BRIEFING PAPER

URBAN STREET TREE VARIABLES AND PARAMETERS IN RELATION TO MEDIAN AND STREETSCAPE DESIGN, PLANTING AND THE STRUCTURE OF VEGETATION IN THE URBAN ENVIRONMENT

PURPOSE

To provide information to those outside the landscape professions about the use of trees in the urban highway setting and considerations for the health and safety of the tree when so used. This document is not intended to address vehicular and pedestrian safety implications related to roadside tree plantings.

BACKGROUND

Local communities are increasingly interested in constructing urban highways in a more aesthetically pleasing and environmentally friendly manner. One of the common approaches is to provide trees along the periphery and in the median of the roadway. The increased interest in tree planting and subsequent recommendations made by the Urban Roadside Treatments Team has brought forth many questions regarding trees and plant growth in the urban streetscape. This paper is an attempt to answer some of these questions and to provide background information for further discussion.

DISCUSSION / INFORMATION

Please note: The numbers following an itemized paragraph or bulleted item indicate references found in the *bibliography* at the end of this paper.

TERMINOLOGY

The organization in space of the individual trees that form a stand (and by extension a vegetation type or a plant association) is called structure. The primary elements of structure are growth-form, stratification and coverage. In their vertical and horizontal expansion, individual plants will differ at successive stages of development i.e. a species may grow rapidly (tall) in the first 20 years of life and then slow vertically and fill out with horizontal growth over the second half of the growth cycle or life span. Others may conversely grow rapidly horizontal and then slowly vertical. [2]

Limiting factors is the principle that the rate of plant process will be most sensitive or constrained by the *primary environmental variable* (ecological amplitude). Precipitation is typically the most limiting factor to plant growth. Tree growth cannot proceed faster than allowed by the amount of rainfall or irrigation. At higher latitudes and elevations, temperature is most often the limiting factor, and at any location, constricted root growth due to compacted, rocky soils is critical. These factors may be compounded. In arid areas fast draining soil (sand) may have a combined effect with limited precipitation to have an even more dynamic effect on plant growth. [2, 7]

Limiting factors in urban locations are most often poor drainage, compacted soil, and limited available root space.

Amplitude is the conditions or environmental factors in which a plant is growing.

Aptitude is the plant or specie characteristics that allow it to adapt to variable growing conditions or amplitude. [2]

Growth-form can be grouped in several ways: Habitat (woody or herbaceous), branching, periodicity (evergreen, semi-evergreen or deciduous, leafless), and leaf type (size, outline, texture). Leaf type or size is more relevant to design, scale and maintenance than actual lifecycle issues. [2, 4]

Canopy/Tree Shape is the uppermost part of the tree that contains the foliage or leaves (vs. trunk, roots) and gives the tree its designated shape (see *Description of Tree Shapes* contained herein). Total canopy coverage (continuous shading) by trees would be less likely to support shrub growth or ground covers. It also contributes to control of invasive plants. Whereas, discontinuous coverage would be more conducive for shrub support and sparse or discontinuous shrubs would better support groundcovers.

STRATIFICATION

Stratification recognizes a more or less permanent layering; an arrangement of individuals at definite heights above ground. 2.

Coverage (shading) is defined as: Barren or sparse, discontinuous, tufts and groups, and continuous. Coverage is generally recorded as a percentage of shading provided by each canopy layer. [2]

Life forms most associated with the urban stand (designed or planned landscape) are trees, shrubs and herbs (herbaceous). [2, 4]

Tree size is classified into three groups; large (over 40 feet), medium (25 – 40 feet) and small (25 feet or less). [2, 13]

ON GROWTH AND SIZE

Size at full maturity cannot be totally and accurately defined as a ratio because of individual specie characteristics, the coverage during the first half of the growth cycle and the environmental conditions (amplitude) in which it is growing. A tree height of 50 meters at 40 years of age will not necessarily be 25 meters at 20 years of age nor will a trunk diameter of 1.5 meters at 40 years be .75 at 20 years. However, over time and quantity of measurements an average estimate may be established. Given certain factors such as controlled growth with proper climatic conditions, location in the strata, sufficient root space, fertilizing and soil balancing, consistent watering, and other proper horticultural practices some tree species could be assumed to maintain a constant and consistent rate of growth.

