The Conundrum of Roadside Trees: Joy for the People, but Plight for the Trees

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Abstract:

If a tree seedling could express a preference as to where in the city it would like to be planted, surely the answer would include “not next to the street, please!”. The roadside is a harsh environment for a tree. Yet that is precisely where a single tree can satisfy the greatest array of values for the widest range of people. We draw on our recent research on street trees, as well as intensive experiences in helping create and implement the urban forest master plan for Halifax, Canada, to support a series of recommendations for better provisioning of trees in a variety of roadside settings. The research has covered various topics including general urban forest values, street-tree diversity in suburbs and city centres, street-tree spacing issues, tree benefits in relation to their location, street-tree survival rates, and urban forests in the context of a changing climate. Halifax’s urban forest master plan was approved by city council in September 2012, with implementation beginning in spring 2013. Emphasis during the first decade of action has been on improving the city’s street-tree populations through planting and pruning. Our recommendations go beyond currently advocated best practices for street-tree installation and maintenance and deal with species selection, stock size, tree spacings and alignments, early and ongoing maintenance, and other themes. The benefits that people can enjoy from trees in the streets are commensurate with the care and intelligence of road engineers, urban foresters, arborists, and others in establishing and maintaining trees in the roadside ecosystem.

Keywords:

Streets, Urban forest values, Canada

Introduction

The urban forest comprises all the trees in the town or city (Duinker et al., 2015). The trees exist on a diversity of property types including: streets and roads; residential lots; business and institutional properties; municipal, provincial/national, and private parks; urban and peri-urban woodlots. The range of tree owners is vast indeed - while a significant proportion of a city's trees may be owned by the municipality, each owner of private property is more or less a free agent with respect to the disposition of trees on the property.

All trees in the city deserve attention when it comes to their abundance, diversity, health, and management requirements. However, we believe that street trees should be accorded top priority within the entire tree population. There are several reasons for this priority-setting. First, as we shall show below, street trees provide a far greater array of benefits to urban dwellers and visitors than do any other urban trees. Second, street trees endure a far greater suite of stresses than do any other urban trees. Third, street trees are the trees that city people experience most readily once they are out of doors and moving about the urban landscape.

For the purposes of this paper, we shall use the words "road" and "street" as synonyms. For us, they represent all the paved automobile-using pathways in the urban setting. This includes the quiet residential street, the busy commercial street, and the higher-speed arteries that commuters use to enter and leave the city. We will assume that the roads and streets to which we refer are in public ownership, specifically the municipality and upon occasion the province (in Canada, it is common for arterial roads to be part of the provincial network). We are much less concerned about trees along private roads as well as those in downtown pedestrian zones and along bicycle paths.

For about a decade, our urban forest research group at Dalhousie University has been examining various aspects of street trees, partly driven by our own academic curiosity and partly in relation to our participation in creating and implementing the Urban Forest Master Plan of the Halifax Regional Municipality (HRM Urban Forest Planning Team, 2013; Charles and Duinker, 2014). The purpose of this paper is to synthesize various research findings into a compact space and to draw insights for management that should, if implemented, enhance the life of trees in the street and thus also the benefits delivered to the people who use those streets.

The paper first summarizes our recent studies on street trees. Then we extract insights from the research that have implications for how street trees should be managed. We close with encouragements to all urban forest stakeholders to implement aggressive programs of street-tree improvement.

Research Findings

Tree Location Matters to Benefits Delivery

While we consider all trees in a city to be part of the urban forest, and agree in broad terms on the benefits they provide (Duinker et al., 2015), not every tree in a city provides the same range or magnitude of benefits. This is clear when discussing energy savings to buildings through provision of shade or wind buffering – only trees near buildings can provide these direct benefits. Similarly, disbenefits of trees are often location-dependent, illustrated by the conflict between trees and utility wires – only trees near utility wires can interfere with them. It is important to understand better the relationship between a tree's effects and its location, especially given the need to prioritize resources for tree planting in diverse urban landscapes.

