Urban Forestry & Urban Greening 22 (2017) 24–35

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Original article

Branching out to residential lands: Missions and strategies of five tree distribution programs in the U.S

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ARTICLE INFO

Article history:
Received 19 June 2016
Received in revised form 18 January 2017
Accepted 18 January 2017
Available online 25 January 2017

Keywords:
Principle-agent relationship
Residential landscape
Social-ecological systems
Urban ecology
Urban forest
Urban tree canopy

ABSTRACT

Residential lands constitute a major component of existing and possible tree canopy in many cities in the United States. To expand the urban forest on these lands, some municipalities and nonprofit organizations have launched residential yard tree distribution programs, also known as tree giveaway programs. This paper describes the operations of five tree distribution programs affiliated with the Urban Ecology Collaborative, a regional network for urban forestry professionals. We analyzed the programs' missions, strategies, and challenges as reported through surveys and interviews conducted with program staff. The programs were led by nonprofit organizations and municipal departments in New York City, NY; Baltimore, MD; Philadelphia, PA; Providence, RI; and Worcester, MA. These organizations focused their tree distribution efforts on private residential lands in response to ambitious tree canopy or planting campaign goals. We assessed these programs through the framework of urban forests as social-ecological systems and discuss the programs' biophysical, social and institutional contexts. Programs face principle-agent problems related to reliance on individual tree recipients to meet goals; their institutional strategies meant to ameliorate these problems varied. Differing organizational and partner resources influenced the programs' abilities to perform outreach and follow-up on tree performance. Programs attempted to connect with diverse neighborhoods through free trees, targeting areas with low existing canopy, and forging partnerships with local community groups. Given tree recipients' demand for smaller flowering or fruiting trees, as well as lack of resources for tree survival monitoring on private lands, program leaders appeared to have turned to social measures of success – spreading a positive message about trees and urban greening – as opposed to biophysical performance metrics. We conclude with suggestions for outcomes monitoring, whether those outcomes are social or biophysical, because monitoring is critical to the sustainability and adaptive management of residential tree programs.

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1. Introduction

To support growing urban populations with the ecosystem services provided by trees, many cities across the United States (US) have set ambitious tree planting and canopy cover goals (Young and McPherson, 2013). These ecosystem services span environmental, economic, and social benefits including provision of shade (Donovan and Butry, 2009), reduction of stormwater runoff (Inkiläinen et al., 2013), increased property values (Conway et al., 2016; Sander et al., 2010), landscape aesthetics (Summit and McPherson, 1998), and deepened civic engagement through tree planting (Fischer et al., 2015). While practice and research in urban forestry have historically focused on street and public park trees, private residential lands in the US possess both a substantial portion of the urban land cover (Nowak et al., 1996) and

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http://dx.doi.org/10.1016/j.ufug.2017.01.007
1618-8667/Published by Elsevier GmbH.

extensive potential for planting (O'Neil-Dunne 2009, 2011, 2012). Thus adding tree canopy to residential properties is essential to meeting urban greening goals.

In light of this, some municipalities and nonprofit organizations have undertaken tree distribution programs as a means to expand the urban forest on private residential lands. Tree distribution programs are defined here as those that offer free or reduced-cost trees to residents for planting on private properties, often in yards; when the trees are free these programs are sometimes called giveaway programs (Roman et al., 2014). For example, in a new program coordinated by the Arbor Day Foundation across the US, over 135,000 free yard trees have been distributed to over 76,000 homeowners in just the past five years (P. Smith, pers. comm.). This program and a 20-year old program in Sacramento, CA aim to provide tree shade to reduce summer energy use, and are sponsored by utility districts (Roman et al., 2014). Residential planting initiatives could also serve municipal goals for green stormwater infrastructure and climate change mitigation (Mason and Montalto, 2015).

The emergence of new residential tree distribution programs represents a substantial shift in urban forest management for many municipalities and nonprofits, who have traditionally concentrated their planting efforts on public lands – streets and parks (Hauer and Peterson, 2016). In those public settings, program staff and volunteers carry out tree planting, monitoring and maintenance (Young and McPherson 2013; Roman et al., 2015; Vogt et al., 2015). In contrast, residential tree distribution programs must gain the interest of and rely upon a heterogeneous mix of private residents (Summit and McPherson, 1998; Locke and Grove, 2016) to plant and maintain trees on their private properties in order to meet program goals associated with producing ecosystem services as public goods.

While there is substantial research on residential preferences, values, and norms related to yard vegetation, as well as varying residential landscape management practices and social-ecological contexts (Cook et al., 2011; Harris et al., 2012, and citations therein), there is a dearth of scholarship on residential tree programs themselves. Research on urban forestry institutions (Mincey et al., 2013; Young and McPherson, 2013) and urban environmental stewardship (Fisher et al., 2015) has largely focused on the public lands where managers traditionally operated, especially street trees. In-depth analyses of residential tree distribution programs and cross-program assessments are lacking. Currently, such information largely flows through communication among practitioners (for example, see Alliance for Community Trees [ACTrees] 2008, Turner and Mitchell, 2013), with little peer-reviewed literature on the subject and little reliance on scholarly theory for understanding program outcomes.

