STREET TREES IN HIGH-DENSITY URBAN HONG KONG

by C. Y. Jim

Abstract. High-density urban Hong Kong has a small population of street trees. A survey of 930 trees in two districts provide information on tree characteristics and for management. Of the 55 species encountered, few are numerically dominant and currently cultivated. The rare species are mainly woodland or garden relics. Species selection is shifting from native/large to introduced/small. Some popular species are not quite suitable for streets; a few rare voluntary species perform well. Most trees are concentrated along a few roads where growth space is available. Plantable space is a major bottleneck. The distribution of trees by growth type, position, and proximal landuse are discussed. Most trees have narrow crowns and are short-statured, suggesting a youthful population and/or a recent trend to plant small species. Two-thirds have arboricultural problems. Lack of tree data and of regular inspections make planning for tree care difficult. Maintenance is grossly inadequate due to lack of skilled workers. The poor tree health and defects are likely to persist.

The densities of roads, buildings, and population in the urban areas of Hong Kong are among the highest in the world. High-rise buildings spread from the center to the edge of the city. Most of the 5.5 million people live in apartments closely packed in 176 km^2 (80 mi^2) of build-up areas. The average density in the main urban areas is 40,000 persons/km^2 (103,600 persons/mi^2) and the maximum exceeds 160,000 persons/km^2 (414,400 persons/mi^2). The predominantly artificial surface and high concentration of air pollutants render the environment unfavorable to tree growth. The rapid population increase and the need to develop and expand the city resulted in massive destruction and negligence of the scarce urban tree resource. The present study aims at street trees which have direct visual and other impacts on urban landscape. A sample of 930 trees in a study area, out of a total estimate of 8,000 street trees, was surveyed in an attempt to understand the nature of the resource and hopefully throw some light on management.

Methods

A survey of all street trees in two of 11 districts in urban Hong Kong was implemented in the summer of 1985. The districts (Central and Western) were selected for: 1) relatively rich endowment in street trees in terms of number and species diversity by local standards; 2) long history of urban development with some of the oldest streets and trees, and new development areas built on land recently reclaimed from the sea, thus providing a wide range of environments and growth conditions; and 3) contain some of the highest density areas with acute growth problems commonly found in the city.

Data on the following groups of attributes were collected: 1) species identification; 2) street name and tree location on 1:2,500 scale map; 3) tree height, height to lowest branch, dbh and average crown diameter; 4) pavement width, trunk to curb distance, and distance to nearest tree; 5) growth type and position; 6) adjacent land use and vehicular traffic volume; 7) pavement cracking, exposed and girdling roots; 8) crown fullness, tree vigor, and physical growth confinements; 9) arboricultural defects and disorders.

Numbers were collected wherever possible, and estimates or ratings for the rest; 25 variables were surveyed. Species were identified with the help of the herbarium staff at the Botany Department, University of Hong Kong. The data were recorded with a microcomputer (IBM/PCXT) and program "DBase III." Data were analyzed with DBase III and the statistical program "Microstat."

Species Composition and Selection

Species richness (15) is high in comparison with some cities in the temperate latitudes (e.g., 5, 18, 24). However, of the 55 species found (Table 1), only 10 have a frequency of 25 or more, and only 18 have 10 or more. Most species are broadleaf and evergreen.

Palms and conifers. The few palms include the common *Phoenix roebelenii* and *Archontophoenix alexandrae*, and the less common *Livistona chinensis*, *Roystonea regia* and *Phoenix hanceana*. The subtropical climate of Hong Kong is well suited for palm growth, but only *P. roebelenii* and *A. alexandrae* are widely used. Because the

final stature of the former rarely exceeds 5 m, it fits cramped roadsides. For lack of local nursery space, most of the palms come from mainland China or Taiwan. The slow-growing conifers, including *Juniperus chinensis*, *Araucaria excelsa*, *Podocarpus macrophyllus* and *Thuja orientalis* are uncommon. All had been on private property and became pavement trees after road realignments.