Our objective, therefore, in this study was to determine, through an extensive search of the literature, the importance of tree location to its benefits and disbenefits (Foster et al., submitted). The wide array of benefits and disbenefits include many that are not easily quantified and monetized, so we made our comparison in relative terms with a scoring system. We first defined tree habitats based on environmental characteristics. While this does not directly relate to ownership, we can make some generalizations (trees near roads are most frequently public, trees near buildings are most frequently private, etc.) that are useful for our purposes. We arrived at three, broadly defined, urban settings: near streets, near buildings, and in open-space parks. These three locations encompass most of the urban forest, favouring tractability over complexity. A fourth category is hinterland or rural countryside, provided for the sake of comparison.

In the context of the four location categories, we conducted a broad search of urban forest literature to determine the relationship between niche and effects, and the magnitude of the benefit or disbenefit. Where there are gaps in location-specific research, we deferred to common sense, logical reasoning, and practical experience to estimate the relative magnitude of effects. These effects were rated using a integer scoring regime from -3 to 3 (see Table 1), where 0 is neutral and the minimum and maximum scores represent the most extreme case of the disbenefit or benefit, respectively. The starting point for building our list of benefits and disbenefits was provided by Duinker et al. (2015).

We found that of the four location categories, trees near roads incurred the most extreme scores (i.e., 3 and -3), indicating that the most significant benefits and disbenefits are provided by street trees (Table 1). Overall, we discovered a correlation between anthropogenicity and frequency of the most significant effects, exemplified by street trees. However, in parks and hinterlands, there is a preponderance of neutral impacts and fewer extreme scores.

Table 1. Summary of ratings for 25 benefits and 11 disbenefits of trees in urban environments. Values of -3 or 3 are assigned to the location category where the most significant disbenefits or benefits are exhibited, respectively. Other values are rated in relation to the extreme case.

	By Roads	Near Buildings	In Parks	In Hinterlands
Aesthetic beauty	3	3	2	2
Conserve fuel	3	2	0	0
Life of infrastructure	3	1	0	0
Community safety	3	2	1	0
Shade	3	3	3	1
Cool the city	3	2	2	1
Energy costs (direct)	2	3	0	0
Energy costs (indirect)	3	3	2	1
Business appeal	3	3	3	0
Enhance tourism	1	1	2	3
Diverse foods	1	2	3	2
Clean air	3	3	3	1
Health and healing	3	3	3	3
Road safety	3	1	0	0
Recreation opportunities	2	2	3	3
Learning opportunities	3	3	3	3
Enhances learning	3	3	3	1
Carbon capture	3	3	3	3
Employment	2	1	1	3
Property values	3	2	3	1
Stormwater flow	3	2	2	1
Water quality	3	2	1	2
Biodiversity	2	1	2	3
Sense of place	3	3	3	2
Sense of well-being	3	3	3	3
Utility lines	-3	-1	0	-1
Underground infrastructure	-3	-3	-1	0
Sidewalks and roads	-3	-1	-1	0
Buildings	-2	-3	0	-3
Health (allergies)	-3	-3	-3	-3
Shade	-1	-3	-1	0
Taxes	-3	-2	-3	-1
Annual debris	-3	-2	-1	0
Management costs	-3	-2	-1	-1
Undesirable wildlife	-1	-1	-2	-3
Perception of Danger	-1	-2	-3	-2

It seems intuitive that trees provide the most benefits where natural conditions are most sparse, i.e. near streets. However, those trees also do the greatest disservice in this location. The correlation between anthropocentricity and magnitude of effects is not a coincidence; trees are at once both cherished and reviled because of their cohabitation with features of the built environment. Trees mitigate inherent issues with infrastructure such as stormwater runoff (Xiao and McPherson, 2002), urban heat island effect (Rosenfeld et al., 1998), and unsightly utility wires. But trees can also conflict with this same infrastructure, the source of a large proportion of the complaints against trees being interference with electrical lines, damage to sidewalks (Randrup et al., 2001), and obstruction of critical view planes. It is worth noting that many of these conflicts can be avoided through insightful planning, both in planting trees and establishing built infrastructure. While the narrative of 'right tree, right place' often dominates urban planning doctrine (Most and Weissman, 2012), built infrastructure can be designed to accommodate a vibrant urban forest.

