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Arborists and Urban Foresters Support for Urban Wildlife and Habitat Sustainability: Results of an Urban Ecology-Focused Survey of Arborists

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Abstract: Urbanization is causing fragmentation of natural areas and impacting urban wildlife populations. Sustainability of wildlife and their habitat in arboriculture has focused on three key areas: retaining wildlife snags and beneficial-tree features (e.g., hollows/cavities), education of arborists and the public, and the adoption of systems-level thinking into arboriculture (i.e., the consideration of wildlife in risk matrices and pruning objectives). We surveyed 805 arborists using an international online survey to examine how arborists perceive these key areas of wildlife conservation and sustainability in urban forest management. Systems-level thinking was the highest rated method for arborists to support urban wildlife, followed by the retaining of wildlife snags. Education and the involvement of conservation groups received lower ratings, and the retainment of branches with hollows or cavities received the lowest ratings. In selecting important factors for wildlife snag retainment, arborists were most concerned with tree risk and targets, followed by setting (urban versus rural) and use of the tree by wildlife. Other factors that are the concern of urban ecologists were less important to respondents. Our findings support continued urban ecology education for arborists which focuses on whole/complex systems thinking to develop sustainable urban forest management practices which benefit urban wildlife.

Keywords: cavities; dead trees; foresters; nesting; tree care for birds; tree doctors; tree risk assessment; tree surgeons; urban ecology

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1. Introduction

The intensification of global urbanization and land use conversion is resulting in the decline of biodiversity and urban wildlife populations [1–3]. In an effort to address urban biodiversity and wildlife crises, habitat retainment and preservation of contiguous canopy cover are thought to help reduce the severity and rapidness with which species richness and evenness is declining [4–7].

Urban wildlife plays a number of valuable roles in the continued success of urban ecosystem functions, including flower and crop pollination [8], pest control through predation [9,10], serving as a prey source, and accelerating tree-cavity production to the benefit of habitat creation [11]. Human-wildlife interactions can also benefit humans directly through betterment of mental health and developing emotional connections with the environment [12,13].

Human dimensions of wildlife conservation and sustainability are increasingly recognized as important components of wildlife management and ecosystem processes [14]. Beginning during the industrial revolution, humans lived in increasingly novel urban environments, causing the subjugation of wildlife [15]. Despite this separation of humans and wildlife in post-industrial society, emotional connections to wildlife remain active components of psychological approaches to human interactions with the natural world, including the biophilia hypothesis and the attention restoration theory [12]. This separation can cause

a greater interest in animal welfare and the preservation of biota [16,17], which may be mediated by interactions between humans and urban wildlife, a concept popularized by the Pigeon Paradox [18], demonstrating that human interactions with wildlife and experiences to nature can foster higher levels of connectedness to nature [19]. If nature connectedness and support for environmental efforts can be supported by human interactions with urban wildlife, then creating cities that are conducive and supportive of wildlife populations can help address global biodiversity losses and support human-wildlife co-existence [20,21]. Designing sustainable cities for wildlife is pivotal to preventing the extinction of wildlife species where urban fringe environments offer the last area of refuge [22]. However, the success of urban wildlife species is constrained by the loss of wildlife habitat in the urban forest, a pressing issue for sustainability in urban forest management.

In addressing urban tree habitat and canopy cover retainment, urban forest management practices can influence the preservation of urban wildlife. In urban environments, efforts to increase the diversity and density of urban wildlife is largely dependent on human management of urban flora [4,23]. A sustainable urban forest has been defined as an urban forest of ecological health and a structure conducive to the provision of ecosystem services [24]. The management objectives of these sustainable urban forests thusly include the assets and resources which support ecological health, including preserving diverse biological ecosystems within urban areas, such as ravines, large wooded areas, and a diversity of successional forest stages [25], and assets and resources for socioecological objectives which support community interaction with beneficial ecosystem services [26]. Thusly, imperatives within urban forest management plans, including increasing canopy cover and habitat availability, can beneficially impact urban wildlife [27].

As a component of urban forest management, arboriculture is concerned with the care and management of individual trees in an urban context [28]. The governance of urban wildlife varies by the political structure of stakeholders, both acting individually and as organizations. Community stakeholders may form their own methods to address wildlife sustainability and coexistence in the urban environment, distinct from the governance and management practices employed by governments and large organizations [29]. Stakeholder engagement is considered fundamental to successful implementation of wildlife management policies and strategies [30].

Consequently, understanding and incorporating arborists' and urban foresters' perceptions of urban wildlife conservation practices and environmental governance can better inform policy implementation. Because arborists have the potential to influence canopy cover and habitat availability, there has been an interest in arboriculture on supporting urban wildlife conservation, focusing on three predominant areas of urban wildlife conservation: education of arborists and clients, the retention of wildlife-beneficial tree features and snags, and the adoption of systems-level thinking in arboriculture and urban forest management [31–34]. Despite the focus of arboricultural organizations and literature on these three areas, there has been little research conducted on arborists' perceptions of wildlife conservation during tree care operations and urban forest management planning. In this study, we first examine the current understanding and focuses of urban wildlife policies and practices suggested by organizations and researchers, followed by examining stakeholder perceptions of these topics using an international survey.

1.1. An Introduction to Arboriculture

A substantial portion of tree care operations in urban environments fall within the practice of arboriculture. Arboriculture centers upon the care and management of individual trees, including tree pruning and removals, typically focused on urbanized areas [28]. It is distinct from both urban forestry and broader forestry practices because of the spatial scale and, in the case of forestry, the ecosystems in which they operate [35]. Because of the multitude of objectives and governance structures within an urban forest, arborists can find themselves working in one of several sectors, including residential, consulting, munic-

ipal, utilities, or at private institutions, such as arboretums or universities/colleges. The differentiation between these sectors can be based on the client and/or the work objectives.

Several organizations exist around the world which certify or license arborists, both within and across various industry sectors. In the United States and Canada, licensing is typically done at the state or provincial/territorial levels, respectively. Certifications in arboriculture are offered by a variety of organizations, with the International Society of Arboriculture (ISA) having the most international scope. The ISA has 35,000 Certified Arborists™ around the world and uses a tiered structure through which arborists can specialize for a given sector. Additionally, and important within the scope of wildlife snags, the ISA offers the Tree Risk Assessment Qualification (TRAQ), a course-based qualification that requires passing an exam. A standardized approach is taught in the course and is reflected in the related textbook [36], as well as the best management practices (BMPs) and industry standards [37].

