’.
- Recreation — For nature walks in forests to sports in fields and lawns.
- Amelioration of local micro-climatic conditions — Reduction of glare (by absorbing most wavelengths of light except some, especially green), control of soil erosion (roots of plants hold soil particles together), entrapping dust (leaves and branches), provision of shade (cast by tree crowns), increasing humidity (through evapotranspiration of the leaves), cooling down areas (much less radiation of heat during the night, unlike concrete buildings), etc.
- Maintenance of water quality — The fine and extensive network of roots of the forests surrounding the reservoirs have a filtering and ion-exchange action to maintain the water quality in the reservoirs.
- Military training — Forests provide suitable sites for soldiers to train in jungle warfare.
- Store of genetic information — A resource of valuable genes for use in industry, biotechnology or biomedical fields.
- Habitat of animals and microorganisms — Plants provide shelter and food for animals and microorganisms, which in turn are a genetic resource in themselves for exploitation in industry, biotechnology and biomedicine.

Further to that, native plants (those indigenous to a particular area) have these additional advantages (Tan & Morgany, 2001):

- Generally best adapted to the local climate and soils where they naturally grow.
- Provide food (nectar, pollen, seeds, leaves, etc.) and shelter to native animals, since they evolved together.
- Less likely to spread, unlike some exotic species which become invasive because the country of introduction lacks the pathogens or herbivores which would keep them in check.

- Are interesting because of the interactions with native fauna such as pollinators or dispersers.
- Are as aesthetically pleasing as exotic ornamentals and will provide a more unique look since plants tend to be geographically specific.

Growing native plants is a popular trend in the developed countries such as the USA and the EU, and one need only search on *Google* for “native plants” to find several websites as well as books of the same. Growing native plants is a temperate trend worth emulating in the tropics, where deforestation is occurring at breakneck speed.

### **WHY NATURE RESERVE PARKS, GARDENS AND STREETSCAPES?**

The ideal design for nature reserve parks, gardens or streetscapes is to mimic the situation found in tropical rain forests: lawnless, massed plantings of as high a plant species diversity (species richness and species evenness) as possible using native plants propagated from Singapore stock (NPSS). Besides being more interesting aesthetically, with numerous textures, colours, crown shapes and forms, massed plantings also easier to maintain with less need for frequent manicuring and no mowing (no lawns to speak of), compared to the more traditional approach of lawns with mostly monocultures of trees and shrubs through the design. A high diversity of plants also reduces the chance of a devastating epidemic, unlike monocultures of trees (e.g., the devastating disease of angkana trees [*Pterocarpus indicus*] killing Singapore trees in 1914 and the 1970s onwards). Lawnless, plantings of mixed tree species with differing crown shapes, particularly those which are flatter and less dense will reduce food sources for and discourage roosting by, respectively, the Javan myna (*Acridotheres javanicus*) and closer plantings of different tree species will partially discourage the roosting by the house crow (*Corvus splendens*) (Sodhi & Sharp, 2006). These are the top two pest birds in Singapore. Controlling the populations of these pest birds is not cheap. The Ministry of the Environment and Water Resources announced a S\$1,000,000 budget for 2003 to cull 50,000 crows (Sodhi & Sharp, 2006)!

NParks has begun streetscaping with massed plantings at various roads all over Singapore with themes ranging from parkway, coastal, forest, rural and gateway (Urban Redevelopment Authority, 2006) so what has been proposed is partially applicable, at least in the style of planting, and coastal and forest themes will feature plants found in similar habitats in primeval Singapore. The next step is to use NPSS for planting!

Why plant NPSS in landscaped areas in Singapore such as parks, gardens and streetscapes? This is so that we can more effectively conserve the Singapore genotypes of Singapore native species in Singapore, that we may benefit from the unique genes and their unique products, if they exist, for use in industry, biotechnology or medicine, for the benefit of Singaporeans and the rest of the World.

By growing threatened plants outside the nature reserves, we can also reduce the risk of loss of extremely rare species which consist of only one or few individuals in one locality, which may be lost through lightning strike (Singapore is one of the most lightning prone areas in the world [National Environment Agency, 2002]), disease, accidental death (killed by other trees falling upon them), fires (the drought of January

to March 2005 resulted in 637 bush fires [Hooi, 2005]), amongst others. It is always risky to put “all your eggs in one basket”; it is more prudent to reduce the risk by planting rare species in many localities.

Each country should be responsible for maintaining and preserving its own genetic resources and in this way, the whole world benefits from the total saved in all countries. It is irrational for any country to conserve the genetic resources of other countries, but neglect its own, but this is what happens if we grow exotic ornamental plants to the exclusion of our own. Singapore must be a responsible citizen of the world with regards to conservation and our commitments to the CBD.