Street-Tree Species Diversity

Street-tree species diversity is influenced by a wide range of factors, including priorities and targets set by municipal policies and urban forest management plans, resource availability and nursery stock, professional cultures and agendas, urban design, climate, and site-specific conditions (Nitoslawski et al., 2016). Knowing this, and recognizing that a diverse urban forest is a more resilient and beneficial one, we sought to characterize the tree-species composition of various neighbourhoods in Halifax to elucidate spatial and temporal patterns in tree-species diversity.

We sampled streets in neighbourhoods defined by biophysical characteristics, historical development, and land use (Steenberg et al., 2013). These included residential neighbourhoods developed in the first half of the 20th century, mixed-use and industrial neighbourhoods located relatively close to the urban centre, suburban neighbourhoods developed during high population growth in the 1960s-1970s, and suburban neighbourhoods developed recently and located far from the urban centre. Trees were identified at the species level and diameter at breast height (DBH) was measured in summer 2015.

Our results suggested that street-tree diversification and a focus on nativeness seem to be very recent phenomena in Halifax. In suburban neighbourhoods developed 40-50 years ago, Norway maple (*Acer platanoides* L.), an alien and potentially invasive species, represented half of the street-tree population (Nitoslawski and Duinker 2016). Similarly, streets in older residential and mixed-use neighbourhoods close to the city centre exhibited low species richness, and were dominated by two or three tree species including Norway maple, linden (*Tilia spp.*), and elm (*Ulmus americana*L.). In one older residential neighbourhood, Norway maple made up almost two thirds of all street trees (Aryal, 2017). In comparison, streets in newer suburban neighbourhoods had greater species richness and evenness, in addition to higher native species representation (37%) compared to older suburban neighbourhoods (7%).

The differences in species selection between older neighbourhoods and newer ones may reflect changes in urban forest research, policy, and management. In the last few decades, many Canadian cities have been devastated by invasive pests and diseases, for example Dutch elm disease and lately by emerald ash borer (*Agrilus planipennis* Fairmaire*)*, that have severely affected street-tree monocultures (Raupp et al., 2006). These experiences are likely to reinforce the importance of diversifying planting stock to avoid widespread canopy loss. In turn, nurseries and garden centres have probably responded to increased demand for various species by diversifying their own stock, contributing to more species availability in recent years (Conway and Vander Vecht, 2015).

In Halifax, many street trees are planted in “tree lawns”, which are strips of grass found between roadway curbs and the sidewalk. Although the presence of the tree lawn may delight pedestrians by shielding traffic in the adjacent street, these narrow strips may also be subject to high soil compaction and render trees more vulnerable to urban stressors, including roadside construction (Hauer et al., 1994). These site-specific issues limit planting choice and the capacity for some tree species to thrive in the long term. Urban design and morphology play subtle yet important roles in species selection and management, and more research is needed to identify the extent of other influential factors.

The ubiquity of Norway maple is not unique to Halifax; many other Canadian cities planted this species extensively along streets and in other public spaces due to its high juvenile resilience to urban stressors. Many of these trees, planted in the latter half of the 20th century, are reaching the end of their lifespan and will soon require replacement. The sheer number of replacement trees needed highlights the challenge that many municipalities are currently facing – how can cities increase canopy cover while so many large trees are succumbing to disease, urban stressors, and simply old age?

Street-Tree Spacing

Among the many decisions municipal urban forest managers have to make is the crucial one of street-tree spacing (i.e., how far apart new trees should be planted). This is not a trivial decision, given the trade-offs between the costs of planting street trees (presently about four hundred dollars (CAD) per tree (Halifax Urban Forest Planning Team, 2013)) and the desire to obtain the myriad benefits associated with street trees as soon as possible.

