Bachelor of Applied Science (Horticulture)

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TREENET : NEW TREE VARIETY ASSESSMENT

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Abstract

Metropolitan Tree Growers Pty Ltd is a company based in Alphington, Melbourne, who supply containerized tree stock to several of Melbourne's municipality council's, which is planted in the streetscape. John Fitzgibbon, the owner of the business, finds it hard to travel around Melbourne and assess all of the new varieties of trees Melbourne councils are planting that are originating from his nursery, although he would like to know their progress and if they are establishing successfully.

Treenet, an organisation based at Adelaide University, Waite campus, runs street tree trials around Australia assessing tree establishment success and making their results available on the internet. Some of Metropolitan Tree Growers stock is listed on a number of trials. Their assessment methods however, are not standardized for all the different trial sites.

Mr Fitzgibbon is interested in the formulation of a standard assessment method to evaluate some of the new tree varieties he is supplying for street tree use.

Introduction

Victorian councils plant many thousands of trees into their streetscapes each year. Included in these plantings are new cultivars and selections, sourced both in Australia and overseas, which have been chosen for particular characteristics that could enable them to become successful street trees. After many years of new cultivar/selection introduction, there is little information available to the organizations in charge of the planting regarding which trees are the most successful in their municipalities. This situation is compounded by the fact that no standard criteria exists in this part of Australia for assessing new plantings and evaluating their health, growth and survival prospects. One organization is attempting to do this in South Eastern Australia (Treenet, based in Adelaide), but they fail to employ a standardized method for measuring success.

The aim of my project is to formulate a standard method for assessing street trees, which could hopefully, in the future, provide councils with information on street tree successes and failures.

Literature Review – Tree Assessment

Literature researched for this project has been very useful in helping to formulate a street tree assessment technique. Articles from both the horticultural and forestry sectors have been evaluated, with many papers complementing each other and ensuring all factors considered for a standard method have been covered.

The most comprehensive information gathered was from Gerhold (1985). In this journal article, a model system for comparing street tree cultivars was developed for American streetscapes to be used by municipal arborists. The model is based on periodic measurements and observations for evaluating tree health and growth. The study was conducted after the author found little information on traits that affect tree survival and health was available, with arborists relying mainly on personal experience in making tree selections rather than published information. As with my project, the author states his objective as 'to provide the street tree industry with reliable and meaningful information on cultivar performance at a reasonable cost'. He explains that although information is available from plantings at arboreta, all these cultivars are growing in similar conditions. Using this data does not take into account the 'real world' environment to which street trees are exposed to.

As the article was only a proposed model at the time of writing, no information is supplied with regards to how any tree cultivars have faired using the system. But the basis for the model is very thorough and explores all practical boundaries relevant for such a method. The method is described in 5 sections.

1) Test plan form – Selecting trees for testing which will fit into the current year's plantings based on possible future applications and where they should be planted.
2) Cultivars suggested for comparison performance tests – Matching cultivars of the same species, or different species of similar appearance into pairs for comparisons at each site.

3) Test design – Includes the specimen numbering system, number of plots, plot type (mixed or pure), nursery source, plot location, number of trees in each plot and date of planting.
4) Plot establishment form – A map of the trees in the plot, tree data (height, stem diameter), distance of tree from nearest building, planting space provided to tree.
5) Performance data – These are taken in years 1, 2, 3, 6, 9, 12, & 15 and include stem diameter, total height, foliage and branch health ratings (measured as a percentage of injured or dead foliage), trunk health rating, causes of injury, maintenance rating.

A well defined possible method for evaluating street trees, which works in conjunction with current planting schedules rather than setting up test streets far removed from proposed council planning.

This method was put into practice 9 years later Gerhold, McElroy & Rhodes (1994) with 10 crabapple cultivars evaluated for street trees, and followed up with a second report Gerhold (2000) on the same stand of trees. Using the above method, the researchers were able to establish which cultivars were more successful than others in different areas and were able to recommend cultivars based on their evaluations. They were also able to determine differences in size and growth rate when comparing space limitations.

Both positives and negatives were experienced with the method. The foliage ratings used in the method pinpointed which cultivars were most affected by pests such as beetles and moths in certain areas. But some opinions varied on some of the rating scales if different observers were used for the same cultivars. These findings can help fine tune future standardized evaluation methods (e.g. observers assigned a cultivar each to eliminate conjecture).

More literature was found on a similar evaluation as above, but this time using *Pyrus calleryana* cultivars as the test subject. Gerhold & McElroy (1994) reported on initial 3rd year results from an eight cultivar study in ten different locations across Pennsylvania, America. Even at this short stage they had singled out one of the specimens

(‘Whitehouse’) as unsuitable for street tree plantings in this area, as it had only increased total height by 2% in 3 years and suffered poor foliage ratings. Other cultivar growth was so exceptional that the authors predicted that these trees could grow so tall that power line interference could occur in some sites in the near future.

Kuser, Robinson & Polanin (2001) directed their *Pyrus calleryana* study on 5 cultivars planted in car park situations in New Jersey, America, over a 4-year period. They gathered considerable information within this period to be able to rank the specimens from 1 to 5, (1 being the best-rated cultivar, 5 the poorest). They noted in their findings that unlike the previous *Pyrus calleryana* report, they found the ‘Whitehouse’ cultivar to be healthy and vigorous on their test site, mentioning the closeness of the Atlantic coast as the possible benefit for the specimens positive health and vigor.

