

8. Life-cycle Maintenance and Management of Trees

8.1 Introduction

Trees are living organisms that naturally grow and age with time. The life spans of trees vary with species and growing conditions. Also, different species have different requirements at each stage of their life-cycle. The life-cycle, by definition, refers to the developmental stages that occur during an organism's life-time. A life-cycle ends when an organism dies.

Trees health conditions will deteriorate with age and change with surroundings. Through proper design and works implementation including provision of adequate planting spaces, selection of quality plant stocks and suitable species, etc., and conducting proper tree care and management, the health of a tree and thus its urban ULE can be increased.

In this Section, the general maintenance and management operations (M&M) for the shortlist of tree species are reviewed. Examples of species that may require special attention are given in **Section 8.3**. Detailed M&M information for each tree species shortlisted can be found in **Appendix A** and **Appendix C**.

8.2 4 Stages of the Tree Life-cycle

The life-cycle of trees is divided into 4 main stages. The 4 stages life-cycle pattern of trees in this Guide is based on literature research and by experience of horticultural and landscape management practitioners to best reflect the current planting practice in urban streets of Hong Kong. It is recommended that professional advice (e.g. qualified arborist) to be sought when identifying the current stage of the tree life-cycle.

A brief description of each life-cycle stage is as below:

1. Propagation to Seedling – This life-cycle stage is assumed to be conducted in a tree nursery, where the seed has been germinated or cuttings have begun to grow new roots. Proper planting techniques and practices are to be adopted. At this stage, the tree is weakest and most sensitive to the surrounding environment.

2. Sapling to Semi-mature - In general, this is the stage where the tree is most adaptable and able to rapidly establish and grow. A light-standard or standard size tree is usually selected for planting at this stage due to their instant visual effects. Both sizes can be found in the sapling to semi-mature stage of the life-cycle. It is common that the tree specimen at this stage will be selected for transplanting to the final receptor site, i.e. CMGZ or RVGZ. After transplanting, the tree may require 1-2 years to recover from transplant shock before resuming its normal growth, the selection of quality stock is therefore of great importance. Proper maintenance and management is also critical at this stage, especially in the first 2 years after transplanting to ensure proper tree establishment in urban street conditions.²⁶

3. Mature - A mature tree is a fully-established tree that has achieved its full height and crown spread. They play an important role in environmental improvement and ecological enrichment. In general, trees in this stage of the life-cycle have a lower ability to tolerate stress when compared to sapling to semi-mature stage.

²⁶ Hitchmough, J., & Fieldhouse, K. (Eds.). (2008). *Plant user handbook: a guide to effective specifying*. John Wiley & Sons.

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4. *Senescence* - At this stage, the tree is in the last stage of its life-cycle with declining vigour and will be most vulnerable to environmental and pathogenic stress. In general, a tree with long life-cycle may indicate a longer period of urban ULE.²⁷ Professional advice should be sought to determine if the tree has reached the end of its urban ULE and whether timely replacement of the tree should be considered.

If fact, life-cycle of trees can be extended beyond senescence by proper use of the felled trees such as recycling them into useful wood products. Further study on this topic is recommended to address the effective disposal of the felled trees.



Figure 8-1 – The life-cycle of street trees

8.3 M&M Operations in 4 Stages of the Life-cycle

A holistic tree care plan can contribute to health and safety of a tree. Although M&M for each tree is dependent on its location, surrounding site environs, past M&M operations and tree species, some general M&M can be applied to most tree species. A summary of the M&M in each of the four stages are given in **Table 8-1**. Details on each M&M is given on the next page.

²⁷ Useful Life Expectancy (ULE) is an estimate of how long a tree is likely to beneficially contribute and remain in the landscape based on health, amenity, environmental services, cultural contributions to the community that warrants the cost of maintenance. Choosing tree species with long ULE could provide benefits to the community for a longer period with less cost.

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Maintenance and Management Operation	1. Propagation to Seedling	2. Sapling to semi-mature	3. Mature	4. Senescence*
Shading	✓			
Irrigation	✓	✓	✓	✓
Weed Control	✓	✓	✓	✓
Pest / Disease Control	✓	✓	✓	✓
Tree Protection	✓	✓		
Tree Staking / Guying		✓	✓	✓
Pruning		✓	✓	✓
Fertilisation & Soil Aeration	✓	✓	✓	✓
Tree Inspection and Monitoring & Tree Risk Assessment		✓	✓	✓

Note: * depends on tree health and state

Table 8-1 - Maintenance and Management Operations for 4 Life-cycle Stages

Shading

In general, shade can be provided through shade cloth or panels in the propagation to seedling stage. Shading prevents the build-up of high soil surface temperatures by intercepting solar radiation and insulating seedlings from the heat source. Shading can increase seedling survival. Germinating seed and recently transplanted seedlings need protection from hot sun and heavy rain. On the other hand, shading reduces the amount of water lost by seedlings.