Considering all the ecosystem services provided by street trees (see Duinker et al., 2015), most of them are directly proportional to the amount of leaf area they bear (Stoffberg et al., 2010; McPherson et al., 2016). Any site growing trees has a finite capacity to support tree foliage. That capacity can be equally fulfilled (within limits) by many small trees or a few large trees. The greater the density of trees planted, the earlier a site can approach its capacity to support tree foliage, and therefore the earlier the site will provide the maximum amount of ecosystem services. Clearly, a site with widely spaced trees will eventually reach full foliage capacity, but because of the wide spacing, this may not occur until several decades after the trees were planted. The key uncertainty is this: what is the optimal spacing of street trees given both the increased costs and the earlier provision of maximum ecosystem services of closer spacings or, conversely, the lower costs and later provision of maximum ecosystem services of wide spacings?

We have studied the actual and optimal spacings of street trees in residential neighbourhoods in the urban centre of the city of Halifax (Aryal, 2017). We divided the city into three zones: old residential blocks, new residential blocks, and downtown areas (as per Jaenson et al., 1992). Only the old residential blocks were considered because of their high proportion of street trees. This zone was further divided into eleven neighbourhoods, eight in Halifax Peninsula and three in Central Dartmouth. The street segments in each neighbourhood were identified for residential properties having sidewalks with a tree lawn and a length of over 100 m between street intersections. Overall, 457 street segments were considered eligible in the population, and 188 were randomly selected (with stratification by neighbourhood).

Over 2000 trees were measured during the summer of 2016. The average spacings in each neighbourhood were calculated and compared with the other neighbourhoods. For simulation of street-tree spacings and growth, we determined correlational relationships between DBH and crown diameter for three of the most abundant species: Norway maple (n=834), American elm (n=453), and European linden (*Tilia cordata* Mill..; n=269). Using a simple tree growth model and simulating trees over 60 years at one-metre spacings from 5 to 20 m, the effects of alternative spacings on crown area were evaluated.

The empirical results showed that the average spacing of street trees in Halifax is wide, over 15 m, with high variation. The basal area of the three dominant species, named above, was over 90% of the total. Wide spacings and high variability can be due to many factors. First, given the abundance of plantable spots in the tree lawns of residential neighbourhoods in Halifax, a limited annual planting budget and a desire to spread the benefits across streets and neighbourhoods in an egalitarian way leads to wide spacing. Second, tree planting has not been able to keep pace with tree mortality, and in many neighbourhoods the Norway maples are dying earlier than expected. Removal of one dead tree in a street with already wide spacing leads to huge distances between trees. Third, the arboricultural view is that street trees, as amenity trees, should each be able to develop as large and perfect a crown as possible, and if trees that are inherently large at maturity are planted, they each need a lot of room to grow that perfect large crown.

The simulation results demonstrate that trees planted closer together provide much greater tree foliage per unit land area after a specific time from planting compared to trees planted far apart. Preliminary calculations show that, using the assumption of full overlap of crowns when they interact (which in reality overestimates leaf area per unit land area), street trees planted 5 m apart can deliver a 50% crown coverage along a street in 18-25 years, whereas the same species planted 10 m apart can do so only in 36-54 years, 15 m apart in 51-79 years, and 20 m apart in 63-99 years. Thus, closely spaced street trees can deliver a specified level of ecosystem services within a mere fraction of the time it takes to get the same ecosystem services from street trees planted far apart. Street-tree spacing is clearly a critical factor in determining the timing of delivery of ecosystem services that depend on the quantity of tree foliage.

Grass Maintenance

Mechanical damage to young trees is a threat that goes by many names: "lawnmower blight" in the United States, "Sheffield blight" in the United Kingdom, and "mechanical wounding" in New Zealand (Morgenroth et al., 2015). There have been few formal studies investigating the prevalence of this problem, despite anecdotal evidence that it is widespread and significant (Morgenroth et al., 2015).