By growing NPSS in parks, gardens and streetscapes, we also optimize the use of land in Singapore, rather than merely planting landscapes just for aesthetics. Native species of Singapore are easily as pretty as exotic ornamental species as seen in the 100 species highlighted in *Growing at Your Doorstep: 35 Native Plants* (Tan and Chua, 2003) and *A Guide to Growing the Native Plants of Singapore* (Tan and Morgany, 2001). In fact, many native species are already commercially utilized for street, garden or park planting, e.g., yellow flame (*Peltophorum pterocarpum*), crinum lily (*Crinum asiaticum*), maiden’s jealousy (*Tristellateia australasiae*), seashore morning glory (*Ipomoea pes-caprae*), sealing wax palm (*Cyrtostachys renda*), rambutan (*Nephelium lappaceum*), sea hibiscus (*Hibiscus tiliaceus*), sea almond (*Terminalia catappa*), rose myrtle (*Rhodomyrtus tomentosa*), sea gutta (*Pouteria obovata*), cabai (*Piper sarmentosum*), etc. Many native species are interesting in their own right and so are worth learning about the natural heritage of Singapore.

If members of the public as private citizens or members of commercial enterprises are allowed to purchase NPSS to grow in their gardens, they will learn the value of native species but better than that, can participate in their conservation and contribute to this national programme.

#### **WHAT IS NEEDED**

The following are options the country should aim for:

1. A massive and long-term programme of collection of fruits, seeds, saplings and cuttings for propagation of as many plants as possible. Landscape designs utilize several thousand plants per year for planting by the NParks, private contractors and hobbyists each year. The project cannot start if there are insufficient plants.
2. As many agencies and commercial enterprises as possible should be willing to try out this way to design their landscapes and be willing to take the risk of trying out the native species, especially those which have not been tried before. What will probably happen is that some experimental plots are developed, and with their success (seeing that the plants perform no worse, or even better than the tried-and-tested exotic ornamental species), more will be willing to try this.
3. Landscape designs are also market driven. If sufficient customers demand this concept, landscape designers and contractors have no choice but to supply the product. Hopefully, books like *Growing at Your Doorstep* (Tan & Chua, 2003) and *A Guide to Growing the Native Plants of Singapore* (Tan & Morgany, 2001) can help educate the public to the attractions of growing native plants so that they ask for such in their condominiums and home gardens, for a start.
4. The most threatened native plants are those found in the nature reserves which belong to the government of Singapore. These should be propagated the first

and the most, to reduce their rarity. If for legal or intellectual property reasons cannot be sold to the public, then NParks must plant these in public parks, gardens, streetscapes, nature areas or nature reserves. If such materials can be sold to the public then even more can participate in the conservation and preservation of Singapore's rare plants (but now no longer rare because of massive increase in numbers of individuals through propagation).

5. Many plants are rare and there is a dearth of information on their biology, such as how they germinate, seed viability, seedling establishment, associated mycorrhiza or other microorganisms needed for good growth, rates of growth, conditions for growing, pests, diseases, horticultural performance, etc. A national database should be set up for this, so all Singaporeans who want to participate and grow such plants can benefit from the information.
6. If Singapore is to fully exploit its genetic resources, it must carefully curate its holdings. Plants of each threatened species, and their progeny should be carefully tagged, tracked and monitored as they are planted out to the parks, gardens and streets, so that each locality has a good mix of genotypes, to avoid the dangers of inbreeding depression with expression of lethal gene combinations. If there are too few plants for sufficient genetic variation, then plants need to be imported from neighbouring countries (e.g, Malaysia and Indonesia) to enrich the gene pool. This aspect is just as important as the rest, and will involve full-time staff members to ensure proper chain-of-custody of the materials from field collections to nurseries to finally planting site. All plants must be tagged for proper identification in the field.

Once the plants are in place, resilient animal species will move into the massed plantings. These most likely species will be birds, bats, squirrels and insects, and depending if there is forest nearby, rarer species.

#### **WHAT HAS BEEN DONE SO FAR**

Some progress has been made in these six aspects, but with different degrees of success. Propagation of NPSS has been initiated by the NParks under the Plant Conservation Strategy with 102 threatened species successfully propagated (Foo, 2006). Saplings of species such as the mangrove trumpet tree (*Dolichandrone spathacea*) have been planted out at Telok Blangah (1,000 plants), Pulau Ubin (50 plants) and Sungei Buloh Wetland Reserve (50 plants). The mangrove tree, *tumu mata buaya* (*Bruguiera sexangula*) has also been propagated and planted at Pasir Ris Park (61 saplings) and Pulau Ubin (20 saplings).

The Plant Systematics Laboratory, Department of Biological Sciences, National University of Singapore (NUS) has also propagated hundreds of threatened native plants, with the permission and collaboration of NParks for materials collected from the nature reserves and parks. Growing materials were also collected from nature areas and other wild areas of Singapore, not under NParks jurisdiction. After propagation, most saplings and seedlings were donated back to NParks for planting in the nature reserves, national parks or streetscapes. The species propagated include the following: baboon's head (*Hydnophytum formicarum*), barking deer's mango (*Irvingia malayana*), crinum lily (*Crinum asiaticum*), gaharu (*Aquilaria microcarpa*), kempas (*Koompassia malaccensis*), lukeh (*Tacca leontopetaloides*), Malayan fern palm (*Cycas edentata*), meranti species (*Shorea bracteolata*, *Shorea pauciflora*), merpauh periang (*Swintonia schwenkii*), Pacific maple (*Aglaia cucullata*), peria laut

(*Colubrina asiatica*), *saga gajah* (*Archidendron ellipticum*), sea beam (*Maranthes corymbosa*), sea lettuce (*Scaevola taccada*), sea teak (*Podocarpus polystachyus*), seashore nutmeg (*Knema globularia*), *sepetir daun tebal* (*Sindora wallichii*), Singapore kopsia (*Kopsia singaporensis*), thorny tree vine (*Leea angulata*), a wild grape (*Cayratia mollissima*), etc. A laboratory of the Natural Sciences and Science Education Division, National Institute of Education, Nanyang Technological University (NTU) has successfully grown up the nationally endangered fern, *Dipteris conjugata*, and propagated other species too.