For the other stages, the tree will need to be appropriately planted in the “right place” where there is adequate amount of sunlight for its growth. Shading in urban streets may occur due to surrounding tall buildings, bridges or fly-overs and / or other structures. These may be temporary, semi-permanent or permanent. Detailed examination of the surrounding environment, future development and the tree’s life-cycle is essential when selecting the “right tree”. Proper planting practices on providing adequate growing space for trees should follow GLTMS guidelines on Proper Planting Practices.²⁸

<p>1. Propagation to Seedling</p>	<p>Provide shade under existing trees, shade cloth or panels to increase seedling survival as it keeps seedlings cooler during the heat of the day, reduces moisture loss from soil and also benefit evergreens in winter by reducing desiccation. For shade cloth or panels, the specific shade percentage or density should be adjusted to suit the species.²⁹ Shade cloth is usually made of loosely woven polyester. The UV filtration factors of 50-60%, 64-75% or 90% are derived from the density of the weave. Cloth with more holes allows more UV light to filter through.</p>
<p>2. Sapling to semi-mature 3. Mature 4. Senescence</p>	<p>Each tree species has a specific shade tolerance level and a sunlight requirement level in order to grow properly. The tree species selected for each site should reflect their preferred environmental needs. For example, <i>Podocarpus macrophyllus</i> is shade tolerant, thus more suitable under partially shaded urban conditions. It can be suitably planted on a street with tall structures on both sides.</p> <p>Once the tree species has been determined, the selected tree specimen should be examined to ensure they are suitable for planting in that environment. This should be done in accordance to the “Select and Plant Good Specimens” promulgated by GLTMS (10/2010).³⁰</p>
<p>Other Remarks</p>	<p>As a general rule of thumb, providing shade to common trees species in Hong Kong after seedling phase does not promote the growth of trees.</p>

²⁸ Greening, Landscape and Tree Management Section, HKSAR Government. (2016). *Handbook on Tree Management*. Hong Kong: Greening, Landscape and Tree Management Section, Development Bureau. Appendix 10 & 11.

²⁹ Dumroese RK, Wenny DL, Barkley YC. (2001). *Plant your seedlings right*. Retrieved from <http://www.lri-lb.org/sites/default/files/Plant%20Your%20Seedling%20Right.pdf>

³⁰ Greening, Landscape and Tree Management Section, HKSAR Government. (2016). *Handbook on Tree Management*. Hong Kong: Greening, Landscape and Tree Management Section, Development Bureau. Appendix 9.

Irrigation

Irrigation is one of the most essential maintenance operations. The need for irrigation depends on the soil type, climate, planter type and the habit of plant species. Neutral pH water is best suited. Irrigation is best done in the early morning or late afternoon to minimize evaporation.³¹ Night-time irrigation is not recommended. Care must be taken to avoid interfering with traffic or blocking pedestrian flow when conducting irrigation. Too much irrigation can just be as harmful as too little irrigation. Signs of overwatering, such as yellowing leaves or stunted growth, and underwatering, such as wilting, should be inspected regularly.

Isolated trees may transpire 2-3 times more than trees planted in large dense groups. If the tree is planted in a single row, more irrigation will generally be required.

A planter at grade may receive more surface run-off than a raised planter, therefore require less irrigation in periods after heavy rain. Similarly, a larger planting area may be able to retain more moisture and therefore, require less irrigation. Understorey planting should not be planted too close to the base of the tree trunk as they will compete with the tree for nutrients. A minimum 150-300mm clearance zone around the tree trunk is recommended. Proper planting practices around the base of the tree should follow GLTMS guidelines on Proper Planting Practices.³²

