Land

UBC SEEDS Project: MacMillan Precinct Oak Management Plan

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1.0 Executive Summary

The Red Oak Avenue provides several challenges to the landscape manager. First, red oak does not grow best in soil that is saturated with water in winter and dry in summer. Second many stresses on the oaks have increased their susceptibility to disease and pests. Finally, removal of the trees could be perceived by the community as a drastic solution. Therefore, several recommendations have been submitted aimed at improving the growing environment for the oaks, improving vigour and increasing resistance to pests and disease. The primary method of improving oak health is to modify growing conditions to suit oaks through maintenance and management interventions, including compaction mitigation measures such as mulching and reduction of pedestrian and vehicular traffic.

2.0 Avenues and lanes

Management of avenues and lanes is fraught with difficulty (Rushforth, 1987). The difficulty stems from the need to identify an appropriate method to replace and renew the avenue (ibid). According to Rushforth gradual replacement is unlikely to create a bold feature that future generations will appreciate (1987). Gradual replacement can lead to an avenue with a mixture of trees with different character and ages, without the visual impression of the original (ibid). Rushforth identifies three strategies for replacing an avenue (ibid).

The first option is to fell the trees and replant with young trees. This option will likely be seen as drastic by the community and cause much debate (ibid). This option can only be acceptable if consultation with the community occurs. According to Rushforth often delaying for as long as possible and waiting for the trees to die of natural causes is the only way to make replacement a viable option (ibid). Rushforth contends that the only way to recreate the majesty of the avenue is through total replacement (ibid). It is unlikely that this option will be acceptable to the UBC Community although this determination will not be considered here.

Rushforth outlines a second option of felling all the trees along one side of the avenue (ibid). Clearly this represents a compromise between removal of all the trees and attempting to maintain some of the impact of the avenue. The third option is to create a new avenue elsewhere in the vicinity (ibid). These options illustrate the limited options available when considering the removal of an avenue. The purpose of this management plan is to outline recommendations that offer another option of rehabilitating the trees in the avenue with careful interventions of mulching, deep nutrient injection, fracturing the soil, careful pruning and monitoring. By changing the management regime it is hoped that the oaks will exhibit increased vigour and less susceptibility to pests and disease.

Previous recommendations concerning the oaks have focused on how to control Oak anthracnose and aphids. Rather than discussing the various treatments available for these specific problems, the focus of this management plan is on methods of increasing the overall health of the trees. Using cultural practices to improve vigour of plants has been outlined by Agrios (1997). According to Agrios cultural practices can increase resistence to pathogen attack(ibid). Agrios suggests that cultural practices can improve growth and have direct and indirect effects on control of a particular disease (ibid). In order to identify useful interventions a brief discussion of Red Oak is required.

3.0 Red Oak

Quercus Rubra L. in the *Fagaceae* family is characteristically found outside of the floodlplain or on moist to dry sites (Benvie, 2000). This particular Oak grows best in deep, fertile, well-drained but moist, fine textured soil with a relatively high water table (ibid). Although the conditions described above are ideal, Red Oak can be found growing on a variety of soil types from clay to gravel and stony thin ground (ibid). Red Oaks have a well developed tap-root complimented with an extensive system of deep spreading laterals. Red Oak is widely used as a street tree and has been used to restore degraded sites, especially those with acidic conditions (ibid).

4.0 Goals

After careful consideration a list of management goals has been developed. As discussed above removal of the avenue is likely to occur only as a last resort. Therefore the goal of this management plan is to outline a number of strategies aimed at improving the growing environment of the trees. Management goals are to use cultural interventions to improve oak health and increase resilience from pathogen and pest attack Management goals must be achievable and measurable. Therefore it will be necessary to outline how these goals can be achieved through the recommendations and interventions. Furthermore it will be necessary to describe a method for measuring how the oaks respond in comparison to the control (oaks not within the MacMillan precinct).

Recommendations will list the best practices that management can implement to reduce stress and increase resilience of oaks to disease and pests. A further discussion will be developed under interventions that will list possible strategies for improvement of oak health. Finally a list of indicators must be developed to help determine how changes in management are impacting the health of the oaks and ultimately the success of the project. The list of indicators must be selected with careful consideration to ensure that indicators can be easily measured in the field and provide an accurate reflection of how well the recommendations and interventions are improving oak health.