We define mechanical damage as any damage that a tree incurs from equipment used for grass maintenance. The damage can range in severity, from minor (affecting only the outer bark) to severe (reaching the cambium layer or even the sapwood). Mechanical damage affects a tree's physiology and adversely affects its ability to grow and thrive. When the cambium cell layer is injured, the tree must undergo a series of defensive, wound-healing processes (Arbelley et al., 2012). The healing begins from the wound margin and goes inward to shield the exposed xylem with healthy, new tissue (Arbelley et al., 2012). After wounding, a tree's functional priorities shift to re-establishment of the mechanical strength and xylem safety, which occurs at the expense of water and food transport and thus future growth (Arbelley et al., 2012).

To assess mechanical damage to young trees in Halifax, five survey routes were selected (Hayden, 2016). The routes varied in length, but were selected on the same criteria: along each route the grass in the tree lawn is primarily maintained by contractors hired by the city, and there is a high proportion of recently planted caliper trees (i.e., 60 mm diameter at root collar). In total, 844 trees were inspected for each round of surveys, and four rounds were completed between June and September of 2016.

The inspection protocol was simple; each tree was observed for the presence of recent mechanical damage, which was identified as the bark being scuffed or even removed. Recent damage was identified by the colour and appearance of the bark. Only the lowest 50 cm of trunk was observed. If no signs of mechanical damage were observed, no further information was collected. If there were signs of mechanical damage, the following information was recorded: location of tree, type of damage (scuff or bark removal, and severity), and size of the damaged area.

Our results confirmed earlier observations that mechanical damage is a significant problem in Halifax. Of the 844 trees assessed, 71 (8%) showed evidence of new damage at some point during the 2016 grass-mowing season. The most instances of mechanical damage were seen during the first inspection in June – 39 cases of recent damage. In mid-July there were 16 new cases, in late July there were 11, and in September there were five. In terms of the size of damage, most cases were smaller than 20 cm^2, but there were 14 instances where the damage was over 50 cm^2 and three trees showed damage over 90 cm^2. In these cases, the trees were almost entirely girdled around the base of the trunk, and their potential for survival is virtually nil.

Tree-Lawn Parameters

Both the ownership and biophysical conditions of the environment adjacent to streets are central to the establishment and survival of street trees. In most Canadian cities and towns, if there are street trees, they are growing in the tree lawn between curb and sidewalk and they are owned by the municipality. Thus, street trees are planted, maintained, and removed by the municipal governments or their contractors. Importantly, municipal governments in Canada hold the primary responsibility for urban forest management, even though the majority of urban trees are often situated on privately-owned residential property (Ordóñez and Duinker, 2013). Unlike privately owned trees, municipal practitioners have direct access to street trees for planting, maintenance, and removal. So while street trees often represent a comparatively small proportion of a city's entire tree population, they are vital for achieving citywide urban forestry objectives.

The biophysical environment of the tree lawn, most notably its width and soil conditions, is a crucial element of street-tree performance. Soil degradation is common in urban areas. Surface sealing and sub-surface compaction frequently occur, both due to pedestrian/vehicular traffic and due to deliberate compaction during road and sidewalk construction (Craul, 1999). Soil compaction in the tree lawn can result in restricted root growth and degraded water infiltration, which, when combined with reduced soil volumes typical of streets, will hinder overall street-tree growth and survival (Urban, 2008). The chemical properties of street-side soils are also typically degraded, with heavy metal and de-icing salt contamination and reduced nutrient levels (Craul, 1999). The conservation of tree-lawn soils (e.g., during construction activities) is as important – if not more so – as the protection of actual street trees.

Tree lawn width is equally important since wider tree lawns equate to larger soil volumes and more growing space for trees, as well as a potential reduction in some of the above-mentioned soil conditions. Tree lawn width is mainly a function of a city's development history, along with variability in density and land use within city boundaries (Steenberg et al., 2017). The unique development history and surrounding geography of a city often explain the size and abundance of tree lawns (see Figure 1). Old cities like Paris have many streets with no opportunity for tree lawns. Newer cities often have substantial tree lawns, like Winnipeg which was developed in the Canadian prairies without geographic barriers to sprawl. Much of the street network there is characterized by large tree lawns and a mature street-tree population (Winnipeg has some 170,000 American elms). There is also considerable variability in tree lawn width within a city, ranging from higher-density or commercial areas on the lower extreme to newer, singlefamily residential areas on the higher extreme.