1. Propagation to Seedling	Good draining soil is usually used if plants are grown in nurseries, since the root system of young trees will not become waterlogged after watering or heavy rain ³³ . If planted in clay soils, watering is recommended once every 2-3 weeks after a thorough watering as clay soils hold moisture very well but do not drain well. ³⁴ Watering thoroughly to moisten the root zone can encourage deep rooting because light watering may only encourage surface roots and make the tree more susceptible to drought.
2. Sapling to semi-mature	Watering thoroughly to moisten the root zone can encourage deep rooting and allows the tree to be structurally more stable by growing more anchor roots. Until the tree is established, regular irrigation is required.
3. Mature 4. Senescence	Irrigation should be done when the top 15-20cm of the soil is dry and no rain is predicted for a few days.
Other Remarks	As a general rule of thumb, plants should be irrigated before they suffer from chronic drought stress and its attendant side effects on growth, appearance, and susceptibility to insects and diseases. Species which are drought-tolerant, on the other hand, do not need too much watering. Over-irrigating will lead to poor health of the tree and waterlogging problems; <i>Wodyetia bifurcata</i> , for example.

³¹ Fini, Alessio, and Cecilia Brunetti. "Irrigation of Urban Trees." *Routledge Handbook of Urban Forestry*, Taylor and Francis Group, 2017, pp. 419–432.

³² Greening, Landscape and Tree Management Section, HKSAR Government. (2016). *Handbook on Tree Management*. Hong Kong: Greening, Landscape and Tree Management Section, Development Bureau. Appendix 12.

³³ Food and Agriculture Organization of the United Nations, "Planning a Tree Nursery," <http://www.fao.org/docrep/006/AD228E/AD228E03.htm>

³⁴ Dumroese RK, Wenny DL, Barkley YC. (2001). *Plant your seedlings right*. Retrieved from <http://www.lri-lb.org/sites/default/files/Plant%20Your%20Seedling%20Right.pdf>

Weed Control	
<p>Weeds compete with trees for nutrients, water and light. Weeds also tend to grow faster and are more vigorous than the trees. As such, weed control should be conducted regularly. Once the tree is established, there will be limited resources for the weeds to grow. Therefore, in the later stages of the life-cycle, regular weed control may be unnecessary.</p>	
1. Propagation to Seedling	<p>There are several ways to minimize weed growth.</p> <ul style="list-style-type: none"> - The planting bed can be prepared up to 4 weeks in advance. The planting bed will be watered and any germinated weeds can be removed prior to planting the seedlings.³⁵ - Mulch can reduce evaporation from soil and lower soil temperature, inhibit weed growth but improve seedling growth and survival. To improve effectiveness, organic mulch is preferable since they can also release organic matter and nutrients into the soil. Apart from weed control, mulching can also prevent soil erosion, evaporation and compaction. - Hand-weeding is preferable to better avoid damage to the seedlings³⁶.
2. Sapling to semi-mature	<p>Weed control is essential for every tree species for the first 1-2 years after it has been planted in the roadside planter. A vegetation clear zone around each tree should be kept. The zone should be 150mm-300mm or wider for larger trees, which also discourages a moist environment for weed or fungal growth around trunk base/root collar³⁷. A thin layer of organic mulching can be added to in this zone under the tree to minimise the possibility of weed growth. Attention to the thickness of the mulch should be made as too much may cause tree rot. Manual removal of weeds in the vegetation clear zone is preferable in order to avoid damaging the root zone³⁸.</p> <p>Climbers and parasitic plants may be found at the tree canopy or on the trunk. They scramble to the tops of tree and blocking the sunlight for photosynthesis. Their roots compete with trees for moisture and nutrients, stunting or even killing them. Hand weeding is recommended to avoid damage to the tree.</p>
3. Mature	
4. Senescence	
Other Remarks	<p>The handling of herbicides should follow AFCD (Cap. 133) Pesticides Ordinance on "Pesticide Registration and Control", General Specification by ASD Section 25, or General Specification (2006) by CEDD Section 3.9. Only herbicides registered in Hong Kong and distributed with a Pesticides License may be used.</p>

³⁵ Krishnan, P. R., Kalia, R. K., Tewari, J. C., & Roy, M. M. (2014). *Plant Nursery Management: Principles and Practices*.

³⁶ Penn State College of Agricultural Sciences. (2017). *Herbicides (Introduction to Weeds and Herbicides)*. Retrieved from <http://extension.psu.edu/pests/weeds/control/introduction-to-weeds-and-herbicides/herbicides>

³⁷ Greening, Landscape and Tree Management Section, HKSAR Government. (2016). *Handbook on Tree Management*. Hong Kong: Greening, Landscape and Tree Management Section, Development Bureau. Appendix 12.

