4. Right Tree

4.1 Roadside Urban Forest Today

A desktop literature review and investigation has been undertaken to understand the current situation of Hong Kong's roadside urban forest. Two major sources of research data have been thoroughly analysed and compared. They are:

1) "Multipurpose census methodology to assess urban forest structure in Hong Kong "(Jim,2008) – This is a large-scale tree survey conducted from 1985 to 2008 by a local university that provides comprehensive data on tree composition, conditions and environmental interactions of urban forests in Hong Kong. The study areas covered 124 km^2 of built-up parts of the core around Victoria Harbour that include ten urban districts. The ten districts are: 1) Central & Western; 2) Southern; 3) Eastern; 4) Wan Chai; 5) Yau Ma Tei & Tsim Sha Tsui; 6) Mong Kok; 7) Sham Shui Po; 8) Kowloon City; 9) Wong Tai Sin; 10) Kwun Tong. All roadside planting in public roads of the 10 districts were studied. Raw data on 19,154 roadside trees from 149 species distributed in 509 different streets was collected. [14]

2) Data gathered from the electronic Tree Management Information System (TMIS) on 2 Oct 2016 – The TMIS, developed by the Greening, Landscape, and Tree Management Section (GLTMS) of Development Bureau, is a tree inventory system of existing trees under the management of various government departments. Data was extracted on 2 October 2016, 698,523 trees from 554 different species were collected from all over Hong Kong, of which 12.27% (or 85,705 nos.) of trees were not identified to species level. The overall percentage of the surveyed tree numbers against the known existing tree numbers in TMIS at the date where the data extracted is approximately 70%.

As revealed from the above data sources, in the past, tree species selection tends to be towards a few dominant species. The top twenty species, out of the total 149 species, contributed to approximately 77.5% of the tree recorded as revealed by the tree survey data (Jim, 2008); while the top twenty species, out of the total 554 species, contributed to approximately 49% of the tree recorded by TMIS data (2016).

Variations were observed between the lists of top 20 common species presented by the roadside tree survey by Jim (2008) and the TMIS data (2016). 8 species have been found on both common species lists (refer to ***Table 4-1***) Variations in the species compositions between the two studies were likely accounted by different groups of tree population. In Jim's study, only street trees located in Victoria Harbour regions were covered, while TMIS's data covers slope plantation, park plantation and including New Territories and Outlying Islands areas. Moreover, the former study's dataset was last updated in 2008 versus the latter survey in 2016. Overall, a limited range of common species has dominated the tree population, and a broad range of uncommon species has enriched the species diversity.

There is a prominent increase in the native species population recorded when comparing the two data sources, from 18% in 2008 to 37% in 2016. The increase in native tree population may be accounted by a larger sampling size and the inclusion of roadside slope forests in the TMIS data. For example, native trees (e.g. *Schima superba; Machilus chekiangensis*) were strategically planted on slope reforestation projects.[15] This may also indicate the recent trend of increased adoption of native species in urban forest

[14] Jim, C. Y. (2008). Multipurpose census methodology to assess urban forest structure in Hong Kong. Arboriculture and Urban Forestry, 34(6), 366-378.

[15] Greening, Landscape and Tree Management Section, HKSAR Government. (2016). *Knowledge Sharing (Special Topics)*. Hong Kong: Greening, Landscape and Tree Management Section, Development Bureau. Retrieved on Feb 2017 from www.greening.gov.hk/en/knowledge_database/special_topics.html

planting. For instance, trial planting of native species (e.g. *Ailanthus fordii; Rhodoleia championii*) was noted in urban parks. In terms of genera diversity, the top three genera (*Acacia, Ficus* and *Bauhinia*) dominated over 21% of the total number of trees recorded in TMIS.

In terms of family diversity, the dominant families included Mimosaceae (10.79%), Myrtaceae (9.9%), Euphorbiaceae (9.11%) and Caesalpiniaceae (8.36%). The dominance of Mimosaceae family was largely contributed by the abundance of *Acacia confusa,* which had an occurrence of 7.87%. Other species in the Mimosaceae family include *Leucaena leucocephala* (0.78%), *Acacia auriculiformis* (0.77%), *Acacia mangium* (0.74%), *Albizia lebbeck* (0.48%), *Albizia julibrissin* (0.04%), *Archidendron lucidum* (0.04%), *Archidendron clypearia* (0.03%) and few minor species which had occurrence less than 0.01% (refer to ***Table 4.1, 4.2*** and ***4.3***).