This is unfortunate as existing empirical data and related theory suggest there are challenges associated with the reliance on private individuals to co-produce public goods associated with urban trees (Mincey et al., 2013). Such challenges can be viewed through the lens of principle-agent relationships (PARs), in which an agent acts on behalf of a principal (Eisendhardt, 1989). This relationship focuses on the challenges of motivating the agent (in our case, residents who receive trees) to act on behalf of the principal (tree distribution program staff) when interests of both parties are not perfectly aligned and the principal has imperfect information on the actions of the agent. Institutional arrangements (rules, norms, strategies) can ameliorate problems associated with PARs by providing incentives and/or information that changes behavior but these arrangements also incur transaction costs (North, 1990).

Suggestive that PAR challenges do exist in residential tree distribution programs, in the Sacramento giveaway program, many residents did not adhere to recommended practices: 15% failed to plant their trees, and many planted trees did not receive adequate maintenance, often related to changing property ownership (Roman et al., 2014). Tree survival, a common metric of success among urban forestry practitioners (Roman et al., 2013), has been documented to be below projected values for that program (Roman et al., 2014; Ko et al., 2014a). These losses represent sunk costs associated with distributed trees' failure to survive to maturity and optimize benefits sought by the program staff (Mincey and Vogt, 2014). There are many potential reasons for these findings from previous research. For example, there may be little incentive for private individuals to incur associated costs of tree maintenance, particularly since environmental benefits are greatest decades after planting, when residents may have moved (Roman et al., 2014; Ko et al., 2015a). Furthermore, landscape management behaviors are rooted in community norms, lifestyles, and even resident emotions (Fraser et al., 2013; Harris et al., 2013; Grove et al., 2014) meaning that tree distribution programs should impact residents themselves in order to grow the urban forest. Supportive of such institutional solutions, survival in street tree planting initiatives can be enhanced with collective neighborhood tree care strategies by volunteers and program staff (Roman et al., 2015; Vogt et al., 2015). However, even though street tree programs can have extensive civic engagement in planting (Fisher et al., 2015), that engagement from volunteers and residents does not necessarily continue through post-planting maintenance (Moskell and Allred, 2013). Yet even with such challenges for street tree maintenance, collective strategies may be more feasible on the public streetscape than in private yards. Thus, with residential tree distribution programs entirely reliant upon residents for tree care in their private yards, it is critical to unpack program strategies for success. Moreover, understanding how these programs define success and which practices lead to success are necessary for adaptive management for sustainable urban forest systems (Clark et al., 1997).

We address the knowledge gap about yard tree programs by qualitatively analyzing the missions, strategies, and challenges of five residential tree distribution programs. Our analytical approach acknowledges urban forests as complex, adaptive social-ecological systems (SESs; Vogt et al., 2015), a framework which outlines three sets of factors that interact to produce outcomes in urban forest management: 1) the biophysical context – characteristics of the trees and the biophysical environment in which they grow; 2) the social or community context; and 3) the institutional context – the rules, norms, and strategies that structure the interactions between the community, the trees and the biophysical context. This framework, particularly when used in comparative cases, allows for identification of relatively important factors and their interactions which produce outcomes of interest (Ostrom, 2009), much needed given the dearth of scholarship on these programs and the central issue that these programs rely upon private residents to meet program goals and thus face principle-agent problems. Given our interest in the missions and operational strategies of distribution programs, our study focuses largely on describing the institutional strategies of programs, while providing relevant details about their biophysical and socioeconomic contexts, including tree species characteristics and geodemographic patterns in tree distribution. We then draw connections between these various interacting factors and relative measures of success.

2. Methods

2.1. Study design

We employed the case study method and drew cases from tree distributions programs participating in the Urban Ecology Collaborative (UEC). The UEC, formed in 2002, is a community of practice in New England and the mid-Atlantic US whose member organizations comprise government agencies, local nonprofits, and researchers (Galvin 2012; Leff, 2013). These organizations' inter-

ests include environmental education and urban forestry, with a history of peer-to-peer networking, best practices exchange, and collaboration with researchers. We focused on UEC participating organizations that run tree distribution programs due to the unique role of the UEC as a regional network for urban forestry professionals.

2.2. Case selection

Tree distribution programs were selected Jul. 2014 based on the following criteria: 1) participation in the UEC, 2) distribution of trees for residents to plant themselves (as opposed to providing rebates or coupons) and 3) a focus primarily on private, residential lands. We identified programs led by the New York Restoration Project (NYRP) in New York, NY; Baltimore City Department of Recreation & Parks (BCRP) in Baltimore, MD (TreeBaltimore program); Philadelphia Parks & Recreation (PPR) in Philadelphia, PA (TreePhilly program); Groundwork Providence in Providence, RI (Trees 2020 program, defunct as of 2013); and the Worcester Tree Initiative (WTI) in Worcester, MA.

2.3. Surveys and interviews

We contacted each organization via email to ascertain which two key staff members were best suited to answer in-depth questions regarding their residential tree distribution program. In cases where the distribution program was operated by just one employee, as with TreeBaltimore and Trees 2020, we interviewed a second person from either the hosting organization or from a close partner. All identified staff members agreed to participate. We emailed surveys in Aug. 2014, consisting of questions about program missions as well as logistical and operational strategies of the program. Up to two additional emails were sent to remind participants to complete the survey. We subsequently conducted phone interviews with both participants from each program to garner more in-depth information regarding the program's context, strategies and outcomes. Interviews took place Sep.–Oct. 2014. The survey and interview instruments are provided in the online supplemental materials.