³⁸ Hitchmough, J., & Fieldhouse, K. (Eds.). (2008). *Plant user handbook: a guide to effective specifying*. John Wiley & Sons.

Pest and Disease Control

Examination on tree health treatment or removal of diseased trees can prevent spread of pests and diseases. Integrated Pest Management (IPM) approach should be undertaken. This is a long-term, ecosystem based strategy to suppress and control the pest population to an acceptable level, through a combination of physical, biological, cultural and chemical methods with the least risk to the environment. IPM is very site-specific. It is based on the identification of pests, accurate measurement of pest populations, assessment of damage and knowledge of available pest management strategies or tactics to make an informed decision.

Signs of pests and diseases and its corresponding treatment should be updated regularly in the maintenance record. If an outbreak occurs, treatment should be immediate. Spraying of pesticides or other chemical products should follow the “Code of Practice for the Safe and Proper Use of Pesticides in Public Areas” jointly issued by AFCD, FEHD and LCSD (Sept. 2014) and “Safe and Proper Use of Pesticides - Turf and Landscape Management” by AFCD (2017, 2nd Ed.). Spraying areas should be temporarily zoned and isolated from pedestrians for safety considerations. Do not apply pesticides when rain is expected within 24 hours, under windy conditions or if the day is expected to reach above 30°C.

<p>1. Propagation to Seedling</p>	<p>Plant in sterilized / fumigated clean planting beds and selecting only healthy seedlings or propagules. Termites are one of the most common insects recorded in the nursery that can cause serious considerable damage. They eat the roots and stems of many tree species and seedlings are especially vulnerable. Termites can be controlled by regularly using pesticides, applying a thin layer of ash (2-3cm thickness) around the seedlings bed or physically removing the termite queen through the use of plant extracts and chemicals. ³⁹</p>
<p>2. Sapling to semi-mature</p>	<p>The selected sapling or semi-mature tree should be inspected closely to ensure it is pest and disease free before planting in its final receptor site. After planting, the tree still requires close monitoring for pests and disease to prevent spreading to adjacent trees.</p>
<p>3. Mature</p>	<p>Regular tree inspection for pests and disease should be conducted to control initial outbreaks and prevent spreading to adjacent trees.</p>
<p>4. Senescence</p>	<p>At this final stage of the life-cycle, trees spend a majority of their energy just to maintain themselves. Thus, senescent trees are more vulnerable due to their decreased resistance to pest and diseases.⁴⁰ Root decay and heart rot are common and can create an ideal habitat for bark beetles and wood boring insects. The affected tree can become a source of a pathogenic inoculum that may affect other nearby healthy trees. ⁴¹</p>

³⁹ Mbora, Anne, et al. (2013). “Good Nursery Practices: A Simple Guide”. *Establishing a tree nursery* | TECA, World Agroforestry Center. Retrieved from teca.fao.org/read/7808.

⁴⁰ Refer to AFCD (Cap. 133) Pesticides Ordinance on “Pesticide Registration and Control”, General Specification by ASD Section 25, and General Specification (2006) by CEDD Section 3.9.

⁴¹ Vince, S. W., Duryea, M. L., Macie, E. A., & Hermansen, A. (Eds.). (2004). *Forests at the wildland-urban interface: conservation and management*. CRC Press.

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Other Remarks	<p><i>Fusicoporia senex</i>, fungus that cause tree canker, can result in symptoms such as crown defoliation, cavities, cracks and eventually leading to death. In Hong Kong, species such as <i>Cassia javanica var. indochinensis</i> are prone to infection⁴².</p> <p>Brown Root Rot Disease caused by fungi pathogen, <i>Phellinus noxius</i>, can lead to rapid health and structural deterioration of trees, ultimately to tree failure. This pathogen has a wide host range and reported on more than 200 plant species, representing 59 families. Some of these plant families include, MORACEAE and LAURACEAE. ⁴³ The management approach for this disease is promulgated by GLTMS “Guidelines on Brown Root Rot Disease” (Dec. 2012).⁴⁴</p> <p>The handling of pesticide should follow AFCD (Cap. 133) Pesticides Ordinance on “Pesticide Registration and Control”, General Specification by ASD Section 25, or General Specification (2006) by CEDD Section 3.9. Only pesticide registered in Hong Kong and distributed with a Pesticides License may be used.</p>
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⁴² Greening, Landscape and Tree Management Section, HKSAR Government. (2015). *Note on Common Wood Decay Fungi on Urban Trees of Hong Kong*. Hong Kong: Greening, Landscape and Tree Management Section, Development Bureau.

