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Global review of incentive schemes for the retention and successful establishment of trees on private urban land

Interim Report

Literature Review

September 2019

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THE UNIVERSITY OF MELBOURNE

In collaboration with:

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EXECUTIVE SUMMARY

Local government strategies and policies aimed at increasing tree planting and canopy-cover have become a familiar feature in many cities. However, the role of private urban land areas in a city's ambitious plans to retain and increase the number of trees and canopy-cover is usually overlooked. In 2019, the University of Melbourne was funded by Horticultural Innovation Australia and partnered with a reference group of local experts, including academics, local government and industry partners, to investigate the mechanisms (regulations and incentives, or "sticks and carrots") that cities have to retain, protect, and plant trees in private lands.

This academic literature review forms the first milestone of this project. The review highlights the importance of private property rights and planning laws for determining how cities influence what happens to trees on private land. Most urban jurisdictions where private property comes with strong rights and planning laws based on a hierarchical, top-down model, cannot protect trees over an owner's right to protect their interests which may involve tree removal. However, many Canadian, Australian, US, and European cities have created local laws to protect private trees from being removed or altered. These provisions include regulatory mechanisms, such as requiring tree removal permits, maintaining significant tree registries, applying compensatory value formulas, or requiring arborist reports or building standards, as well as educational and social mechanisms, such as sponsoring volunteer programs and tree-give-away programs.

Some researchers have argued for jurisdictions to remove strict individual tree protections (i.e., those that protect specific trees to be removed, as in significant tree registries, or blanket laws that protect all trees from removal or alteration) because they are not effective. To support this, they have highlighted their limited coverage, such as exclusion of major land uses and medium/small trees, and the high approval rates of tree-removal permits. Enforcing existing regulations continues to be a challenge for many local governments. The effectiveness of existing regulations is dependent on the ability, willingness, and resourcing capacity of the authority that enforces it. Researchers have lauded the use of other mechanisms, such as education, to help protect trees in private lands. However, not only have these mechanisms not been described adequately, but their effectiveness has not been directly measured.

Only a few empirical studies have assessed the effectiveness of tree-protection laws in terms of increased tree numbers or tree-canopy cover. The usual approach is to compare tree-cover or tree numbers among cities with and without these protections between two points in time. These studies have shown mixed results. In the US, tree-protection laws appear to be effective, which means that cities with tree-protections have increased or retained tree-cover over two points of time. However, in other contexts, tree protections are not as effective, since increased tree-cover cannot be explained solely by the effect of these protections. The different context of cities and the different types of tree-protection specifications makes this type of research difficult to conduct.

This research will be complemented by a review of progressive case studies, mining information from non-academic sources, and by a synthesis of the opinions and experiences of international experts on the efficacy of tree-protection mechanisms through interviews and international workshops carried out in during 2019.

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INTRODUCTION

The sustainability and liveability of cities depends on retaining established trees, and on planting new trees. In leading cities, much effort has been directed at protecting and enhancing the urban forest on public lands, such as parks and streets. However, in some cities a considerable proportion of urban vegetation exists on private land. Therefore, to ensure an abundant urban forest, attention also needs to be directed at private urban lands, such as residential yards, gardens, or commercial and industrial areas.

While local governments usually have direct control and responsibility for retaining and planting trees in public spaces, their control on private lands is restricted. However, given that a significant portion of the trees and canopy cover of a city is concentrated in private lands, cities must pay attention to these areas. Therefore, it is important to understand the mechanisms that cities have to retain or protect existing trees and plant more trees on private lands.

Trees and Canopy Cover in Private lands

In many world cities, about half of the trees and half of the canopy cover is concentrated in private lands, areas of the cities where governments have limited jurisdiction. Researchers have documented these challenges for the retention and increase of trees and canopy cover in private lands, including in US (Nowak & Greenfield, 2012) and Australian cities (Jacobs et al., 2014). There are three important reasons why the distribution of trees and canopy cover in private lands constitutes a challenge for local governments:

First, this distribution makes it challenging for them to respond to and meet current sustainability and liveability requirements based on greening (Australian Government, 2018), since many tree decisions in private spaces are made by private homeowners or landowners, with little influence from local governments.

Second, both the private ownership of trees and their unequal distribution in private spaces contributes to justice and equity issues (Heynen et al., 2006; Pham et al., 2012; Schwarz et al., 2015; Nesbitt et al., 2019). While everybody benefits from some of the services private trees

provide, such as wildlife habitat provision or pleasant views, at least some services that these trees provide remain inaccessible to the public, such as localized microclimate regulation.

Third, because of increasing urban density, aimed at accommodating increasing urban populations whilst avoiding urban sprawl, many cities are losing lots of trees in private lands due to processes such as subdivision, expansion, and consolidation (Figure 1; see also Infrastructure Australia, 2019). However, it is still unclear what is the role that the loss of tree numbers and canopy cover in private lands plays in urban forest dynamics in global cities.

If we accept the notion that the services that urban trees provide are to be enjoyed collectively, then local governments have an important role to play in encouraging or regulating what happens to trees in private lands.