NUS has landscaped a small portion of the grounds of its new 4-hectare Bukit Timah Campus with NPSS, and in the midst of landscaping a small garden area and the two sides of Research Link at Kent Ridge Campus, so these are good starts. Most of the plants to be grown will be beach forest plants which are more tolerant of street conditions, since beach conditions are as similarly extreme or more so than roadsides. However, this is but a tiny drop in the total landscapes established each year by the government and private sectors.

#### **WHAT MORE NEEDS TO BE DONE**

What is most needed is the political will and the funding to carry this project through so Singapore can reap the benefits of beautiful, unique landscape designs which conserve its genetic resources for use in biotechnology, industry and medicine.

However, more can be done, especially in the collection of planting materials and in the propagation with full-time staff to collect materials year-round from nature reserves and other wild areas of Singapore, and to grow these in nurseries in as large a quantity as possible. If commercial nurseries can be involved, the output of plants will be even higher.

More clients and end-users should request landscape designers to design NPSS landscapes and streetscapes, but be willing to take the risk of the occasional failure. (It must be noted that even designs with the supposedly tried-and-tested exotic ornamentals, also occasionally fail, which is why there is often the guarantee period built into contracts. So failure or flaws are not the monopoly of the new concept.)

What would be a great “shot in the arm” is that material from the nature reserves may be sold to members of the public or commercial enterprises for planting and/or propagation. If intellectual property worries are an issue (e.g., patenting of unique genes and their products for commercial exploitation), then this option is out. However, materials can be released only to the NParks for planting in areas under its jurisdiction which cover a hefty 9,383.9 hectares according to the NParks Annual Report 2004/5 (National Parks Board, 2005). These are issues that must seriously be considered.

So far, there is no information available on the biology and horticulture of native plants, save that for those few species which have been exploited for cultivation. Much more can be done, such as setting up a central database with staff to receive inputs from horticulturists and compile these into a fixed format. Some information is already available at the NParks website at the native plants of Singapore hyperlink (<http://www.nparks.gov.sg/PlantSubCategory.aspx?id=32>) where so far, 146 species with brief habit and growing information are available. That list

has some overlap with the 100 species of native plants found in *Growing at Your Doorstep* (Tan & Chua [2003]) and *A Guide to Growing the Native Plants of Singapore* (Tan & Morgany ([2001]), but the descriptions in these are much more detailed. A more comprehensive list of the native species of vascular plants is available at the back of *A Guide to the Threatened Plants of Singapore* (Tan, 1995).

The National Biodiversity Reference Centre (NBRC) set up by the NParks on 22 May 2006, is probably the most suitable agency to help manage this information on the biology and horticultural characteristics of native plant species, some of its roles are to “Function as a one-stop centre for information portal to enable access to local biodiversity information.” and “Provide feedback and advice on issues pertaining to flora and fauna biodiversity conservation...” (National Parks Board, 2006). Curation of the threatened plants, their propagules and their localities of planting could also be managed by staff of this centre as one of the main functions of the NBRC is to take responsibility for the conservation of the flora and fauna in Singapore.

Much needs to be done, but it will be worth it in the end, as these plants are utilized optimally.

It may horrify many people that the ultimate future of tropical countries will be like Singapore and what may horrify even more, is that this would be the best case scenario! The tropics are home to some of the most densely populated places in the world, and there is the constant pressure for land development for farms, building residences, factories, etc., as populations keep increasing through births and/or immigration. Singapore lost most of its forest cover by the end of the 19th century and the current level of about 4% forest cover but all the rest is mostly covered by urban habitats such as roads, buildings, airport runways, reservoirs, canals and rivers, etc. As other tropical countries become more and more developed, the same will happen. In other words, urban habitats will become the dominant habitats in areas which were once covered by tropical rain forest. In the worst case scenario, soil erosion will be so serious that there will be no soil for crops to grow, and this will result in literally a wet desert of bare ground, but with no growth of plants although rainfall may be very high throughout the year because with no soil, plants cannot grow.

Lost forest cannot be recovered easily without much effort but that assumes that the land is available. If the land cannot be taken back for its original purpose because it is occupied, what can be done? One viable solution is to move the forest into the urban areas — make streets, parks, gardens, etc., into nature reserves by planting native species propagated from local provenance, as has been proposed. This is not an ideal situation, but is the next best thing to losing all a nation’s plant genetic resources, which, once lost, can never be regained.

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