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A Private Tree By-Law's Contribution to Maintaining a Diverse Urban Forest: Exploring Homeowners' Replanting Compliance and the Role of Construction Activities in Toronto, Canada

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Abstract. Many municipalities are working to protect and grow their urban forest, including adopting private tree regulations. Such regulations typically require property owners to apply for a permit to remove trees and, if the permit is granted, plant replacement trees. Even with such regulations, many private trees are removed each year, particularly on residential property. Property-level construction activity, including expanding building footprints, replacing an older home with a new one, and increasing hardscaping, is emerging as a key driver of residential tree loss. This study addresses whether homeowners who receive a permit to remove one or more trees comply with the requirement to plant replacement trees to better understand the effect of private tree regulation. We explore this question through a written survey of homeowners who received a tree removal permit and site visits in Toronto (Ontario, Canada). While 70% of all survey participants planted the required replacement trees 2 to 3 years after receiving the permit, only 54% of homeowners whose permit was associated with construction planted. Additionally, most replacement trees were in good health but were dominated by a few genera. We also found significant differences in replacement planting and tree survival across the city's 4 management districts. This study highlights that if resources supporting private tree regulations are limited, tree permits associated with construction should be prioritized for follow-up. Additionally, guidance about diverse species to plant should be communicated to ensure that private tree regulations are supporting the long-term protection of the urban forest.

Keywords. By-Law; Ordinance; Private Urban Forest; Property Redevelopment; Residential.

INTRODUCTION

Given the range of ecosystem services provided by urban forests, many cities across North America are working to protect and grow their urban forests over the long term. Part of these efforts include retaining existing trees to ensure the benefits they provide are available now and into the future (Kielbaso et al. 1988; Rines et al. 2011). Efforts are increasingly including privately owned land, as these spaces collectively contain the majority of trees in many cities (Nowak and Greenfield 2020), and private tree benefits often extend beyond the property boundary (Konijnendijk van den Bosch 2016). Thus, protection of private trees is essential to maintain the urban forest as a whole and its associated benefits.

A recent review examining private tree retention highlighted that most case studies in forested ecosystems indicate a loss of canopy on private land over time (Ordóñez-Barona et al. 2021). Property-level construction activity is emerging as a major cause of private tree canopy loss (Croeser et al. 2020), particularly on residential property (Lee et al. 2017; Steenberg et al. 2018). This includes expanding building footprints, replacing an existing house with a new one, and/or adding additional hardscaping (Lee et al. 2017; Morgenroth et al. 2017). Trees are often removed during construction activities so that equipment can more easily access the site (Guo et al. 2018); trees were identified as increasing redevelopment costs by developers and landscape architects surveyed in Tampa, Florida (USA)(Landry et al. 2013). Other trees do not survive the construction phase due to direct damage and/or soil compaction (Koeser et al. 2013). Additionally, expanding building footprints

and other impervious surfaces may also reduce the amount of space available for trees, triggering removal of existing trees on a property (Jim 1998; Lee et al. 2017).

While there is a long history of local governments regulating removal of public trees through ordinances or by-laws, recent efforts have expanded to also protect trees on private property (Ordóñez-Barona et al. 2021). Often, local regulations exist to protect private trees during the (re)development process, with a study in Highland Park, Illinois (USA), suggesting such efforts are effective at tree preservation (Pike et al. 2021). Increasingly, blanket private tree regulations have also been adopted in the US and Canada that outline a permit process required of all property owners wanting to remove trees (Hill et al. 2010). Such regulations usually identify the size of regulated trees, criteria for approving a permit, and penalties for removing a tree without a permit (Lavy and Hagelman 2017). Additionally, permits typically require one or more trees to be planted to replace those removed (Coughlin et al. 1988; Conway and Lue 2018).

Recent research suggests that regulation of private tree removal can be effective. Municipalities with private tree protection regulations have more tree canopy cover (Landry and Pu 2010; Sung 2012; Hilbert et al. 2019) and higher average tree heights (Sung 2013) than comparable municipalities without such regulations.

But there are also challenges associated with private tree regulations. Limited enforcement makes it unclear how frequently regulated trees are removed without following the permit process (Conway and Urbani 2007; Landry and Pu 2010). In addition, some permitting regulations may exclude significant numbers of trees or have fines that are low enough, particularly in the context of major construction, that they do not serve as a deterrent to tree removal (Coughlin et al. 1988). In Falls Church, Virginia (USA), Chojnacky et al. (2020) found that the local ordinance requiring 20% property-level canopy cover 10 years after redevelopment often did not force replacement of trees removed during construction because many properties already exceed 20% canopy cover. A final challenge is that removal permits are typically issued with the requirement to plant replacement trees, but that planting may not occur (Conway and Lue 2018). Thus, the number of trees is reduced, and tree canopy extent will likely not recover.

This study examines if the tree replacement requirement associated with a private tree removal regulation is supporting long-term protection of the urban forest through a case study of Toronto, Ontario (Canada). We addressed three specific objectives: (1) measure compliance rates associated with the tree replacement requirement of residential tree removal permits; (2) determine if property-level construction or homeowner characteristics are related to the likelihood that replacement trees are planted; (3) determine the health and species of replacement trees to see if planted trees will contribute to growing a diverse urban forest. These objectives are addressed through an analysis of a written survey of homeowners who received a tree removal permit and follow-up site visits to a subset of survey participants. We end by considering challenges and opportunities for regulating private trees through a permitting process.

METHODS

Study Area

The City of Toronto (Ontario, Canada) serves as a case study to explore homeowner compliance with replacement tree planting associated with a private tree removal regulation. The city is located on the north shore of Lake Ontario, with a population of 2,731,571 (Statistics Canada 2016). Toronto's canopy cover was between 28% and 31% in 2018, with 55% of trees located on private property (City of Toronto 2018). While a recent city report identified residential property as containing the most planting opportunities, it is also the land use that has added the most impervious surface in the last decade (City of Toronto 2018).