⁴³ Ann, P. J., Chang, T. T., & Ko, W. H. (2002). *Phellinus noxius* brown root rot of fruit and ornamental trees in Taiwan. *Plant Disease*, 86(8), 820-826.

⁴⁴ Greening, Landscape and Tree Management Section, HKSAR Government. (2016). *Handbook on Tree Management*. Hong Kong: Greening, Landscape and Tree Management Section, Development Bureau. Appendix 20.

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Tree Protection

Tree protection provides a physical barrier between the tree and the harsh environment. With suitable protection in place, it is possible to enhance and extend the urban ULE of street trees. Tree protection operations should be inspected regularly to ensure they are providing adequate protection and not being detrimental to tree health. Proper tree protection should be carried out in accordance with the following guidelines by GLTMS, “Tree Care During Construction,” “Guidelines on Tree Preservation during Development” (4/2015) and “Design for Tree Protection Zone”.

1. Propagation to Seedling	Protection from weather conditions such as fierce winds, heavy rains and sunlight is needed as this is a delicate stage in the tree’s life-cycle. Fencing with mesh roof cover (usually doubled up as a cover for shade protection) may also protect against human, wild animals and insects damage. For example, wild animals, such as rodents, can cause serious damage by eating the seedlings. Birds may also eat seedlings that have just germinated.
2. Sapling to semi-mature	Protection for the tree in urban streets is usually in the form of tree guards, which are used to deter vandalism, urban traffic and provide support in windy conditions. Tree guards need to be large enough to avoid inhibiting the growth of the tree whilst not affecting the pedestrian or traffic flow. Water should be allowed to flow freely into the tree planting area so that the tree can receive irrigation naturally. Regular inspection of the tree guard and the trees are required to ensure they are properly in place and not inhibiting the growth of trees.
3. Mature	Removal of tree guard is necessary when the tree has reached the mature stage.
4. Senescence	
Other Remarks	Trees with buttress roots or large trunk flare, for example <i>Ficus virens</i> , should be planted in large planting areas where sufficient space is provided for their growth. Planting in tree pits is not recommended. Meanwhile, <i>Ficus spp.</i> are recommended for large planting areas as it would not only provide adequate space, but also allowing aerial roots to grow and reach the ground for stability.

Tree Staking / Guying

Tree stakes and guys should not be installed in areas where they can become a potential tripping hazard or safety concern to the public. Some movement should be allowed so that the tree is better able to adapt to the environment. Regular inspection should be conducted to adjust the staking or guying to benefit tree health. Once the tree can support itself, tree stakes and guys should be removed immediately. Proper tree staking and guying practices should be carried out in accordance to the following guideline by GLTMS, “Staking and Guying of Trees.

1. Propagation to Seedling	Nil
2. Sapling to semi-mature	<p>Since Hong Kong is located in typhoon-prone zone, sapling and semi-mature street trees are usually supported by stakes. The staking method should avoid damaging the rootball. Connection of the stakes to the tree should be smooth, elastic and non-abrasive. The attachment should not be too high (around one third of the tree height) as this may result in smaller root systems and slender stems. ⁴⁵</p> <p>Most street trees require a maximum of 2 years of staking and should be removed after establishment. In windy areas, as many as 3-4 stakes might be required. The general exception to this is palms. Palms, such as <i>Wodyetia bifurcata</i>, may require some staking if planted in high wind areas in the first few years. ⁴⁶</p>
3. Mature	<p>Most trees should not require staking during this stage in the life-cycle, with the exception that if the tree is transplanted to the roadside during this stage. Similar to the previous stage of the life-cycle, the staking method should avoid damaging the rootball</p> <p>In some cases, cabling is used at this stage. Cabling is a way to stabilize a tree, which if otherwise left uncorrected, may shorten its urban ULE due to structural failure. As a tree matures, the weight of the canopy and additional load imposed by rain or wind may increase the stress of the limb. This is especially true if the tree species is prone to included bark or V-shaped crotch, for example, <i>Cassia javanica var. indochinensis</i>. Properly installed cables can aid in redistributing the load and allow the limbs to support each other. Cabling is used as an alternative to large pruning cuts that may otherwise be required to reduce risk of failure. Often, cabling is used to provide stability until the end of the tree urban ULE. The cabling system should be inspected regularly by a tree-care professional and determined if they need to be replaced or readjusted. ⁴⁷</p>
4. Senescence	<p>At this stage, the tree may become more vulnerable to limb breakage. A properly installed tree support system reduces the risk of tree failure and extends its lifespan. However, extensive metal frame supporting system is not recommended as it can compromise the ability of the tree to support itself by becoming more dependent on the metal support.</p>
Other Remarks	<p>In some cases, pavement renovation works may directly or indirectly affect tree roots and thus the tree stability. Proper inspection and planning is required before the works to assess whether tree staking is needed. “Guideline on Pavement Renovation Works and Tree Stability” by GLTMS (4/2013) should be followed.</p>