Conflicting results in the literature, like the two previous reports, show that certain factors (climate in this instance) have an enormous affect on tree evaluation ratings. When researchers use the same standardized assessment method, this conflicting information can be easily recognized, noted, and passed on to the relevant organizations.

Costello, Scott & Drake (2004) also found climate a defining factor when testing 4 elm cultivars for Dutch elm disease (DED) resistance in California, America. Although this test was carried in a field plot, and not a streetscape like the previous literature, the information gathered on growth habit alone by some cultivars was enough to recommend certain specimens not be transferred into streets in that area in the future. Apart from determining the initial focus of the research (DED resistance), evaluators also discovered which cultivars required the least maintenance to become an established tree. Street tree maintenance is an expensive part of council budgets and the report found the elm cultivar ‘Valley Forge’ had such accelerated growth rates that it was impossible to establish a central leader which resulted in poor branch structure. Its structural characteristics were deemed so poor that it was removed from the test plot after just 3 years. Research results such as these, although not carried out in the streetscape, are just as interesting for the evaluation of specimens grown in certain climatic areas.

Several journal articles focused on the assessment of streets where street trees of unknown composition, health, age and population existed. The first from Valentine, Westfall & Manion (1978) focused on two areas of New York, America. This article was more statistically motivated and could be likened to a tree census as well as a tree assessment. Aerial photography was used to establish sample plots, and a standardized evaluation method was used, high in detail, consisting of 7 physical characteristics, 17 measures of health and 7 factors of physical environment. Information gathered like this can be good for establishing health and long term replacement plans for mature stands of city trees (particularly large cities like New York), but it is not as useful when evaluating recently planted trees. The same scenario was documented in Cumming et al (2001) in the state of Maryland, America, except that the standard evaluation method used was developed by The National Forest Health Monitoring Program in 1990. This method was not described in its entirety, and only data was provided on crown density readings obtained by researchers. One useful point mentioned in the article was the use of a Global Positioning System (GPS) by the researchers to record exact tree positioning. Equipment like this can be extremely useful for both evaluator and client organization in pinpointing particular tree taxon locations for tree data bases, and subsequent updated evaluations.

Literature analysis – Significant Associated Factors of Tree Assessment

The most decisive factor for tree establishment is irrigation. This was strongly expressed in several literature texts researched. Although the above mentioned assessment research did not include irrigation information during their assessments, I believe that water is a critical factor to include. For example, a certain variety of tree is being assessed in streets that are located within 2 different municipal boundaries, with one Council having a more frequent irrigation regime than the other (especially in the first 12 months). Tree health for the frequently irrigated test lot will most probably be better than the lesser irrigated in this case. This information should be investigated to produce a more realistic evaluation.

The harsh environment conditions which a street tree faces (especially those in pavements) was highlighted by Kjeldren & Clark (1989) who tested the evaporation of water from park and pavement planted trees in Seattle, America. They found evaporation of water from the pavement trees was 50% greater than those at the park, highlighting the greater risk of water stress for these trees.

Research by Gilman, Black & Dehgan (1998) investigated irrigation volume and frequency during a trees establishment period. They found that frequency was the more important factor for quicker tree establishment, not volume of water provided. Their research showed that the tested species of tree (*Qurcus virginiana*) required only 1.2 L of water / cm stem diameter to promote good growth after planting, anymore than this was considered excessive. The only trees to die during the research were those from the infrequently irrigated test lot (10% of the stand perished) after only 7 weeks, with the remaining tree from this section suffering some shoot and leaf damage.

Irrigation frequency was also a telling factor in research on *Acer rubrum* establishment Gilman et al (2003). Container type was also focused on, but was found to be an insignificant factor after the 5-year interval of the trial. All container types produced trees with equal quality root systems pertaining to root number and distribution in the soil. But trees frequently irrigated in the first 24 weeks after planting had twice the root weight than those of infrequent irrigated, and had greater root distribution in the top 30cm of soil. Radial distribution of roots was also more uniform when tested in 45-degree sections around each tree. Larger trunks were also measured for this group (175cm^2 in area compared to 137cm^2), a difference of 35%. The author suggests the difference in trunk area was due to infrequently irrigated roots growing deeper into the soil profile to access sufficient moisture.

Although both the previous irrigation tests were carried out in a field plot and not a street situation specifically, there is a presumption that similar results would have resulted.

Footpath trees were specifically targeted by Foster & Blaine (1978) in the American city of Boston regarding survival rates and the changing infrastructure. This research studied both young trees (<10 years old) and older established trees (from a stand planted in

1910). The established trees had only 83 remaining from an initial number of 350. It was noted by a landscape architect in 1937 that the whole stand was "thriving'. Changing conditions such as the introduction of motor cars, and impervious concrete footpaths replacing bricks and sand, were accredited to the large mortality rate. When the city replanted 3 streets in the early 1970's, only an average of 70% survived the first 3 years, with many in poor condition. Car damage (35%), vandalism (18%) and stake damage (65%) were the main problems sighted. However, the article does say the streets are narrow and steep, with trees out the front of stores with the worst car damage. There is no picture given of how the trees had been staked. As this article is 26 years old, the staking method may have been inappropriate compared to the systems used currently. One point they do make which has greater merit is the belief that the city engineer is the worst offender for tree mortality. This includes actual construction damage and altered, unsuitable growing conditions remaining after construction.