The City of Toronto adopted a private tree by-law in 2004 (Private Tree By-Law, Toronto Municipal Code Chapter 813, Article III) obliging property owners, including residential homeowners, to apply for a permit to remove any tree over a diameter of 30 cm at 1.4 m above the ground. Any tree determined by city staff to be terminally diseased, dead, or imminently hazardous are exempt from the permit process. Moreover, for major construction projects (e.g., constructing a high-rise, multi-unit dwelling), tree retention and planting is often part of negotiations that occur during the planning approval process (e.g., site approval, zoning variances, and building permits) outside the private tree by-law. Thus, this study focused on situations where non-exempt trees were removed on residential property that were not part of major development projects.

The permit process involves an application submitted to the Urban Forestry unit, which must include

an arborist report, a replanting plan, and site and elevation plans if the application is related to construction. The application cost is $124 or $370 CAD per tree for non-construction permits and construction-related permits, respectively. A site visit from a municipal arborist may occur after the permit application is submitted. Toronto also requires a (minimum) 14-day period of public notice if the arborist determines the tree is in good health and not a hazard to nearby structures (Private Tree By-Law, Toronto Municipal Code Chapter 813, Article III). While the decision to issue a permit is made by city staff, the local city council member is consulted before a permit is issued. Ultimately, removal permits are granted over 95% of the time (Rider 2016).

When a permit is issued, property owners are required to plant at least one replacement tree for each tree removed. If no suitable planting site is available on the property, planting at another location or a cash in lieu payment may be accepted. Property owners are required to contact Urban Forestry once replacement trees are planted. A fine of $500 to $100,000 CAD per tree can be issued if the permit process is not followed (Private Tree By-Law, Toronto Municipal Code Chapter 813, Article III).

A 2018 Auditor General's Report focusing on permit issuance and by-law enforcement by Toronto's Urban Forestry unit found significant flaws in the process. One issue highlighted in the report is the lack of follow-up by city officials to ensure compliance with the replacement tree planting requirement; city staff do not regularly complete site visits, and property owners frequently do not notify the city when they replant (Romeo-Beehler 2018). Additionally, there is no official review of the proposed replanting site and inconsistent recommendations about which species to plant (Romeo-Beehler 2018). Enforcement of required replanting is therefore minimal, and city staff indicate that fines are rarely issued.

Non-compliance with replacement requirements is particularly concerning in Toronto, given the overwhelming percentage of private tree removal applications that are approved at the same time as the city is implementing a long-term strategic management plan to increase total canopy cover and species diversity (City of Toronto 2013). While the rate of permit approval may be high in Toronto, limited enforcement and follow-up of private tree regulations is not unique to the city (Coughlin et al. 1988; Conway and Urbani 2007), so a better understanding of tree replacement can highlight the strengths and challenges of a private tree removal permit process more generally.

Survey and Site Data

In 2019, a total of 1,992 addresses associated with private tree removal permits issued in 2016 and 2017 for residential property were provided by staff in the Urban Forestry unit of the Parks, Forestry, and Recreation Division of the City of Toronto. The 2-year time period was chosen as it is recent enough to reduce the likelihood of a new owner since the permit was issued, but also allows several years for tree removal and replanting to have been reasonably completed by the time of the survey. The addresses received represent a sample of all permits on residential property issued in that 2-year period, stratified by the 4 management districts used by Urban Forestry: 280 in East, 517 in North, 714 in South, 481 in West (Figure 1). In the data provided by city staff, 484 addresses were labeled as tree removal permits associated with construction activity, 1,077 were labeled as non-construction permits, and the permit type was not given for 431 addresses. Of the addresses, 43 were clearly for non-residential properties (e.g., a church, university property), so 1,949 addresses were retained for the study (Table 1).

In the summer of 2019, a multi-contact approach was used to administer the mail-based survey following standard procedures to generate strong response rates (Dillman et al. 2014). First, information postcards were sent to the addresses, notifying them a survey would soon arrive in the mail or they could complete it online. Within a week, a package that included an information and consent letter, the survey, a stamped return envelope, and a site visit permission form was mailed. Two weeks later, a reminder postcard, followed in two more weeks by a second copy of the survey packet, were sent if a survey for the address had not yet been completed. All survey materials were given a unique code so we could track completed surveys.

The survey began by confirming that the homeowner who applied for the permit still lived at the address associated with the tree removals. Next, there were questions that assessed homeowners' basic attitudes towards regulation of private tree removal; type of permit issued; status and characteristics of replacement trees, including species and source of any tree(s) planted; and basic socio-demographic characteristics