Many survey questions were closed-ended and analyses of those responses were tabulations of possible response categories. Open-ended questions from the survey and interview were assessed for common themes that were not pre-determined. The analytical procedure was adapted from Babbie (2007). Responses were analyzed independently by two researchers, with discrepancies in findings resolved through discussion afterwards. Interpretations in the discussion reflect conversations among the co-authors, including researchers with long-standing ties to the UEC member organizations, as well as urban forest managers from the UEC who envisioned this study concept and also served as participants. The authors are therefore embedded within the UEC network and have situated experiences that reflexively shaped our interpretations (Haraway, 1991; Mansvelt and Berg, 2005).

2.4. Biological context

The study sites, colonial era cities located in New England and the mid-Atlantic states, were generally forested prior to European settlement, then subsequently deforested, with urban forest cover later increasing through parks development and urban design that favored trees (Cranz, 1982; Zipperer et al., 1997). Urban tree planting campaigns in this region are sometimes framed as afforestation to restore canopy cover (Oldfield et al., 2013).

Existing and possible urban tree canopy (defined here as the non-road, non-building, non-water, non-existing tree area) was determined based on prior analyses. Possible tree canopy in Baltimore, New York City and Philadelphia was derived primarily from LiDAR (O'Neil-Dunne et al., 2014). In Providence, Quickbird imagery was used to create the land cover map, and in Worcester, tree canopy polygons were derived from NAIP imagery. In all cases, residential lands represented a substantial portion of the urban forest and opportunities for additional canopy (Table 1). These lands include single-family residential properties, both detached and attached (e.g., row houses, twins), and multi-family residential properties.

In the survey, we asked participants to list the five most common species distributed. We then summarized key characteristics of those species: native to the state, fruit edible for human consumption, very showy flowers, and mature size (University of Florida, 2013; MissouriBotanicalGarden, 2016; USDA, 2016).

2.5. Socioeconomic context

Socioeconomic characteristics of these cities varied (Table 1). All had substantial racial diversity. New York City had the highest population density, and the lowest percentage of owner-occupied housing units. Philadelphia had the lowest median income.

To understand the socioeconomic context of where the programs were operating, we analyzed equity patterns of trees distributed by NYRP, TreeBaltimore, and TreePhilly. These analyses were initiated by program staff prior to the present study, using an external Geographic Information Systems (GIS) analyst, in part to understand where their programs were working and to strategize outreach efforts (Locke et al., 2014; Locke and Grove, 2015; Locke et al., 2015a). We did not analyze the tree distribution patterns for the other two programs due to incomplete tree distribution data.

Specifically, tree distribution was analyzed in terms of geodemographic segments, which are socio-spatial categories that represent different lifestyle groups (ESRI, 2011). A primary use of geodemographic segments is to help characterize consumer behaviors in support of crafting marketing strategies or locating retail centers (Weiss, 2000; Holbrook, 2001). To examine participation in giveaway programs by market segment, first, the overall adoption rate per city was calculated as the number of trees given away divided by the total number of households. Then an expected value was calculated as that rate times the number of households per segment per city. This expected value is the number of households that would participate per market segment per city if the giveaways were evenly distributed with respect to the number of households in each segment, and in each city. An odds ratio was then calculated as the actual number of giveaways per segment divided by the expected value; an odds ratio higher than 1 indicates that a segment received relatively more trees than expected under equitable conditions. 95% confidence intervals (CI) were calculated using the pois.exact() function from the epitools package in R (Aragon, 2012; R Development Core Team 2015). For consistency, only data from spring 2013 was used.

3. Results

3.1. Organizational arrangements

All residential tree distribution programs were orchestrated by organizations already invested in tree canopy and/or urban greening goals. The five programs were either run directly by municipal governments or run by non-profit organizations that partnered with municipal governments. These hosting organizations – the organizations running the tree distribution programs – had varying numbers of staff which supported their programs (Table 2). Trees 2020, Groundwork Providence's program, was non-operational at

Table 1
Socioeconomic characteristics and urban tree canopy (UTC) in the study cities. Socioeconomic and demographic information is from 2010 (US Census Bureau, 2014) unless otherwise noted.

City	New York City, NY	Baltimore, MD	Philadelphia, PA	Providence, RI	Worcester, MA
UTC context					
% Existing canopy	21	27	20	23	40[c]
% Residential out of total existing canopy	28	41	23	62	35[c]
% Possible additional canopy	44	44	49	53	n/a
% Residential out of possible additional canopy	35	27	24	47	n/a
Year of canopy analysis	2010	2007	2008	2007	2010
UTC Source	O'Neil-Dunne (2012)	O'Neil-Dunne (2009)	O'Neil-Dunne et al. (2011)	City of Providence (2008)	MA DCR and Hostetler et al. (2013)
Socioeconomic context					
Population	8,175,133	620,961	1,526,006	178,042	181,045
Population density (per km[b])	9572	2945	4129	3657	1818
Median household income (2010 USD)[a]	$52,737[b]	$39,386	$36,251	$36,925	$45,036
% Housing vacant units	8	16	11	12	8
% Housing owner-occupied units	29	40	48	31	41
% Population (aged 25 and older) with a high school diploma or higher[a]	79	77	79	73	84
% White	44	30	41	50	69
% African-American	26	64	43	16	12
% Hispanic	29	4	12	38	21
% Asian	13	2	6	6	6

[a] US Census Bureau. (2010). American Community Survey (ACS) 5-year estimates, Accessed May 10, 2016.
[b] US Census Bureau. (2014). American Community Survey (ACS) 5-Year Estimates, Accessed May 10, 2016. Values in 2014 inflation-adjusted dollars.
[c] Represents post-ALB canopy.