1.2. Retention of Wildlife-Beneficial Tree Features and Snags

1.2.1. Weighing the Risks

Within the *Best Management Practices: Tree Risk Assessment* (2nd ed.), tree risk is defined as "the likelihood of a conflict or tree failure occurring and affecting a target, and the severity of the associated consequences—personal injury, property damage, or disruption of activities" [37] (p. 7). This is important in understanding how urban wildlife directly and indirectly influences tree risk. For example, insects and other animals occupying the tree are included within potential tree-related conflicts and thus can be a potential source of conflict between humans and trees (and the broader environment) according to the definition proposed by the ISA's BMPs [37]. An example of this could occur when a beaver (*Castor* sp.) causes a tree to become unstable at its base, risking falling over and striking infrastructure or a person.

Wildlife foraging in the tree is also cited as an indicator of potentially unsafe and/or structurally unsound wood. Notice of this can be found within industry literature and safety booklets, including guidance that climbers support their weight on their climb lines rather than on the tree limbs when woodpecker damage is present [38].

Tree features such as cavities and nesting holes also influence failure potential of tree parts [37,39], and the ISA *Best Management Practices: Pruning* (3rd Ed.) mentions decayed limb removal as decreasing likelihood of failure [40]. Industry literature also classifies hollows or decay pockets as tree defects [38]. Because of the impact of tree defects on structural integrity and their impact on workplace safety during tree removal, especially in the context of climbing and rigging safety, hollows and decay pockets are described negatively [38].

Because of the elevation of risk due to the presence of such tree features, a common pruning practice in arboriculture has been "deadwooding" trees, a term that references the removal of dead or heavily diseased wood to promote faster compartmentalization [41–43]. However, according to French [31], the removal of deadwood, cavities, and hollows decreases the availability of habitat for wildlife in the urban environment. Thus, a conflict exists between managing trees for perceived risks versus maintaining cavities for natural habitats.

1.2.2. Wildlife Snag Creation

Despite the increased risk resulting from retaining wildlife snag-friendly features and uncertainty regarding the extent to which arborists believe that wildlife snags can and should be retained in urban areas, it has been recommended that arborists internationally apply snag-creation techniques for the promotion of wildlife habitat [31,42,44–46]. Wildlife snags are dead or dying trees which provide habitats for wildlife, both for nesting and as a prey source. Early into a snag's ecological role, it may be inhabited by primary excavators, such as woodpeckers and predatory insects, followed by secondary cavity users, including owls, bats, bees, and chickadees [47]. In particular, large, old trees typically have features such as cavities resulting from years of exposure to weather, insects, and cavity-creating

birds which provide elements of successional forest development that can be difficult to replicate in urban settings.

There are several factors influencing suitability of a snag for habitat development. At the broad spatial scale, there must be prey sources and, depending on the species, the snag may need to be close to a waterbody, riparian areas, or under low human disturbance [48]. Beneficial features of the snag itself include existing cavities, decay, landing platforms, diversity in branching structures, and protection from pests and predators [47,49]. Factors pertaining to individual cavities include temperature, ventilation, draining, light exclusion, height, and internal dimensions [31,49]. Consequently, snags of greater heights and greater structural diversity offer more diversity in habitat structure for a greater diversity of species [31].

Species of wildlife, especially birds, differ in their tree species selection and nesting and foraging patterns (e.g., height of foraging, density of foraging patterns, and depth of foraging into tree) [50]. Some tree features, such as hollows, will be suitable for some species but not others, as visitation is species-specific [51]. Consequently, habitat creation seeks to match the habitat preferences of expected or preferred regional species, recognizing factors such as preferred tree species amongst various wildlife, height of cavities from the ground, size of entrance holes, and cavity dimensions [31]. This is supported by literature recommending the use of species preferences lists in determining the appropriate height and size of cavities based on their suitability for specific species [31,49]. As a result, artificial hollow creation can be effective in targeted development of habitat for specific species [51].

Wildlife makes use of wildlife snags in several ways, including nesting and cavity dwelling. While more wildlife is present in dead trees than live ones [31,52], the presence of cavities is a limiting factor for species classified as secondary cavity-nesters, as opposed to general tree mortality [53]. Based on species specifications, retainment of trees with cavity development provides habitat for secondary cavity-nesters.

1.2.3. Artificial Habitat Creation

Arborists are increasingly using artificial habitat creation to support wildlife in the urban ecosystem, a specialized approach that uses tools such as chain saws, drills, or other power equipment. The techniques consider wildlife snag features, especially cavity creation, and the environment or spatial considerations that might influence its occupation by wildlife.

According to Brown [47], general habitat creation techniques include providing openings to internal hollows which are free of obstructions, providing egress and ingress routes, and mimicking natural processes in wildlife snag development. This includes irregular, angled cuts made with chain saws, promoting decay and increasing surface area of the cuts. Likewise, artificially creating superficial bark flaking can help expose the cambium to insects, mimicking the effects of lightning strikes. Such pruning is in contradiction to arboriculture pruning standards which seeks flat plane-surfaces to reduce surface area of the cut, encouraging faster compartmentalization of the cut [40]. Fracture pruning, or natural fracture pruning, uses tools to artificially mimic tears and fractures of natural processes, such as those seen following wind disturbance, results in larger surface areas of cuts, fiber separation, and splintering of the linear, radial, and circumferential planes. Through this process, fracture pruning promotes the microhabitats needed for microorganisms and successional and associated species [42,47].

1.3. Education of Arborists and Clients

Education of the public towards wildlife conservation has been highlighted as a method for increasing urban wildlife conservation efforts and sustainable practices [54]. Books such as *Silent Spring* [55] highlight themes of negative human effects on the environment, introducing the public to ecological interdependence [56]. In arboriculture and urban forestry, there has been emphasis on creating resources about wildlife and arboriculture

for the public [32]; however, there exists little research on how education can influence arborists' perception of wildlife.

Educational programs for arborists have been recommended in key areas of urban wildlife conservation [32]. As the enhancement of wildlife conservation becomes increasingly adopted within urban forest management objectives [57], it is important for arborists to understand how to both protect wildlife and comply with local bylaws and legislation [31]. Accordingly, arboriculture conferences and independent programs are offering education to arborists about tree care operations that protect wildlife and enhance wildlife-beneficial features.

1.4. Adoption of Systems-Level Thinking in Arboriculture and Urban Forest Management

The role of arborists in urban wildlife conservation is increasingly recognized in the environmental arboriculture ethos, first described by [44] and later adopted into system-level thinking in arboriculture [32,58].