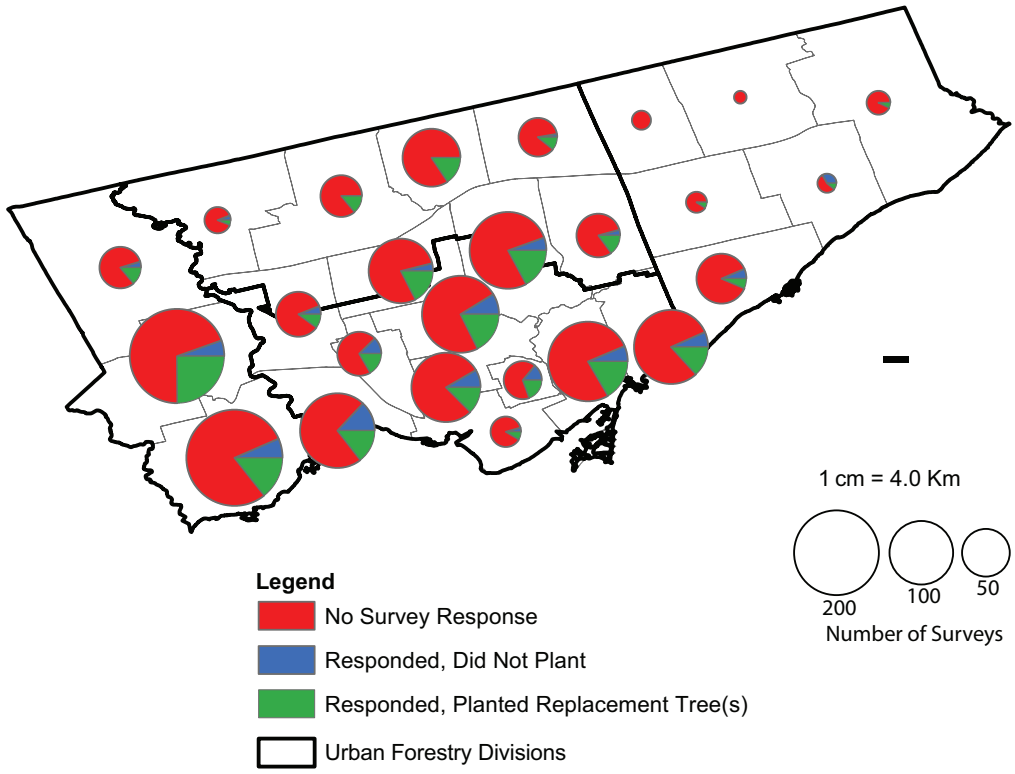

Figure 1. Percent of surveys mailed with no response, a response indicating tree replacement, and a response indicating no tree replacement, summarized by municipal ward. The size of the pie chart represents the number of surveys.

Table 1. Surveys mailed and sites visited across the 4 management districts.

District	Surveys mailed	Sites visited	Replacement trees assessed
East	277	11	27
North	516	25	45
South	686	33	61
West	470	27	50
Total	1,949	96	183

of the homeowners (see Appendix). Permit type included construction permits, necessary when the request to remove trees is related to construction activities such as expanding a house's footprint or replacing an old house with a new one, and non-construction permits, which are associated with removing a tree due to any non-construction reason.

We sought to reduce any concerns participants may have had about repercussions if they had not planted the required trees by clearly communicating that all responses would remain confidential, and we would not share individual responses with the city. This was stated in the information letter and again as part of the question about replacement trees: "One of the requirements of the City of Toronto Tree Removal Permit is to plant and maintain (a) replacement tree(s). Was a replacement tree (or trees) ever planted on your property? This information will NOT BE SHARED with the City of Toronto."

We also assessed whether homeowners were more likely to complete the survey or more likely to indicate that they had not planted the required trees if the confidentiality of their responses was highlighted at the start of the survey. To do this, 50% of the surveys had the following anonymity statement in bold at the top of the first page: "DISCLAIMER: All information collected in this survey is reported anonymously. Individual surveys and raw data will not be shared with the City of Toronto. As such, there are no negative repercussions based on survey responses."

In addition to the written survey, site visits were conducted on properties when the homeowner provided permission to access the property. A total of 174 homeowners agreed to site visits, and 96 of these

were completed between July and October 2019 (Table 1). Altogether, 183 replacement trees were evaluated across the properties. In addition to identifying the species, the health status of each tree was assessed using a grading scheme based on the Neighbourwoods protocol (Kenney and Puric-Mladenovic 2014). To analyze the presence of crown defoliation, weak or yellowing foliage, and signs of pathogens on the replacement trees, a value of 0 to 3 was assigned in each category: "0" indicated that there was no presence of a negative health condition, while "3" showed extensive damage visible to over 50% of the tree. Finally, the percent of hard surface (e.g., paved walkways, rock gardens, or any structures) located under the drip line of each tree was visually estimated following the Neighbourwoods protocol.

Analysis

Survey responses were entered into a database, and an error checking procedure was used to ensure accuracy of the data. The data collected during the site visits went through the same process. First, simple summaries of the survey responses and site visit data were completed, including the number of respondents who had planted the required replacement trees.

Second, statistical tests were conducted to see if significant ($P < 0.05$) correlations existed between survey response rate, replacement planting, presence of anonymity statement on survey, management district, permit type (construction or non-construction), attitudes towards tree regulation, and 3 socio-demographic measures that are often correlated with residential yard tree actions (household income, education level, and age). Cross tabulations were calculated using the chi-square test statistic, Cramer's V test statistic when comparing categorical variables where at least 1 variable has more than 2 classes, or Fisher tests when smaller and irregular category sizes were present.

We also compared the species homeowners listed as planting in the survey and the species identification of the tree(s) based on the site visits to better understand if homeowners were reliably identifying the replacement tree species. As most homeowners listed the common name at the genus level (e.g., maple), we summarized and compared the tree identification data by genera. For the site visit data, we also examined the percent of native species planted, defining native species as those historically found in the Toronto region (City of Toronto 2010; Farrar 2017). Hybrid species such as the Freeman maple (*A.* × *freemanii*) were considered native because its parent species, the red maple (*Acer rubrum*) and silver maple (*Acer saccharinum*), are endemic to southern Ontario.

RESULTS

Of the 1,949 surveys mailed, 1,824 were successfully delivered, while 125 surveys were "returned to sender" (i.e., never reached the intended destination). The "returned to sender" number is relatively high given that the mailing label only included addresses and not names; it reflects addresses that do not exist according to Canada Post, rather than a homeowner no longer living at that address, suggesting errors in the City of Toronto's record keeping. A total of 605 surveys were returned. After filtering for surveys that did not answer yes to the screening question, surveys with missing answers to the tree permit and replacement questions were removed, leaving a total of 429 responses. Thus, the survey response rate is 24%. This is typical for a mailed survey that is not addressed to homeowners by name (Dillman et al. 2014). We found no significant difference in response rate between surveys with (21%) and without (24%) the anonymity protection statement at the top of the survey, although underreporting of permit violations may have occurred, as survey data tends to underrepresent illegal activities (Aday and Cornelius 2006).

The initial 1,949 sample has an uneven spatial distribution, with few permits located in the central and northern part of the East District and the western part of the North District (Figure 1). These areas have relatively low canopy cover compared to the city as a whole, so may have fewer trees that are covered by the private tree by-law. The spatial distribution of survey responses generally follows the same pattern, suggesting that the response group is not spatially biased.

The majority of survey respondents reported income above $120,000 CAD and held a university degree (Table 2), thus respondents were wealthier and better educated than Toronto residents in general. However, there is no demographic data available for homeowners who participate in the permit program, so it is unclear if these characteristics reflect permit holders as a group. The majority of respondents were between 40 and 70 years old, as expected given that all participants are homeowners. No one under 30 responded to the survey.