Table 2
Residential tree distribution programs studied and variables relating to size and scope of programs and their hosting organizations (2013). Programs varied in full-time staff dedicated to the program, volunteer support, funding and hosting organization size.

Hosting organization[a] and tree distribution program name (if different)	New York Restoration Project (NYRP)	Baltimore City Department of Recreation & Parks (BCRP): TreeBaltimore program	Philadelphia Parks & Recreation (PPR): TreePhilly program	Groundwork Providence: Trees 2020 program[d]	Worcester Tree Initiative (WTI)
Type	Nonprofit	Municipal	Municipal	Nonprofit	Nonprofit
Tree distribution program began	2008	2009	2012	2008	2009
FTE[b] of hosting organization	50	20[e]	40[e]	3	1.5
FTE[b] of program	2	0.25	2	0.5	1.5
Volunteers for program	Approx. 700	Approx. 25	170	2	23
Annual trees distributed	8875	875	Approx. 4000	Approx. 100	1.152
Trees distributed total[c]	35,314	8000	10,000	1100	6200
No. species offered	92 (4–8 per event)	6–8 per season	29 (approx. 10–15 per season)	25	25
Annual program budget	$350,000	$20,000	$100,000	$50,000	$100,000
Website	https://www.nyrp.org/green-spaces/tree-giveaway/	http://treebaltimore.org/get-a-free-tree	http://treephilly.org/free-trees/yard-trees/	http://groundworkprovidence.org/trees-2020/	http://www.treeworcester.org/trees-available.html

[a] Hosting organization refers to the main organizational body that presides over the distribution initiative.
[b] Full-time equivalent (FTE) staff.
[c] Trees distributed from founding of program to August 2014 (the time of our survey). These numbers are approximations with the exception of NYRP.
[d] Groundwork Providence's distribution program, Trees 2020, ended in 2012. For this program, we asked respondents to answer for the last year of the program.
[e] For TreePhilly and TreeBaltimore, the listed number of FTE represents the number of staff in their respective parks departments' forestry divisions.

the time of the study; the other programs continue to operate at the time of publication.

3.2. Program origins, missions, and evolving definitions of success

The five programs were created in response to municipal tree planting goals, either a target number of trees to plant or a canopy cover goal (Table 3). Representatives from three organizations (NYRP, TreeBaltimore, Trees 2020) cited high-resolution urban tree canopy assessments that demonstrated the city-wide need for increased canopy (i.e., the studies cited in Table 1) as a central motivating factor for beginning their residential tree distribution programs. In Philadelphia, the process was reversed: respondents told us that after Philadelphia's mayor set a sustainability plan that included a canopy goal of 30% in every neighborhood (City of Philadelphia, 2009), the city commissioned an urban tree canopy assessment to help determine how to achieve that goal. Prior to developing residential tree programs, NYRP, TreeBaltimore and TreePhilly had focused on larger-scale planting projects in public or very large private spaces (e.g., school campuses). NYRP's and TreeBaltimore's respondents commented that they then looked increasingly to the residential tree program as a way to meet canopy goals as they ran out of larger properties to plant. Politicians rallied support for WTI's residential tree program (Bird 2014), which began in response to the removal of 30,000 trees within an established Asian Longhorn Beetle (ALB; *Anoplophora glabripennis*) quarantine zone (Hostetler et al., 2013). The 30,000 tree goal was accomplished

Table 3
Program mission statements and targets, as reported by participants.

Hosting Organization	Mission statement	Targets
NYRP	"To improve the physical and social environment of NYC by expanding the urban tree canopy. In order to achieve this goal, NYRP set the following objectives across five boroughs: 1) Strengthen stewardship through community partnerships and engagement; 2) Improve NYRP institutional capacity for the tree giveaway program; 3) Increase urban tree canopy on private land."	Tree planting (1 million)
TreeBaltimore	"To increase awareness and outreach of TreeBaltimore and its efforts to increase the tree canopy. Specifically we are trying to target planting on private property, because it is the largest availability plantable space in Baltimore City."	Canopy cover (40%)
TreePhilly	"To provide free trees and education to Philadelphians so they can plant trees on their private property. This program is one of several TreePhilly programs that are aimed at meeting Mayor Michael Nutter's Greenworks Philadelphia goal to increase tree canopy to 30% in every neighborhood in Philadelphia by 2025."	Canopy cover (30%)
Trees 2020	"Plant 40,000 trees in the city by year 2020 in order to improve our environment and make Providence a better place to live."	Tree planting (40,000)
WTI	"WTI is committed to the stewardship of our urban forest. We offer education and training around the value of trees and how to plant and take care of trees. Our goal of replanting the 30,000 trees cut down because of the Asian Longhorned Beetle will be met by Oct 6th 2014 but we will continue to advocate for trees and educate the community about tree value and tree care."	Tree planting (30,000)

in 2014 through the efforts of both WTI and a state-sponsored reforestation program.