⁴⁵ Greening, Landscape and Tree Management Section, HKSAR Government. (2016). *Handbook on Tree Management*. Hong Kong: Greening, Landscape and Tree Management Section, Development Bureau. Appendix 12.

⁴⁶ Roloff, A. (Ed.). (2016). *Urban tree management: for the sustainable development of green cities*. John Wiley & Sons.

⁴⁷ Gilman, E. F. (2011). *An illustrated guide to pruning*. Cengage Learning.

Pruning	
<p>Pruning involves the selective removal of certain parts of a tree, usually branches or twigs. Commonly done to street trees to improve health, reduce potential public risk, shaping, or ensuring sightlines are not blocked. Proper pruning techniques should refer the “General Guidelines on Tree Pruning” by ETWB, 2007, “Do’s and Don’ts in Pruning” and “How to Prune a Tree” by GLTMS. Pruning should be performed by trained personnel and under proper supervision by experienced personnel with expertise in horticulture, arboriculture and tree care.</p>	
1. Propagation to Seedling	Nil
2. Sapling to semi-mature	<p>Structural pruning is an essential practice for saplings in assisting the young and developing tree to provide a desirable and stable form at maturity. For instance, <i>Plumeria rubra</i> is a tree species which is more likely to develop two or more central leaders or stems, together with the presence of included bark. It is recommended to remove the weaker stems when the tree is still young so that the tree can develop a strong central stem. Some smaller lower branches may be kept temporarily for tree health reasons if they do not block traffic or pedestrian flow. These may eventually be pruned as the tree matures.</p> <p>Hong Kong is located in a typhoon-prone zone and strong winds can be experienced in urban streets. Regular thinning or reduction of tree crowns before the typhoon season begins can ensure less wind load. Thus, the tree can receive less damage during these tropical storms.⁴⁸ The percentage of crown thinning or reduction must be adjusted to account for inherent tolerance, age and condition and environmental factors. ANSI A300 Pruning Standards state that “not more than 25 percent of a tree’s foliage should be removed within an annual growing season⁴⁹.”</p>
3. Mature	<p>If trained properly in the early stages of growth, a mature tree usually does not need pruning often. However, they should be inspected annually to identify and remove hazards. Usually, during crown cleaning, crown thinning, crown raising or crown reduction a maximum of 25% of the foliage can be removed at any given time. Removal of too much foliage may affect the tree’s health.⁵⁰ Proper pruning practices should follow the “Management Guidelines for Mature Trees” by GLTMS (12/2014).</p> <p>Due to the constraints of the street environment, regular pruning for most species is inevitable - including but not limited to removal of structural defects, dead or hazardous branches. The lower branches of tree species (e.g. <i>Polyspora axillaris</i>) may interfere with people or vehicles, or block visibility of signs or street lighting; sometimes their branches may grow into buildings, then pruning of overgrown branches is required.⁵¹</p>
4. Senescence	<p>Special care is needed when pruning senescence trees. Pruning should only be conducted if there is a safety concern or emergency. As senescent tree energy reserves are small, removing large amounts of wood is not recommended and can hasten tree decline.</p>

⁴⁸ Gilman, E. F., Masters, F., & Grabosky, J. C. (2008). Pruning affects tree movement in hurricane force wind. *Arboriculture and Urban Forestry*, 34(1), 20.

⁴⁹ Works Branch Development Bureau Government Secretariat, HKSAR Government. “Development Bureau Technical Circular (Works) No. 7/2015 Tree Preservation.”

⁵⁰ Hartman, J. R., Pirone, T. P., & Sall, M. A. (2000). *Pirone’s tree maintenance*. Oxford University Press.