Table 2. Basic demographics of homeowners by percent of survey responses.

Household income (CAD)				
$0 – $24,999	**$25,000 – $49,999**	**$50,000 – $74,999**	**$75,000 – $119,999**	**$120,000 or more**
2	4	11	14	53
Level of education				
No certificate, diploma, or degree	**High school certificate or equivalent**	**Apprenticeship, college, or other non-university certificate or diploma**	**University bachelor's degree**	**Master's or doctorate degree**
2	7	14	36	35
Age of respondent				
30 – 40 years	**41 – 50 years**	**51 – 60 years**	**61 – 70 years**	**71 – 100 years**
11	20	23	21	18

Tree Removal Permits and Replacement Trees

"Non-Construction" tree removal permits were the most common type of permit obtained by respondents (68%), whereas only 20% of respondents reported obtaining a "Construction" permit (Table 3). Most of the homeowners who checked "Other" for permit type wrote that they did not know what type of permit they received, often noting that the application was handled by a construction contractor or tree professional. Five other respondents indicated that their application was declined or they submitted a tree protection plan rather than a tree removal permit. This later group again suggests that the City of Toronto records have some inaccuracies that include mixing permit types. There are no statistically significant differences in permit type across the 4 districts.

Of those who completed the survey and received a permit, 70% said they had planted the required replacement tree(s), while 30% had not (Table 4). Eighty-five percent said that the requirement to replace trees removed was clearly communicated through the permit process, including a number who had not planted replacement trees. There was no statistically significant difference in replacement tree planting compliance between respondents with (68%) and without (72%) the anonymity protection statement at the top of the survey. We also did not find any significant difference based on household income, education level, or age of survey respondents.

Overall, attitudes towards private tree regulation were mostly positive, which is not surprising given that everyone in the survey complied with the private tree by-law requirement to obtain a permit to remove regulated trees (Figure 2). There was not a significant difference between attitudes towards regulating tree removal or replacement tree planting and actually planting the required replacement trees, although more people who replanted indicated strongly agreeing with regulating replacement planting as compared to those who did not replant.

Table 3. Percent of different types of tree removal permits obtained by survey participants. Percentages based on the number of trees per district.

District	Construction	Non-construction	Other
East	8 (15%)	36 (68%)	9 (17%)
North	20 (18%)	77 (69%)	15 (13%)
South	36 (24%)	98 (66%)	14 (9%)
West	22 (20%)	75 (69%)	12 (11%)
Total	86 (20%)	286 (68%)	50 (12%)

The type of tree removal permit did have a significant relationship with replacing trees, with 76% of non-construction permit holders planting the required tree(s), while only 54% of construction permit holders planted ($X^2 = 11.408$, $P < 0.001$). Additionally, the replacement compliance level is also significantly different among survey responses across the 4 districts, with 84% of the respondents from the North District replanting following their tree removal, but only 61% in the West District (Table 4).

Replacement Trees' Source, Health, and Composition

Contractors, which includes landscapers, arborists, and other members of the private sector, planted more of the required replacement trees than any other party

Table 4. Number (*N* = 429) of survey respondents who planted the required tree(s) or did not plant. Percentages based on the number of trees per district.

District	Planted tree(s)	Did not plant tree(s)
East	39 (74%)	14 (26%)
North	99 (84%)	19 (16%)
South	98 (65%)	52 (35%)
West	66 (61%)	42 (39%)
Total	302 (70%)	127 (30%)

Fisher's Exact Test for Count Data comparing difference between districts: $P < 0.001$.

(32%), followed by property owners planting the tree(s) themselves (26%). Five percent of the survey respondents received their tree through a regional non-governmental organization that runs a subsidized yard tree planting program (LEAF 2020). Additionally, some survey participants indicated that their multiple replacement trees were planted by more than one party, which was accounted for in the data summary (Table 5).

The overall survival rate of the 619 replacement trees was high (94%) over the short time period since planting (maximum of 3 years). The survival rate in the West District was significantly lower than the other districts at only 88% (Fisher's Exact Test for Count Data; $P = 0.0419$). City-planted trees have a higher mortality rate than other sources, while LEAF-planted trees in our sample experienced no mortality (Table 6), although these differences were not significantly different.

Of the 183 trees assessed during the site visits, the majority (73%) of them did not exhibit any signs of crown defoliation, while only 3% were assigned a value that suggests signs of likely not surviving (Table 7). The majority of the assessed replacement trees (78%) also had no signs of weak or yellowing foliage, nor any evidence of pests or disease that may cause serious health issues in the future (92%). Many had no surrounding hard surface (43%), while 50% of the assessed trees had 10% to 30% hard surface in the

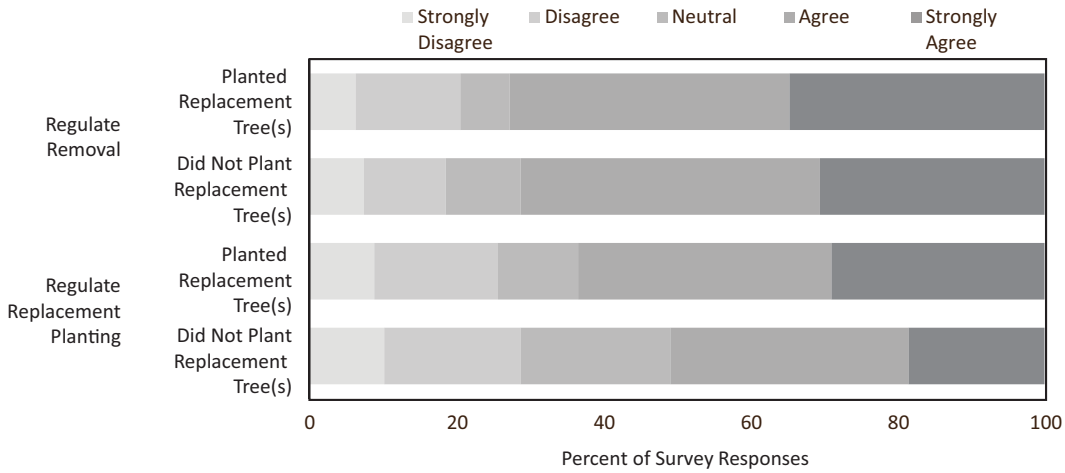

Figure 2. Level of agreement with private tree regulation by survey participants who did and did not plant required replacement trees. *Regulate removal* represents responses to the statement: "Medium and large trees on private property should be regulated through municipal by-laws," while *Regulate replacement planting* represents responses to the statement: "Tree planting to replace trees removed on private property should be regulated through municipal by-laws."