Although mission statements were consistently linked to planting a particular number of trees or canopy cover goals (Table 3), personal definitions of success varied from respondent to respondent, occasionally even between respondents speaking for the same program. Respondents also reported that their definitions of success shifted over time. Most respondents linked success to the number of trees that were distributed and/or related record keeping. Two programs' respondents mentioned that giving away all the trees they purchased that year was an indicator of success (NYRP, TreePhilly). Maintaining sound records about the trees distributed was particularly important for NYRP to count trees for MillionTreesNYC. WTI respondents also connected success to how well they maintained their data.

Several programs had social objectives embedded in their missions as well, and most interviewees were keenly interested in growing people's sense of connection with and appreciation for trees. For example, TreePhilly and WTI had education, training and stewardship of trees in their mission statements. Respondents also often connected success with making people happy and "getting good trees to good homes" (WTI).

Respondents from four programs (all except Trees 2020) reported adjusting their goals over time away from increasing canopy cover to alluring prospective recipients with popular small, flowering or fruiting trees and to urban greening in general. As one NYRP respondent said, "the benefit of getting people excited about trees in general outweighs the lack of environmental benefit that some of these smaller trees offer." NYRP's representatives explained that their objectives eventually shifted from focusing on increasing canopy to "getting people into the fold" of urban greening – in other words, reaching out through the giveaways to inspire people to participate in further urban greening activities. A TreePhilly respondent shared a similar sentiment: the program is "raising awareness, not necessarily of their benefits, but of trees [being] a nice amenity." Suggesting that success should still be related to relatively larger contributions to future canopy, one of TreeBaltimore's respondents explained that they point out to tree recipients that trees do not flower for long, and suggest going for larger canopy trees with showy seasonal colors.

Program staff gave some consideration to tree survival in their definitions of success, but admitted a lack of capacity for field work to monitor tree performance. A TreeBaltimore respondent stated that they preferred to tie success with the number of people engaged, rather than survival, because "the idea of trees [is put in their] minds."

3.3. Networks, sponsors and public-nonprofit partnerships

Respondents reported that financial stability of tree distribution programs on private lands required new funding approaches. Private lands were out of the traditional scope of influence for municipalities. TreeBaltimore and TreePhilly avoided potential issues of using city funds for trees on private lands by using money paid by developers affecting water quality and wildlife habitat (called state mandate fees), and corporate sponsorship, respectively. NYRP and WTI respondents also commented that corporate sponsorship was particularly important to their programs. Other sources of funding for the five programs included municipal/state/federal government(s), utility companies, local/national foundations, universities and private giving. Trees 2020 was the only program that did not receive some sort of financial support from a governmental body, instead funding its program mostly through a grant from a local foundation as well as fees from tree recipients. Trees 2020 ended in 2013, largely due to the end of foundation funding, though Groundwork Providence still distributes trees to individual homeowners and other entities through its Hope Tree Nursery, a 300-tree nursery in a converted brownfield.

All programs were embedded in public-nonprofit partnerships, including other nonprofits in the respective cities. TreeBaltimore's principal nonprofit partner, Blue Water Baltimore, ran some of their giveaway events. TreePhilly's nonprofit partners coordinated the giveaway's funding and supported marketing efforts (Fairmount Park Conservancy) and assisted with tree care education (Pennsylvania Horticultural Society). Trees 2020 received technical tree ordering and care advice, mulch, help with delivery, and outreach support from the Providence Parks Department. NYRP's giveaway program was situated within the MillionTreesNYC initiative, a public-private partnership between NYRP and the New York City Department of Parks and Recreation, with a large budget and political mandate (Young and McPherson, 2013; Campbell, 2014). NYRP and WTI both partnered with city departments to meet municipal planting goals. However, WTI was unique in its receiving ALB funding from the state and federal government and its close relationship with the state's ALB goals.

All programs have participated in the UEC and other professional networks. The UEC was seen by respondents as the "convener and facilitator of information shar[ing]" for like-minded urban forestry professionals in the region. Membership in the UEC provided a timely means to discuss ideas and hear what worked for colleagues from other cities through monthly conference calls, webinars, and annual meetings covering a broad spectrum of featured topics. TreePhilly and WTI were also able to visit NYRP's program managers and subsequently adapted some of their practices. Some

programs also participated in other national and regional professional networks (e.g., ACTrees, Society for Municipal Arborists, and New York ReLeaf) and conferences (e.g., the Arbor Day Foundation's Partners in Community Forestry conference).

3.4. Program models and operations

3.4.1. Program models

Four of the programs centered on giveaway events at which private residents could come to receive trees free of charge (NYRP, TreeBaltimore, TreePhilly, and WTI). These events took place at venues such as recreation centers, farmers markets and parks and were sometimes combined with other community events through related community partners to bolster attendance and interest. Trees 2020 had a different operational model compared to the other four programs, distributing trees at a charge and exclusively via delivery. Beyond these two models, programs differed in terms of their operational strategies, including their geographic areas for distribution, participant recruitment, staffing, requirements of tree recipients, available tree species and stock, as well as their monitoring and program assessments.