TMIS did not include data on tree size and age. From Jim (2008), data showed that small-sized trees dominated roadside planting. Two-thirds of the trees surveyed had height less than 5m, crown spread less than 5m and diameter at breast height (DBH) less than 150mm. Only approximately 10% of trees were large in size (with DBH more than 300mm). Jim (2008) concluded that a majority of young and small-sized trees represented a recent spate of diligent planting efforts. Also, many trees failed to reach their maximum dimensions due to urban environmental constraints such as limited roadside planting space, close proximity to buildings and overhead structures. These harsh urban environment constraints also restricted the planting of trees with larger mature sizes.

Scientific Name	Chinese Common Name	Family	Provenance	Occurrence (%)
Acacia confusa *	台灣相思	MIMOSACEAE	Exotic	7.87
Melaleuca cajuputi subsp. *cumingiana* *	白千層	MYRTACEAE	Exotic	3.80
Bauhinia x *blakeana* *	洋紫荊	CAESALPINIACEAE	Native	3.62
Macaranga tanarius var. *tomentosa*	血桐	EUPHORBIACEAE	Native	3.59
Ficus microcarpa *	榕樹(細葉榕)	MORACEAE	Native	3.37
Schefflera heptaphylla	鵝掌柴(鴨腳木)	ARALIACEAE	Native	2.48
Casuarina equisetifolia	木麻黃	CASUARINACEAE	Exotic	2.41
Lagerstroemia speciosa	大花紫薇(洋紫薇)	LYTHRACEAE	Exotic	2.31
Livistona chinensis *	蒲葵	ARECACEAE	Exotic	2.27
Celtis sinensis	朴樹	ULMACEAE	Native	2.27
Sterculia lanceolata	假蘋婆	STERCULIACEAE	Native	2.17
Cinnamomum camphora	樟	LAURACEAE	Native	2.03
Lophostemon confertus	紅膠木	MYRTACEAE	Exotic	1.57
Delonix regia *	鳳凰木	CAESALPINIACEAE	Exotic	1.44
Eucalyptus spp.	桉屬	MYRTACEAE	Exotic	1.41
Mallotus paniculatus	白楸	EUPHORBIACEAE	Native	1.40
Aleurites moluccana *	石栗	EUPHORBIACEAE	Exotic	1.32
Hibiscus tiliaceus *	黃槿	MALVACEAE	Native	1.29
Spathodea campanulata	火焰樹	BIGNONIACEAE	Exotic	1.21
Bauhinia variegata	宮粉羊蹄甲	CAESALPINIACEAE	Exotic	1.19
Total			**Exotic: Native 1.2:1 (by species) 1:1 (by occurrence)**	**49.02%**

Note: * species also being the top 20 common species in the roadside tree survey by Jim (2008).

Table 4-1 - Frequency of Occurrence of the Top 20 Common Urban Trees in Hong Kong on TMIS (2 October 2016)

Genus	Genus (Chinese)	Family	Family (Chinese)	Occurrence (%)
ACACIA	金合歡屬	MIMOSACEAE	含羞草科	9.38
FICUS	榕屬	MORACEAE	桑科	6.09
BAUHINIA	羊蹄甲屬	CAESALPINIACEAE	蘇木科	5.80
MELALEUCA	白千層屬	MYRTACEAE	桃金娘科	3.82
MACARANGA	血桐屬	EUPHORBIACEAE	大戟科	3.59
CINNAMOMUM	樟屬	LAURACEAE	樟科	2.89
EUCALYPTUS	桉屬	MYRTACEAE	桃金娘科	2.62
SCHEFFLERA	鵝掌柴屬	ARALIACEAE	五加科	2.60
CASUARINA	木麻黃屬	CASUARINACEAE	木麻黃科	2.41
LAGERSTROEMIA	紫薇屬	LYTHRACEAE	千屈菜科	2.36
CELTIS	朴屬	ULMACEAE	榆科	2.30
LIVISTONA	蒲葵屬	ARECACEAE	棕櫚科	2.28
STERCULIA	蘋婆屬	STERCULIACEAE	梧桐科	2.18
LOPHOSTEMON	紅膠木屬	MYRTACEAE	桃金娘科	1.57
MALLOTUS	野桐屬	EUPHORBIACEAE	大戟科	1.44
DELONIX	鳳凰木屬	CAESALPINIACEAE	蘇木科	1.44
MACHILUS	潤楠屬	LAURACEAE	樟科	1.35
ALEURITES	石栗屬	EUPHORBIACEAE	大戟科	1.32
HIBISCUS	木槿屬	MALVACEAE	錦葵科	1.29
SPATHODEA	火焰木屬	BIGNONIACEAE	紫葳科	1.21
Total				57.95