⁵¹ William, E. (2005). *Pruning Landscape Trees*. Retrieved from <http://extension.psu.edu/natural-resources/forests/urban-community/publications/pruning-landscape-trees>

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	<p>If the senescent tree is required to be kept, a qualified professional should inspect the tree for potential or existing hazards and create a long-term pruning plan for the tree if necessary. Crown-reduction may be recommended to reduce height and width of the canopy and encourage new interior growth. Weaker structures should be pruned away to make the tree safe.⁵²</p>
<p>Other Remarks</p>	<p>Trees that develop aerial root or buttress root should not be planted in tree pits or small planters as this will restrict their growth or cause root girdling.</p> <p>Pruning of aerial roots may be necessary for some species. <i>Ficus spp.</i> (especially <i>Ficus religiosa</i>) requires aerial root management in their mature stage due to their "adventitious" growth habit. Aerial root management is important as aerial roots are used for water and nutrient absorption from the surroundings and provides additional lignified support. In this case, aerial roots should be retained unless they become a nuisance. For stonewall trees, pruning may result in wall or tree stability issues. Proper maintenance strategies and operations should refer to "Management Guidelines for Stonewall Trees" by GLTMS (12/2013).</p> <p>Other types of pruning include formative pruning, crown lifting, crown reduction, crown thinning and crown cleaning.⁵³ The frequency and type of pruning is dependent on tree species and the street typology. For example, <i>Pongamia pinnata</i> may require more frequent pruning because it is a fast-grower. It requires formative pruning in the sapling to semi-mature stage. Crown reduction pruning may be required depending on the site context.</p>

⁵² Roddick, C., & Hanson, B. (2007). *The Tree Care Primer (No. 186)*. Brooklyn Botanic Garden.

⁵³ Greening, Landscape and Tree Management Section, HKSAR Government. (2016). *Handbook on Tree Management*. Hong Kong: Greening, Landscape and Tree Management Section, Development Bureau.

Fertilisation & Soil Aeration

Misapplication of fertiliser can be detrimental to a tree’s health. The best time to apply fertilizer is when the tree can use it, i.e. the active growing season. The type of fertiliser, application method and nutrients should be based on the species, life-cycle stage, tree health, soil ability to absorb nutrients and location factors.

Slow-release fertiliser is recommended for most tree species. Application of water-soluble fertiliser is not recommended during the rainy season as the fertiliser can quickly leach away before the tree can absorb the nutrients. Deep root fertilisation is preferable as this method can also reduce soil compaction and provide some degree of soil aeration. Also, it ensures that human activity or pets will not remove the fertiliser accidentally.⁵⁴

Prevention is better than cure concerning soil compaction causing insufficient oxygen level reaching tree roots. Methods to prevent soil compaction include the application of mulch, tilling, replacement of soil or planting of complementary vegetation mix. Tree guards can be extended to protect not only the tree but the entire planting area from possible soil compaction due to foot traffic. Signs of soil compaction include hard soil, standing water, poor plant growth and surface crusting. If soil compaction occurs, it can be alleviated through soil aeration. Soil aeration can be done by core aeration, vertical mulching, radial trenching or air excavation. It is recommended to conduct soil aeration operations at the same time when applying fertiliser.

Application of structural elements in pavement, such as structural frames or root cell is an alternative measure to resolve the soil compaction problem. It also enables an integrated design for planting, paving and underground utilities where the soil volume and quality for tree growth could be maintained without compromising the structural integrity of the footpaths.

1. Propagation to Seedling	Mulch, a layer of material applied to surface soil, is used to protect seed beds to prevent overheating and rapid drying of surface soil, heavy raindrops, and washing or blowing away of fine soil particles. Fertilizers should be applied to growing nursery plants for needs of nutrient shortage or change of pH ⁵⁵ .
2. Sapling to semi-mature	Compacted soil, generally found in urban roadside planting sites, can greatly reduce the soil ability to hold onto nutrients. Additionally, root loss from tree transplant further limits the uptake of nutrients. Fertilisation at the planting stage may yield minimal results. However, if coupled with soil remediation practices such as raking and harrowing, fertilisation can aid in improving initial tree growth and establishment. A soil test should be performed prior to planting, to determine if there are nutrients deficiency and how the soil can be ameliorated. ⁵⁶
3. Mature	As the tree reaches maturity, the need for nitrogen drops as their growth rate naturally slows down. Application of fertilisation can be reduced and a low maintenance level is needed to maintain the tree in healthy condition without excessive vegetative growth. Where possible, it is recommended to conduct a soil

⁵⁴ IH, A. E. S., Koriesh, E. M., Moghazy, E. I., & Hefni, M. M. (2013). Comparison Between Two Methods of Fertilizer Applications and Fertilizer Rates for Young Urban Tree *Ficus retusa*, Linn. Implanted in Sandy Soil. *Hortscience Journal of Suez Canal University*, Hort. Dep. Suez Canal University, 2013.