Table 5. Source of tree(s) planted to meet replacement requirement. Some survey respondents received their trees from more than one source, and this is reflected in the counts.

District	City	Contractor	Landowner	LEAF	Other	Unknown	Total
East	1	21	12	2	4	14	54
North	2	37	39	10	2	25	115
South	5	62	47	7	3	64	188
West	6	30	24	5	3	44	112
Total	14 (3%)	150 (32%)	122 (26%)	24 (5%)	12 (3%)	147 (31%)	469

immediate surroundings. These trees were most commonly planted along fences. Of the 183 trees, 9 had a hard surface of 50% or greater, primarily planted in rock gardens or between walkways and built structures.

The most frequently planted genera based on the homeowner survey responses were *Acer* (40% of all trees reported), *Quercus* (10%), *Fagus* (9%), *Ginkgo* (6%), and *Liriodendron* (5%)(Table 8). Five percent of survey respondents who indicated they had planted one or more replacement trees were unsure or could not remember the type of tree(s) planted. On the other hand, the most common species identified through the site visits were *Fagus sylvatica* (23%), *Acer saccharum* (8%), and *Acer* × *freemanii* (7%)(Table 8).

Table 6. Number of trees that survived by source. Percentages based on the number of trees per source.

Source/planter	Trees that survived	Trees that did not survive
City	15 (88%)	2 (12%)
Contractor	349 (95%)	17 (5%)
Landowner	174 (91%)	16 (9%)
LEAF	28 (100%)	0 (0%)
Other	16 (89%)	2 (11%)
Total	582 (94%)	37 (6%)

The differences between the 2 data sets may be partially due to the different sample sizes, as only 22% of the properties with survey responses have site visit data. However, when the site data and survey were both available, 18% of the time the 2 sources were different at the level of genus, and 13% of the properties include some but not all trees differently identified. Of the remaining 68%, the same genera were identical in the 2 data sets, but in many cases the homeowner did not specify the species, or the species information was present but differed. Thus, at least some of the differences in genera frequency between the survey and site data is due to misidentification, likely by homeowners.

Based on the site visit data, the overall number of native and non-native species is roughly equal, but this was highly variable across the 4 districts, with only 26% of trees considered native in the East District and 75% in the West District (Table 9).

DISCUSSION

The majority of homeowners who participated in the survey complied with the tree replacement requirement of their tree removal permit, and nearly all of the trees planted were in good health 0 to 3 years after planting. Not surprisingly, the survey participants,

Table 7. Health assessment of 183 trees from site visits.

Condition	0 (no sign of condition)	1	2	3 (visible over 50% of canopy)
Crown defoliation	134 (73%)	35 (19%)	9 (5%)	5 (3%)
Weak or yellowing foliage	143 (78%)	31 (17%)	5 (3%)	4 (2%)
Signs of pathogens	168 (92%)	7 (4%)	4 (2%)	4 (2%)

Table 8. Most common genera based on survey responses and most common species based on site visits.

Genus	Survey reported (%)	Species	Site visit identifications (%)
Acer	248 (40%)	*Fagus sylvatica*	42 (23%)
Quercus	62 (10%)	*Acer saccharum*	14 (8%)
Fagus	56 (9%)	*Acer* × *freemanii*	12 (7%)
Ginkgo	37 (6%)	*Ginkgo biloba*	11 (6%)
Liriodendron	31 (5%)	*Thuja occidentalis*	11 (6%)
Betula	18 (3%)	*Quercus rubra*	11 (6%)
Cedrus	18 (3%)	*Picea glauca*	8 (4%)
Ostrya	18 (3%)	*Liriodendron tulipifera*	8 (4%)
Robinia	18 (3%)	*Malus sylvestris*	7 (3%)
Tilia	18 (3%)		

Table 9. Native and non-native species identified through the site visits.

District	Native trees	Non-native trees
East	7 (26%)	20 (74%)
North	24 (53%)	21 (47%)
South	29 (48%)	32 (52%)
West	30 (75%)	20 (25%)
Total	90 (49%)	93 (51%)

who all engaged with the permit process, collectively have a more supportive attitude towards private tree by-laws than found in recent surveys of Greater Toronto Area residents (Conway and Lue 2018).

On the other hand, 30% of respondents did not plant the tree(s) required by their removal permit. Given the percentage of respondents who indicated that the requirement to plant replacement trees was clear, many non-compliant homeowners are aware of the requirement but are choosing to violate the terms of the permit. The survey and site data also suggest that replacement trees are dominated by just a few genera. Thus, there is a disconnect between maintaining tree counts, City of Toronto species diversity goals, and actual practices captured in the study.

Although most surveyed homeowners are complying with the replacement tree requirement, key groups have significantly lower rates of replacement planting. Specifically, holders of construction-based tree removal permits were less likely to plant than non-construction permit holders. These findings confirm recent research highlighting the negative impact of property-level construction on tree retention (Lee et al. 2017; Guo et al. 2018) and the potential for cumulative property (re)development-related tree removal to have a substantial impact on neighborhood and city-wide urban forest cover (Steenberg et al. 2018; Croeser et al. 2020).