Environmental arboriculture conceptualizes holistic approaches to tree care [44], including deliberate and purposeful consideration of symbiotic natural processes of the microhabitat of trees and their associated counterparts, including flora, fauna, and fungi whose co-evolutionary processes are integral for the long-term health and success of the tree. More recently, the ethos of environmental arboriculture has included the introduction of regional arboricultural best management practices (BMPs) for conservation of wildlife during tree care operations [32], and, in response to the loss of urban wildlife habitat with urbanization [6,23], arborists are increasingly recognizing the benefits of natural tree features, especially hollows and wildlife snags, in urban forest sustainability and wildlife conservation [31,47,51].

In practice, this influences several areas of arboriculture and urban forest management. In conducting tree risk assessments, arborists weigh the benefits of a tree versus its risk of failure in making recommendations about remedial actions [36]. Accounting for the benefits that a tree provides to wildlife—whether as habitat or as a prey source—helps account for the systems-level impacts of tree removal within the tree risk assessment matrices. In writing pruning objectives, arborists are encouraged to consider whether the removal of branch hollows will negatively affect wildlife [40]. The same is true in vegetation management where the removal of large areas of trees can impact wildlife [59].

1.5. Study Rationale

Recent publications have discussed the application of habitat-creation techniques in arboriculture and related industry guidance on the conservation of wildlife during tree care operations has provided methodology for this objective. Additionally, there is increasing focus in the governance of arboriculture to guide arborists towards more systems-thinking approaches to urban forest sustainability [32]. Despite the ongoing work to adopt urban ecological principles into arboriculture and urban forest management, little is understood beyond anecdotal and committee-based discussions about the willingness of arborists to preserve wildlife-beneficial features in professional practice.

This research study aims to explore the factors influencing arborists' perception of the suitability to retain wildlife snags and the components which compound their decisions. Specifically, this research study addresses the following research questions: (1) Do arborists consider wildlife snags and wildlife-beneficial features as important components in supporting urban wildlife? (2) What management and sustainability factors are considered in the decision to recommend retaining wildlife snags? (3) What professional factors (e.g., education, certifications) are associated with respondents' perceptions of wildlife snag and hollow branch retainment? To examine these research questions, we conducted an online survey of arborists.

2. Methods

2.1. Sampling and Data Collection

Data collection was conducted through an international online survey via Qualtrics, offered in English and approved by the University of British Columbia's Behavioural Research Ethics Board (Ethics ID: H21-00629). To be eligible to partake in the survey, participants had to be currently employed in the tree care industry and be above the age of majority in their place of residence. A consent statement and survey information comprised the initial page of the survey and, per the consent statement, advancement through the survey implied consent.

The survey was open from April to June of 2021 and was disseminated internationally through Facebook groups, email, and listservs. The cover letter and postings requested that respondents help "snowball" the survey by sharing the survey link with arborists and urban foresters within their networks. The method of snowball sampling is common among practitioner surveys due to its ability to reach a larger survey pool [60] and has been previously used in arboriculture and urban forestry research [61] but can result in biases in the responses by limiting randomness through the survey being shared within the communities of the initial respondents [60]. Consequently, while the snowball sampling method of survey distribution is commonly used in surveys of professionals, there may be industry sectors that are underrepresented because of the redistribution by the initial participants.

Entry into a gift card draw was offered as an incentive to participation. Two gift cards were offered in the amount of CAD 75 each, awarded by a random drawing. Respondents did not need to complete the survey to enter the gift card draw. The gift card draw was hosted through a separate Qualtrics survey, linked through an anonymous survey which prevented the identification of respondents between the survey and gift card draw.

2.2. Survey Questions

The survey included 28 questions, divided across several topics, including demographic questions pertaining to employment, education and industry certifications, 13 of which are analyzed in this paper (Supplemental File S1). To determine what arborists consider to be the primary opportunities for supporting wildlife in the urban forest, we asked respondents to identify the top three items from a list of wildlife support methods that have been previously identified in the literature (the table in Section 3.3). An additional text entry box was provided to help capture alternative methods identified as important by the respondents.

Because of the focus of recent articles and the potential internationalization of wildlife-focused BMPs, we also examined factors that influenced arborists' decision to recommend wildlife snag retainment to clients. Respondents were also invited to provide additional commentary to their responses—the related ones are provided in the results section of this paper.

2.3. Data Cleaning and Statistical Analysis

Response data were cleaned to remove no-response surveys (i.e., respondent did not advance past the consent page) and survey responses that included identical autogenerated comments in the open text sections ($n = 39$). Nonresponse data for individual questions were coded as missing. For univariate analysis, nonresponse data are included in frequencies. For bivariate and multivariate analysis, nonresponse data are excluded.

Phi coefficients were used to compare the association of two binary variables. Only statistically significant Phi coefficients with a power greater than ± 0.100 are reported. Pearson Chi-square tests were used provided that expected cell counts less than five accounted for less than 20.0% of the expected cells and that the minimum expected count was at least one. If these assumptions were violated, likelihood ratio was used.

3. Results

There were 805 respondents who completed at least one question of the survey, and 794 respondents completed the survey to its completion.

3.1. Demographics of Respondents

Table 1 outlines the demographic variables reported by respondents. Despite being distributed internationally, the respondent pool biased Canada and the United States. The United States of America was the most common birthplace of respondents (n = 396, 49.2%) and country of employment (n = 484, 60.1%). Canada was the second most represented country in both birth country (n = 146, 18.1%) and country of employment (n = 197, 24.5%).

Table 1. Demographic variables of survey respondents.

Variable	Count (*n*)	Proportion (%)
Gender		
Male	576	71.6%
Female	177	22.0%
Non-Binary	15	1.9%
Other and prefer not to say	16	2.0%
Highest Education Level Attained		
Primary (grade school) education	4	0.5%
Some secondary (high school) education	23	2.9%
High school diploma or equivalent	111	13.8%
State or provincial arboriculture program	105	13.0%
Industry trade certificate	113	14.0%
Apprenticeship	40	5.0%
Diploma	81	10.1%
Bachelors degree	242	30.1%
Masters degree	56	7.0%
Doctorate degree	15	1.9%
Country of origin		
United States	396	49.2%
Canada	146	18.1%
Australia	37	4.6%
United Kingdom	17	2.1%
European Union	34	4.2%
Other	94	11.7%
Country of current employment		
United States	484	60.1%
Canada	197	24.5%
Australia	39	4.8%
United Kingdom	32	4.0%
European Union	23	2.9%
Other	18	2.2%

In both Canada and the United States, the proportion of arborists by employed state/province/territory was well distributed. No state in the United States was represented with a proportion greater than 7.0%, and all 10 Canadian provinces and one territory (Yukon) were reported in Canada.