Figure 1: Illustration of the challenges for privately owned trees in cities (Greater Melbourne Area, Blackburn, Victoria, Australia), including densification driven by increased house sizes (left) and increased number of dwellings in the same area (right) (Source The Nature Conservancy, 2019)

Types of Tree Protections in Private Lands

Around the world, local governments are experimenting with a range of mechanisms to influence what happens to trees in private lands. The mechanisms can be categorized in two simple ways: penalties and regulations, or "sticks", and incentives and promotions, or "carrots".

Regulations, or the sticks, are specific rules and penalties that prevent the removal of existing trees or require the provision of new trees in private lands. While these regulations are usually focused on preventing the removal of public trees (Conway & Urbani, 2007), many cities are now looking into implementing similar regulations for private lands (i.e., private tree protection bylaws, or ordinances, depending on context; see Landry & Pu, 2010; Sung, 2012).

Incentives, or the carrots, are specific activities that encourage the retention of existing trees or the planting of new trees in private lands. For many years, the default incentive of many local governments to promote trees has been to give out trees for private gardeners to plant or to educate the public about the importance of trees (Ordóñez & Duinker, 2013). Nonetheless, there are other incentives that urban jurisdictions can implement, including rate rebates for planting or retaining trees, providing free service or support for tree-care, supporting citizen-led activities focused on planting or protecting private trees, awarding prizes for volunteer activities (Ordóñez & Duinker, 2013; Watson, 2015).

The desire to protect, retain, and plant trees in private lands have forced municipal governments to think creatively about the level of control they can have over what is privately and publicly owned. Many local governments have strategically conceptualized their urban forest as a continuous resource that needs to be managed collectively to maximise its benefits, regardless of ownership (Ordóñez & Duinker, 2013). These strategies require the establishment of strong community frameworks for urban forest governance that can better enable private stewardship over the protection, retention, and planting of trees in private lands (Molin & Konijnendijk, 2014; Roman et al., 2015; Phelan et al., 2019).

However, it is still unclear whether these stick or carrot mechanisms (or a combination of both) are effective in preventing the loss of trees and canopy cover from private lands, or if they do result in an increase. Collecting case studies from a range of cities with different characteristics (e.g., size, climate, government styles, distribution and patterns of private and public ownership) can help to building a more comprehensive understanding of the pros and cons of each instrument. Nonetheless, few studies, if any, have been able to document, synthesise, and

generalize on the initiatives that cities pursue to influence what happens to trees on private lands. This is mostly because knowledge about these mechanisms is restricted to the jurisdictional and governmental context of each city, region, or nation, so most of this information lies buried in reports and local legislation. Few studies have documented and synthesised these initiatives. There is also limited rigorous data on canopy cover or tree numbers in private land for a comprehensive evaluation. This diminishes the ability of cities to learn from each other and facilitate innovation to address the challenge of retaining and planting trees in private lands.

Purpose of this Study

The goal of this project is to understand how cities can contribute to retaining existing trees and planting more trees on private lands. To do this, we undertake an extensive and systematic review of international literature. The review is documented in this report and answers the following research questions:

1) What is the context (including legal, planning, and policy frameworks) for understanding how cities retain, protect, and plant trees in private lands, including any legal or policy frameworks?
2) What do we know about the loss and gain of trees and/or canopy cover in private lands?
3) What are the types of mechanisms that cities use to retain, protect, and plant trees in private lands?
4) What is the effect of these mechanisms for maintaining or increasing tree numbers or canopy cover in private lands?

The findings and recommendations from this review will provide a blue-print template for the most promising suite of mechanisms to retain and increase urban tree numbers and canopy cover in global cities.

METHODS OF REVIEW

Design

Following systematic review guidelines (Pullin & Stewart, 2006; Moher et al., 2009; CEE, 2013), we developed a protocol for searching, finding, and selecting academic articles. The

scope of the search was global and limited to English articles. Studies were selected for assessment based on their relevance to research questions (above; see also Appendix 1).

Searching, Finding, and Selecting Articles

Systematizing academic literature reviews is important to avoid the subjective and purposeful selection of articles (Pullin & Stewart, 2006; Moher et al., 2009; CEE, 2013). The protocol used here was designed to be as replicable as possible. It was limited to academic peer-reviewed articles and excluded book chapters, conference proceedings, or other publications. To facilitate the searches, keywords were developed and grouped in four themes that reflected our inclusion and exclusion criteria: 1) the space (i.e., urban areas, cities, local government); 2) the focus (i.e., trees, urban forests); 3) tree retention or removals; and 4) private urban lands (including all iterations or alterations of the word urban, such as peri-urban, or ex-urban, among many others). Three academic databases were searched using keywords in the period of 1970 to 2019. The search was carried out in two stages: 1) applying keywords interchangeably in online search systems; and 2) re-applying keywords to the titles and abstracts of the initial hits to filter out the more relevant results. The search finalized in June 30, 2019. Articles were then selected for subsequent analyses according to the above criteria. Only articles with full-text access were used for analysis (see Appendix 1).

Classification, Analysis, and Synthesis

Once the final set of articles and other documents was obtained (Appendix 2), we conducted a qualitative content analysis. This entailed reading the articles in full, extracting information from them, synthesizing these insights into a cohesive narrative, and classifying the information within these documents to develop a typology of the mechanisms to protect trees in private urban lands. The classification items that we used were not pre-determined, but rather emerged from our reading of the articles and documents, as our study was exploratory in nature.