Native and voluntary species. Street tree diversity is governed by natural and cultural factors.

Table 1. Names and frequencies of 55 species enumerated.

Name	Frequency	Percent of total
1. *Phoenix roebelenii*, Dwarf Date Palm	175	18.8
*2. *Ficus microcarpa*, Chinese Banyan	105	11.3
3. *Cassia surattensis*, Sunshine Tree	85	9.1
4. *Aleurites moluccana*, Candlenut Tree	50	5.5
*5. *Bombax malabaricum*, Cotton Tree	45	4.7
*6. *Celtis sinensis*, Chinese Hackberry	44	4.5
7. *Washingtonea robusta*, Petticoat Palm	35	3.7
* 8. *Bauhinia blakeana*, Hong Kong Orchid Tree	26	2.8
9. *Delonix regia*, Flame-of-the-forest	25	2.6
*10. *Erythrina spp.*, Coralbean	25	2.6
11. *Melaleuca leucadendron*, Paper Bark Tree	19	2.1
12. *Acacia confusa*, Acacia	19	2.0
13. *Thevetia peruviana*, Yellow Oleander	18	2.0
14. *Juniperus sinensis*, Chinese Juniper	18	2.0
15. *Archontophoenix alexandrae*, King Palm	16	1.7
16. *Crateva religiosa*, Spider Tree	11	1.3
*17. *Ficus virens*, Large-leaved Banyan	11	1.3
18. *Mangifera indica*, Mango	10	1.1
19. *Pterocarpus indicus*, Burmese Rosewood	9	1.0
20. *Casuarina equisetifolia*, Horsetail Tree	8	0.9
*21. *Broussonetia papyrifera*, Paper Mulberry	8	0.9
*22. *Litsea glutinosa*, Pond Spice	7	0.8
*23. *Livistonia chinensis*, Chinese Fan Palm	7	0.8
24. *Bauhinia variegata*, Camel's Foot Tree	6	0.6
25. *Plumeria rubra*, Fragipani	6	0.6
*26. *Cinnamomum camphora*, Camphor Tree	6	0.6
*27. *Ailanthus fordii*, Ailanthus	6	0.6
28. *Araucaria excelsa*, Norfolk Island Pine	6	0.6
*29. *Litsea monopetala*, Persimmon-leaved Litsea	6	0.6
30. *Terminalia catappa*, Indian Almond	5	0.5
31. *Podocarpus macrophyllus*, Buddhist Pine	5	0.5
32. *Ficus elastica*, Indian Rubber Tree	5	0.5
33. *Albizia lebbek*, Lebbek Tree	5	0.5
34. *Macaranga tanarius*, Elephant's Ear	5	0.5
35. *Cassia fistula*, Golden-shower Tree	4	0.4
36. *Roystonea regia*, Royal Palm	4	0.4
37. *Thuja orientalis*, Chinese Arbor-vitae	4	0.4
*38. *Hibiscus tiliaceus*, Cuban Bast	4	0.4
*39. *Cerbera manghas*, Cerbera	3	0.3
40. *Euphoria longan*, Lung Ngaan Tree	2	0.2
*41. *Cratoxylum ligustrinum*, (nil)	2	0.2
*42. *Choerospondias axillaris*, Hog Plum	2	0.2
43. *Michelia alba*, White Champak	2	0.2
44. *Magnolia grandiflora*, Lotus-flowered Magnolia	1	0.1
*45. *Ficus variegata*, Green-fruited Fig	1	0.1
46. *Persea americana*, Avocado	1	0.1
*47. *Schefflera octophylla*, Ivy Tree	1	0.1
48. *Syzygium samarangense*, Java Apple	1	0.1
49. *Peltophorum pterocarpum*, Yellow Poinciana	1	0.1
50. *Morus alba*, White Mulberry	1	0.1
51. *Eucalyptus robusta*, Swamp Mahogany	1	0.1
*52. *Phoenix hanceana*, Spiny Date Palm	1	0.1
*53. *Bischofia trifoliata*, Autumn Maple	1	0.1
*54. *Ficus superba*, (nil)	1	0.1
55. *Litchi chinensis*, Lychee	1	0.1