Amongst respondents currently employed in the United Kingdom, England had the most respondents at n = 13 (1.6%), followed by Scotland (1.1%; n = 9) and Wales (1.1%; n = 9). From the European Union, Finland had the greatest number of respondents (1.2%; n = 10). The highest frequency country included in the "Other" text box was New Zealand (0.6%; n = 5).

3.2. Industry Experience

Varying class intervals of an ordinal count scale were used to record the number of years that the respondents have been involved in the tree care industry. Listed with their frequency and proportion, the class intervals were 0–2 years (n = 91; 11.3%), 3–4 years (n = 145; 18.0%), 5–10 years (n = 216; 26.8%), and 10+ years (n = 350, 43.5%).

The majority of respondents worked primarily in the commercial/residential sector (n = 336; 41.7%), followed by municipal/government organizations (n = 175; 21.7%) and utilities sector (n = 123; 15.3%) (Table 2). The majority of respondents were consulting arborists (n = 184; 22.9%), followed by tree climbers (n = 121; 15.0%) and urban forestry technicians (n = 108; 13.4%).

Table 2. Professional variables of respondents.

Variable	Frequency	Percent
Industry Sector Employed Within		
Commercial	336	41.7%
Municipal/government	175	21.7%
Utility	123	15.3%
Consulting	79	9.8%
Private institution (arboretum, botanical gardens)	61	7.6%
Academic institution	23	2.9%
Other	8	1.0%
Primary Job Position		
Consulting arborist	184	22.9%
Tree climber	121	15.0%
Urban forestry technician	108	13.4%
Business owner	106	13.2%
Supervisor	89	11.1%
Ground worker	53	6.6%
Aerial lift (bucket truck) operator	39	4.8%
Pesticide applicator	33	4.1%
Urban forester	16	2.0%
Educator	13	1.6%
Manager	5	0.6%
Municipal arborist	3	0.4%
Other	19	2.4%
Certifications and Qualifications *		
ISA Tree Risk Assessment Qualification	486	60.4%
ISA Certified Arborist	480	59.6%
ISA Board Certified Master Arborist	111	13.8%
ISA Municipal Specialist	84	10.4%
TCIA Certified Treecare Safety Professional	80	9.9%
ISA Utility Specialist	76	9.4%
ISA Tree Worker—Climber Specialist	75	9.3%
ASCA Registered Consulting Arborist	55	6.8%
European Tree Worker	35	4.3%
ISA Tree Worker—Aerial Lift Specialist	34	4.2%
European Tree Technician	33	4.1%
ASCA Tree and Plant Appraisal Qualification	30	3.7%
Provincial or State Licensing	28	3.5%
Fachagrarwirt Baumpflege	24	3.0%
New Zealand National Certification in Horticulture	17	2.1%
Registered Professional Forester or akin	14	1.7%
UK Qualification and Credit Framework	13	1.6%
Finnish National Certification	6	0.7%
Other	73	9.1%
No Certifications or Licenses	65	8.1%

* cumulative percentage greater than 100% as respondents may hold multiple certifications.

The majority of respondents held the ISA Certified Arborist® designation (n = 480; 59.6%), with all other International Society of Arboriculture (ISA) certifications and qualifications being well represented across the respondent pool (Table 2). Outside of the ISA, the Tree Care Industry Association (TCIA) Certified Treecare Safety Professional had the highest number of respondents certified (n = 80; 9.9%), followed by the American Society of Consulting Arborists (ASCA) Registered Consulting Arborist designation (n = 55; 6.8%).

3.3. Supporting Wildlife in the Urban Forest

Respondents were asked to identify the top three methods for arborists to support wildlife in the urban forest. The most highly rated option was to consider the benefits of trees for wildlife before a tree is removed (n = 523, 65.70%), followed by retaining wildlife snags (n = 424, 53.27%) (Table 3). Support was varied and approximately equal in proportion for contacting conservation groups, receiving training, and educating clients to support wildlife. The least popular method was to retain branches with hollows to support wildlife (n = 200, 25.13%). Only 23 respondents (2.89%) stated that arborists do not need to support wildlife conservation. Associations between selection of wildlife supporting mechanisms and industry and demographic factors are listed in Table 4 and described in following subsections.

Table 3. Methods for arborists to support wildlife in the urban forest, ranked based on the number of respondents (n) who selected the method as one of the top three methods for arborist-supported urban wildlife conservation.

Wildlife Supporting Mechanism	Count (n)	Proportion (%)
Consider the benefits that trees have to wildlife in the consideration to remove a tree	523	65.7
Retain dead trees as wildlife habitat	424	53.27
Contact conservation groups to relocate wildlife before tree care operations	363	45.6
Receive arboriculture-specific training on wildlife conservation	337	42.34
Educate clients on the benefits of trees for wildlife	336	42.21
Retain branches with hollows to support wildlife	200	25.13
Arborists do not need to support wildlife conservation	23	2.89

Additional methods provided by respondents in the "Other" option of the question included raising the public profile of wildlife (n = 2), using tree protection bylaws and legislation to restrict removals during nesting season (n = 4), and maintaining natural ecosystems and healthy trees, especially during development (n = 2). Individual answers included conducting nesting bird surveys (n = 1), educating employers on how arborists make decisions to delay work (n = 1), obtaining migratory bird information from local societies and organization (n = 1), and creating nesting platforms (n = 1). One survey respondent stated that there were difficulties in knowing that other arborists will work on the trees even if it violates personal or industry ethical codes:

Municipalities need to avoid issuing permits for tree removals that are valid during the nesting season. Knowing the client can, and usually will, find someone else to hire to remove a tree you find a nest in, makes the decision to not perform that removal harder and creates contention between managers/sales reps and arborists. If the city enforced the rules subtly by not issuing permits, the whole issue would be avoided.

In the open comments section, the need for further education was a common discussion point. Thirty-six respondents commented that greater education of arborists was needed and nine respondents said that greater education of the general public is needed. One respondent specifically suggested that "[I] have found many materials available through ISA regarding wildlife. Perhaps there could be more mention of these materials in the TRAQ course".

Table 4. Association between industry background and personal demographic factors with support for six mechanisms through which arborists can support urban wildlife. The respondents were asked to select what they considered the three top options for wildlife conservation.