⁵⁵ Food and Agriculture Organization of the United Nations. (n.d.). “Planning a Tree Nursery”. Retrieved from <http://www.fao.org/docrep/006/AD228E/AD228E03.htm>

⁵⁶ Harris, J. R., Day, S. D., & Kane, B. (2008). Nitrogen fertilization during planting and establishment of the urban forest: a collection of five studies. *Urban Forestry & Urban Greening*, 7(3), 195-206.

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	test to determine the type of fertiliser is needed. Depending on species, fertilisation can be carried out once every 2-3 years to maintain foliage and vigour. ⁵⁷
4. Senescence	Nil
Other Remarks	For evergreen tree species, such as <i>Podocarpus macrophyllus</i> , a fertilizer mix that encourages foliar growth (one with a higher ratio of Nitrogen) is recommended to be added during the growing season which is in the early spring. In addition, extra supplements of iron and magnesium are beneficial to its health. ⁵⁸ Similarly, for flowering tree species, a fertilizer mix that encourages blossoming and flowering (one with higher ratio for Phosphorous) should be applied

⁵⁷ Starbuck, C. J. (1999). Fertilizing shade trees.

⁵⁸ Jeff, C. & Carl, R. (2000). Tree fertilization: A guide for fertilizing new and established trees in the landscape. United States: University of Minnesota Extension. Retrieved from <https://www.extension.umn.edu/garden/yard-garden/trees-shrubs/tree-fertilization-guide>

Tree Inspection and Monitoring & Tree Risk Assessment

Proper inspection, monitoring and undertaking of tree risk assessment will minimise risk of tree failure. This should be conducted by qualified professionals for arboricultural works. The information should be gathered across different government departments and centralised for record keeping. Operations requiring emergency response should be done immediately.

1. Propagation to Seedling	Nil
2. Sapling to semi-mature	The mortality rate of a sapling or semi-mature tree is the highest in the first 3 years after transplanting to the roadside receptor site. Close monitoring during these first few years is crucial in identifying and mitigating site conditions linked to low rates of survival and establishment rate. ⁵⁹
3. Mature	Regular inspection should be carried out at least once a year to identify if there are any changes to the tree condition or surrounding site. Recommendation for treatment should be identified and carried out in accordance with the Guidelines for Tree Risk Assessment and Management Arrangement by GLTMS, DevB. ⁶⁰ .
4. Senescence	<p>Close tree monitoring and inspection is recommended to be conducted by qualified professionals for arboricultural works. Injuries and decay that happened in the earlier stages of the life-cycle, can become more problematic as the tree reaches senescence. Senescent trees become less effective in compartmentalization, which leads to the spread of infection. Likewise, as the tree becomes more vulnerable, close inspection for pests and diseases should be conducted to prevent spreading.</p> <p>Depending on the tree species, detailed annual or half-yearly tree risk assessment may be necessary. For example, <i>Plumeria rubra</i> may require half-yearly assessments as it has relatively brittle branches and is a fast-grower. Some indicators may not be clearly visible and specialized instruments, e.g. resistographs, should be used to determine the amount of decay or other defects in the wood.</p>
Other Remarks	The purpose of tree risk assessment is to identify potential tree risks and carry out mitigation measures in a timely manner to reduce risk. Tree management departments are required to carry out tree risk assessment in accordance with the “Guidelines for Tree Risk Assessment and Management Arrangement” promulgated by GLTMS (currently the November 2015 edition or the latest edition after).

⁵⁹ Koeser, A. K., Gilman, E. F., Paz, M., & Harchick, C. (2014). Factors influencing urban tree planting program growth and survival in Florida, United States. *Urban forestry & urban greening*, 13(4), 655-661.

⁶⁰ Greening, Landscape and Tree Management Section, HKSAR Government. (2015). *Guidelines for Tree Risk Assessment and Management Arrangement*. Hong Kong: Greening, Landscape and Tree Management Section, Development Bureau.