The indigenous tropical woodlands have a high inherent diversity. Urban encroachment into the woodlands at the city fringe could leave a few relic trees which happen to fall on future sidewalks. Most rare native species are in sloping areas formerly covered by woodlands that are believed to have been left. The notable examples are the weed trees *Litsea glutinosa*, *Macaranga tanarius*, *Schefflera octophylla* which are commonly found in local woodlands. Other voluntary species include *Celtis sinensis*, *Broussonetia papyrifera*, *Ailanthus fordii*, *Hibiscus tiliaceus*, *Ficus variegata* and *Bischofia trifoliata* which are sparsely cultivated. Many of the woodlands species cannot survive the drastic changes in habitat conditions associated with urbanization. The successful species provide a potential pool from which candidates can be selected for street planting to enrich diversity. A systematic evaluation (2, 3, 4, 13) of these rare native trees is worthwhile.

Exotic garden species. Some of the exotic species were previously cultivated in private grounds where tree selection followed the preferences of the property-owners or managers. Site redevelopment and the associated lot-boundary readjustments and road-widening exercises could transpose these private trees into the public roadside space. Some prominent examples are *Mangifera indica, Euphoria longan, Syzygium samarangense,* and *Litchi chinensis* (fruit trees), also *Araucaria excelsa, Podocarpus macrophyllus* and *Morus alba*. None of these species was planted by the government at roadside sites. Some of these popular south China garden species prove to be rather suitable by virtue of their tree form and physiological tolerance to street planting. More widespread planting of, for example, *M. indica*, *E. longan*, and *S. samarangense* should be encouraged.

Favoured species. The introduced *Phoenix roebelenii* and *Cassia surattensis*, both with low stature and narrow crown spread appropriate to street use, are widely planted recently. Their visual impacts are more important than their ameliorative effects on the harsh urban environment. Although *Aleurites moluccana* is the most abundant street tree in Hong Kong, in our study area other species are more common. Its ease of propagation, rapid growth rate, vigor in resprouting, dense foliage, compact crown, and quick greening effect make it popular with the city's tree managers, but its soft wood is prone to typhoon and pest damage. *Bombax malabaricum*, another common fast-growing tree, is poor for street planting, especially at exposed sites, because of brittle branches. *Bauhinia blakeana*, a common street tree selected as the "city tree" of Hong Kong mainly for its beautiful flowers, has straggly growth and weak branches. *Melaleuca leucadendron*, a sturdy tree whose columnar form is suitable for streets is gaining in popularity.

Out-of-favour species. Ficus microcarpa, a large, beautiful, hardy, long-living, evergreen indigenous species has fallen out of favour. It was planted exclusively from the 1840s, when the city was founded by the British, until the 1930s. It becomes too big for the high-density modern Hong Kong. Its wide crown and its aggressive

Fig. 1. This *Ficus microcarpa* (Chinese Banyan) had been lopped so excessively that the effort to keep it is rendered meaningless.

searching roots render it suitable for street planting only in ample roadside spaces. Many large specimens were sacrificed as the city expanded. Most of these trees have reached full size, and many show signs of decline. Some survivors are stranded incongruously in narrow streets, abutting adjacent buildings. Excessive pruning or lopping often were carried out to prevent obstruction to traffic or building redevelopment (Fig. 1). These maltreatments, plus senescence, leave few good trees of this species.

This long-lived species once gave a unique character to the city. The tree is revered, even worshipped, by many traditionally minded old people. Felling an old *F. microcarpa*, however diseased or dangerous, evoked strong sentiments, but few young ones were planted. Its normal lifespan (several hundred years) is much longer than the city's regeneration cycle. Hence trees planted in the past, that suited the site then, became out of place as the city evolved. Because it would be unthinkable to have no *F. microcarpa* along Hong Kong streets, adequate space should be opened to plant this species.