		Considering the Benefits That Trees Have to Wildlife	**Contacting Conservation Groups to Relocate Wildlife**	**Training on Wildlife Conservation**
Industry Background	Certifications/Licenses		(multiple)	$\varphi = -0.102$ **
	Country of Practice			
	Organization Type			
	Primary Job Position			
	Years Experience	$X^2_{3,802} = 9.604$ *	$X^2_{3,802} = 24.752$ ***	
Personal Demographics	Age	$X^2_{6,791} = 21.926$ ***	$X^2_{6,791} = 20.259$ **	
	Annual Income			
	Country of Birth	$X^2_{5,724} = 13.064$ *		$X^2_{5,793} = 13.611$ *
	Gender			
	Highest Education		$X^2_{9,790} = 33.788$ ***	
		Educating Clients	Retaining Wildlife Snags	Retaining Branches with Hollows
Industry Background	Certifications/Licenses	(multiple)	(multiple)	(multiple)
	Country of Practice			$X^2_{5,793} = 26.533$ ***
	Organization Type	$X^2_{6,805} = 17.080$ **	$X^2_{6,805} = 15.288$ *	
	Primary Job Position	$X^2_{12,789} = 50.120$ ***		Likelihood ratio *
	Years Experience	$X^2_{3,802} = 37.438$ ***	$X^2_{3,802} = 11.005$ *	$X^2_{3,802} = 11.685$ **
Personal Demographics	Age	$X^2_{6,791} = 19.530$ *		
	Annual Income			
	Country of Birth			
	Gender			
	Highest Education	$X^2_{9,790} = 33.051$ ***		$X^2_{9,790} = 29.364$ ***

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

3.3.1. Considering the Benefits That Trees Have to Wildlife

Considering the benefits that trees have to wildlife was more commonly selected by respondents from Canada and the United Kingdom and less commonly selected by respondents from Australia, the European Union, the United States of America, and other countries ($X^2_{5,724} = 13.064$, $p = 0.023$). Considering the benefits that trees have to wildlife was also more commonly selected by older respondents ($X^2_{6,791} = 21.926$, $p = 0.001$). With a lower X^2 value than age, considering the benefits that trees have to wildlife was also more commonly selected by respondents who had worked more than 10 years in arboriculture ($X^2_{3,802} = 9.604$, $p = 0.022$).

3.3.2. Contacting Conservation Groups to Relocate Wildlife

Contacting conservation groups to relocate wildlife was a more frequently identified measure by respondents who were newer to the industry (0–10 years) ($X^2_{3,802} = 24.752$, $p < 0.001$) and respondents under 45 years old ($X^2_{6,791} = 20.259$, $p = 0.002$). Respondents with education in arboriculture through apprenticeships, industry trade certificates, and state or provincial arboriculture training programs were more likely to identify contacting conservation groups to relocate wildlife as a method for arborists to support urban wildlife ($X^2_{9,790} = 33.788$, $p < 0.001$).

Contacting conservation groups was less frequently selected by ISA Certified Arborists ($\varphi = -0.129$, $p = 0.000$), ISA TRAQ credential holders ($\varphi = -0.106$, $p = 0.003$), and registered professional foresters ($\varphi = -0.101$, $p = 0.004$). It was more frequently selected by ISA Utility Specialists ($\varphi = 0.100$, $p = 0.004$).

3.3.3. Training on Wildlife Conservation

Receiving training on wildlife conservation was more frequently selected by respondents from the United States and Australia as opposed to all other countries ($X^2_{5,793} = 13.611$, $p < 0.018$). Receiving training on wildlife conservation was less frequently selected by ISA TRAQ credential holders ($\varphi = -0.102$, $p = 0.004$).

3.3.4. Educating Clients

Educating clients was more frequently selected by arborists over 46 years old ($X^2_{6,791} = 19.530$, $p = 0.003$) and/or arborists with more than 10 years experience in arboriculture ($X^2_{3,802} = 37.438$, $p < 0.001$). It was more commonly selected by business owners, educators, managers, supervisors, and tree climbers ($X^2_{12,789} = 50.120$, $p < 0.001$), as well as respondents working in academia, consulting, commercial arboriculture, and municipal arboriculture, but less frequently selected by those working for private institutions (e.g., arboretums) and utilities ($X^2_{6,805} = 17.080$, $p = 0.009$).

Respondents who held a university or college diploma or bachelors, masters, or PhD were more likely to select educating clients ($X^2_{9,790} = 33.051$, $p < 0.001$). Contacting conservation groups was less frequently selected by ISA Utility Specialists ($\varphi = -0.135$, $p = 0.000$), ISA Board Certified Master Arborists ($\varphi = -0.170$, $p = 0.000$), and ISA TRAQ holders ($\varphi = -0.179$, $p = 0.000$). Educating clients was negatively correlated with the number of certifications held by the respondent ($r_{805} = -0.207$, $p = 0.000$).

3.3.5. Retaining Wildlife Snags

The majority of respondents ($n = 428$, 53.2%) considered retaining wildlife snags to be one of the top methods for arborists to better support wildlife in the urban forest. This was more common among respondents who had worked more than 10 years in arboriculture ($X^2_{3,802} = 11.005$, $p = 0.012$) and/or who work in the commercial and municipal sectors ($X^2_{6,805} = 15.288$, $p = 0.018$).

Two industry certifications were significantly associated above ± 0.100 magnitude with the belief that arborists could retain wildlife snags for wildlife conservation: ISA Certified Arborists ($\varphi = 0.146$, $p < 0.001$) and TCIA Certified Treecare Safety Professional ($\varphi = -0.121$, $p < 0.001$). This indicates that while ISA Certified Arborists were more likely to consider wildlife snag retainment for wildlife, it was less likely among TCIA Certified Treecare Safety Professionals.

3.3.6. Retaining Branches with Hollows

By contrast, only 24.8% ($n = 200$) of the respondents selected retaining branches with hollows as a method for arborist-based support of wildlife. This was more frequently selected by respondents with a higher number of arboriculture certifications ($r_{805} = 0.147$, $p < 0.001$) and amongst respondents whose highest level of education was an industry trade certificate or Masters degree ($X^2_{9,790} = 29.364$, $p < 0.001$).

Arborists who had worked in the industry between 3–10 years were more likely to select hollow branch retainment than those within the first two years or greater than 10 years working in arboriculture ($X^2_{3,802} = 11.685$, $p = 0.009$).