It is somewhat surprising that relatively low compliance is associated with construction-based removal permits in this case, as everyone included in the survey sample conformed to the by-law by acquiring a tree removal permit. There are a few possible reasons why a homeowner would follow the requirement to obtain a removal permit but not meet the permit requirement of planting replacement trees. First, homeowners may have intended to plant replacement trees, but due to extended construction activities they had not yet had the chance at the time of the survey. However, we sought to minimize this occurrence by surveying people who received removal permits 2 to 3 years prior to the survey. Second, those who received construction-based tree removal permits may have been more likely to pay the fee in lieu of planting replacement trees. We do not have enough information to determine the frequency of this occurrence. Third, non-compliance with the permit may indicate a lack of agency felt by homeowners who did not personally apply for the permit (i.e., a contractor or other service professional applied on their behalf). Finally, those who received construction-based permits may be less willing to plant replacement trees precisely because of the construction on the property.

Previous studies have found that homeowners with higher income and/or education are more likely to remove trees on private property, but also more frequently plant trees and increase overall tree numbers on their property over time (Kirkpatrick et al. 2013; Lavy and Hagelman 2017). On the other hand, older homeowners have been associated with a higher likelihood to remove trees and not plant new ones nor support regulations protecting trees (Kirkpatrick et al. 2013; Conway and Bang 2014).

This survey did not find any relationships between replanting and income, education, or age of homeowners, possibly because the homeowners included in the survey were limited to those who applied for the removal permit in the first place, while homeowners who remove trees outside the permit process may be different in terms of socio-demographic factors, level of engagement with the city, and/or knowledge and attitudes about trees. Additionally, the majority of the surveyed homeowners had relatively high income, post-secondary education, and were in a limited age range. Thus, the homogeneity of the survey population may have muted the socio-demographic effects often associated with costs, knowledge, and attitudes.

Based on the data from the site visits, the species planted were slightly more likely to be non-native than the city's current species composition on residential property (over 50% native; City of Toronto 2013). Instead, the survey and site data sources suggest that non-native tree species and/or those that were smaller in stature are frequently planted. For example, European beech (*F. sylvatica*) was planted at several properties to create a hedge, so unlikely to be allowed to grow to a large form.

A broader concern is that homeowner's reporting was typically limited to common names that could

represent native or non-native species (e.g., maple) and often conflicted with the site visit identifications made. This creates uncertainty about species planted, suggesting many homeowners had limited awareness of the trees planted on their property and cannot be relied on to accurately report what species is planted unless an invoice or other documentation is required. Additionally, without clear guidance and follow-up from city staff, it is likely that homeowners will favor trees that are easy to acquire, potentially limiting diversity.

Based on the data collected from the site visits, the overall tree health appears to be very encouraging for the future survivorship, with few signs of crown defoliation, weak or yellowing canopy, or pathogen impact. This bodes well for the future of these trees, considering they are at their most vulnerable in the initial years following planting (Roman et al. 2014a). Furthermore, the majority of replacement trees have little to no hard surface in the immediate surroundings, reflecting that the trees are planted in locations with ample growing space. This is particularly encouraging considering the challenges associated with limited spaces in urban environments.

Trees planted by homeowners had a higher mortality rate compared to other entities providing planting services. Studies have indeed shown that trees planted by homeowners have a higher mortality rate than those planted and maintained by professionals (Roman et al. 2014b; Smith et al. 2019). Ensuring the use of proper planting methods, including encouraging a professional to plant replacement trees, would help promote tree health and survivability during the establishment period (Pauleit et al. 2002).

Variations in replanting rate, percent of native species, and survival also existed between the city's management districts, with the lowest replacement tree planting rate in the West District. It is unclear why. There was a similar percent of construction-based permits associated with surveys across the districts, and respondents in the West were equally likely to state that the requirement to plant replacement tree(s) was clear. Further investigations are needed to understand why these differences exist in Toronto. More generally, it highlights the challenges of equally implementing a private tree regulation where there is some discretion in permit approval and replacement tree requirements.

Beyond the potential that the level of communication varies across the city, the survey highlighted errors in record keeping, including incorrect mailing addresses linked with approved permits, and incomplete permit records, including missing or incorrect information about the type of permit issued. While staff are supposed to provide a list of approved species for replacement planting, this information was largely absent from the data record provided. Limitation in record keeping was a known issue in Toronto (Romeo-Beehler 2018). This study provides further evidence that monitoring outcomes and enforcement of private tree regulations cannot occur without accurate records.

Toronto and other municipalities have sought to maintain their urban forests, in part, through the regulation of private tree removal. Based on this study, Toronto's tree removal permit process is falling short of maintaining tree numbers, with construction a particular threat to the long-term protection of the urban forest. Given the high approval rate for tree removal permit applications in Toronto, the permit process is not stopping most removals, making replacement tree planting even more important. But, even in situations where fewer permits are approved, these results indicate not everyone who requests a tree removal permit will comply with its requirements. When limited follow-up and enforcement capacity exists, tree removal permits associated with construction should be prioritized based on the lower replacement tree compliance rates found in this study. Clear direction about diverse species to plant could also avoid homeowners selecting a limited number of species to plant. Collectively, these actions would contribute to a private tree regulation effectively protecting and diversifying a city's urban forest.

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Résumé. Plusieurs municipalités s'efforcent de protéger et de développer leur forêt urbaine, notamment en adoptant des règlements sur les arbres privés. Ces règlements exigent généralement des propriétaires qu'ils demandent un permis d'abattage d'arbres et, si le permis est accordé, qu'ils plantent des arbres de substitution. Malgré de telles réglementations, de nombreux arbres privés sont abattus chaque année, particulièrement sur les propriétés résidentielles. L'activité de construction au niveau des propriétés, notamment l'extension de l'emprise au sol des bâtiments, le remplacement de vieilles maisons par de nouvelles et l'intensification des aménagements extérieurs, apparaît comme un facteur clé de la perte d'arbres résidentiels. Cette étude vise à déterminer si les propriétaires qui reçoivent un permis d'abattage pour un ou plusieurs arbres, respectent l'obligation de planter des arbres de substitution afin de mieux saisir l'impact de la réglementation privée sur les arbres. Nous analysons cette question par le biais d'une enquête écrite auprès de propriétaires ayant reçu un permis d'abattage d'arbres et de visites sur le terrain à Toronto en Ontario, Canada. Alors que 70 % de tous les participants à l'enquête reconnaissaient avoir planté les arbres de substitution requis, 2 à 3 ans après avoir reçu leur permis, seuls 54 % des propriétaires dont le permis était associé à une activité de construction avaient effectivement planté les arbres exigés. En outre, la plupart des arbres plantés en substitution étaient en bonne santé, mais dominés par un faible nombre de genres. Nous avons également constaté des différences significatives dans les plantations de substitution et leur survie parmi les quatre districts administratifs de la ville. Cette étude souligne que si les ressources pour assurer l'application des réglementations privées sur les arbres sont limitées, les permis d'abattage d'arbres demandés en lien avec l'activité de construction devraient être suivis en priorité. De plus, des conseils sur les diverses espèces à planter devraient être offerts afin de s'assurer que les règlements sur les arbres privés favorisent la protection à long terme de la forêt urbaine.