3.4.2. Areas for distribution and participant recruitment

Programs operated in particular geographic areas due to a variety of institutional, social and biophysical factors. Most programs operated within their respective city boundaries, except WTI, which distributed trees to Worcester and neighboring cities impacted by ALB. Their unique sponsorship from the state and federal agencies allowed for this broader geographic reach. While programs distributed the bulk of their trees to be planted on residential lands, some programs also worked with other land use types (Fig. 1) as part of the larger organizational missions to increase the extent of the urban forest.

For the four programs that operated through giveaway events, community partners – defined here as organizations independently created and run by private residents – were key for successful outreach to gain participation from individual residents and diverse neighborhoods. For many organizations, the community partners helped staff giveaway events as well. Thus community partners represented an important parameter determining programming areas. To target areas in social and biophysical need, NYRP often recruited its community partners from neighborhoods with low canopy, high population density and low income. TreePhilly also targeted low canopy areas; initially, it hosted its giveaways in target areas of low canopy with substantial plantable space, later expanding into other areas where the program became popular. Avoiding relying solely on community partners for recruiting participants, TreePhilly engaged in special outreach efforts, including phone calls, to remind residents in low canopy neighborhoods of upcoming events.

Unlike the other programs, Trees 2020 planted where individual residents communicated their desire for planted trees, after a site assessment by staff to evaluate suitable planting sites. Efforts to target specific areas were attempted through direct letters and brochures to residents in neighborhoods with low canopy as informed by a "windshield survey" (i.e., mapping trees by driving around Providence) but respondents reported that this method was not productive.

In some cases, programs needed to combat stigmas and concerns about trees in order to recruit participants. Respondents from TreeBaltimore and TreePhilly noted that trees were sometimes seen as messy, a hassle or dangerous (e.g., branch failure). Respondents also reported that residents sometimes worried about infrastructure conflicts with water pipes and power lines. Programs differed in approaches to address residents' concerns. TreePhilly distributed flyers "myth-busting" these issues, whereas TreeBaltimore chose to reinforce the positive aspect of trees. Different messages seemed to work for different constituencies. As an example, a TreeBaltimore respondent noted that renters might not be compelled to ask the landowner's permission to plant a tree if the prominent outreach message was how trees increase property value (and therefore rent), but renters may better appreciate that trees can reduce cooling costs.

3.4.3. Staffing

Programs had varied staffing levels (Table 2) and strategies. During the hectic planting seasons, with many weekend events, several respondents commented that staffing for giveaway events could easily fall short. This required the programs to find varying configurations of program staff and volunteers to minimize burnout of human resources. The event-focused programs relied on employees and local community organizations as a source of volunteers and/or to coordinate tree distribution events with community events. Specifically, NYRP, TreePhilly and WTI had community partners central to their program operations. NYRP's operational model, the neighborhood distribution event, relied predominantly on community partners' volunteers to conduct outreach and run the giveaway event alongside two NYRP staff. To manage the logistics of large giveaway events, NYRP set a consistent, tightly managed process for all of its community partners. TreePhilly's initial giveaway event model brought out around thirteen staff, some borrowed from PPR, to each event to help greet, register, and educate tree recipients. Eventually, as inspired by NYRP's less staff- and expert-intensive model, TreePhilly began a "Community Yard Tree Giveaway Grant", which allowed a community group to run a giveaway event semi-autonomously. WTI's staff managed all of the registration and distribution, with some volunteer help in unloading trees and training residents. TreeBaltimore's giveaway events were run either by the program's sole employee or by non-profit program partners (e.g., Blue Water Baltimore), with occasional volunteer assistance from Baltimore City's Forestry Board.

Trees 2020′s unique model through which recipients paid for and received trees by delivery utilized a single staff member; during their period of operation, the director and sole employee of the program organized tree requests and made required site inspections. Originally, Trees 2020 intended for volunteers to do the site assessments, but ultimately the work fell onto the program director. As the program progressed, the director also helped recipients plant their trees at the proper depth and remove girdling roots.

3.4.4. Requirements of tree recipients

Programs differed in terms of their requirements of tree recipients. As noted, only one program, Trees 2020, charged a fee. Recipients needed to have a site assessment and pay the subsidized cost of the tree (approximately $55-75) prior to having a tree delivered to their home. The Trees 2020 respondent told us that this fee was intended primarily to help pay for the program operation costs (including the cost of trees), and also to make the recipient value the tree more than they would a free tree.