Literature Review Conclusion

After reviewing the literature, I have established that there is existing useful information available to assist with formulating a street tree assessment technique for use on Treenet. Although much of the research is based on northern hemisphere studies, I believe street tree conditions would be similar in both hemispheres. Although extreme cold is encountered in many parts of their area, the trees planted are selected for such conditions, as are trees in Australia selected for our conditions. So climate conditions between where the research was carried out and where it will be used should not be a telling factor.

Standardized evaluation methods have proved to be very useful in assessing, which trees grow best where, and under what conditions they are most successful. Henry Gerhold seems to be the leader in the evaluation field, yet his model leaves out the important factor of irrigation frequency, which proved to be an important factor in associated research. Combining several of the methods obtained could result in a system that is more accurate at evaluating street trees than is shown in the literature.

Methods and Materials

Environment is the complex combination of soil, climate, and tree arrangement (Kozlowski 1962). This statement by Kozlowski points to the many environmental characteristics important for successful tree growth. In a streetscape situation, a number of environmental qualities are non-adequate for optimal tree growth, and trees planted into these situations must be selected to suit these special conditions. Such conditions encountered by street trees include soil compaction, restricted growing space (both above and below the ground), both excessive and reduced sunlight, and lack of maintenance.

Information is readily available regarding the important factors to be considered for successful tree establishment. Texts compiled by Handreck & Black covering soil characteristics, and arboricultural issues sighted by Harris, Kozlowski, and Gilman in their books, cover all aspects of tree assessment and their establishment guidelines. When pooled together, this information can provide a detailed analysis of the best methods to achieve successful tree growth in the landscape.

pH Range

Soil

The soil pH level is a very important factor for plant growth, and can greatly influence the following four categories…

- Availability of nutrients to plants.
- Amount of nutrients held in the soils.
- Toxicities.
- Micro-organisms.

Different tree species have different optimum pH ranges eg. Trees that have evolved on very acid soils can grow well in soils with low pH, while those that grow well on highly calcareous soils (pH over 8) may be harmed at pH6 (Handreck & Black 1994).

Nutrients

Handreck & Black (1994) further state that the availability to plants of nutrient elements varies with pH.

- Most nutrients are reasonably available in the range of 6-7.5.
- Plants vary greatly in their abilities to extract nutrients from soils. Some are poisoned by high levels of soluble manganese in acidic soils; others cannot gain enough iron from alkaline soils.
- The effect of pH on nutrient availability is particularly important when the supply of nutrients is poor.
- In low pH soils, manganese and aluminium can destroy root and leaf cells. Aluminium toxicity can also prevent trees from gaining sufficient phosphorous amounts from the soil.

Micro-organisms

Micro-organisms have preferential pH ranges which they survive and grow best in.

- Rhizobium bacteria : >5
- Mycorrhizae : 4-6
- Organic decomposers : 5-9
- Bacteria for NH_4+ to NH_3- : >6

(Handreck & Black 1994)

Competition

Trees

Crowns of slower growing trees located near faster growing trees can become shaded if too closely planted. The competitive capacity of shaded branches for water and even perhaps nitrogen is reduced. Any resulting inhibition of photosynthesis of the suppressed tree reduces their supply of carbohydrates and possibly growth hormones leading to a reduction in cambial and root tissue growth. The inhibition of root growth decreases absorption of water and minerals, which further reduces growth (Kozlowski *et al* 1991).

Turf

Grass competes with trees for both water and minerals. It can out-compete tree roots by 30% for available soil moisture. Field tests have shown a decrease in leaf nitrogen concentration when trees are grown amongst grass swards. A potassium increase can be seen in the same leaves as a result of reduced growth, causing a concentration increase.
Eg. A 24 year fertilizer application increased a tree's nitrogen content by 0.15%, but a grass sward reduced it by 0.45% in a 2 year period. (Kozlowski *et al* 1991)

Restriction

Canopy space

My reference states that trees require above-ground space to spread so that their canopies can develop natural form. Sufficient above-ground space is essential for maximum light capturing capacity of the canopy to maintain plant vitality. Typical canopy trees may be as broad as they are tall. So a canopy tree of approximately 5 metres in height would require an above-ground space of 5 metres in width dimensions to achieve its full canopy potential (along with adequate sunlight).

Soil volume

Tree root distribution is generally shallow, and horizontal in orientation, with 95% of the root mass contained in the top 600mm of soil. Horizontal spread can cover an area up to 3 times the tree canopy width. The large percentage of root mass is found at this depth as it is in this section of the soil profile that contains the two essential resources for tree viability – water and nutrients. As a general estimate, it is recommended that $2m^3$ of soil be available for each m^2 of crown projection (Sorrell 2002).

Using this recommendation by Sorrell (2002), a tree with a crown spread of approximately 5 metres would require a soil volume of around $40m^3$. To achieve this volume using only the top 600mm of soil, an approximate area of $66m^2$ would be needed.