Very little data has been collected or is available regarding urban tree growth. Older street and urban forest trees are considered an asset and are maintained rather than cut down. It is slowly becoming "industry standard" to gather size, age, and condition data on live specimens and on trees when they are lost and removal is required. Many cities are now conducting tree inventories and gathering of growth data is strongly recommended when removal of a tree is necessary.

POINTS OF INTEREST

Economic Benefits

- Trees can be a stimulus to economic development, attracting new business and tourism. [21]
- Commercial retail areas are more attractive to shoppers and space in a treed area is more valuable to rent or sell. [13, 21]
- Shade from trees can save as much as $175 per year per structure (residential studies) in air conditioning costs. [1, 15, 21]
- Healthy, mature trees can add an average of ten percent to a developed property's value and 30% to undeveloped land or open space values. [18, 21]

Environmental Benefits

- The planting of trees improves water quality, results in less runoff and erosion, helps in recharging the ground water supply, and helps prevent sediment and chemicals reaching stream systems. [19, 21]
- A large tree absorbs 10 pounds of air pollution solids per year with a emission reduction value of $45 (1998 – 2000). [19, 21]
- A large tree can clean 330 pounds or more of carbon dioxide from the atmosphere through direct sequestration in the tree's wood. This equals the same amount released by a typical car driven 388 miles. [1]

- A mature evergreen tree (75 feet or more) in coastal regions is estimated to intercept 4,000 gallons of rainfall per year and at any given time sequester up to 200 gallons. [19]
- One acre of trees absorbs over six tons of carbon dioxide and provides four tons of oxygen per year. This is enough to meet the needs of 18 people. [19, 20]
- Trees modify climate by reducing solar radiation, air temperature and wind speed. [12]
- Evergreens may act as a winter buffer and help retain heat near buildings.
- Trees can prevent snow drifting across highways.

Societal Benefits

- Many cities have approved street tree lists and usage ordinances. It is widely recognized that trees are an asset to the community and many cities have memorial and historic tree programs as well.
- Trees in the streetscape provide a softened visual experience that surveys have shown make people feel safer. [21]
- Trees provide vertical and horizontal elements which may result in traffic calming.
- In laboratory research, visual exposure to settings with trees has produced significant recovery from emotional stress in less time and has been shown to reduce road or travel related stress. [18, 21]

DESIGN CONSIDERATIONS

Trees in General

- Age slows the upward growth even though the tree trunk diameter may continue to grow. At a certain age a tree stops growing completely in height. [6]
- There is a correlation between trunk diameter (caliper) and canopy diameter, but not to height for open growing trees. Height does not seem to relate to any other measurements in natural growing conditions. [6]
- There is however, a correlation between caliper, root ball diameter and survivability for street trees. [8] There are height to caliper standards and caliper to root ball size standards for controlled field grown nursery stock. These standards were formulated by the American National Standards Institute in 1986 and are known as standard ANSI Z60.1. These standards were developed to give an indication of survivability (overall plant vigor) for trees to be planted in the landscape.
- Due to many factors including a wide range of environmental variables and limiting factors, ecologists have long since given up trying to determine an age/size relationship (outside field grown nursery conditions). [7]
- Tree diameter is typically measured at 42 to 54 inches above grade. Grade must be level three feet from trunk in all directions. Sloped c factors into consideration that may cause (acceptable subjective) measurements at higher or lower levels. [6]onditions bring other
- Tree spacing rule of thumb: Trees of thirty feet in height or less may routinely be place twenty-five to forty feet apart depending on canopy width per species.