RESULTS & DISCUSSION

The results from this review, and insights gained, are presented below and it is structured by the themes that emerged from our analysis.

Context for Tree Protection in Private Lands

The law of a country is one of the first important steps that determine what mechanisms are available for a local government to retain, protect, or plant trees in private lands. The most fundamental determinant is private property law, meaning considerations of the right of any individual to hold land. This is followed by laws that regulate planning and development, including town or city planning, which define the way urban planning and development control is mandated and structured, specifically, whether it is hierarchal top-down (i.e., from national to regional and local levels), hierarchical bottom-up (i.e., from local to regional and national levels; this is rare), or a mix of both, which means emanating from different centres of power, or with local and regional areas having different but complementary planning mandates. A mixed planning hierarchy is usually the default in many countries.

Besides what is written in law, the structing of institutions, how they interact and relate, are as important for governing what happens to trees in private lands. The hierarchical structure of many planning systems, mandated by nation or state and passed on to local areas, leaves little freedom for local municipal governments to develop local laws (Mincey et al., 2013a). In addition, the interpretation of planning policies is up to the discretion of the regulatory body or decision-maker (i.e., planning reviewer), as to whether any challenge to the planning regulation should or should not trigger a legal process.

The essence of tree protection and provision on private lands is then whether governments have provisions that allow them to have jurisdiction over trees in private lands. These provisions, which can be some type of policy or regulation, can then turn into a specific local rule that does not allow people to remove or alter trees from their front or backyards, even if these trees are in the land they own; or that as part of approval process for development, the provision of trees (or conditions to support trees) are required of the proponent. While this may seem to contradict private property laws , there are many instances where local authorities have legal provisions to regulate natural resources in private land, including water, soil, and, in this case trees (Kelly, 2014; Watson, 2015).

The notion of being able to regulate common resources located in private land is captured in policy documents created by municipalities, such as urban forest strategies or management plans, where the urban forest is defined as a continuous resource, spanning across both public and private areas, as many Canadian (Ordóñez & Duinker, 2013) and Australian (Jones & Instone, 2016) cities have done in the past 20 to 15 years . However, there are many other definitions of urban forests, including those only restricted to trees in public areas, or woodlots within municipal limits (Konijnendijk et al., 2006). Nonetheless, this notion of being able to regulate common resources located in private lands has allowed allows many cities to create local laws that protect individual private trees from being removed, destroyed, damaged, cut, truncated, modified, or even pruned, regardless of jurisdiction, ownership, or tenancy. Many of these so-called "command and control" regulations have been in place since the 1970s in Canada, US, Australia, and many European countries (Coughlin et al., 1988; Cooper, 1996; Kenney & Idziak, 2000; Watson, 2015; Kelly, 2014).

Tree Loss and Removal from Private Lands in Urban Areas

It is important to also evaluate how cities are performing in terms of gains and losses of tree numbers and canopy cover in private lands, as this contextualizes the need for tree protection. This includes reviewing the research that assesses tree-canopy cover change and urban tree mortality and removal in private areas (Table 1), and the research that assesses the relationship between urban tree loss or removal and development processes, such as construction activities, in private lands (Table 2).

Most of what has been inferred about urban tree loss and removal in private lands is through the measurement of tree-canopy cover change (Table 1), but this has its limitations. First, the presence or absence of trees is difficult to assess by studying tree-canopy cover patterns alone (Kaspar et al., 2017). This is because most canopy cover studies assess net changes at large spatial scales (whole of city), or only over a single time-period (between two measurement events). Therefore, canopy cover net change is contextualized spatially and temporally by the characteristics of previous land uses (Kendal et al., 2012; examples in Table 1). Second, the distribution of tree-canopy cover varies so widely across and between cities that results are difficult to interpret (Nowak & Greenfield, 2012; Merry et al., 2014; Kaspar et al., 2017;). Third,

scale and classification matter in this context, since, in many cases, land-cover classification and tree-canopy cover fragmentation are not usually aligned (Mincey et al., 2013b). Finally, tree-canopy cover is strongly associated with the characteristics of the space, such as a neighbourhood's level of income (Dobbs et al., 2013; Roman et al., 2014; Vogt et al., 2015; Chuang et al., 2017; Elmes et al., 2018), so decoupling the effects of these variables from the effect of ownership (i.e., public vs. private) on tree-canopy change is difficult.

There has been little research directed towards identifying the relationship between tree removals and development in private lands, and the proportional importance of the motivating factors behind tree removals. One limitation is that the relationship between tree removal and development can only be assessed at finer spatial scales (Steenberg et al., 2018a). Tree-canopy cover data may not be useful here, since it may not reflect or correlate well with instances of tree removal at this small scale (Kaspar et al., 2017). This is because canopy cover loss can occur from pruning (not removal) and the removal of large, mature trees, but the patterns for smaller, younger trees may not be well represented. Also, site characteristics, such as ownership (i.e., public/private), are difficult to obtain from these data. Another limitation is that researchers struggle to obtain reliable data about tree removals from either the private or public realm, let alone data on the stated reasons for tree removal. Tree removal in private lands can occur for many possible reasons, such as outgrowing (over-sized) the planted location; old age or over-maturity; the level of risk the tree poses to humans or infrastructure; the inconvenience the tree poses to construction activities; or even blocked views (Lavy & Hagelman III, 2017). Nevertheless, some studies have managed to assess the empirical relationship between urban tree removal and development by using either proxies or limited field data, including the application for, or the award of, tree removal permits (Table 2). Other interesting case studies have shed some light on what type of tree is more likely to be removed if construction occurs around it, but these studies are difficult to replicate given that they are carried out in the context of extraordinary circumstances (e.g., the consequences of an earthquake and the redevelopment that followed in Christchurch; see Table 2). Also, these insights do not reflect business-as-usual scenarios of urban development.