Critical root zone

The two main functions of woody roots are tree anchorage and stability, and the transport of water and nutrients which have been absorbed by the non-woody roots. The area that woody roots occupy in the soil is referred to as the 'critical root zone'. The radius of the critical root zone is directly proportional to a trees stem diameter eg. Stem diameter of 16cm = critical root zone radius of 1.5m. Taking this figure into account, no development or activity that could damage tree roots should take place within 1.5m of a tree of this size. (Sorrell 2002)

Soil characteristics

Compaction

Urban soils can impose serious constraints on tree establishment and growth, due to their impact on root growth and function. Urban soils are those that have been disturbed and changed by the process involved in the development of the urban infrastructure (Smith *et al* 2001).

Compaction occurs in urban soils when crumbs and particles are pressed together so that the spaces between them are reduced in size. Such occurrences can reduce water infiltration rates, which results in increased surface runoff and reduced water in the soil for trees. A reduction of pore space also decreases water and air availability to tree roots. Water is held more tightly in small pores, so tree roots must use extra force to replenish their needs. After soil drainage has occurred, the reduced size of the pores means more water is held, resulting in less available air (Handreck & Black 1994).

Soil strength

Roots find it harder to push their way through the soil and use more energy than usual to establish themselves when growing in compacted soil. The more energy used to establish roots, the less energy that can be used to produce foliage, potentially inducing stunted growth patterns. Young roots are especially affected by high soil strength with limited large pore space reducing the extensiveness of the root network. With less soil being able to be explored, the root system becomes small and shallow in structure, also retarding the trees ability to take up sufficient water and nutrients (Handreck & Black 1994).

Waterlogging

Waterlogging occurs due to soil profile characteristics leading to alterations in infiltration patterns, and poor surface and sub-surface drainage (Smith *et al* 2001). When a large percentage of soil pores are filled with water, oxygen movement to roots is very slow, which can often lead to root desiccation. Lack of oxygen in waterlogged soils can also retard tree growth in other ways.

- Organic toxins such as methane and ethylene retarding root growth.
- Hydrogen sulphide (rotten egg gas) killing root tips.
- Toxic levels of soluble iron and manganese.
- Losses of nitrogen, as nitrates convert too quickly to nitrogen oxides and gas which trees cannot use.
- Beneficial micro-organisms being unable to withstand the anaerobic conditions.

- Increased pathogen attack due to tree stress.

(Handreck & Black 2004)

Aspect

Light

Gilman (1997) states that most large trees grow best in full sun; this can be calculated by a minimum of 6 hours of direct sunlight. Trees suited to partial sun situations can grow happily with 3 hours of direct sun, and those categorised as 'shade loving' can survive on less than 3 hours, or a full day of filtered sunlight.

Some urban trees are required to survive close to buildings, and are exposed to conditions of reflected light from light coloured walls and large glass panels. Although these trees may receive reduced full sun due to the shadows cast by infrastructure, when they are exposed, the heat load is intensified for the sunny part of the day. Such trees require a substantial provision of soil for water absorption due to this light intensity, or they can suffer from leaf wilt and marginal leaf scorch (Gilman 1997).

Wind

Water loss from trees is increased by the presence of strong wind patterns. Increased wind exposure can also compound existing site problems such as soil compaction and root restriction, where root systems are confined and unable to explore for better water uptake (Eg. Trees planted in concrete cut-outs surrounded by buildings). Such situations result in the root zone drying very quickly through increased transpiration increases brought on by excessive wind exposure. In these circumstances, tree species selection for drought tolerance is terribly important (Gilman 1997).

Coastal site

Airborne salt can affect trees by causing twig and foliage damage. Root damage can also occur as salt leaches into the ground after being deposited on the surface. Any tree planted within 200 metres of a coastal shoreline should have some tolerance of airborne salt spray. Any salt sensitive trees planted too close to the coast will suffer foliage burns. Overall tree health and vigour can be affected by this outcome (Gilman 1997).

Stock quality

Root systems

A well developed, healthy root system is essential for tree stock that is to be planted into the urban landscape, as they will live for many years and greatly increase in size. Main roots should be free of kinks, and not circling or 'girdling' the pot or bag which they have been transplanted from. When removed from the pot or bag, there should be sufficient fibrous root mass to hold the root ball together and retain its integral shape (Harris 1992).

Root systems on container grown stock can be improved using several different root pruning methods. The first is with a product called Rocketpot ®, where tiny holes in the perimeter of the container air-prune root tips when they reach the pot's horizontal surface, reducing girdling and increasing fibrous root mass. The second production method is Spinout ®, which is a cupric hydroxide solution painted onto the interior of solid pots to achieve the same results as the first method except using chemical root pruning methods (Gilman *et al* 2003).

Stem caliper

When a tree grows in its natural environment (with no staking or pruning) it is capable of supporting itself when exposed to high wind loads. From seedling size, most trees grow with a certain height-to-caliper ratio, with sufficient stem taper and crown form that distributes any wind load along the stem. When a tree is grown commercially, these characteristics must be maintained (Harris 1992).

Height-to-caliper ratios must be adhered to, to reduce the instances of tall stock with spindly stems, which are unable to stand upright in full leaf under their canopy weight.