In addition to *F. microcarpa*, species popular in the past that now are rarely planted include *Celtis sinensis* (due to large size), *Delonix regia* (due to large size, tendency to damage pavement, and brittle branches), *Acacia confusa* (due to straggly habit, low branches, and aggressive roots), and *Crateva religiosa* (no apparent reason)—a beautiful tree relatively free from troubles.

There is a recent tendency to choose introduced, small trees. Excessive reliance on a handful of well-tried species can increase the hazards of any epidemic. For lack of research on the suitability of tropical species for street planting, the use of any new species is only trial and error. Attention should be paid to maintenance costs.

Tree Growth Space and Structure

Limited growth space. Lack of space for street trees limits urban planting in Hong Kong. High-density, high-rise buildings stretch from city center to fringe. Most sites have a 100% building-and-pavement coverage. This drab environment pervades the city, except a few residential neighbourhoods. Lack of growth space is acute in the older part planned when controls were lax and when standards were low. New developments have more planting spaces.

Most pavements are too narrow (less than 2 m) for street planting. The common practice of building above them prevents planting in much of the city. Thus most of the trees are along a few of the roads. Of the street trees, 60% are separated from their nearest neighbour by less than 4 m, and 84% by less than 8 m (Fig. 2a). In all, less than 5% of the trees are solitary (no neighbour tree within 16 m). Most such isolated trees are mature or old, private garden relics or remnants. Because of narrow sidewalks, 75% of the trees are less than 4 m from the curb (Fig. 2b). With little on-street parking, fast moving vehicles, including double-decker buses, graze the tree crowns. Although most sidewalks with trees are wider than 2 m, 16% of the trees are found in sidewalks narrower than 1 m or where no sidewalk is present (Fig. 2c). The Highways Department normally does not allow planting where sidewalks are less than 2 m wide, for sake of road safety and pedestrian flow.

Types of growth space. Although nine types of street growth space are common in Hong Kong, about half of the trees are found in one of the three types of planting strips (Fig. 3). Most of these strips are narrower than 2 m but they are, by local standards, very generous. Most of these strips are along the few roads through low density areas, or new roads where space was reserved, by new planning standards, for amenity planting. Very few roads have more than one line of trees. About 16% of the trees are reared in pits, most of which are undersized and not equipped with grilles.

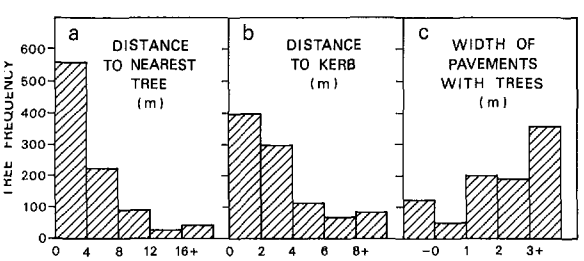

Fig. 2. The frequency of trees by the distance to the nearest tree, the distance to curb, and the width of pavements with trees.

Concrete was paved all the way to the trunk of 7.5% of the trees, leaving no soil surface for water and air exchange. This negligent failure to open tree pits or to use grilles is baffling. The remaining trees grow in stony and shallow soils, or in concrete planters which are getting popular where there are underground restrictions mainly due to the masses of buried services (including electricity, telephone, traffic control, water, gas, and sewers).