5.0 Recommendations

This section outlines the recommendations for pruning practices, monitoring, fertilizing, mulching and soil remediation. An attempt has been made to provide specific information where possible for management interventions.

5.1 Pruning

Mature trees should be pruned minimally to remove deadwood, Oaks are particularly susceptible to die back from self shading (Rushford, 1987).

5.2 Monitoring

It is recommended that a thorough inspection of the oaks within the MacMillan precinct occur every 6 months. Further more detailed inspections can periodically be considered. These Oaks should be inspected frequently for fungal decay and dead or broken branches (Rushford, 1987). Furthermore inspections should assess damage done from both aphids and Oak anthracnose. Inspections of Oaks could look for smaller thinner foliage, late flushing or early leaf kill, retention of leaves or fruit beyond normal, abnormal fruiting, exudation of slime or water from bark, branches rubbing, fungal fruit bodies, holes in main stem and lifting of soil around roots (ibid). The advice of a qualified arboriculturalist should be sought.

5.3 Fertilizer

Until recently woody landscape plants rarely were fertilized in natural and urban settings. Unfortunately typical nutrient deficiency symptoms such as off-colour foliage and weak growth can also occur due to drought, compacted soil and saturated soil among other things (Harris, Clark and Matheny 1999). Trees that have sustained damage to root system or foliage can benefit from fertilizer applications (Rushforth, 1987). According to Rushforth, trees have a better chance of recovery and exhibit reduces risk of succumbing to harmful fungi, disease or insects if proper nutrition is provided (ibid). Urban soils are often nutritionally deficient either from a limited root zone or natural deficiency of a limiting nutrient (ibid). Soil conditions at UBC are likely heterogeneous, however, there is a significant possibility that several Red Oak trees are growing in an area containing a limited root zone. Rushforth contends that trees are very efficient at recycling nutrients, however, if the rooting zone is limited and particularly if leaf litter is removed from soil, an increase in supply of nutrients can increase vigour (ibid). The management regime at UBC includes the removal of leaf litter and grass clippings. Therefore it is unlikely that the trees are receiving adequate nutrition. In addition the fertility of the soil becomes increasingly important as trees mature.

Several methods of nutrient application are available to the landscape manager, however, the recommendation is to use deep injections of nutrients. Trees grown adjacent to close mown grass or pavement should be fertilized either with deep injection or holes drilled within the root spread of tree. Holes are generally 5 cm in diameter, 30 cm deep with a 60 cm spacing (Rushforth 1987). Harris, Clark and Matheny estimate that holes should be placed at a rate of 100-275/m^2 (110-250/1000ft^2) up to 25% past the area of the dripline (1999). According to Rushforth fertilizer should be mixed with soil and applied at a rate of 100-150 g/m^2 (1987). Slow release fertilizer such as Osmocote or Ticote work well and trace elements can be added as desired (ibid). Soil incorporation of nutrients from holes or injection also contributes to increased aeration and drainage (Harris, Clark and Matheny 1999).

Another method of application available to the landscape manager is fertalizer injection into the soil. This technique can be combined with equipment used to fracture the soil as discussed further in section 4.5. Fertilizer injection technology uses only nutrients that are soluble in water (Harris, Clark and Matheny 1999). Water soluble fertilizers tend to be more expensive (ibid). A list of water soluble fertilizers has been provided.

Water Soluble Fertilizers:

- Ammonium Phosphate
- Potassium Phosphate
- Potasium Nitrate
- Potassium Chloride

According to Harris, Clark and Matheny the use of a high pressure hydraulic sprayer is the most economical delivery system for nutrient injection (1999). Care must be taken to clean equipment thoroughly after use because the fertilizer solution is corrosive (ibid). Further reductions in maintenance can be gained by lining the tanks with stainless steel or plastic, however, pumplines must still be cleaned carefully (ibid).

Typical specifications for deep injection include a probe depth of 6 inches at 150-200 psi at a rate of 800 L/100 m^2 or 200 gal/1000 ft^2 (ibid). At this rate of application each injection will use approximately 5 L or 1.2 gal (ibid).

In summary the recommendation is to use deep nutrient injections to provide nutrition to the deep feeder roots of the Oak trees. Nutrient injection should be combined with soil fracturing to mitigate compaction problems.