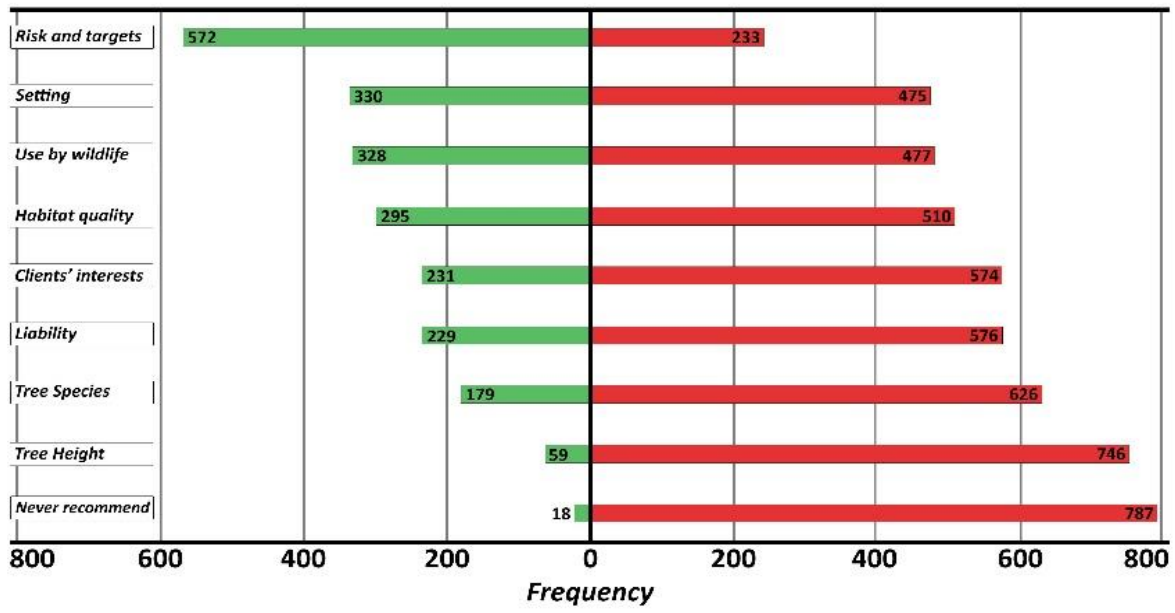
Respondents currently employed in Australia, the European Union, and the United Kingdom were more likely to select hollow branch retainment, whereas respondents from Canada and the United States and other countries (miscellaneous) were not ($X^2_{5,793} = 26.533$, $p < 0.001$).

Two industry certifications were significantly associated above ± 0.100 magnitude with the selection of retaining branches with hollows: ISA Board Certified Master Ar-

borists ($\varphi = 0.154$, $p < 0.001$) and/or ISA Tree Risk Assessment Qualification ($\varphi = 0.131$, $p < 0.001$). Urban forestry technicians, supervisors, pesticide applicators, municipal arborists, educators, and consulting arborists were more likely to select hollow branch retainment (likelihood ratio $p = 0.040$).

3.4. Factors in Wildlife Snag Retainment

Respondents were asked to identify the three most important factors in deciding to recommend wildlife snag retainment to clients. The given factors were (F1) risk of tree failure and presence of targets, (F2) Setting (rural versus urban), (F3) Observed use of the tree by wildlife, (F4) Quality of habitat at the site, (F5) Clients' interest in retaining the tree for wildlife, (F6) Liability, (F7) Tree species, (F8) Height of the tree, and (F9) "I never recommend retaining wildlife snags". Figure 1 shows the frequency with which these factors were selected.



Facors influencing recommendation to retain wildlife snags	Yes	No
Risk of tree failure and presence of targets	572	233
Setting (rural versus urban)	330	475
Observed use of the tree by wildlife	328	477
Quality of habitat at the site	295	510
Clients' interest in retaining the tree for wildlife	231	574
Liability	229	576
Tree species	179	626
Height of the tree	59	746
I never recommend retaining wildlife snags	18	787

Figure 1. Factors influencing respondents' recommendations to retain wildlife snags; respondents limited to top three factors.

Respondents with longer tenure in the industry were more likely to indicate risk of tree failure and presence of targets ($r_{802} = 0.217$, $p < 0.001$) and liability ($r_{802} = 0.095$, $p = 0.007$) as foremost factors in deciding to recommend the retainment of wildlife snags.

Similarly, age was positively correlated with considering risk of tree failure and presence of targets ($r_{791} = 0.158$, $p < 0.001$).

Five respondents provided additional factors on wildlife snag retainment in an open comment section. These factors included risk posed to power lines, overall objectives for the site, distance from structures, and whether the snag was a potential fire or fuel source. A respondent who works for a power utility company said that their priority is "safe reliable electricity" and that they "do not make recommendations to clients related to wildlife. If a dead tree is a threat to the power lines, it is removed. If it is not a threat, we do not remove it".

3.5. Comments on Wildlife and Biodiversity Sustainability in Urban Forest Management

One comment applied the arborist adage "right tree, right place, right time" in the context of wildlife snags, saying that a large wildlife snag that had "died many years ago" would not be suitable for retainment in a high-density urban area, but a "recently cut live spar poles on larger properties" helps to retain wildlife habitat to the benefit of flora and fauna in an urban area, which the respondent perceived to "lack proper habitat".

Another respondent said they encouraged clients to "leave 10–12 foot peg[s] [i.e., trunks of trees] standing but remove other parts of the tree". This was seconded by another respondent: "I personally use 'high stump dead heads'. These allow best of both worlds with dead trees that are nonthreatening to houses".

One respondent indicated that changing public perception about wildlife snag trees is "essential to better provide habitat for wildlife". Similarly, one comment said that "trees as habitat, individual and groups, do not receive enough priority attention as they should". The caveat to this, as indicated by a respondent, is that perception of wildlife changes between stakeholders. Some birds and squirrels, while wildlife, may be pests and cause damage to property, and homeowners may be looking to have trees removed as they provided habitat for these wildlife species.

Five respondents highlighted that educating the client is needed to preserve wildlife snags. Three comments underscored the "not in my backyard" mentality that has been noted in other urban forestry issues, where the public supports efforts at the greater scale, but not on their property if it does not meet their management objectives. As one respondent stated, "human 'safety' is almost always prioritized above habitat". This was also commented on by others, reinforcing that human safety and risk abatement will regularly—if not always—triumph over creating or retaining wildlife habitat.

Two comments on BMPs and legislation's impacts discussed whether BMPs might lead the public to perceive trees as always being retained for wildlife habitat under government control, and thus dissuading their planting because of the risk that the trees would pose to their financial investment. The second comment expanded into how the legislation would be framed and whether liability could be released from the arborist in the event of tree failure if the trees were protected/retained as wildlife snags.