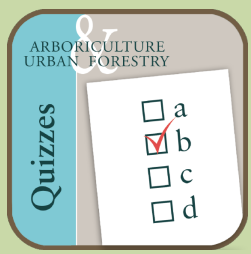
Zusammenfassung. Viele Gemeinden bemühen sich um den Schutz und die Vergrößerung ihres städtischen Waldes, beispielsweise durch die Verabschiedung privater Baumschutzvorschriften. Solche Vorschriften verlangen in der Regel, dass Grundstückseigentümer eine Genehmigung für die Entfernung von Bäumen beantragen und bei Genehmigung Ersatzbäume pflanzen. Trotz solcher Vorschriften werden jedes Jahr viele private Bäume entfernt, insbesondere auf Wohngrundstücken. Die Bautätigkeit auf Grundstücksebene, einschließlich der Vergrößerung der Grundfläche von Gebäuden, des Umbaus älterer Häuser und der zunehmenden Gestaltung von Außenanlagen, erweist sich als eine der

Hauptursachen für den Verlust von Bäumen in Wohngebieten. Um die Auswirkungen privater Baumvorschriften besser zu verstehen, wird in dieser Studie untersucht, ob Hausbesitzer der Verpflichtung zum Pflanzen von Ersatzbäumen nachkommen, wenn sie eine Genehmigung zur Entfernung eines oder mehrerer Bäume erhalten haben. Wir untersuchen diese Frage anhand einer schriftlichen Befragung von Hausbesitzern, die eine Genehmigung zur Entfernung von Bäumen erhalten haben, sowie durch Ortsbesichtigungen in Toronto (Ontario, Kanada). Während 70 % aller Umfrageteilnehmer die geforderten Ersatzbäume 2 bis 3 Jahre nach Erhalt der Genehmigung pflanzten. Lediglich 54 % der Hausbesitzer, deren Genehmigung mit Baumaßnahmen verbunden war, pflanzten Ersatzbäume. Zudem waren die meisten Ersatzbäume in gutem Zustand, wurden aber von einigen wenigen Gattungen dominiert. Wir fanden auch erhebliche Unterschiede bei der Ersatzpflanzung und dem Überleben der Bäume in den 4 Verwaltungsbezirken der Stadt. Diese Studie unterstreicht, dass bei begrenzten Ressourcen zur Unterstützung privater Baumschutzbestimmungen Baumgenehmigungen im Zusammenhang mit Baumaßnahmen vorrangig verfolgt werden sollten. Darüber hinaus sollten Anleitungen für die Anpflanzung verschiedener Arten gegeben werden, um sicherzustellen, dass private Baumschutzvorschriften den langfristigen Schutz des städtischen Waldes unterstützen.

Resumen. Muchos municipios están trabajando para proteger y hacer crecer su bosque urbano, incluida la adopción de regulaciones sobre árboles en áreas privadas. Tales regulaciones generalmente requieren que los propietarios soliciten un permiso para eliminar árboles y, si se otorga el permiso, plantar árboles de reemplazo. Sin embargo, aún con tales regulaciones, muchos árboles se eliminan cada año, particularmente en propiedades residenciales. La actividad de construcción a nivel de propiedad, incluida la expansión de las huellas de los edificios, la sustitución de una casa más antigua por una nueva y el aumento de los pavimentos está emergiendo como un factor clave de la pérdida de árboles residenciales. Este estudio aborda si los propietarios de viviendas que reciben un permiso para eliminar uno o más árboles cumplen con el requisito de plantar árboles de reemplazo; esto con el fin de comprender mejor el efecto de la regulación privada de árboles. Exploramos esta pregunta a través de una encuesta escrita de propietarios de viviendas que recibieron un permiso de remoción de árboles y visitas al sitio en Toronto (Ontario, Canadá). Mientras que el 70% de todos los participantes de la encuesta plantaron los árboles de reemplazo requeridos 2 a 3 años después de recibir el permiso, solo el 54% de los propietarios, cuyo permiso estaba asociado con la construcción, lo plantaron. Además, la mayoría de los árboles de reemplazo estaban en buen estado de salud, pero estaban dominados por unos pocos géneros. También encontramos diferencias significativas en la plantación de reemplazo y la supervivencia de los árboles en los 4 distritos bajo administración de la ciudad. Este estudio destaca que, si los recursos que apoyan las regulaciones privadas de árboles son limitados, los permisos de árboles asociados con la construcción deben priorizarse para el seguimiento. Además, se debe orientar sobre diversas especies para plantar con el propósito de garantizar que las regulaciones privadas de árboles apoyen la protección del bosque urbano a largo plazo.

Arboriculture & Urban Forestry Quiz Questions

To complete this quiz, go to the ISA website, log into your MyISA account, and make your way to the page for *Arboriculture & Urban Forestry* CEU Quizzes (www.isa-arbor.com/store/ceuquizzes/113).



Add the quiz to your cart, proceed through checkout, and look for the content to appear on your personal dashboard under the header, "My Quizzes." If you need a username and password, send us an e-mail (isa@isa-arbor.com).

A passing score for this quiz requires sixteen correct answers. Quiz results will display immediately upon quiz completion. CEU(s) are processed immediately. You may take the quiz as often as is necessary to pass.