Table 4-2 - Frequency of Occurrence of the Top 20 Genera of Urban Trees in Hong Kong on TMIS (2 October 2016)

Family	Family (Chinese)	Occurrence (%)
MIMOSACEAE	含羞草科	10.79
MYRTACEAE	桃金娘科	9.90
EUPHORBIACEAE	大戟科	9.11
CAESALPINIACEAE	蘇木科	8.36
MORACEAE	桑科	6.64
ARECACEAE	棕櫚科	6.03
LAURACEAE	樟科	5.09
ARALIACEAE	五加科	2.61
CASUARINACEAE	木麻黃科	2.41
LYTHRACEAE	千屈菜科	2.36
ULMACEAE	榆科	2.32
STERCULIACEAE	梧桐科	2.27
BIGNONIACEAE	紫葳科	1.50
MALVACEAE	錦葵科	1.32
CUPRESSACEAE	柏科	1.18
MELIACEAE	楝科	1.15
THEACEAE	山茶科	0.97
APOCYNACEAE	夾竹桃科	0.94
BOMBACACEAE	木棉科	0.88
SAPINDACEAE	無患子科	0.86
Total		**76.69**

Table 4-3 - Frequency of Occurrence of the Top 20 Families of Urban Trees in Hong Kong on TMIS (2 October 2016)

4.2 Limitation of Research Information

The survey conducted by Jim in 2008 is considered to be outdated as it was done 10 years ago and only selected urban areas were surveyed. Also, some urban trees may no longer exist due to various reasons, such as, collapsed during inclement weather, construction works, etc. As such, the TMIS has been used as the main basis for this Study as it is the best available and most comprehensive data source covering a large extent of Hong Kong urban areas at the time of the Study. The TMIS covers tree data from eight core tree management departments, namely AFCD, ArchSD, CEDD, DSD, HYD, HD, LCSD and WSD. It is noted that there are some unidentified tree species within the gathered TMIS data. However, these species only covered a small majority of tree data gathered and should not have a significant effect on the general analysis on the dominance of tree species planted. Also, the TMIS data does not include information on tree size, dimension, age, date of planting, and roadside trees under private maintenance and management. This information, if available could facilitate the analysis on the distribution of tree size diversity and tree age population within the urban area.

The TMIS tree data sorted covers roadside street trees, man-made slope plantation and trees with public parks and government properties under the management of ArchSD, CEDD, HyD, LCSD and other government departments. This data adopted gives a good baseline on the tree species mix of our existing urban forest. However, it does not provide analysis of tree health condition and their suitability of planting in different road hierarchies.

Finally, although many researches have been conducted on the benefits and ULE of urban trees, these studies are conducted outside of Hong Kong. The extent of benefits brought by urban trees, especially in the context of economic and social aspects, are not specific to Hong Kong.

4.3 Approach to the Guide

The urban environment is predominantly man-made built-up areas. Roadside planting environments are especially harsh for trees. The effects of climate change may make the environments even more difficult for trees to grow. In the Guide, the recommended tree species for Hong Kong urban streets shall be species that can establish and survive in stressful urban conditions and fulfil their required functions, rather than simply restricted to only native species. Vegetation diversity is essential for a resilient urban forest. Planting a mix of exotic and native species can help maintain the health and resilience of the urban forest. Basing on this, the Guide has examined both native and exotic tree species to match street planting requirements.