4. Discussion

Urban land expansion is forecasted to cause the decline of biodiversity and extinction of species [62], precipitated by the impacts of climate change [63]. To address the impacts of biodiversity losses in urban environments, wildlife conservation has been suggested as an integral component of sustainable urban planning [64,65]. Because canopy cover and tree composition and structure are important aspects of the suitability of an ecosystem to support wildlife populations [66,67], arborists and urban foresters can play important roles in fostering and maintaining a sustainable urban forest for wildlife populations. Using a survey, we examined arborists' perceptions of three key recommended areas for wildlife conservation and sustainability in urban forest management, namely (1) public and professional education, (2) accounting for wildlife in risk matrices and objectives, and (3) the retainment of wildlife-beneficial tree features. We found support from survey respondents towards increased ecological discourse and management for the support of urban wildlife.

This survey contributes to the ongoing discussion about urban ecological concepts and wildlife conservation within urban planning and management generally [65] and arboriculture and urban forest management specifically [32]. In combating urbanization and its ensuing loss of natural habitat features for urban wildlife, arborists serve an important role in minimizing negative impacts to wildlife. The interest in promoting wildlife conservation in arboricultural practices has been considered for adoption within organizational policies, ethics, and best practices [32,33]. This study indicates that practitioners would be supportive of the adoption of wildlife-focused education and policies in the tree care industry.

4.1. Accounting for Wildlife in Risk Matrices and Objectives

The high rated option of considering the benefits that trees provide wildlife when considering to remove a tree is a more seamless introduction of wildlife conservation into arboriculture practices as there already exist recommendations to do so within industry documents [28,36,37,40]. Further adoption of this method into practical arboriculture would thusly not be impeded by existing practices; however, it may require greater weighting placed on wildlife-supporting ecosystem services.

Risk of tree failure and the presence of targets was also the highest ranked factor considered by arborists in recommending retaining wildlife snags. This highlights the presence of risk assessment throughout the facets of arboriculture. In the ISA tree risk assessment framework, it is recommended that arborists consider the benefits of a tree within its ecosystem, including the benefits provided to wildlife [36]. Other risk assessment frameworks, such as British Columbia's Wildlife/Danger Tree Assessor, have more explicitly included wildlife habitat within their tree risk assessment processes. Shifting increased importance or weighting to the ecosystem services of trees for supporting wildlife can help provide cause for delaying the removal of a tree or promoting risk mitigation options that retain the tree while reducing the likelihood of hurting a person or damaging assets.

4.2. Public and Professional Education

Public and professional education scored lower than both adopting greater systems-level thinking into risk assessments and objectives and retaining wildlife snags. Arborists receiving training on wildlife conservation had few correlations; however, ISA TRAQ credential holders were less likely to identify wildlife conservation training as a method of supporting urban wildlife. This is counter to the preceding theme of introducing wildlife-specific benefits into tree risk assessments, especially when lacking education can be a hinderance to operationalization of environmental policies surrounding urban wildlife.

Higher education of respondents within academia—rather than industry training and education—was associated with respondents identifying education of their clients. For those engaged in environmental policy and conservation of wildlife, this finding indicates that industry training alone, as well as increased certifications, may not be likely to increase the prioritization of client education.

Education of clients was more common amongst older and more experienced arborists. This may be due to a greater comfort in interacting with clients in an educational manner which could be linked to age more generally, or due to more developed relationships between arborists and repeat customers/clients. This would be supported by the finding that those in higher management roles within organizations more frequently identified client education as a pathway for urban wildlife conservation.

In utility arboriculture, the consistent client—the owner of the utilities—and their objectives for maintaining clearance from the utilities would be factors that contribute to the low selection of client education amongst utility arborists.

4.3. Retaining Wildlife-Beneficial Tree Features

Support for retaining wildlife snags in the urban environment received greater support than retaining branches with hollows. This may reflect the current ethos surrounding

wildlife conservation in arboriculture where wildlife snags have been popularized in trade journals and magazines [31], but not at the expense of managing risk [33]. Because hollow branch retainment inherently increases likelihood of failure, removal of hollow branches is a risk abatement tactic described in the pruning BMPs [40], highlighted by respondents who provided comments on removing branches to create large spar poles. The inherent risk attributed to hollow branch retainment may dissuade arborists from maintaining hollow branches in urban contexts, consistent with the prioritization of risk as a factor in recommending retaining wildlife snags (Figure 1). Because of the importance of hollows and cavities in snag suitability for wildlife, creating snags which do not include branches, cavities, or other features can negate their usefulness for urban wildlife.

There was commonality for both retaining wildlife snags and branches with hollows that municipal and commercial sectors of arboriculture and their related professions were more likely to select these wildlife-supporting methods. For both the municipal and commercial sectors of arboriculture, retaining wildlife snags and branches with hollows can more readily fit the sectors' management objectives, as opposed to, for example, utility line clearance operations where management objectives prioritize minimizing disruption to distribution of a given utility (e.g., gas, electricity).

4.4. Factors in Wildlife Snag Retainment

The factors influencing the recommendation to retain wildlife snags (Figure 1) can be broadly categorized into anthropogenic factors (Risk and Targets, Clients' Interests, and Liability) and wildlife factors (Setting, Use by Wildlife, Habitat Quality, Tree Species, Tree Height), although Setting (rural versus urban) and Tree Height fall into both categories when assessing risk. While Risk and Targets were a dominant factor, anthropogenic and wildlife factors are relatively evenly distributed. An ongoing challenge for arborists hoping to retain wildlife habitat is that an urban setting will typically mean increased risks and targets, creating a discord between best practice for habitat retention versus best practice for risk management.

While observed use of a wildlife snag by wildlife provides clear indication that the snag is serving a beneficial supporting role in the ecosystem, the artificial creation of wildlife snags relies on arborists' ability to replicate suitable snag structure to encourage wildlife usage. In many cases, a tree turned into a wildlife snag may not have evidence of wildlife usage. This poses a particular issue when considering the lower ranking of factors specific to the wildlife snag itself, including tree species and height of the snag. Tree species can be a determining factor in the suitability of a snag for wildlife [50], with genera such as *Quercus*, *Thuja*, and *Pinus* tending to decay more slowly, and thus preferred for snag creation. Additionally, snags of greater heights can better support biodiversity because of the diverse preferences amongst species for nesting heights [31], but at the same time pose a greater likelihood of impacting more targets than shorter trees, consequently elevating the risk level of the potential snag [36].