Figure 1. The extremes of streetside tree habitats: (a) the best, as in this Winnipeg

residential neighbourhood; and (b) the worst, as in this Paris business/residential neighbourhood.

Management Considerations

We take as given the desirability of having a healthy and abundant tree canopy above every street in a city. Of course, the design of streets in many cities around the world, and on many streets in virtually every city, prevents this goal from being reached. Many streetscapes were designed without regard for any trees beside the roadway. Some cities around the world have so little annual precipitation that supporting a vibrant tree canopy in the streets would require enormous amounts of irrigation. For the purposes of the following discussion, let us assume a landscape that would support trees in fully natural ecosystems.

What directions should city designers and managers take to develop healthy and abundant tree canopies above streets? We present a series of considerations based on our research, as summarized above, and our intensive involvement in development and implementation of the Urban Forest Master Plan for Halifax (HRM Urban Forest Planning Team, 2013). Some of our propositions may already be well known to practitioners and researchers, and some may fly in the face of conventional arboricultural wisdom. They are offered to stimulate discussion among street-tree stakeholders.

Creating the Tree Lawn

Consideration for trees – and the necessary sites and growing conditions for them – is paramount in the urban design process. In Canada, this is still too often an afterthought in new developments, and while trees might be desired by property owners, the necessary conditions to establish and grow them are absent. Implementation of enforceable municipal specifications and standards for tree lawn width, soil volumes, and soil conditions for new developments and re-developments is a dependable way to ensure the long-term presence of long-lived, healthy street trees. We are currently assisting municipal staff in Halifax to develop such standards. Among the many inadequate conditions for growing trees alongside streets that these standards aim to prevent is the narrow tree lawn. Many Halifax streets have less than one metre between curb and sidewalk – only rarely can trees do well in this setting, especially with contemporary approaches to subsoil compaction.

Our view is that a wide tree lawn is the best roadside environment for a tree. If a tree lawn is impossible or undesirable for some reason, street designers can consider alternative site types for street trees. The emerging specifications and standards manual for Halifax street trees prioritizes tree lawns in the public right-of-way over all other site types for new developments. However, in some cases the installation of tree lawns may not be feasible, as with the redevelopment of existing, high-traffic streets. There are many options for such settings, ranging from simple soil vaults and raised planters to more complex suspended-pavement systems and structural soil cells (Trowbridge and Bassuk, 2004; Urban, 2008). Research into best practices for selection and design are still fairly scarce in the literature and many site designs have had mixed success. For example, in Toronto soil cells are increasingly used to grow large street trees in streetscapes with dense infrastructure. While some developments have been successful, others like the high profile Bloor Street Revitalization project experienced 100% tree mortality despite major investments in urban design and soil cells (Millward et al., 2017). We urge municipal street planners to use tree lawns over other site types where at all possible, and to carefully consider and research the use of other designs where necessary.

Street-Tree Species Diversity

Guidelines for street-tree species diversity have been offered in the literature for decades (e.g., Santamour, 1990). In the Halifax street-tree planting program under the Urban Forest Master Plan, a palette of about twelve species, mostly native, is prescribed for spring planting, and about six for autumn planting. In situations where a street is to receive many trees over a relatively short distance, trees are to be chosen for each plantable spot in a random draw from at least six of the prescribed species. Norway maple is prohibited. General guidelines for species choices are given, neighbourhood by neighbourhood, in the Plan and were based on the species distributions of the extant urban forest. Raising species richness in the streetscape, with an emphasis on native species, is the guiding principle.