To promote vegetation diversity, this Guide seeks to explore lesser known species for urban street planting to enrich biodiversity based on the 10-20-30 rule (refer to ***Section 1.6***). The existing top 20 dominant roadside tree species are therefore not selected for further study and inclusion into the Guide (***Table 4-1***).

Under the principle of "Right Tree, Right Place" and the strategies mentioned in Section 3, the decision-making criteria affecting street tree selection were deduced (***Figure 4-1***).

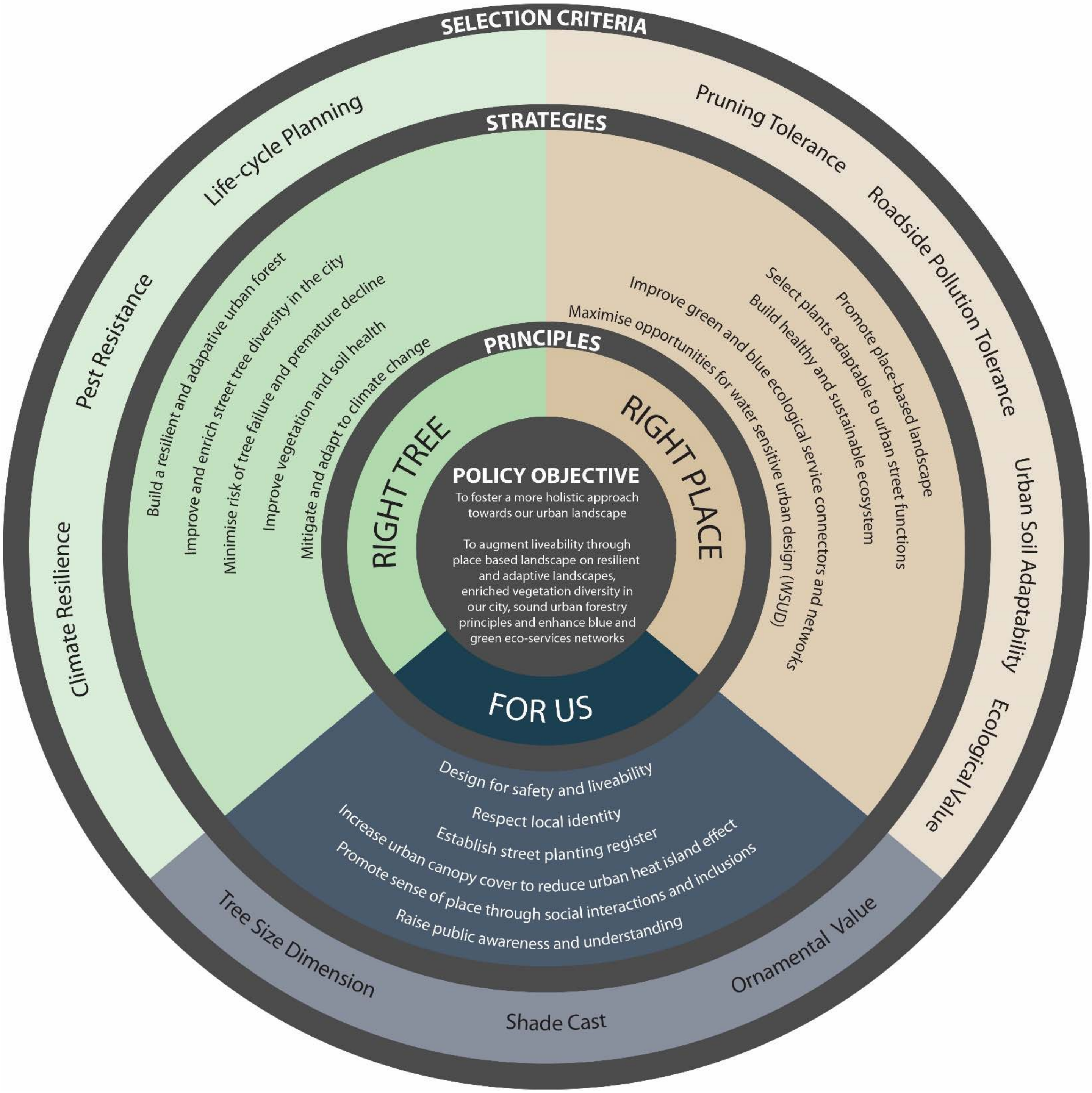

Figure 4-1 - Tree Selection Criteria

To summarise, the main strategies in selecting tree species appropriate for Hong Kong urban street planting are as follows:

- Non-dominant species to enhance urban forest diversity
- Tree species that nurture local biodiversity by providing ecological benefits to local fauna in Hong Kong
- Native tree species with good potential for street planting
- Species that can be propagated with existing technology or species that are currently commercially available
- Tree species planted in Hong Kong under similar roadside environments and observed to have relatively good tree health and condition. For instance, *Machilus spp.* is observed to do quite well in highly polluted areas.

4.4 Street Tree Selection Criteria – Essential Attributes

The Essential Attributes are the fundamental abilities of the tree to survive and maintain its physiological functions in the urban street environment. These are the basic requirements that need to be met before a tree species will be further considered. Species with a “low” rating in any essential attribute is regarded as not suitable and therefore has not been shortlisted. Details for the rating are included in ***Appendix B***. The Essential Attributes and their ratings are described below:

Climate Resilience

- **Heat tolerance**

Hong Kong has a sub-tropical climate, where mean temperature in summer is generally around 26°C but the temperature often exceeds 31°C in the afternoon. It is expected that the overall mean temperature to increase further by 1.5-3°C by mid-21st century[16] due to global warming. Recorded by the Hong Kong Observatory (HKO), the mean temperature for summer in Hong Kong is 29.1ºC in 2016.[17] Species that can withstand to 29ºC summer mean temperature but with sign of leaf or bark burn or abnormal health stresses are rated as "low" and have not been considered further as they are unable to tolerate mean summer temperature and anticipated adverse climatic conditions.

- **Drought tolerance**

Hong Kong experiences a hot and humid summer and relative dry and cool winter. Dry spells occasionally occur starting from November to February and can last up to 3 months. Severe drought may affect water supply and reliance on irrigation may not be sustainable in the long run. According

[16] Byrne, L. B., & Grewal, P. (2008). Introduction to ecological landscaping: a holistic description and framework to guide the study and management of urban landscape parcels. Urban Horticulture. 2016, 10.1201/b21180-3, pp. 3-32

[17] Hong Kong Observatory. (2017). The Year's Weather - 2016. Retrieved from http://www.hko.gov.hk/wxinfo/pastwx/2016/ywx2016.htm

to HKO, in the past 10 years, the longest dry spell with monthly rainfall below 10mm lasted for a period of 3 months. One of the measures to decrease water usage is through planting suitable tree species. According to HKO, maximum duration of absolute drought in Hong Kong is 60 days in the last century.[18] Established roadside tree species that can tolerate less than 1 month dry spell and require supplemental watering were rated "low" due to their high water demand and have not been considered further.

- **Waterlogging tolerance**

As reported by HKO, extreme precipitation has become more frequent in the last 100 years, with the hourly rainfall records increasing more than 60%, breaking past rainfall records at an unprecedented rate. It is predicted that the annual rainfall and occurrence for extremely wet years for Hong Kong and around southern China will increase. [19] Large volumes of stormwater runoff may cause sudden flooding and water-logged soil conditions. Most tree species can withstand one to four months of flooding during the dormant season. However, when flooding occurs during the growing season, especially during warmer weather, one to two weeks of flooding can cause major and long-term root damage to sensitive trees and shrubs, leading to tree decline and even death with some species.[20] Tree that require well-drained pit, or cannot survive in a saturated pit for less than one week were rated "low" and have not been considered further.

Life-Cycle Planning

Street tree planting should be designed for safety and liveability. One of the ways to do this is through proper life-cycle planning for urban trees. Life-cycle planning can be broken down into the following four key aspects:

- **Urban Useful Life Expectancy**

Urban Useful Life Expectancy (urban ULE) is an estimate of how long a tree is likely to beneficially contribute and remain in the urban landscape based on health, amenity, environmental services, cultural contributions to the community that warrants the cost of maintenance. The urban ULE gives the approximate time in which tree replacement should be considered, and thus continuing the life-cycle.