Practices such as hard staking of stems and early removal of lower lateral branching can also reduce sufficient stem taper qualities. Tree stock produced using such methods will bend along one section of the stem in windy circumstances, often so much that the canopy touches the ground. If the stem taper is extremely low, the tree will not recover from such positions and remain bent to the ground (Harris 1992).

Crown form

Uniform branching on a young tree will help distribute wind stress when it is planted in the landscape. The best situation for the tree is to centre the wind loads about 2/3 of the total tree height. Therefore, 50% or more of the tree's foliage should be contained on the lower 2/3 of the stem (Harris 1992).

Root-shoot ratio

Trees grown in bags or containers must have a root system large enough to absorb sufficient water supplies for the canopy, especially once planted in the landscape. Under normal conditions, a root mass that is 1/5 of the canopy weight is usually sufficient. Large tree stock planted with undersized root systems can quickly suffer from water deficiency if the small root system cannot supply the large transpiring surface area of the canopy in summer sun condition. (Harris 1992)

Planting technique

The hole in which the tree stock is to be planted must be no deeper than the root ball itself. If the root ball is too deep, then the roots may not receive sufficient moisture. Try and keep the top of the root ball free from backfill soil. The different texture between the soil and the container media is so different, water may not percolate from the finer textured soil (where water is tightly bound) into the coarse, easily drained root ball media. The base of the planting hole should be solid, and free from any disturbed or loosened soil. If not, after several irrigations and normal rainfall, the root ball may settle and sink deeper into the hole (Gilman 1997). A root ball that is sunken will tend to collect water that surrounds the base of the stem, often resulting in crown rot (Harris 1992).

Mulch placed over and around the planting hole will help in reducing moisture loss (through evaporation), moderating surface soil temperatures, and reducing soil cracking and settling. Creating a berm, or ridge, around the root ball perimeter will ensure irrigation water targets the root ball itself (where all of the tree's roots are at planting). Irrigation water applied outside the root ball will not assist in establishment as no roots are present there (Harris 1992).

Landscape Maintenance

Irrigation

Gilman (1998) established that frequently irrigated trees establish more quickly than those receiving infrequent irrigation. He also concluded that a larger volume of water application did not compensate for irrigation infrequency. The more frequent the irrigation, the better the chance of tree survival and quicker establishment (Gilman calculated that 1.2L / cm stem calliper was a sufficient volume application.

Another study compiled by Gilman (2003) found the first 24 weeks after planting were the most crucial for healthy establishment of landscape trees.

Mulching

In a text by Harris (1992), the many benefits of mulching newly planted trees are listed as follows.

- Soil moisture conservation through reduced evaporation.
- Control of weeds (which can use large quantities of water.
- Holding water where it falls for increased soaking ability.
- Reducing soil erosion.
- Increased nutrient availability.

- Improved soil aeration.

Staking

Advanced trees in the streetscape require some degree of staking to provide initial support until the new roots of the tree can spread into the surrounding soil. Such support is also helpful due to the instances of constant public contact that the tree is likely to encounter, particularly lawn mowers and attempted vandalism (Hitchmough 1994).

If the trees are to be staked, it should be done in a manner that the basal taper of the stem is not compromised. The best method is to supply two support stakes with one flexible tie near the top of each one. This will keep the tree upright, provide flexibility, and minimize stem injury. Trees should be staked at no higher than 1/3 of their total height, to minimise wind stress to the top of the canopy (Harris 1992).

Results

This project was never intended to be a quantitative analysis of large stands of street tree specimens, but rather the development of a standardized evaluation method to be tested on three different street tree species. The three species that John Fitzgibbon was interested in applying it to are listed below.

- *Angophora costata* (provenance Bullio State Forest, N.S.W).
- *Ulmus parvifolia* 'Murray's Form'.
- *Eucalyptus leucoxylon* ssp.*megalocarpa* Eukie Dwarf .

After viewing the literature available on street tree assessment, I formulated a set of guidelines that would be used on random specimens already established in the streetscape.

Revised Criteria for Street Tree Assessment

- Tree stock source (and type of production method used).
- Tree data (height, stem diameter, canopy structure).
- Soil type.
- Competition.
- Growing space provided.
- Irrigation provided.
- Post planting maintenance (mulching, formative pruning, correct stake positioning).
- Comparison with a specimen (of similar age) growing in more ideal conditions.

Maintenance specifications for trees located within the Boroondara municipality were supplied by Stuart Campbell (2004, pers.comm., 15 September).

Maintenance specifications for trees located within the Whitehorse municipality were supplied by Andrew Wright (2004, pers.comm., 17 September).

Maintenance specifications for trees located within the Darebin municipality were supplied by Andrew Hepburn (2004, pers.comm., 28 October). Although no specific irrigation scheduling was carried out by the municipality when the trees in this report were planted, a detailed regime has been adopted by the Council in the past 6 months for future street tree planting.

Stem diameter readings were taken at 2 different heights. The 30cm height reference is used by the nursery industry for stem calliper measurements (Fitzgibbon, J. 2004. pers.comm 10 August). The 1.3m height reference is used by arborists when determining DBH (Diameter at Breast Height) for mature tree specimens (Harris 1992).

Soil textures were determined using the Bolus Ribbon Method (Handreck & Black 1994).