Table 1: A synthesis of the research studies on tree-loss and removal in private lands

Type of measure	*Findings*	*Location*	*Reference*
Tree-canopy cover changes	Decreasing canopy cover at the scale of the whole city in big US cities	20 cities in US	Nowak & Greenfield, 2018
	Most tree-canopy loss in urban areas is in residential areas due trees being removed for development	Worchester, MA, US	Hostetler et al., 2013
	Tree-canopy cover in residential areas in the US has increased since the 1950s mostly due to re-forestation of agricultural land	Minneapolis–Saint Paul (Twin cities), metro area, MN, US	Berland, 2012
	Tree-canopy-cover has remained stagnant in the past 5 years, with gains and losses depending on the suburb	Melbourne, VIC, Australia	Hurley et al., 2019
	Tree-canopy cover in private residential lands was less in parcels built after 1990 than parcels built before. Tree-canopy cover was correlated with dwelling density, housing age, terrain slope, high school education, and household income	Brisbane, Australia	Daniel et al., 2016
Combined tree-canopy and tree-removal changes	Tree-canopy cover has decreased in US cities, and this decrease is strongly correlated with tree removal patterns	Denver, CO, and Milwaukee, WI, US	Ossola & Hopton, 2018

Table 2: A synthesis of the research studies on the relationship between tree-loss and removal with development in private lands

Type of measure	*Findings*	*Location*	*Reference*
Tree-removal permits (both public and private trees)	The number of tree removal permits increases both toward the urban core and toward the periphery	Austin, TX, US	Lavy & Hagelman III, 2017
	The number of tree removal permits increases in areas with higher education, property ownership, population density, major streets, and older properties	Toronto, ON, Canada	Steenberg et al., 2018a; 2018b
Individual tree removals (both public and private trees)	Public trees close to a construction site are more likely to be removed if its smaller/younger, and if it is in areas where property prices are high	Christchurch, New Zealand	Morgenroth et al., 2017
	Private trees in residential areas where construction occurs (i.e., home expansion, home rebuilding, infilling) are more likely to be removed if it is smaller/younger, and if it is in areas where property prices are high	Christchurch, New Zealand	Guo et al., 2018; 2019

Type of Mechanisms to Retain, Protect, or Plant Trees in Private Lands

There are few academic reviews or empirical research on the mechanisms that cities have to protect trees (i.e., also known as tree bylaws or ordinances, depending on context), yet the existing studies are insightful.

In their historical discussion of tree protection in the US, Coughlin et al. (1988) note how some local protections, which in the US are known as private tree ordinances, suffered from limited coverage, such as exempting major land uses (e.g., transport ways, military bases), and exempting small and medium sized trees. These regulations usually demanded permit submissions by private landowners to remove a tree, but the approval rates of these permits were high, and many permits were being granted after plans for development had already been approved. They noted few court challenges or tests for existing protections. They also argued how regulations did not account for a municipality's topography, existing mature tree stands, and patterns of buildings and open space.

Similar and complementary accounts include those of Kelly (2014), who provides a legal and historical perspective on tree preservation orders in NSW, Australia, and of Watson (2015), who provides a historical description of tree protections in the US. Australian regulations had derived from those defined in the UK's Environmental & Planning Act, which currently include tree protection as part of planning activities. Kelly (2014) has argued that the goal of these regulations had been initially to develop wealthy, leafy neighbourhoods, leaving other new suburbs and developments out of the regulation. Watson (2015) has argued that there are still no incentives for individuals to protect or retain their privately-owned trees, as most of the existing regulations were not strictly part of development planning. Many authors that present historically accounts of urban tree protections in private lands have argued for municipalities to get rid of strict and individual local tree-protection laws (i.e., trees protected by registries or by blanket local laws applied to all trees), and instead use planning provisions to regulate development, rather than the trees themselves. These provisions may include using zoning mechanisms to protect some private trees; using incentives to stimulate tree retention or planting, for example by creating an urban tree fund from the compensations received from removing trees; and/or using

education programs to raise awareness about the benefits of private trees (see also Cooper, 1996; Mincey et al., 2013b).

More empirical academic studies include that one by Profus & Loeb (1990) who, after collecting information on this topic from 37 countries through postal surveys, found a diverse set of tree protections, and noted that most legal and strict tree protections were triggered by a tree's size, defined specifically by diameter at breast height (DBH) or height. Similarly, Schmied & Pillmann (2003) surveyed 25 city websites in Europe and found that most tree protection laws depended mostly on a tree's size.