In general, a mixed ULE for urban street trees is preferable to minimize the potential loss of visual quality from sudden loss of a large group of trees at the same time. Choosing tree species with long urban ULE provide benefits to the community for a longer period with less cost. However, long urban ULE should be balanced against other tree selection criteria and the age of the tree community in the surrounding. Tree species with a very short urban ULE require higher maintenance cost as they need to be replaced sooner. Species projected with less than 20 year

[18] Royal Observatory (Hong Kong), & Starbuck, L. (1950). A statistical survey of Hong Kong rainfall. Noronha. Retrieved from http://www.hko.gov.hk/publica/tm/TM_2.pdf

[19] Cheung, M. S., Chan, H. S., & Tong, H. W. Rainfall Projection for Southern China in the 21st Century using CMIP5 Models.

[20] Flooding effects on trees. (2010). Retrieved from http://www.extension.umn.edu/environment/trees-woodlands/flooding-effects-on-trees/

growth before senescence were rated “low” due to their short lifespan and have not been considered further.

- **Wind Tolerance**

Wind is the main mechanical stress on trees in Hong Kong due to tropical cyclones and monsoons typically occurring from April to October. They can cause severe damage to trees incurring risk to public safety and properties. There are two main types of tree damages. Brittle trees may lose their branches, leaves or even major limbs during intense winds; and shallow-rooted trees may blow over entirely. Adequate tree support can stabilise the trees during establishment and reduces the occurrences of tree limb failure. Nevertheless, trees that have brittle limbs and low mechanical stress requiring extra support throughout most of the tree’s life-cycle were rated “low” and have not been considered further as they required high maintenance cost maintenance and lead to safety issues.

- **Manageability**

Newly planted street trees require regular maintenance (e.g. irrigation, weeding, fertilisation, etc.) during the establishment period. The need of maintenance lessens as the tree reaches establishment and maturity. Other maintenance issues may arise due to extensive tree branches, aggressive root system, leaf littering and fruit dropping on footpaths, blocked drains, etc. which would be a nuisance and safety concern to public. Tree species that do not require regular high maintenance frequency are preferred. Species with large amount of plant litter with potential to block drains, or with fruit or seed drops creating sticky footpath surfaces were rated "low" and have not been considered further.

- **Crown Management**

In urban roadside area, accessibility for pruning may be an issue in particularly for trees planted within the central median. Partial closure of a lane may be required to carry out tree pruning works as part of the normal horticultural maintenance and also to avoid obstruction to traffic sightlines. Smaller sized trees with fast growth rate and wide spreading crown will require frequent pruning and were rated “low” due to high maintenance cost.

Pest and Disease Resistance

Changes in temperature and moisture will directly affect the growth, spread, range and survival of pests, pathogens, vectors and competitors. As this will have significant direct effects on pests and pathogens’ behaviour and population, the timing and severity of outbreaks may also be affected. Diseased trees require higher and more regular maintenance and may present hazards to pedestrians and vehicles alike. A “low” rating was given to tree species with a history of pathogen outbreaks in Hong Kong or require an aggressive regime of treatment and have not been considered further.

4.5 Street Tree Selection Criteria – Valued Attributes

Valued Attributes are the tree characteristics that will benefit ecological, human or/and other valued aspect. These are the desirable criteria and are applied depending on the local site context and road hierarchies and conditions. Details for the rating are included in ***Appendix B***. The Valued Attributes are described below:

Roadside Pollution Tolerance

Street trees in urban areas should be able to withstand the polluted roadside environments. For example, trees planted in the central median greening zone have to tolerate a high level of traffic density which causes air and runoff pollution. Therefore, a highly valued attribute for street tree selection is the capability to tolerate urban pollution. Some tree species may even be effective in reducing pollutants and / or particulates. [21]

Pruning Tolerance

Most roadside trees require pruning from time to time to maintain clear headroom for pedestrians and vehicles, clear sightlines, reduce wind resistance, maintain or improve tree appearance and promote or reduce tree growth. Pruning tolerance of a species is assessed by its ability to compartmentalize and recover from pruning wounds over a period of time.