These factors, coupled with the low preference for reserving branches with hollows despite their ecological importance [53], indicate a need for greater education of arborists about the ecological factors important in retaining wildlife snags. This is underscored by additional comments from respondents who discussed leaving pegs or spar poles as wildlife snags. Trunks, without branching structures, can limit snag potential [47,49]. If arboriculture is to further adopt an urban ecology ethos into professional practices, it would do well to complement BMPs with industry education and grapple with meeting anthropogenic management objectives while balancing beneficial wildlife features in the landscape, rather than simply prioritizing risk management over habitat retention.

Retaining branches with hollows to support wildlife was a low rated method for conserving wildlife in the urban forest. While this method directly contrasts with general conceptions of tree risk reduction in the urban forest [36], the retainment of hollows on both live and dead trees is understood to be a primary dependent factor in wildlife selection of habitat trees [68]. In urban ecology, a focused concern of wildlife habitat loss surrounds

hollows and cavities [69,70]. If arborists are retaining wildlife snags that do not contain hollows/cavities or other beneficial tree features (nesting roosts, open branching structures, peeling bark), wildlife snags can miss key opportunities to provide benefits to urban wildlife [71,72]. Educating arborists and urban foresters about the importance of beneficial-tree features, rather than the indiscriminate retainment of featureless wildlife snags, can help ensure the sustainability of wildlife habitat in the urban forest.

4.5. Implications for Practitioners and Arboriculture Organizations

In the forest industry, regulations and standard management procedures exist which govern the retainment of snags or dead trees for the benefit of wildlife [47,73,74]. Such requirements reflect the importance of wildlife snags as a keystone structure that is imperative to the support of wildlife populations [75,76]. Associations between wildlife species and snag habitats can be quite high; for example, in Oregon and Washington, at least 96 vertebrate species are associated with snags [77]. The adoption of wildlife BMPs into arboriculture can offer an avenue for arborists to conserve wildlife-benefiting tree features in the urban environment and alleviate the impacts of urban forest disturbance and the fragmentation of natural areas.

It is likely worth repurposing forestry management techniques for arboriculture considering the support we found for further guidance and education on wildlife protection and conservation in arboriculture. Decay categorization tables and their resulting suitability for different species and habitat potential can be found in regional silviculture prescription handbooks [78]. These silviculture handbooks help practitioners to understand what characteristics support certain species in the region.

Because of the social and ecological dynamics of wildlife snag retainment and the complexity of factors which determine snag suitability, training arborists in wildlife snag retainment can provide an economic opportunity for consulting arborists and snag-creation specialists to advise clients on snag-creation and preservation. In support of wildlife training specific to arborists, arboricultural organizations would need to perform outreach and public education in collaboration with wildlife specialists. However, the creation of a wildlife-specific sector of arboriculture may be limited as indicated by precedent from the forest industry where private clients were found to rarely engage forestry professionals in wildlife habitat creation [79], which is likely to be true for arboriculture as well.

As a component of public outreach, terminology will play an important role with perception and uptake of wildlife snag retainment [73]. While terms such as "danger tree" convey a degree of threat and risk, "hazardous tree" insinuates less peril, and "wildlife snag" provides a clear management objective within the term. However, public perception of wildlife snags does not negate liability and wildlife snags may have implications on tree retainment liability [67]. As a result, retained wildlife snags must be routinely assessed for tree risk [31,45] and municipalities must determine how to adjust or incorporate their tree risk threshold to account for the benefits provided by wildlife snags and branches with hollows.

4.6. Implications for Environmental Governance and Policies

In the forest industry, regulations support active wildlife conservation and technology is increasingly being used towards mapping areas of high importance and function for wildlife [80]. While previous urban forestry studies have examined the commonality of cavities in urban trees, their likelihood of failure, and their potential to support urban wildlife [81], local regulations can restrict property owners' abilities to maintain beneficial features for wildlife, such as deadwood or snags [82]. Consequently, the success of national and state/provincial laws which aim to protect wildlife in the face of climate change and urbanization are constrained by local governance and policies.

While we found that arborists and urban foresters were supportive of actions that support urban wildlife, including the preservation of wildlife snags, governance and policies may confine meaningful action. Further, the litigious environment which surrounds urban

forestry and urban trees is unsupportive of the retainment of wildlife snags. Homeowners are suggested to have the wherewithal to evaluate common tree defects which can pose hazard to the surrounding people and assets [83] and the threat of a tree causing harm to people and assets is a commonly identified disservice of urban trees [84]. While liability was ranked lower by arborists, the potential impact that a wildlife snag could have on people was ranked higher than the usefulness of the snag to wildlife. Likewise, retaining wildlife beneficial features such as cavities and hollows were ranked the lowest of any wildlife supporting mechanism.

While risk and liability are recurrent themes in the discourse on urban forest habitat structure [67], discussions about the role of urban wildlife often focuses on the decision making processes of property owners and the actions of stakeholders, excluding the role of environmental governance and policies in the decision making process. Shifting municipal regulations to be more conducive to sustainable urban forest management will be imperative if we are to actionably adopt the practices supported by arborists and urban foresters, including legislation supporting the retainment of wildlife snags under reduced liability.

5. Conclusions

In addressing the impacts of urbanization and human development and the consequential loss of wildlife on beneficial tree features, arborists can play a vital role in sustainability of biodiversity in the urban forest. Recently, interest in adopting increased governance policies related to wildlife has set the stage for systems-thinking in urban tree care operations. Through the results of an international survey of 805 arborists, our survey helps support continued initiatives to protect and conserve wildlife in the urban forest, largely focused on the underlying processes of tree care operations that can foster conservation efforts. The consideration of wildlife in arboriculture was the favoured option amongst respondents, followed by retaining wildlife snags in the urban forest. Greater focuses on education of arborists will help to ensure that the retained wildlife snags are beneficial for their intended focus, preventing failed initiatives which unintentionally create non-beneficial environmental features, also known as "greenwasting" [85], in sustainable urban forest management objectives.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su142315962/s1, Supplemental File S1: Survey Questions.

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Institutional Review Board Statement: This study was conducted according to the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans–TCPS 2 (2018) and approved by the Behavioral Research Ethics Board of the University of British Columbia (Ethics ID: H21-00629) on 20 April 2021.

Informed Consent Statement: Per the cover letter consent statement of the survey, consent was implied by advancement past the initial consent statement and survey information page of the survey.

Data Availability Statement: The data presented in this study is available on request from the corresponding author. The data is not publicly available due to the ethics approval of the study.

Conflicts of Interest: Alexander Martin holds certifications with the International Society of Arboriculture and Tree Care Industry Association. Andrew Almas reports no conflict of interest.

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