While we have used the seminal work discussed above to develop a comprehensive typology of existing protections for private trees (Table 3), we expand this work in three important ways. First, we consider the importance of compensatory value formulas and arborist reports as types of mechanisms for tree protection in private lands. Valuation formulas exist under the assumption that by making it exceedingly expensive to remove a tree, private landowners will find it less desirable (Nowak, 1993). Many cities around the world use these formulas, yet they vary widely in their assumptions and the data they use (e.g., CAVAT formula in the UK; CTLA formula in the US; see Cullen, 2007; Doick et al., 2018). Some compensatory value formulas have been updated using calculations of the economic value of the services provided by trees, but the vast majority of them are still based on willingness to pay methods, the cost of tree replacement, the value of a tree to its owner, or data based on amenity valuations generated by expert panels (Nowak et al., 2002). Generally, the monetary value of a tree changes with changing land prices and other local characteristics, so these formulas are always specific to a locale and are usually based on amenity values.

Second, we have defined the educational mechanisms for tree protection, since previous research has never elaborated on the type of mechanisms that actually exist. Here we use the work by Ordóñez & Duinker (2013), which synthesizes the content of Canadian urban forest management plans, and stakeholder opinions (see next section) to elaborate on these mechanisms.

Third, we have assigned Australian examples for each type of mechanism to help translate the information in this typology to an Australian context (see Table 3).

Opinions of Stakeholders about Tree Protection in Private Lands

Understanding the opinion of urban forest stakeholders, including local government officers, planners, consultants, developers, non-governmental organizations, and community members, among other important urban forest stakeholders, helps us understand not only the social context behind tree protection mechanisms, but also their effectiveness and level of buy-in from key actors. This is important because, while the effectiveness of these mechanisms is ultimately reflected in the increase or maintenance of tree numbers and amount of canopy cover (see next section), these mechanisms may make it easier or more difficult to make decisions about trees. This ultimately influences the capacity that stakeholders have to retain or increase tree numbers and canopy cover in private lands.

A review of these studies shows that some urban forest stakeholders see policies that stimulate better urban growth (e.g., smart or sustainable growth) as being more effective for cities to preserve trees and tree canopy than simply having strict and individual tree protections (i.e., trees protected by registries or by blanket local laws applied to all trees). The public also generally has a positive attitude towards trees planted in both public and private lands, and towards city tree-planting programs. However, attitudes for specific trees in specific places, such as the tree in front of a residence's house or backyard, vary widely depending on a person's background, including a person's knowledge and experience of trees, such as recent gardening activity, and demographics, such as age, education level, and rental situation (i.e., renter vs. owner). Generally, private homeowners plant trees in their private gardens or yards for aesthetic reasons, but also to provide shade, habitat, and food (Table 4).

Table 3: Types of urban tree protections in private urban land

Category	*Subcategory*	*Mechanism*	*General Description*	*Examples in Australia*	*Type*
Legal or Regulatory	Protected sites	Parks & natural areas	Planning overlays	Environmental Significance Overlay (ESO), Vegetation Protection Overlays (VPO), Significant Landscape Overlay (SLO) Specific for each landholder (e.g., hospitals, schools, military bases)	Stick
		Historical or heritage sites			Stick
		Scenic or special landscapes			Stick
		Educational, commercial, or scientific sites			Stick
		Protection of area where tree grows	If tree in imminent danger, e.g., soil volumes Depends on site and type of activity	Local tree-protection law, ESO, VPO Specific for each landholder (e.g., hospitals, schools, military bases)	Stick
	Protected species or specimens	Rare or large specimens	Depends on type of tree		Stick
		Protected Species	Trigger usually species CITES		Stick
		Protected types of trees	Depends on type of tree e.g., fruit trees, conifers or deciduous or native species		Stick
		By community or public demand	Varies	Varies	Stick
	Tree protections	Permits or licenses requirements for removing trees	• Trigger usually size (DBH or height or canopy-cover), minimum or maximum, or species/specimen • Applies to both public and private trees • Could be calculated via compensatory value formulas (see below) • Requires or complemented by arborist report (see below)	Local tree-protection law Specific for each landholder (e.g., hospitals, schools, military bases)	Stick
		Significant, exceptional, or heritage tree registries			Stick
		Fines for illegal tree removals			Stick

Table 3: Types of urban tree protections in private urban land (cont.)

Category	*Subcategory*	*Mechanism*	*General Description*	*Examples in Australia*	*Type*
Legal or Regulatory	Tree protections	Compensatory value formulas	• Also known as valuation formulas • Based on tree characteristics (usually size, species, etc.) • Usually based on amenity value, not environmental services value • Some examples include the Council of Tree and Landscaper Appraisers (CTLA) in US, and the Capital Assets Value Amenity Trees, (CAVAT), in UK • Could be calculated based on tree characteristics of as a single price for any tree	Local tree-protection law Specific for each landholder (e.g., hospitals, schools, military bases)	Stick

	Tree management requirements for new constructions or developments	Arborist report	• Could be specified in local building requirements
			• Trigger usually size (DBH or height or canopy-cover), minimum or maximum, or species/specimen
			• Applies to both public and private trees
			• Could specify type of effect:
			  ○ to remove
			  ○ to destroy totally or partially
			  ○ to damage totally or partially
			  ○ to cut, to truncate totally or partially
			  ○ to modify
			  ○ to enhance decay
			• Could be calculated via compensatory value formulas (see below), or single price for any tree
			• Uses compensatory value formulas (a.k.a. valuation formulas) (e.g., Council of Tree and Landscaper Appraisers (CTLA) in US; Capital Assets Value Amenity Trees, (CAVAT), in UK)
				Local tree-protection law
				
				Building Code of Australia (BCA)
				
				Specific for each landholder (e.g., hospitals, schools, military bases)
					Stick

		Building requirements			Stick Carrot

Table 3: Types of urban tree protections in private urban land (cont.)