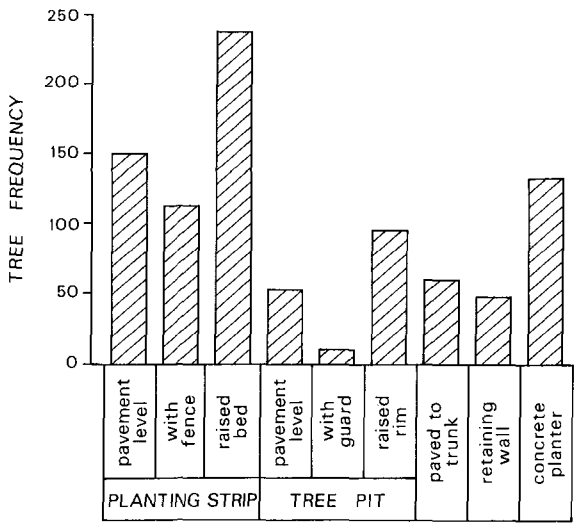

Fig. 3. The frequency of trees by nine types of growth space.

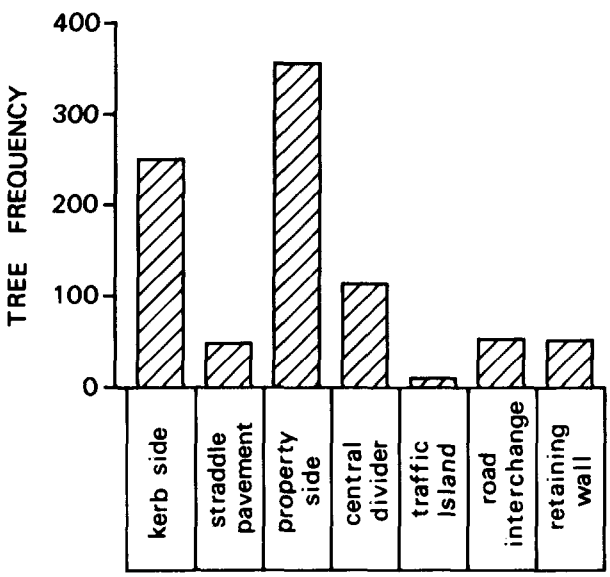

Fig. 4. The frequency of trees by seven types of growth position.

Figure 4 shows the trees' growth positions. Most are on property or curb side of the sidewalk. But some straddle the sidewalk obstructing pedestrians due to road alignments (Fig. 5). About 13% are in the few recently built central dividers.

Results on proximal landuse show that government and institutional is the most frequent. Other landuses (including commercial, residential low and medium densities, open space, and transportational) have roughly equal shares, except high-density residential areas which lack growth space, and housing estates, where most trees are away from the roads.

Tree structure. Tree sizes are given in Figure 6. Half the trees are less than 4 m tall, since many were planted in the past decade. Two recently planted species, *Phoenix roebelenii* and *Cassia surattensis*, have small final size. Very few trees exceed 12 m height, mostly *Ficus microcarpa* but some *Celtis sinensis* and *Aleurites moluccana*. The dbh has a similar pattern: two-thirds are less than 20 cm (Fig. 6b). And 62% have crowns narrower than 4 m (Fig. 6c). The small crowns result also from space limitations along streets. Often, large trees are heavily pruned to fit.

Large street trees are rare due to senescence, diseases and urban redevelopments. The new trees, small to medium in final size, cannot replace them. Thus the sylvan character of the city declines. Since most of the plantable space is now used up, future planting must be in new developments or renewed districts.

Tree Condition and Care

Foliage, trunk and branch problems. Of the 930 trees studied, 611 had defects and disorders, an average of 1.8 items per tree. Hong Kong typifies the wide range of tree problems (Table 2) of any high-density environment (1, 20). Over half the trees showed foliage symptoms (9, 21): discoloration, spots, wilting, insect feeding, and defoliation, often quite acute. Without diagnosis, hostile environment (14, 21) and injuries by people were assumed to open them to attacks by pests and pathogens (11, 12) which led to decline and dieback. The fact that no systematic pathological study of street trees has ever been

attempted in Hong Kong hinders proper tree care.