CEU quiz by Eric North, University of Minnesota, Minneapolis, MN, USA

Appendix on following page

Appendix. Survey questions assessing homeowners' basic attitudes towards regulation of private tree removal; type of permit issued; status and characteristics of replacement trees, including species and source of any tree(s) planted; and basic socio-demographic characteristics.

You have been selected to complete this survey about your experiences with the City of Toronto Tree Removal Permit based on records that indicate a tree removal permit was granted for your property between 2016 and 2017.

Are you currently living in the same home as you were at the time the tree removal permit was issued? (Mark one)

____Yes: Please complete the survey questions below.

____No: Please return the blank survey in the envelope provided.

Part I. Attitudes Towards Tree Regulation

1. Please indicate your level of agreement with the two statements given below.

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Medium and large trees on private property should be regulated through municipal by-laws.					
Tree planting to replace regulated trees removed on private property should be regulated through municipal by-laws.					

Part II. Trees on Your Property

Questions 2–5 ask about your trees. A tree is defined as a woody perennial usually having one dominant trunk and a mature height greater than 5 meters (16 feet).

2. How many trees are on your property (please exclude trees on the municipally owned boulevard in front of your house)? _____

3. Is there a tree(s) located in the municipally owned boulevard in front of your house?

____YES ____NO ____Unsure (Please explain): _____

_____

4. How many trees have you **planted** in your current yard:

In the past 3 years? _____ Longer than 3 years ago? _____

Please briefly state your reasons for **planting** trees in your yard. _____

_____

5. How many trees in your current yard have you **removed**:

In the past 3 years? _____ Longer than 3 years ago? _____

Please briefly state your reasons for **removing** trees in your yard. _____

_____

Part III. Tree Removal and Replacement Permit

6. What type of tree removal permit was issued to you by the City of Toronto? (Please select one)

____CONSTRUCTION PERMIT: needed when building, demolition, excavation, storage of construction materials, etc. is associated with tree removal. This may include situations where a minor variance, consent, and/or building permits were required.

____NON-CONSTRUCTION PERMIT

____OTHER (Please explain): _____

7. One of the requirements of the City of Toronto Tree Removal Permit is to plant and maintain (a) replacement tree(s). Was a replacement tree (or trees) ever planted on your property? **This information will NOT BE SHARED with the City of Toronto.**

____YES, the required number were planted.

____ ONE OR MORE TREES were planted but fewer than the required number.

____ NO: **please skip to Question 14.**

8. Has the replacement tree(s) survived?

Number of planted trees that survived: _____

Number of planted trees that did not survive: _____

9. Was the replacement tree(s) removed for any reason besides "the tree did not survive"?

YES____

NO____

If yes, please explain why the replacement tree(s) was removed? _____

_____

10. Where did you acquire the replanted tree(s) from?

____ Seasonal garden center at Canadian Tire, Walmart, Lowe's, or similar store

____ Nursery or garden center

____ LEAF's Backyard Tree Planting program

____ Local environmental organization that was not LEAF

____The forest or other location where the tree was already growing

____Other (please specify): _____

11. Who planted the replacement tree? (Check all that apply)

____ I planted it
____ Another household member
____ Contractor/landscaper
____ City employee
____ LEAF
____ Local environmental organization that was not LEAF
____ Other (please specify): _____

12. What species of tree(s) is/are the replanted tree(s)? (Please be specific)

_____

13. Are you satisfied with the replacement tree(s) on your property?

YES____ NO____ UNSURE____

Please explain your answer: _____

_____

Everyone Should Answer the Remaining Questions

14. Did you feel that the tree removal permit was clear about the requirement to replant (a) tree(s) on your property?

YES____ NO____ UNSURE____

If NO or UNSURE, what did you find unclear about the tree removal permit requirements? _____

_____

15. Were you aware that replacement trees are protected under the private tree by-law and a permit would be required for their removal?

YES____ NO____

Part IV. Future Plans

16. I plan on planting (an) additional tree(s) on my property within the next 3 years.

YES____ NO____ MAYBE_____

17. Please check the **top three** factors you would consider if you were going to plant a tree in your yard.

____ Ability to provide shade in yard or garden
____ Ability to provide food and shelter for animals
____ If it is a native tree
____ Tree improves the beauty of your home/yard
____ Age span of tree
____ Size and shape
____ Maintenance requirements
____ Ability to provide oxygen
____ Creates a calming effect
____ Increases property value
____ Reduces noise or sight lines
____ Avoids hazards (dead limbs, large fruit)
____Other: _____
____ Do not want trees in my yard

Part V. Household Demographics

Please answer the following questions about you and your household.

18. What is your age? _____

19. What is your gender? _____

20. What is the highest education level you have attained?

____ No certificate, diploma, or degree

____ High school certificate or equivalent

____ Apprenticeship, college, CEGEP, or other non-university certificate or diploma

____ University bachelor's degree

____ Master's or doctorate degree

21. Please indicate your ethnic origin(s). Check all that apply.

____ British Isles

____ European

____ South Asian

____ East & Southeast Asian

____ Caribbean

____ Other: _____

22. Please indicate where you were born:

____ Toronto

____ Canada, but not Toronto

____ Outside Canada, please write country: _____

23. How long have you lived at your current address?

____ Less than 5 years

____ 5 to 9 years

____ 10 to 14 years

____ 15 to 19 years

____ 20 or more years

24. Do you or someone in your household own your house?

____ NO

____ YES

25. Please indicate your type of house.

____ Detached

____ Semi-detached

____ Row house/town house

____ Other: _____

26. What is your annual household income, in dollars?

____ $0 to $24,999

____ $25,000 to $49,999

____ $50,000 to $74,999

____ $75,000 to $119,999

____ $120,000 or more

27. How many adults 65 and over are in your household? _____

28. How many adults 45 to 64 are in your household? _____

29. How many adults 18 to 44 are in your household? _____

30. How many children (< 18 years) are in your household? _____

31. Is there anything else you would like to tell us about your experience with the Private Tree By-Law or your tree removal permit? _____

_____