Category	*Subcategory*	*Mechanism*	*General Description*	*Examples in Australia*	*Type*
Legal	Strategic policy guidelines	Resource continuity	Definition of the urban forest as a continuous resource regardless of ownership across public and private lands	National, State, or Local policy or strategic documents (e.g., biodiversity plans, sustainability plans, development plans, building plans, heritage plans) Specific for each landholder (e.g., hospitals, schools, military bases)	Mixed

		Inclusion of urban forest strategies or themes in other policies/strategies	• Overseen by state or national planning regulations
			• Applies to both public and private trees
			• Specifics depend on context:
			  ○ National documents/policies
			  ○ State policies/documents
			  ○ Local laws or documents/policies
					Mixed

		Guidelines for legal personhood of urban forest or trees	• To allow legal representation of the urban forest as a natural resource or entity • None for urban forests yet, only theoretical, but similar examples exist (e.g., New Zealand, Whanganui river)		Mixed

Voluntary standards or guidelines	Management guidelines	Tree management guidelines for new constructions or developments	• Could be specified in national, regional, local building standards, or standards that are part of a third-party certification
			• Could specify type of incentive:
			  ○ to minimize tree removal
			  ○ to reduce tree removal
			  ○ to increase tree retention
			  ○ to maximize greenspace
			• Triggers vary
			• Applies to private trees only
			• Could be calculated via compensatory value formulas, or single price for any tree
			• Could require third-party arborist report (see above)
			• Could be done via tax breaks or credits (e.g., carbon credits)
				Local tree-protection law
				
				Specific to consulting or certification companies (e.g., International Standards Organization; Standards Australia)
				
				Specific for each landholder (e.g., hospitals, schools, military bases)
					Mixed

	Planting incentives	Tree planting or replacement incentives for new constructions or developments Sponsored or financed tree planting			Stick

Table 3: Types of urban tree protections in private urban land (cont.)

Category	*Subcategory*	*Mechanism*	*General Description*	*Examples in Australia*	*Type*
Education & Awareness	Raise awareness	Material for communication & outreach	Websites, flyers and brochures	National, State, or Local policy or strategic documents (e.g., biodiversity plans, sustainability plans, development plans, building plans, heritage plans, urban forest strategies, urban forest management plans, communications plans) Local tree-protection laws Specific for each landholder (e.g., hospitals, schools, military bases)	Carrot
		Public information centres	Info centres in arboreta; interpretation sites in natural areas		Carrot
		Site interpretation			Carrot
	Free services	Free arboricultural services	Free pruning or removal and re-planting		Carrot
		Free tree resources	Seed or seedling giveaway program		Carrot
	Participation, Stewardship, & Engagement	Private stewardship	Celebrations or competitions of private tree stewardship Tree days and tree competitions (e.g., ArborDay, Tree Week) Adopt-a-tree/greenway programs (e.g., New York's tree-adoption program)		Carrot
		Volunteering	Tree-planting volunteers Includes celebration of volunteer activities		Carrot
		Public/community input requirements for activities	Public input on trees to be removed or altered by new development projects		Carrot
		Community partnerships and leadership	Steering communities or working groups on urban-tree decisions Creation of community-led organizations (e.g., tree-planting groups in neighborhood)		Carrot
		Citizen science	Citizen-led programs for collection of tree data, such as an inventory (e.g., Citizen Forester program)		Carrot
	Education	Educational programs	Information workshops; partnerships with universities to do research or undertake urban forest courses; walking tours (e.g., Nature Stewards program)		Carrot
		Educational centres	Centres with information or educational programs (e.g., arboreta)		Carrot

Table 4: A synthesis of the research studies on stakeholder opinion about trees in private lands