5.4 Compaction

Increased foot traffic and vehicular traffic on campus has contributed to severe compaction near mature trees. This can be visually confirmed by the presence of exposed roots around Red Oaks in front of the Barn. Other contributing factors to the compaction problem is a lack of organic inputs to the soil and removal of leaf litter. Compaction impairs water infiltration and aeration of the soil (Harris, Clark and Matheny, 1999). Compaction mitigation strategies have been outlined in depth by Harris, Clark and Matheny (ibid).

Harris, Clark and Matheny suggest compaction mitigation can be undertaken through vertical mulching, radial soil removal and organic mulches. Since radial soil removal is usually only implemented in extreme situations involving a specimen tree it was not considered a viable option in this case. What follows is a discussion concerning compaction mitigation from vertical mulching and the use of organic mulches as well as some cultural initiatives designed to reduce traffic by changing behaviour of individuals in the UBC community.

One way of reducing the impact of foot and vehicular traffic is the use of a thick coarse layer of organic mulch to disperse the load. Harris Clark and Matheny suggest that landscaping (i.e. grass) under trees that are susceptible to high moisture rates or poor aeration should be avoided (1999). The use of mulch around the Red Oaks would necessitate the removal of grass in this area. This may in fact have some unintended positive benefit for the trees. According to Rushforth, removal of grass boosts growth of trees (1987). Harris, Clark and Matheny suggest that appropriate plant choices under trees require little or no irrigation (1999). Rather than discussing plant selection, it is important to first establish the benefits of organic mulches surrounding trees.

The organic matter content of soil decomposes over time and must be continuously replenished. Under normal circumstances trees replenish the organic content of the soil through annual leaf litter, however, if leaf litter is removed for aesthetic purposes than mulches provide a similar service. Mulches improve the biological activity within the soil because soil microorganisms are dependant on organic material for their survival (Harris, Clark and Matheny 1999).

Organic mulches conserve soil moisture, increase aeration, reduce erosion and water loss (ibid). In addition soil fertility is increased by organic mulches either through leaching or decomposition (ibid). Other benefits of organic mulches include reduced competition for nutrients and improved soil structure (ibid). Organic mulches improve soil structure by increasing the size of soil aggregates, voids and total porosity (ibid). The absence of cultivation, reduced compaction and increased biological activity contribute to a higher infiltration rate with more uniform water distribution (ibid). Soil compaction from rain and sprinkler droplets can also be reduced and organic mulches help disperse the weight of vehicles, people and animals (ibid).

In contrast seriously compacted bare soil prevents the movement of water and air within the soil impeding root growth (Harris, Clark and Methany, 1999). Compared with bare soil organic mulches provide an improved surface for traffic (ibid). The problems associated with organic mulches have also been discussed by Harris, Clark and Methany (1999).

Problems of nutrient deficiency, excessive moisture and toxicity can be avoided by careful preparation and distribution of quality organic mulches (ibid). In a review of studies that compared compaction mitigation methods, the use of organic mulches provided the most beneficial results (ibid).

5.5 Fracturing Soil

Fracturing the soil with compressed air to improve aeration and drainage under certain circumstances can improve growth, however, the literature provides conflicting reviews about the usefulness of this technique. A review of the subject has been included, because the particular situation at UBC may be improved with this technique. Without specific knowledge of the soils beneath the Oaks it is difficult to assess whether an intervention of this magnitude is warranted. Unfortunately urban soils are often a heterogenous mixture of unconsolidated fill from construction, imported top-soil and native soil. The soil over UBC covers an extensive, impenetrable and compacted layer of glacial till. Since it is not known at what depth the impermeable layer begins, it has been assumed that the soil on top of the glacial till becomes saturated during winter. Since the soil is compacted, water does not flow away from the site. As mentioned above much of the organic portion of the soil has decomposed over time and therefore it is probable that what remains is a highly compacted mineral soil overlaying an impermeable layer of glacial till. Perhaps the use of vertical mulching techniques would improve drainage and thus contribute to oak health.