For these other four programs, trees were given away free of charge. When asked why they distributed trees free of charge, reasons included: the logistical difficulties of fees and reimbursements, reducing barriers to participation for low-income residents, decreasing competition with local nurseries for bigger stock, and a desire to push out more trees. Free trees were also "flashier" (TreePhilly) and thus could more easily attract funders (also noted by NYRP). Free trees came with their own sets of challenges, however. As one TreePhilly respondent noted, sometimes recipients did not take free trees seriously. In the first couple of seasons, people often missed their assigned giveaway event. NYRP, which did not limit the number of trees taken, encountered hoarders and those who took trees to resell them. Conversely, with Trees 2020,

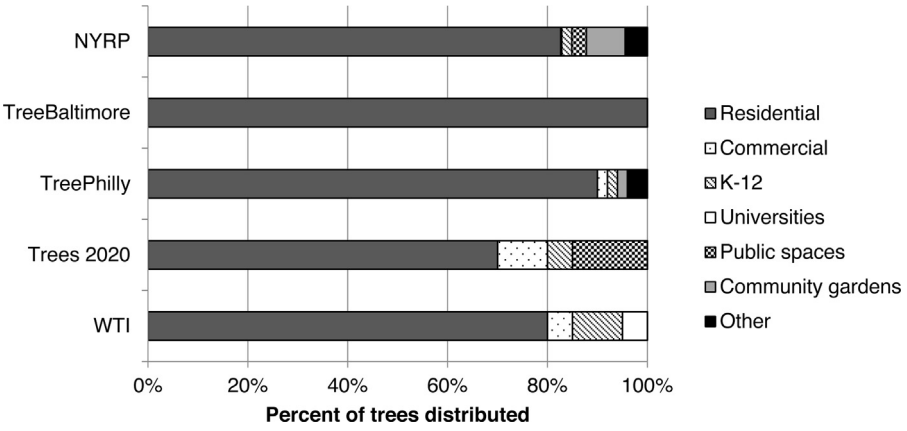

Fig. 1. Property types to which trees are distributed, as estimated by program staff.

program staff noted problems with fees—it was perceived as a barrier to low-income individuals and dampened interest from the public.

Free trees in these other four programs were generally picked up by recipients at the giveaway events. Delivery of trees was made available in special situations, such as leftover trees delivered to recipients who could take more than 10 trees (NYRP), physical inability to pick up and plant a tree (TreePhilly), or when neighborhoods had at least 10 recipients (TreeBaltimore). A requisite for recipients of three programs was preregistration to choose a tree species ahead of time, as only a small proportion of trees were available for first-come, first-serve at events (NYRP, TreePhilly and WTI). Furthermore, at the giveaway event, TreePhilly and WTI required residents to attend a demonstration on how to properly plant a tree prior to receiving a tree. WTI respondents also noted that preregistration helps with data organization and management. TreeBaltimore, on the other hand, had recipients sign up directly at the giveaway event but prior to giving the recipient a tree, an employee would talk to each recipient regarding species selection and care, as well as provide them printed or online educational materials.

3.4.5. Tree species and stock

Respondents reported a number of factors affecting the programs' selection of trees including nursery availability (especially considering the large number of trees ordered by the programs), ease of transport (particularly an issue for New York City residents reliant on subways), price, available planting space in yards and recipients' preferences. All five programs offered containerized stock, ranging from 7 to 55 L pots. WTI gave away the largest stock of trees (35–55 L containers), in part to help residents more satisfactorily fill in the space left by the removal of their older, larger trees during the ALB quarantine, but after visiting NYRP conceded that smaller stock sizes were appealing for ease of transport.

Originally, all of the programs were interested in emphasizing species that would grow into large shade trees to achieve maximum canopy. However, all programs found that recipients often desired smaller, fruiting or flowering trees for aesthetics, edible fruits, perceived lower maintenance needs, lower potential hazards of failing branches, and/or limited space from urban density or utility lines. Respondents from NYRP and TreeBaltimore also noted that small yard size in low canopy, low income areas meant there was little space for adding large trees. Among the five most common species for each program, half had very showy flowers, roughly one quarter were large trees, and one fifth provide edible fruits (Table 4). None of the common trees for NYRP were large. Respondents for three of the programs told us that they have increasingly introduced cultivated fruit trees into their palette due to the popularity of these species among recipients and in order to boost program participation (NYRP, TreePhilly, WTI). In fact, NYRP ran a fall giveaway season solely with fruit trees to encourage greater participation. That said, Trees 2020 also reported that three of its five most commonly distributed trees were large canopy trees (Table 4). Also of note, the most commonly distributed species in NYRP and TreePhilly were natives, and TreeBaltimore's program was offered nearly exclusively native trees overall, save for common fig (*Ficus carica*).

3.4.6. Post-delivery communication and assessment

Most programs had some kind of post-delivery communication with residents and assessment, including online surveys and in-person tree evaluations. After their giveaway events, NYRP, TreePhilly and WTI performed follow-up with recipients. NYRP sent recipients emails, one to thank them and another to remind them to water. TreePhilly followed their events with an online survey asking recipients what they liked about the event, what could be done better, whether they planted the tree and how healthy their tree currently was. WTI sent out surveys via email to their tree recipients and then followed up with phone calls to ask about how their trees were doing.

Four of the five programs made efforts to monitor tree performance. TreeBaltimore and NYRP conducted rough observational surveys, where interns examined a non-random sample of trees that were visible at registered addresses to estimate the survival rate. TreeBaltimore's 2012 survey estimated that ~70–80% of trees had been planted, and NYRP's 2011 survey estimated tree survival at 1–3 years after planting to range from 63.5% to 97.4%, depending on how survival was defined and missing trees were handled. WTI began drive-by surveys in 2012, but respondents reported that it was difficult to determine how backyard trees were doing; subsequently, tree performance information was collected through the email surveys and follow-up phone calls. While TreePhilly's email surveys focused on gathering feedback about the events and emphasizing the importance of planting the trees, they also asked recipients to self-report the status of their trees. For their fall 2013 season, 86% of survey respondents reported that their tree was healthy 1–2 months after planting.