Type of measure	*Findings*	*Method*	*Sample information*	*Location*	*Reference*
Opinion of urban forest experts	Experts think that cities preserve trees and tree canopy more by the combination of tree protection ordinances with policies that stimulate smart growth, having a person in charge of tree programs, and the presence of a steering board for making decisions about trees, than just having a tree protection ordinance by itself	Electronic online survey	286 experts (e.g., arborists, planners, architects)	Georgia (state-wide), US	Hill et al., 2010
	Experts think that appropriate tree species selection mitigates some of the conflicts related to public and private tree decisions	Interviews	52 experts (e.g., arborists, architects planners)	Hobart, Melbourne, Adelaide, Sydney, Brisbane, Townsville, Australia	Kirkpatrick et al., 2013a
Opinion of private residents	Homeowners in suburban areas plant trees for aesthetics and food (fruit)	Phone surveys	751 homeowners	Seattle, WA, US	Dilley & Wolf, 2013
	Homeowners plant trees for aesthetics, shade, bird habitat, privacy, and removing pollutants	Postal and electronic online surveys	1,200 homeowners	Salt Lake City, Los Angeles, US	Avolio et al., 2015; 2018
	Tree-planting program coordinators in residential areas say that participants in their programs prefer to plant trees with small flowers and fruits	Electronic online surveys and phone interviews	Coordinators (number not stated)	NYC, Baltimore, Philadelphia, Providence, Worcester, US	Nguyen et al., 2017
	Residents plant trees for aesthetics, increasing privacy, shade, connecting to nature, and improving health. Age, education, property-level tree density, recent tree planting, and age of house, influence attitudes towards trees	Postal surveys and interviews	442 residents	Toronto, ON, Canada	Conway & Bang, 2014 Shakeel & Conway, 2014 Conway & Vander Vecht, 2015 Conway, 2016
	Private residents have a positive attitude towards trees in their property and plant them mostly for aesthetics, privacy, shade, habitat for wildlife, and improving health	Eletronic online survey	736 residents	Hobart, Melbourne, Adelaide, Sydney, Brisbane, Townsville, Australia	Kirkpatrick et al., 2012; 2013b

Effect of Tree Protections on Tree numbers or Canopy Cover

The effectiveness of tree protection mechanisms is ultimately reflected in the increase or maintenance of the number of trees and amount of tree-canopy cover in a city, but it has been difficult to evaluate the effect of individual tree-protection mechanisms.

While many authors have argued that strict regulations (i.e., trees protected by registries or by blanket local laws applied to all trees), or sticks, are not effective because they suffer from high approval rates for removing the trees, and a cause of that may be that they are not enshrined private property or planning laws (see Coughlin et al., 1988; Profus & Loeb, 1990; Cooper, 1996; Schmied & Pillmann, 2003; Watson, 2015), the authors in these studies draw their conclusions on the basis of an immersed experience in the cities they discuss, mostly US and European cities, rather than from empirical data.

Empirical studies that assessed the effectiveness of tree-protection laws in terms of increased or tree numbers have usually used tree-canopy cover data over two periods of time (usually before and after the law was implemented), and compared cities with laws with cities without laws. The results using this approach have been mixed, with some studies showing a negative effect of the regulations and others showing a positive effect (Table 5). Some limitations of this research include that not all the tree-protection laws are the same, and not all legal and governance contexts are the same. Some protections relate to the specific characteristics of a tree, others speak generally about every tree; some protections may be very detailed, while others may be simple guidelines; and some protections between cities may be the same, but in one city they may be enshrined in planning schemes, which allows cities to have a stronger enforcement capacity, while in another city they are not (Landry & Pu, 2010). This means that, in many cases, the change in tree-canopy cover is as much an effect of internal variations in the laws than their actual effectiveness (Conway & Urbani, 2007). All of these studies point to some of the caveats of assessing the effectiveness of tree protection mechanisms, including: 1) the different contexts of cities; 2) the variation in the specifics of the laws or regulations; 3) the lack of comparable data due to variable spatial and temporal parameters; 4) the lack of available data on tree loss and removal from private lands; and, most importantly, 5) what is effective in one context may not be

considered so in another context, so effectiveness itself lacks a clear, objective, definition (Table 5).

Table 5: A synthesis of the research studies on the effect of tree-protections and tree numbers or tree-canopy cover

Type of measure	*Findings*	*Location*	*Reference*
Presence of absence of tree-protection bylaws and tree-canopy cover	Urban areas with tree-protection bylaws have the same rates of tree-canopy cover loss as areas with no tree protection. Tree protection may be ineffective, but there is a lot of variation in local laws, effect is difficult to measure	Toronto, ON, Canada	Conway & Urbani, 2007
	Urban areas with tree-protection policies had more tree-canopy cover in private residential areas than cities without these policies. Cities with tree protections that were incorporated into planning schemes had higher tree-canopy cover	Tampa, FL, US	Florida, US, (Landry & Pu, 2010
	An urban area with tree-protection bylaw lost less mean tree-canopy height than an adjacent urban area without the bylaw. Mean tree-canopy cover was the same for both.	Lakeway, TX, US	Sung, 2012
Significant tree registries	Most trees in the Council's Schedule of Notable Trees were protected for cultural and not biodiversity reasons, and that they were mostly old, large trees in wealthy, leafy neighborhoods	Auckland, New Zealand	Wyse et al., 2015

CONCLUSION & FUTURE RESEARCH

Cities have a wide range of mechanisms to retain, protect, and plant trees in private lands. Developing strict protections for individual trees (i.e., trees protected by registries or by blanket local laws applied to all trees) has been the focus on many so-called local tree-protection laws, bylaws, or ordinances, depending on context. Many authors have argued that such efforts at local regulation is not be effective for increasing or maintaining the number of trees or tree-canopy cover in a city because the regulation is usually not enshrined in private property or planning laws. These regulations do not consider trees of smaller sizes and have high approval rates for removal despite the trees being listed as protected. Authors have argued that for the regulation to be effective they must be enshrined in planning overlays or zoning mechanisms, or combined

with policies that regulate development, rather than being stand-alone restrictions. Other authors have argued that local governments should focus on regulating urban development rather than protecting individual trees directly.