The trees urgently need expert attention: nearly 40% have structural defects. Some have forms unsuitable for streets (curved or crooked trunk, low branching habit, heavy branches, close branching intervals, V-shaped crotches, or straggling branching). Most of these problems were exacerbated with age, without shaping in the nurseries or later (8, 9, 10). The trees with split trunk and branches, plus those with large cavities, wounds and broken branches, are hazards.

Less serious, but not minor, defects include avoidable wounds from construction (16, 19). Canker and wood-decay pathogens enter the uncared-for wounds. Some trunks are willfully damaged by nails and other sharp implements.

Root problems. Slightly over 10% of the trees have exposed or girdling roots often with cracked or heaved sidewalks. Such trees have aggressive, thick roots (6, 17) and are in undersized tree pits or strips, or compact soil (7, 8, 22, 23). Unfortunately, some of these species are common and a few are still actively used: *Acacia confusa*, *Aleurites moluccana*, *Bombax malabaricum*, *Crateva religiosa*, and *Delonix regia*. The problems arise when nursery stock grows in small containers. The roots should be spread out during transplanting. Excavations and grade changes also damage tree roots.

Physical restrictions. Above-ground space is very restricted for 7% of the trees. Physical obstacles include buildings (especially with awnings), vehicles, signs and lamp-posts (Fig. 1 and 5). The trees' crowns are incomplete. Wrong species, mis-siting, typhoon damage, construction, and general decline and dieback also cause this. Building or road development often has priority over trees' crowns (Fig. 1 and 5). Selection and siting cannot preclude landuse change.

Tree care. Most trees have low to medium

Fig. 5. This *Ficus microcarpa* (Chinese Banyan) has been severely deformed and left trapped on a narrow sidewalk without a tree pit as a result of building redevelopment.

Table 2. Frequency of trees with defects and disorders (319 out of 930 trees surveyed are free from problems).

Attributes	Attribute rating			
	Low	*Medium*	*High*	*Total*
Leaves				
Discoloration and spots	101	72	125	298
Wilting	26	27	69	122
Insect feeding	23	7	16	46
Defoliation	1	3	4	8
Subtotal	151	109	214	474
Trunk and branches				
Damaged bark	3	6	8	17
Broken branch	27	18	12	57
Splitting	7	1	5	13
Wound or cavity	25	8	18	51
Wound or cavity with decay	23	11	9	43
Other wood decay	40	11	5	56
Fungal infection	56	13	8	77
Swollen trunk or gall	5	0	0	5
With nails and other willful damages	19	11	0	30
Subtotal	205	79	65	349
Exposed or girdling root	21	39	48	108
Cracked or heaved pavement	27	27	10	54
Subaerial physical confinement	34	29	5	68
Crown fullness	61	562	307	930
Tree vigour	171	737	22	930

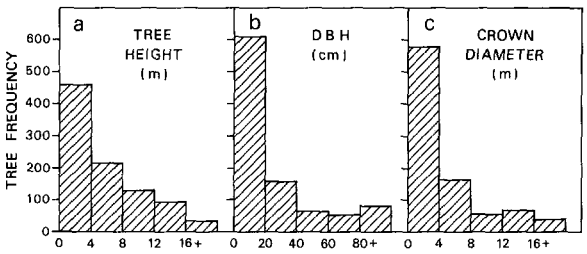

Fig. 6. The frequency of trees by three structural attributes of height, dbh, and average crown diameter.

vigor, and many have acute untreated problems. Without prompt care, minor problems become major and irredeemable, because of shortage of skilled arborists. The tree staff has hardly any time for remedial or preventive work. There is no inventory of trees with problems and no regular schedule of tree inspection. This lack makes planning tree work almost impossible. Heavy investments in tree planting waste away, leaving eyesores, management liabilities, and hazards. Eventually, typhoons purge the weak and diseased trees.