Fracturing soil with compressed can be done using a Grow Gun, Robin Dagger or Terralift equipment (Smiley et al 1990). Studies of these technologies have yielded mixed results. Soil compaction is a widespread problem in urban areas, especially in areas that are subjected to heavy vehicular and foot traffic (ibid). Soil compaction contributes to reduced growth and vigour of trees (ibid). Soil with high bulk densities (> 1.5 g/cc) can impede root growth by physically restricting penetration and by lack of air movement (ibid). Studies have been done to test the effectiveness of compressed air treatments as a means of mitigating soil compaction (Smiley et al 1990, Hodge 1993 and Smiley 2001). The use of compressed air technology must be preceded by evaluation of soil type, moisture content and factors limiting growth. Furthermore, the use of compressed air technology does not impact bulk density, but can ameliorate perched water tables. Finally, compressed air technology should be compared on the basis of soil fracture capability, evaluation of tree performance and economic considerations.

According to Hodge the effectiveness of compressed air in mitigating soil compaction problems is dependant on soil type, moisture status and the root cause or factor limiting growth (1993). Compressed air treatments can be effective in creating a fracture in soil allowing vertical movement of water and air (ibid). The literature indicates that bulk density of compacted soil is not significantly impacted by compressed air, however, Hodge appears to support the use of compressed air to alleviate problems involving a perched water table (ibid). Various technologies that employ compressed air have been compared (Smiley et al 1990, Hodge 1993 and Smiley 2001).

Smiley et al suggests that the Grow Gun and Terralift technologies do not significantly alter bulk densities (1990). Both the Grow Gun and Terralift produced saucer shaped fractures (ibid). Terralift was found to produce fracture at least twice the size of those produced by the Grow Gun (ibid). According to Smiley oxygen diffusion only improved at the fracture line (ibid). Another means of evaluating compressed air technology is assessment of tree performance.

Hodge suggests that tree performance can be made on the basis of several quantifiable measurements including diameter at breast height, annual shoot extension and crown density. According to Hodge compressed air injection significantly improved shoot extension of Birch on compacted sandy loam, however, no positive effect was found on sweet chestnut on compacted clay loam (1993). The study used compressed air injection from a machine called the Robin Dagger. Having compared different technologies on the basis of tree performance, economic and technical factors must also be compared.

It has been discovered that Terralift operates three times faster than the Grow Gun and requires a minimum of one operator, while the Grow Gun requires two operators. Approximate costs of Terralift versus the Grow Gun are $18,000 –26,000 and 3,000 – 4,000 respectively (Smiley et al 1990).. Although the Grow Gun is cheaper, the price does not include the purchase of a compressor (approx $12,000)(ibid). Further operational comparisons can be found in the appendix.

In summary, the effective use of compressed air technology involves the evaluation of soil type, moisture content and factor that is limiting growth. Furthermore existing technologies do not significantly impact bulk density, however, compressed air can be used to ameliorate perched water tables. Finally analysis concerning what type of compressed air technology to use requires a comparison of soil fracture characteristics, assessment of tree performance and careful consideration of economic factors.

5.6 Human Behaviour

Perhaps the best way to decrease the impact off vehicular and foot traffic on the site is to alter our behaviour and patterns of use. According to Harris, Clark and Methany, this can be done by scheduling maintenance work when the soil is dry, keeping travel over the site to a minimum and using lightweight vehicles with low pressure tires (1999). Other options would require design and installation of boardwalks or foot paths that kept pedestrians away from the trees, signage posted to educate the community and outreach to inform people about the need to be aware of our impact on the health of the Red Oaks.

6.0 Required Interventions

Pruning: Mature trees should be pruned minimally to remove deadwood, Oaks are particularly susceptible to die back from self shading (Rushford, 1987).

Mulching: One way of reducing the impact of foot and vehicular traffic is the use of a thick coarse layer of organic mulch to disperse the load. The use of mulch around the Red Oaks would necessitate the removal of grass in this area. This may in fact have some unintended positive benefit for the trees. According to Rushforth, removal of grass boosts growth of trees (ibid).

Fertilizer: Deep nutrient injections provide nutrition to the deep feeder roots of the Oak trees. Nutrient injection should be combined with soil fracturing to mitigate compaction problems. Typical specifications for deep injection include a probe depth of 6 inches at 150-200 psi at a rate of 800 L/100 m^2 or 200 gal/1000 ft^2

(Harris, Clark and Methany, 1999). At this rate of application each injection will use approximately 5 L or 1.2 gal (ibid).