Lose implementation and lack of enforcement are key determinants in the effectiveness of strict tree-protection mechanisms, but there is a lack of research in this area. Strict protections add a tier of bureaucracy to city governments and increase processing costs, such as those required to process permit applications and arborist reports. Therefore, the effectiveness of these 'stick' mechanisms is dependent on the ability, willingness, and resourcing capacity of the authority to implement and enforce the regulation. A well-designed regulation is only as good as the accompanying processes and systems to enforce it. However, many local governments do not have the resources to invest in the personnel that could implement existing policies and ensure that local laws are being respected.

Incentives to protect, retain, or plant trees in private lands (i.e., "carrot" approaches) may be more desirable for many local governments, because they reduce bureaucracy and pose a good option for governments who do not have the resources for stringent enforcement of strict regulations. However, almost no research has been conducted on the type of carrot approaches and even less so on the effectiveness of these mechanisms. In fact, this report may be the first time educational and awareness mechanisms are articulated within the scope of the overall suite of mechanisms to protect or increase provision of urban trees. It is still unclear how financial incentives, tax cuts, and other carrot approaches are used by cities. Also, it is unclear whether volunteering programs or educational programs result in more trees. While developing a comprehensive methodology on how to assess this is beyond the scope of this report, we propose a brief list of considerations for this research to move forward: 1) selecting similar case studies (could be two similar neighbourhoods, or two similar cities); 2) selecting similar tree-protection mechanisms (e.g., a similar tree-planting program); 3) using comparable data in terms of spatial and temporal parameters; 4) define effectiveness in terms of educational (e.g., increased knowledge), psychological (e.g., increased awareness or satisfaction; increased subjective wellbeing), social (e.g., number of volunteers; increased social cohesion of neighbourhoods), or ecological (e.g., tree cover, tree numbers) measures.

Like any review, this review has some limitations. Some important limitations include the fact that there is no way we could have included other peer-reviewed literature that exists in other languages or databases. Also, some arboricultural journals (e.g., ISA Arboriculture & Urban Forestry journal; UK's Arboricultural journal) are not indexed.

This review will soon be complemented by a non-systematic and purposeful review of local and regional reports (i.e., grey literature review). These documents will be selected for assessment based on their relevance to Australian context (i.e., comparative urban, demographic, and cultural characteristics). It will also be complemented by garnering and synthesizing the opinions and experiences of international experts on the efficacy of mechanisms (regulations and incentives) for urban tree retention, protection, and increased planting in the private realm using interviews and workshops to be conducted at the European Forum on Urban Forestry, in Cologne, Germany, and at the Nature of Cities Summit, in Paris, France.

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APPENDIX 1

Details of review stages, including search procedures and selection criteria

<table>
<tr><th>Review stage</th><th>Goal</th><th>Types of documents</th><th>Procedure</th><th>Details</th></tr>
<tr><td>Data Collection</td><td>Systematically review & synthesize academic publications related urban to tree retention, protection, and planting initiatives on private land within, or around urban centres</td><td>Research articles published in academic peer-reviewed journals</td><td>Search of databases and individual journal by title and abstract using keywords from 1990 to 2019.

<u>Databases used:</u>
Scopus
Web of Science
ScienceDirect

<u>Journals used:</u>
Urban Forestry and Urban Greening;
Arboriculture and Urban Forestry;
Landscape and Urban Planning;
Urban Ecosystems;
Arboricultural Journal;
Forests</td><td><u>Keywords used*:</u>

<u>Group 1:</u>
Urban
City
Municipal
Local government
Council

<u>Group 2</u>
Canopy cover
forest
greening
green area
green infrastructure
green space
nature
natural area
street trees
tree
vegetation
woodland

<u>Group 3</u>
Protection
Retention
Planting
Loss
Removal

<u>Group 4:</u>
Private
Private lands
Private areas
Private space</td></tr>
<tr><td>Data Screening & Eligibility</td><td>Screen and select abstracts of initial database using selection criteria</td><td>As above</td><td>Read titles and abstracts, or executive summaries

Obtain full-text articles or reports</td><td>Selection Criteria
1. Focuses on cities or urban areas
2. Focuses on trees or urban forests (i.e., tree-dominated systems, including urban wooded area, treed or forested urban area or space)
3. Focuses on retention, protection, or planting
4. Focuses on private lands, areas, or spaces</td></tr>
<tr><td>Data analysis</td><td>Classify and densify the information</td><td>As above</td><td>Densification & classification</td><td>Build a database of all studies, densify content, develop categories for classification items, use data to create synthesis tables and diagrams</td></tr>
<tr><td colspan="5">* Bolean operators such as AND OR were used in between groups to include or exclude words in the search</td></tr>
</table>

APPENDIX 2

Results of systematic review searches in academic databases and individual journals

Stage	*Database*	Main keywords	Re-apply keywords within title and abstract
Results	Web of Science	72	9
	Scopus	363	66
	ScienceDirect	584	0
	Individual Journals*	3,294	738

* see Appendix 1