Angophora costata

Location – Whitehorse Rd, Nunawading, Victoria.
Age – 4 Years old.
Original stock – 40L SpinOut treated black squat pot.

Eastern view of tree.

Picture displaying limited soil volume.

Stem diameter (30cm)	127mm
(1.3m)	107mm
Height	Approx 6m
Distance to curb (Sth)	0.93m
(Nth)	1.27m
Soil type	Clay Loam

Competition – Similar size trees 10m away on both sides, light patches of turf.

Maintenance regime

- Mulched when first planted
- Irrigated to field capacity on a 2 year cycle (temperature dependant on 1, 2 or 3 applications per week).
- Annual inspection and formative pruning

Observations – Soil aspect drops approx 200mm to the north curb.

Angophora costata

Location – Foley Park, Kew, Victoria.
Age – 2 Years old.
Original stock – 40L SpinOut treated black squat pot.

Eastern view of tree.

Picture displaying lush surrounds & mulch.

Stem diameter (30cm)	63mm
(1.3m)	55mm
Height	Approx 4m
Soil type	Sandy Clay Loam

Competition – 2 mature trees approx 7m away to the south & east

Maintenance regime

- Mulched (100mm depth), which also provides a watering well volume of 10L.
- 2 year irrigation cycle delivering a minimum of 40L per visit, 3 times a fortnight, between October & April (35 scheduled waterings).
- Trees re-mulched in the second establishment year.
- Irrigation can continue into a 3rd year if drought conditions are impeding growth.

Observations

- Well mulched.
- Surrounded by lush grass, still staked, but established.

Ulmus parvifolia ‘Murray’s Form’

Location – Newbigin St, Burwood, Victoria.
Age – 6 Years old.
Original stock – 40L SpinOut treated black squat pot.

Eastern view of tree.

Picture displaying lush grass & curb distance.

Stem diameter (30cm)	100mm
(1.3m)	92mm
Height	Approx 4m
Distance to curb (Sth)	1.15m
(Nth)	1m
Soil type	Light Clay

Competition – 1 tree 15m to the west.

Maintenance regime

- Mulched when first planted
- Irrigated to field capacity on a 2 year cycle (temperature dependant on 1, 2 or 3 applications per week).
- Annual inspection and formative pruning

Observations

- Nature strip is lush lawn.
- Soil aspect drops approx 100mm to the south curb.

Ulmus parvifolia 'Murray's Form'

Location – Murray Rd Reserve, Hawthorn, Victoria.
Age – 3 Years old.
Original stock – 40L SpinOut treated black squat pot.

Northern view – Note: no central leader causing strong lateral branch dominance.

Close up view shows lush swards of grass.

Stem diameter (30cm)	97mm
(1.3m)	82mm
Height	Approx 3m
Distance to curb (East)	6m
Soil type	Light Clay

Competition – Mature park trees approx 10-12m away in all directions.

Maintenance regime

- Mulched (100mm depth), which also provides a watering well volume of 10L.
- 2 year irrigation cycle delivering a minimum of 40L per visit, 3 times a fortnight, between October & April (35 scheduled waterings).
- Trees re-mulched in the second establishment year.
- Irrigation can continue into a 3rd year if drought conditions are impeding growth.

Observations – Surrounded by lush turf.

Ulmus parvifolia 'Murray's Form'

Location – Ilma Gve, Northcote.
Age – 4 Years old.
Original stock – 40L SpinOut treated black squat pot.

Southern view of tree showing street slope.

Close view emphasizes bitumen cut-out.

Stem diameter (30cm)	37mm
(1.3m)	16mm
Height	Approx 2.5m
Distance to curb	Tree is in a 1.2m x 1.2m bitumen cut-out
Soil type	Granitic Sand

Competition – none

Observations

- Tree has established itself (no ground movement if stem pushed).
- Street slopes steeply to the east (tree is at top of street).

Maintenance regime

- Staked and mulched at planting.
- No specific watering schedule.

Eucalyptus leucoxylon ssp.*megalocarpa* Eukie Dwarf

Location – Separation St, Alphington.
Age – 4 Years old.
Original stock – 40L SpinOut treated black squat pot.

Southern view of tree with 2 storey house to the north.

Close view shows the nature strip well below the pavement surface.

Stem diameter (30cm)	77mm
(1.3m)	62mm
Height	Approx 4m
Distance to curb (Sth)	1m
(Nth)	0.85m
Soil type	Light Clay

Competition – Similar size tree across the road and 15m to the west.

Observations – Two storey house 5m from canopy to the north alongside three 5m high trees.

Maintenance regime

- Staked and mulched at planting.
- No specific watering schedule.

Eucalyptus leucoxylon ssp.*megalocarpa* Eukie Dwarf

Location – Warwick Ave Reserve, Surrey Hills, Victoria.
Age – 4 Years old.
Original stock – 40L SpinOut treated black squat pot.

Eastern view of tree.

The view from the south facing up the hill.

Stem diameter (30cm)	81mm
(1.3m)	74mm
Height	Approx 4.5m
Distance to curb (Sth)	3.6m
(East)	3.4m
Soil type	Loamy Sand

Competition – 4m *Acacia* sp. 5m away to the north.