Street-Tree Spacing

We do not support the approach to street-tree spacing contained in many cities' plans and bylaws where the range is from as low as six metres for trees small at maturity up to 16 metres for trees expected to become large. On the premises that (a) the delivery of many ecosystem services of trees depends on the amount of tree foliage per unit area and not per tree, and (b) city dwellers deserve an expeditious delivery of such ecosystem services, our recommendation is to plant all species of street trees an average of between 5 and 10 metres apart. Rather than specify the distance between trees, we prefer a specification for the number of trees per 100 metres of street length – say, 13 – with no trees spaced further than 12 metres apart and none closer than six metres. This gives the street designer flexibility to consider better how to position built infrastructure – e.g., driveways, power poles, fire hydrants – into the tree lawn.

Of course, if street trees are established with closer spacing than is customary, costs will concomitantly rise per unit street length as long as stock sizes remain constant. Our position is that urban forest decision makers, in Canada at least, need to consider planting stock smaller than the standard 60 mm root-collar-diameter balled-and-burlapped material. In conversations with practitioners, we have been led to believe that the main reason for large stock is resistance to vandalism. In many Canadian streetscapes, we think this notion needs to be challenged. We call for a range of experiments to be conducted with smaller stock, perhaps 20-40 mm root-collar diameter. Acquisition and installation costs for the smaller stock are much lower per unit, and this allows for densification of new street trees without concomitant increases in overall cost. The smaller trees, if well installed and protected, are unlikely to be significantly behind, if at all, in growth, compared to the usual larger stock, some years after planting.

Tree Protection

To eliminate mechanical damage to trees, a three-pronged approach is warranted. Cities should start with preventative measures and education. Mandatory education for both the landscaping company managers and the grass-cutters themselves should be specified in grass-cutting contract tenders. Education can also occur through the means of articles in trade magazines and presentations at trade conferences.

Secondly, protection against mechanical damage can be accomplished using physical barriers on trees and changing the ground material surrounding trees. In Halifax, new street trees currently enjoy two forms of physical protection: plastic trunk guards and mulching. The plastic trunk guards are made from perforated drainage tile and are a new addition to the city's tree planting protocol. What we do not yet know is whether the lawn-mowing personnel may be hitting the young protected trees even harder than usual on account of the trunk guards. We have no empirical evidence as to whether the guards and mulch are reducing trunk damage.

If prevention and protection are not effective, the focus then needs to shift to accountability. Currently, Halifax grass-cutting contracts outline the types of unacceptable damage and the penalties associated with them. Unfortunately, so far, contractors have not been penalized. The penalties should be applied to the fullest extent possible when damage occurs to ensure that contractors maintain contract integrity and take reasonable efforts to avoid damaging trees.

Conclusions

To repeat messages above, street trees satisfy the greatest array of urban forest values compared to trees in any other location in the city. Because of the variety and density of built infrastructure and human activity in the streetscape, this is also the location where trees generate the greatest array of disbenefits, and where the stresses on tree growth and survival are the greatest. We know from numerous urban settings across Canada that a healthy and abundant tree canopy in the streetscape is possible. But we also know that many Canadian streetscapes are bereft of trees. Assuming that the will exists to change such situations and fill those barren streetscapes with trees, what factors need to coalesce? The ideal set of circumstances begins like this:

- Streetside property owners and street users (e.g., pedestrians, motorists) desire a fullsome tree canopy
- Street landscape designers put tree habitats into their plans first, not last, so that soils are designed to support large trees and overhead infrastructure is designed

to be compatible with them
- Street trees to be planted are selected carefully for longevity (especially in a changing climate), structural integrity, long life, diversity, and other factors
- Street trees are adequately protected from mechanical damage
- Street trees are located close enough together to generate rapid early delivery of ecosystem services

Streetscapes are not the only site type for trees in the urban forest – parks, cemeteries, institutional properties like universities and school grounds, front and back yards of residential properties, and others are all excellent places to promote more and better trees. We urge urban foresters to keep all site types in focus for urban forest improvements. However, our view is that streetscapes deserve the lion's share of any municipality's attention because it owns the trees there, they are readily accessible, people notice them, and they benefit urban people the most, leaf for leaf. A key indicator of a city's progress in the pursuit of sustainability should be the quantity and quality of its street trees.

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