Fracturing Soil: Effective use of compressed air technology involves the evaluation of soil type, moisture content and factor that is limiting growth. Analysis concerning what type of compressed air technology to use requires a comparison of soil fracture characteristics, assessment of tree performance and careful consideration of economic factors. Specifications are not provided here since probe depth, pressure and and spacing vary with technology used and soil characteristics. Probe depths can range from 8-70 cm (Smiley et al, 1990).

7.0 Monitoring

Given the size of the trees, visual inspections are the most practical way of assessing tree health. Assessment of crown damage from insect and disease with visual inspections can be done by estimating damage in stages. First an estimate is made as to whether the damage is greater or less than 50%. If the estimate is greater than 50%, an estimation of whether damage is greater than or less than 75% and so on. Another option is to measure leaf area index. Visual inspections of leaf size and internode length can provide preliminary evidence of oak vigour.

Basic tools for diagnosing fertility problems have been outlined by Brady and Weil. According to Brady and Weil effectively diagnosing fertility problems requires integrating field observations, tissue analysis and soil analysis. The use of photography has been suggested as a means of record keeping for crown damage.

8.0 Framework for Assessing Success of Project

As previously discussed management of avenues, especially at institutions involves several challenges and very few management options are available to the landscape manager. A framework for the success of the project should address three key areas. First, are recommended management interventions shown to improve the health and resilience of Oaks to disease and pests. Second does the project foster an environment of cooperation between landscape professionals, professors and students that can be used to develop a mutually beneficial participatory atmosphere of education, problem solving and cooperation. Third does the project provide the landscape manager with practical usable information.

9.0 References

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10.0 Appendix

Table 2. Comparison of soil aeration equipment: operational aspects

Factor	*Terralift*	*Grow Gun*
Safety	High pressure system appears safe. Storage bottles will need to be inspected/tested regularly, hydraulic hoses need regular inspection (similar to stump grinder). Operator is 12+ inches from high pressure system, safety shield can be erected if needed.	One potentially serious accident in California; problem has been corrected. Operator's chest is 6 inches or less above top of machine.
Safety equipment required	Hardhat, face shield, hearing protection required.	Hardhat, face shield required. Hearing protection for drill/generator and compressor recommended.
Crew training time	4 hours +	2 hours or less
Speed	Average 3 minutes/hole; discharges at two levels per site, 2 liters of fill discharge.	10-12 person minutes/hole using 1 discharge per hole, and 2 liters of fill.
Crew size	1 or 2 people	2 people - operator must be able to lift heavy loads (40-60 lbs.) repeatedly.
Frequency of repair	8 problems in 15 hours of operation. 3 did or could stop operation for 15-30 minutes; 2 of these serious problems have been designed out in new version.	0 mechanical problems in 20 + hours at Bartlett Tree Research Lab. Parts readily available.
Suitable for multiple operators	No - requires well trained operator.	Yes
Fill material	Will accept styrofoam 'C' beads, perlite or vermiculite; will not accept fine water absorbing polyacrylimide in moist environment, will not accept peat with large particles; may accept course water absorbing polyacrylimides and fine peat (not tested).	Will not accept peat with large particles. Will accept all other tested materials. May accept fine peat (not tested).
Transportation	Requires trailer or full size pick-up truck with ramps.	Full size pick-up truck is suitable (must tow heavy compressor).
Property access	Climbs 20+% slope; jumps curbs with difficulty.	Must be within air hose distance of compressor (50 or 100 feet increments). Hand carried over any terrain.
Operation under low limbed trees	Requires 6+' of overhead clearance.	Drill and operator more limiting than machine.
Terrain	Climbs 20+% slope, outrigger requires close to level soil.	Requires "20" diameter circle of flat surface. Tufts of grass may interfere with operation.
Recommended options	Heavy duty engine (Kohler), US manufactured air powered wheel motors, O-ring free main control valve.	Slightly less than 2" diam. drill bit. Lighter weight (aluminum) model 'Grow Gun Lite'.
Approximate cost	$18,500 - 26,000	$3,000 - Grow Gun - Steel $4,000 - Grow Gun Lite $50 - Auger $250 - Gas Drill or Generator rental $12,000 - Compressor or $50-75/day rental
Major advantages	Speed, able to fracture soil at multiple depths.	Low initial cost without compressor purchase. Low repair cost

(Smiley et al, 1990. pp 122)