Trees thirty to forty feet in (mature) height should be placed a minimum of forty feet apart. If fastigate or columnar trees are used, spacing could be closer. [16]

- Only small trees of 25 feet mature expected height should be planted within 20 feet of overhead utility lines. [13]
- Oxygenation of roots is critical to tree survival. Design layouts should provide sufficient area to accommodate roots for the size of tree specified. Berming of the planting area and good drainage are recommended to prevent anaerobic conditions and to provide tree root aeration.
- Structural soils may be used under adjacent paved areas to provide additional rooting space.
- Soil aeration systems (under pavements) have not been proven to work, but may only slow the inevitable. Root aeration by auger of compacted soils over roots has also been shown to have limited results and should only be done as a last resort protective action. [3]
- Median specie selection should be made with available space in mind or the median should be designed towards the desired tree selection allowing for optimum growth conditions. The location for trees should have enough space to allow for growth without *severe* pruning or root constriction. Cutting a tree back to size or topping is perhaps the most harmful tree practice known. [9]
- Select trees that are known to do well in the area and are suited for the intended purpose. [9]

<u>Tree Roots</u>

- Because roots need oxygen, they normally don't grow in the compacted oxygen-poor soil under roadways. [13]
- The framework of major roots usually lies less than 8-12 inches below the surface. [13, 17]
- Roots often grow outward to a diameter three to five times the height of the tree. (open or field growing) [13]
- Downward forced root growth usually ends up with roots back at the surface where girdling may occur. Trees planted with limited root space may girdle or strangle themselves without proper root maintenance. [17,18]
- The use of root barriers prevents significant damage to surrounding hardscape. However, the limiting factor of available soil volume and pit design does have an effect on the overall health and vigor of the tree. Recent research shows successful use of root barriers is questionable.
- Testing and studies of trees with limited root growth have shown trees may become top heavy and easily overturned in high winds when soils are dry. However, root barrier systems that force downward then outward root growth have some stabilizing effect to windthrow. [9]
- Urban street trees may last 12 to 18 years or even longer. It may take years for root problems to become apparent. Trees may do well for four or five years then begin to decline.[14]

Maintenance

- A regularly scheduled tree maintenance and management program is essential to long term health and appearance of the tree and prevents damage to the surrounding street paving, curbs and sidewalks. Maintenance should be done in conformance with International Society of Arborculture (ISA) standards to assure long term success of an urban street tree program.
- The typical city spends an average of $35 per year (2000) maintenance per urban tree. [11]
- Limiting tree size through excessive canopy and root pruning, and root space availability is not an economical practice due to high maintenance costs. Chronic problems with pests and disease are symptoms of improper planting and care and may result in high maintenance activity and the use of treatments to include pesticides to save the tree. [9, 17]
- Leaf size is a critical element in controlling storm water runoff. A few large leaves may quickly block a catch basin, whereas smaller leaves can pass through. It should be recognized, however, that some larger leaved trees have desirable benefits such as detention of runoff in planted areas, and increased evapotranspiration. Seasonal maintenance should be provided and some cities have asked that local area residence' help in keeping catch basins clear.
- Soil type, fertilizing and PH are critical to street tree growth. Regular monitoring and balancing of soil conditions for specific tree specie requirements should be part of regular tree maintenance. [16]

SUMMARY

There are a multitude of considerations and qualifications that define street trees and their usage. *No one tree fulfills all the requirements of the perfect street tree*. Some of the desirable tree qualifications are that it is long lived and capable of reasonable rapid growth. It will be clean, neat and resistant to damage by wind and ice loads, disease and insect attack. It will be tolerant to dust, car exhaust and smoke, upright in growth, and attractive in shape. It will not raise or break pavement, nor clog storm water sewers with roots or fall foliage drop.

Soil and atmospheric conditions, width of the street, proximity of planting areas to buildings and overhead wires, density of vehicular traffic, amount of impervious pavement and size of planting area available are some of the most critical design considerations. There are many resources available to assist in design and horticultural practices. These include University Extension Services, local city arborists, state and federal agencies such as The Department of Natural Resources or the Department the Interior. Many cities have recently begun street tree inventories and management programs to be included with open grown urban stands, parks, cemetery, school trees, public and private neighborhood trees, memorial tree programs and historically significant tree monitoring. Trees are a critical asset to any community and with proper design, maintenance and long term management following best landscape and horticultural practices, costs of urban tree management may be offset by positive environmental and socio-economical benefits.

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