Conclusions

Hong Kong, with meager greenery, is overwhelmingly artificial. Tree planting along streets can ameliorate this stark urban environment. More street planting is limited by a severe space shortage. Existing trees are allowed to degrade due to lack of care and growth space. There is urgent need for more and better tree staff for tree maintenance. Species selection can be improved by thorough evaluation. A regularly updated tree database, with records on tree characteristics and maintenance requirements, is recommended. A city-wide master tree plan should be instituted. As an integral part of a city's infrastructure, trees should be adequately funded and staffed.

Acknowledgments. I thank Meimei Cheung, Rebecca Leung, and Grace Jim for their help in the preparation of this manuscript, and the Hui Oi Chow Trust Fund for research grant support.

Literature Cited

1. Bernatsky, A. 1978. Tree Ecology and Preservation. Elsevier, Amsterdam.
2. Dewers, R. S. 1981. *Evaluation of native and exotic woody plants under severe environmental stress.* J. Arboric. 7(11):299-302.
3. Gerhold, H. D. 1985. *Performance testing of street tree cultivars: a model project.* J. Arboric. 11(9):263-271.
4. Gerhold, H. D., and Sacksteder, C. J. 1982. *Better ways of selecting trees for urban plantings.* J. Arboric. 8(6):145-153.
5. Gilbertson, P., and Bradshaw, A. D. 1985. *Tree survival in cities: the extent and nature of the problem.* Arboric. J. 9:131-142.
6. Hamilton, W. D. 1984a. *Sidewalk/curb-breaking tree roots. 1. Why tree roots cause pavement problems.* Arboric. J. 8:37-44.
7. Hamilton, W. D. 1984b. *Sidewalk/curb-breaking tree roots. 2. Management to minimize existing pavement problems by tree roots.* Arboric. J. 8:223-234.
8. Harris, R. W. 1980. *Structural development of trees.* J. Arboric. 6(4):105-107.
9. Harris, R. W. 1983. Arboriculture: Care of Trees, Shrubs, and Vines in the Landscape. Prentice-Hall, Englewood Cliffs.
10. Harris, R. W., Hamilton, W. D., Davis, W. B., and Leiser, A. T. 1975. *Training young trees.* J. Arboric. 1(8):154-157.
11. Houston, D. R. 1984. *Stress related to diseases.* Arboric. J. 8:137-149.
12. Houston, D. R. 1985. *Dieback and declines of urban trees.* J. Arboric. 11(3):65-69.
13. Karnosky, D. F., Gerhold, H. D., and Collins, W. H. 1982. *Metria projects on species trials and cultivar testing.* J. Arboric. 8(7):178-181.
14. Kozlowski, T. T. 1985. *Tree growth in response to environmental stresses.* J. Arboric. 11(4):97-111.
15. Krebs, C. J. 1978. Ecology: the Experimental Analysis of Distribution and Abundance, second edition. Harper & Row, New York.
16. Partyka, R. E. 1982. *The ways we kill a plant.* J. Arboric. 8(3):57-66.
17. Perry, T. O. 1982. *The ecology of tree roots and the practical significance thereof.* J. Arboric. 8(8):197-211.
18. Richards, N. A., and Stevens, J. C. 1979. *Streetside space and street trees in Syracuse—1978.* College of Environmental Science and Forestry, State University of New York.
19. Schoeneweiss, D. F. 1982. *Prevention and treatment of construction damage to shade trees.* J. Arboric. 8(7):169-175.
20. Tattar, T. A. 1978. Diseases of Shade Trees. Academic Press, New York.
21. Tattar, T. A. 1981. *Stress models for trees in the urban environment.* Arboric. J. 5:55-56.
22. Wagar, J. A. 1985. *Reducing surface rooting of trees with control planters and wells.* J. Arboric. 11(6):165-171.
23. Wagar, J. A., and Barker, P. A. 1983. *Tree root damage to sidewalks and curbs.* J. Arboric. 9(7):171-179.
24. Yau, D. P. 1982. *Street trees of Melbourne.* Arboric. J. 6:95-105.

Department of Geography & Geology
University of Hong Kong
Pokfulam Road
Hong Kong