Maintenance regime

- Mulched (100mm depth), which also provides a watering well volume of 10L.
- 2 year irrigation cycle delivering a minimum of 40L per visit, 3 times a fortnight, between October & April (35 scheduled waterings).
- Trees re-mulched in the second establishment year.
- Irrigation can continue into a 3rd year if drought conditions are impeding growth.

Observations

- Road looks newly constructed, so soil sample may not be a true indication of type.
- Reserve slopes down to the south (tree is at bottom of reserve).

Discussion of Results

***Angophora costata* (4 yrs old, Whitehorse Rd)**

This randomly selected specimen, considering its location and site conditions, seemed to be quite healthy and vigorous in its growth. The limited growing space allotted to this tree (approx 1m distance either side of the stem to the curb), at this stage, has little bearing on the establishment of the tree. Other factors apparent that could possibly affect other tree species in this situation also seem to have limited impact. Conditions such as high aerial pollution due to the proximity of a 6 lane arterial road, excessive water run-off (due to both fall in soil aspect and hard, bare soil surface), and widespread compaction of surrounding soil (3 road lanes directly to the north, 2 lanes to the south), could hamper the establishment of other tree species at this site. Competition from other trees (which are 10m away) is of no consequence, although in latter years, these trees could compete for certain resources, given their size at maturity.

The 2 year maintenance regime that this tree received could also have contributed to its success, along with the clay loam soil it is planted within. Clay loam is seen as some as the ideal medium to grow plants in (Handreck & Black 1994). Tree canopy form is sound, with no signs of stem bifurcations and a strong central leader present.

***Angophora costata* (2 yrs old, Foley Park)**

This specimen was one of many *Angophora* sp. located in this park, all of which looked healthy and of similar size to each other. There is ample growing space provided for the tree, although some competition would be encountered from the 2 mature tree specimens approx 7m away. Competition could also come from the thick swards of grass and broad leaf weeds surrounding the tree, although directly above the original root ball is a thick supply of composted bark mulch.

The presence of lush grass surroundings indicates sufficient water reserves in this position and maintenance irrigation for this tree is constant and in high volumes. The soil texture in this park is of a sandy clay loam type, indicating both water holding capacity and good drainage. The tree form exhibits a strong central leader and no signs of poor branch structure.

***Angophora costata* - Comparison of 2 specimens**

With its superior growing conditions, especially the greater below ground space provided, I expected the Foley Park specimen to be growing at a far greater rate than the Whitehorse Rd tree. But taking the stem diameter readings into account, the two trees seem to be growing at the same rate. This is only an assumption based on the fact that the stem diameters of the 4 year old (Whitehorse Rd) tree of 127mm (30cm from ground) and 107mm (1.3m) are approximately twice that of the 2 year old (Foley Park) tree findings of 63mm (30cm) and 55mm(1.3m).

Considering the seemingly harsh site the Whitehorse Rd specimen has had to establish in, it appears to be growing at a rate that a park specimen in better growing conditions would achieve. If this growing rate continues to mirror that of the park specimen, this taxa could be considered an ideal species for harsh, roadsides in other areas (with similar soil textures and maintenance regimes). Recommendations for sites with greater soil diversity and lower maintenance (as these trees appear to have frequent maintenance in their first 2 years in the landscape) needs researching.

***Ulmus parvifolia* 'Murray's Form' (6 yrs old, Newbigin St)**

The street on which this tree was located contained many of the same species, all similar in appearance and health. As for most street trees, the growing space was quite restrictive, and had a lush cover of nature strip grass. Water run-off could be a problem for this site, as the soil profile falls quite sharply towards the curb (approx 100mm in 1.15m).Any water penetrating the soil surface would percolate slowly through it due to the high clay content (40-50%) of the light clay texture (Handreck & Black 1994). Although the tree looked healthy, I was expecting a larger specimen than the one I encountered, knowing that it was 6 years old. No other trees were in the vicinity to cause any competition, and the maintenance provided to the tree post-planting was frequent and lasted two years.

Tree form was average, with a definite lack of a central leading stem in the crown. This form could have arisen due to lack of formative pruning in the earlier stages of growth (Harris 1992).

Ulmus parvifolia **'Murray's Form' (4 yrs old, Ilma Gve)**

This tree specimen, although seemingly established by the lack of ground movement when the stem is rocked back and forth (Burnley test method), looks to be an inappropriate choice for this planting site. A severe lack of below ground space, presence of granitic sand in the planting hole, and steep angle of the site surface (for increased water run-off), have combined together to keep this tree in a state of stasis. No visible signs of stem calliper or canopy growth are present, with the stem diameter reading of 37mm (30cm) probably similar to that which it left the nursery 4 years prior.

There is no competition from any other trees, as most of them are in the same state as the targeted specimen.

Ulmus parvifolia **'Murray's Form' (3 yrs old, Morang Rd Res)**

This park was heavily populated by mature tree specimens, many of which were located around the *Ulmus* sp. used for this report. This scenario created fairly shady surrounds and competition for the tree, limiting full sun availability in the afternoon. Dense, lush grass also habituated the site. Below ground space was ample, as the other trees were approx 10-12m away, and the nearest road was 6m away across open space.

Canopy form was again average, with 3 or 4 lateral branches dominating the branching structure. As the tree looked very vigorous in its growth, I have no doubt that formative pruning could have greatly increased the potential height by reducing the lateral dominance.