Urban Soil Adaptability

- **Soil Compaction Tolerance**

Soil compaction is defined as the mechanical increasing of soil density. Soil compaction is affected by soil type, changes in soil moisture content and the type of stress applied to the soil. Many urban planting sites are surrounded by hard paving with compacted sub-soil base. Soil compaction in urban streets may increase over time through regular foot traffic. Compacted soils have poor aeration and lower oxygen level. Tree selected for these sites should have the ability to tolerate relatively low soil oxygen levels and compacted soil conditions (e.g. *Taxodium distichum* & *Juniperus chinensis* cv. Kaizuka). Species that can survive with restricted soil aeration were rated "High".

- **Root System (Manageability)**

Aggressive tree root system can uplift pavement causing tripping hazard to pedestrians. Species with aggressive root system should only be considered where there is sufficient space to accommodate the tree root system or where there is no significant limitation to soil volume.

[21] Jin, S., Guo, J., Wheeler, S., Kan, L., & Che, S. (2014). Evaluation of impacts of trees on PM2. 5 dispersion in urban streets. *Atmospheric Environment*, 99, 277-287.

- **Soil Volume Tolerance**

Confined planting sites (e.g. planting area with narrow width and/or closed, compacted bottom with defined volume of soil) are common to roadside planting situations. Trees with large rooting system in a confined planting site may result in root girdling, shallow rooting surface and pre-mature decline. Generally, species with larger mature size will have larger rooting system. Small-sized species with smaller root system would be more suitable for planting in sites with confined soil volume (e.g. *Polyalthia longifolia* & *Pongamia pinnata*). Tree species that can perform in small planting sites (1.2m to 1.5m dia. x 1.2m depth) are rated as “High”.

- **pH of Soil (Range)**

Urban soil with alkaline condition is common as soils are often contaminated by construction debris containing calcareous materials. Literature suggests that a pH in the range of 6.0 to 6.5 is generally favourable for most plants. Planting areas (either new or existing) will be filled with new topsoil with the acceptable soil pH level of 5.5 – 7.0, according to ArchSD GS 25.02 (a)(iii)[22] and CEDD GS 3.30 (2)(a)[23]. However even though soil pH level can be modified, for cost-effectiveness, soil pH tolerance should also be considered as one of the valued attributes.

Tree Size Dimension

Generally large trees provide more positive impacts on urban ecology and the living environment than small-sized trees. They can increase urban biodiversity by providing more habitat areas, mitigate UHI effect, conserve more energy, improving local microclimate, soil and water quality, reducing stormwater runoff, enhancing visual attractiveness, promoting health and well-being better than small trees. Under the main principle, the selection of tree species should be appropriate to local environment conditions and constraints of the planting site. Given due consideration to site constraints, tree species with large ultimate size are encouraged for planting as far as practicable.

Ecological Value

Trees that provide a stable food source or habitat for wildlife (e.g. birds, fruit bats, butterflies, etc) could create ecological corridors in urban areas and enhance the green linkage between natural habitats and improve urban biodiversity and genetic diversity for both plants and animals. Establishing a stable ecosystem can help regulate pests and diseases through activities of its natural predators and parasites.

Ornamental Value

Species that relate to Hong Kong’s cultural or historical context, appeals to one of the 5 senses, have unique tree form, bear fragrant flowers or fruits and provide high ornamental value for a prolonged period of time were rated as having high ornamental value.

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[22] Architectural Services Department, HKSAR Government. (2017). *General Specification for Building.*

[23] Civil Engineering and Development Department, HKSAR Government. (2006) *General Specification for Civil Engineering Works, Volume 1.*

Shade Cast

Shade casted by trees can help to reduce heat absorption by paved surfaces, buildings and road and thus reduce UHI effect. This rating provides a qualitative estimate of the degree of shade cast projected by a tree. In general, the larger the crown spread coupled with higher foliage density and bigger leaf size/area, the better shade cast is expected to be provided by the tree. Since Hong Kong winters are usually mild, summer shade is considered to be of greater importance in offering a comfortable walking environment to the pedestrian. The ratings of shade cast in this Guide are primarily based on scientific and visual judgement of the canopy.