***Ulmus parvifolia* 'Murray's Form' – Comparison of 2 specimens**

<u>Newbigin St & Morang Rd Res specimens</u>

Although only half the age of the Newbigin St tree, the Morang Rd Res tree has achieved similar stem diameter and height readings from a site that is lacking full afternoon sun. This would suggest that it is growing at twice the rate of the Newbigin St specimen, possibly concluding that limited below ground growing space substantially reduces the establishment time for this species (in light clay soils).

This is not to suggest that this species is a poor street tree species, but that it will probably take longer to attain a substantial presence (in a limited space situation) than say the *Angophora* sp. that was first discussed in this report.

<u>Ilma Gve & Morang Rd Res specimens</u>

This comparison greatly emphasises the reduced growth rate of the Ilma Gve specimen. The tree in the Morang Rd Res, growing in fairly ideal conditions (except for reduced sunlight due to light competition), has reached a stem diameter of almost triple that of the Ilma Gve tree, even though it was planted one year after. This information further displays the difference in successful establishment for this species where growing space is reduced below the ground, and the absence of a specified watering program.

The fact that granitic sand was used in the planter hole in Ilma Gve could also be a detrimental factor, but this would have to be investigated with other *Ulmus* sp. that maybe have more below ground space to establish for a better comparison.

***Eucalyptus leucoxylon* ssp.*megalocarpa* Eukie Dwarf (4 yrs old, Separation St)**

This randomly selected specimen of a large stand of the same species, looked to be in a very healthy condition, and not affected by the limited growing space it had been allotted. When visited, it was in full flower, and was exhibiting plenty of young growth in the canopy, of which is sound in form. Competition for this tree came in the shape of a double storey house 5m from the canopy on the northern side, along with several tall trees adjacent to the end of the house. This structure seemed to reduce a substantial amount of afternoon sun available to the tree, as it is nearly twice as high as the tree’s canopy.

Water catchment for the tree would probably be boosted by the fact that the soil surface is approx 60mm lower than the pavement surface, ensuring heavy rainfall would cause a substantial run-off onto the soil, where it could collect and slowly filter in the soil sub-surface. The light clay texture of the soil would ensure good water retention also.

***Eucalyptus leucoxylon* ssp.*megalocarpa* Eukie Dwarf (4 yrs old, Warwick Ave Res)**

Another healthy looking specimen with good structural form, it was situated in a small roadside reserve on a fairly steep incline (the tree was situated in the middle of the incline). The road adjacent to the reserve looks newly built and maybe only a couple of years old.

The soil sample taken from beneath the tree was determined as a loamy sand, but I don’t think this is a true indication of the type the tree is growing in. When the road was constructed I suspect that a thin layer of top soil was added to the verges for cosmetic reasons, and that a more clay type soil lies beneath.

The tree has competition in the form of an *Acacia* sp. up the slope approx 5m away, but viewing the site in the middle afternoon, I did not see any problems with shading or the like.

Eucalyptus leucoxylon **ssp.*megalocarpa* Eukie Dwarf – Comparison of 2 specimens**

These two specimens, at the same age of 4 years, have virtually the same stem diameter readings (77mm – Separation St, 81mm – Warwick Ave Res) and are only different in height by approx 0.5m. The height difference could be a result of less afternoon sun available to the Separation St specimen, due to the proximity of the 2 storey house. Even with more below ground space available to the Warwick Ave Res tree, the more restricted Separation St tree appears to be establishing at the same rate.

Water infiltration could be less at the Warwick Ave site due to the steep incline of the reserve, and the fact that the tree is situated half way down where run-off would be greatest.

Conclusions

Although only a limited number of tree specimens were targeted in this small assessment trial, I believe the results obtained were significant to lend this method of evaluation for consideration on a larger scale. The time constraints encountered for this project restricted my ability to target a broader geographical area than the one reported on. Longer operation times could see a number of specimens from many different sites evaluated, making it easier for one to compare specimens of all the same age (as some of my specimens were of different age, resulting in a few assumptions).

My theory of including maintenance regimes as part of the assessment was aimed at highlighting the lack of irrigation frequency for one target specimen, as a possible factor for its poor establishment. The maintenance regime of both Boroondara and Whitehorse Council's appears very thorough, so an irrigation comparison between two trees under their care might not be appropriate. But Darebin Council's lack of a specified irrigation program in past years, clearly inferior to the watering schedules of the other two municipalities, might have been a telling factor.

The most poorly established tree was by far the *Ulmus parvifolia* 'Murray's Form' located in Ilma Grove, in the Darebin locality. Research showed that it may have received an inadequate irrigation supply post-planting, and this information could be added to the knowledge that a 1.2m X 1.2m sized, granitic sand filled planting hole, might be inappropriate conditions for this species. If a similar specimen was found, in the same planting conditions, but well looked after in the irrigation department, then this telling factor could easily be highlighted.

I believe recipients of Treenet's information would benefit from a well defined street tree evaluation criteria. There is sufficient literature available to correctly formulate a standard method, and trees evaluated should include specimens situated on different sites and under different maintenance regimes. Purchasing quality stock, post-planting irrigation, and structural formative pruning can determine the success rating of a street tree, not purely a species selection to suit site conditions alone.

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