3.4.7. Geodemographic patterns of tree distribution

The analyses of Spring 2013 tree distributions for TreeBaltimore, TreePhilly, and NYRP (Locke et al., 2014; Locke and Grove, 2015; Locke et al., 2015a; Locke and Grove, 2016) showed relatively higher participation in high-income market segments, particularly with TreeBaltimore and NYRP, where Upscale Avenues and High Society block groups (which are well-educated and affluent

Table 4
Characteristics of the five most common species distributed by each program in 2013. We did not generally distinguish between *Amalanchier*, *Prunus*, and *Malus* species because the various cultivars and hybrids used by the programs have similar characteristics. Classifications follow University of Florida (2013) for most information, with two species (*) characterized based on MissouriBotanicalGarden (2016). Native status was based on USDA (2016). For mature size, trees are classified as small (S, ≤9.1 m height), medium (M, >9.1 m and ≤18.3 m), large (>18.3 m). Combined mature sizes are for *Amelanchier* spp. and *Prunus* spp. which spanned categories.

Program	Species	Native to state	Edible fruit	Very showy flowers	Mature size
NYRP	*Cercis canadensis*	X		X	S
	Magnolia virginiana	X		X	M
	Amelanchier laevis	X	X	X	M
	Carpinus caroliniana	X			S
	*Cornus alternifolia**	X		X	S
Tree Baltimore	*Cercis canadensis*	X		X	S
	Amalanchier spp.	X	X	X	S/M
	Acer rubrum	X			L
	*Ficus carica**		X		S
	Nyssa sylvatica	X			L
TreePhilly	*Cercis canadensis*	X		X	S
	Cornus florida	X		X	S
	Magnolia virginiana	X		X	M
	Amelanchier spp.	X	X	X	S/M
	Nyssa sylvatica	X			L
Trees 2020	*Acer rubrum*	X			L
	Tilia americana	X			L
	Quercus rubra	X			L
	Prunus spp			X	S/M
	Ulmus parvifolia				M
WTI	*Prunus* spp.			X	S/M
	Cornus kousa			X	S
	Quercus rubra	X			L
	Picea pungens				M
	Malus spp.		X	X	S

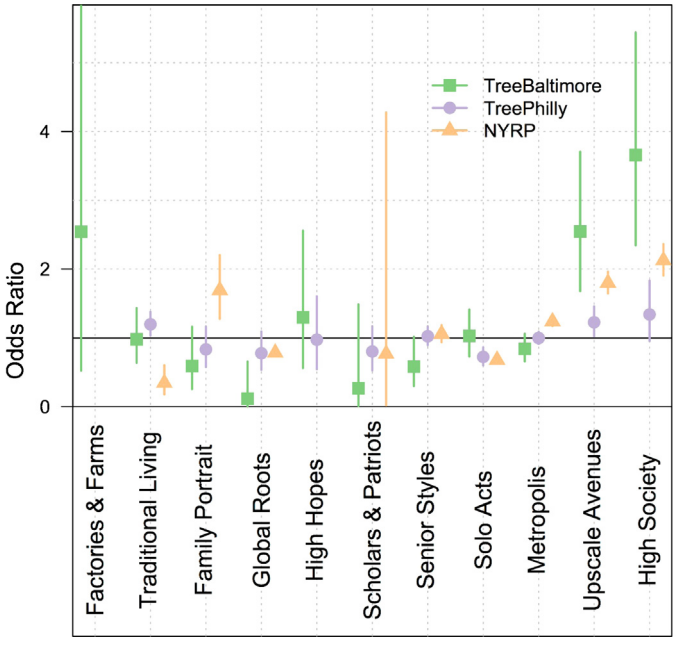

Fig. 2. Participation in tree distribution programs in spring 2013 for TreeBaltimore, TreePhilly, and NYRP based on lifestyle groups, as defined by Tapestry LifeMode (ESRI, 2011). Lifestyle groups are ordered from lowest income (left) to highest (right). The point indicates the estimated odds ratio and the bars are the 95% CI. Odds ratio of 1 indicates that the proportion of trees received by that lifestyle group is the same as the proportion of that lifestyle group in the city.

neighborhoods with less racial diversity) were more likely to receive trees (Fig. 2). In Philadelphia, the odds ratios for most of the market segments were not statistically distinguishable from equitable (i.e., 95% CI crossed 1 for all but two market segments). Participation was low among Global Roots segments (ethnically diverse families, with many recent immigrants) in all three cities, and in Solo Acts (well-educated singles who prefer city life) for TreePhilly and NYRP. Based on prior related research, for TreeBaltimore, most of the free trees were associated with higher income areas that had the most tree canopy (Locke and Grove, 2016).

4. Discussion

Our results demonstrate that residential tree giveaway programs are complex and adaptive, reflecting urban forests as SESs with interlocking biophysical, social and institutional components. In these programs' fundamental relationships with private residents, they are subject to principal-agent problems, involving decisions that attempt to balance private residents' interests and desires related to trees along with municipal and nonprofit interests in the larger public good. Program strategies also operate in the context of biophysical constraints, such as available planting space, as well as the administrative capacities of the hosting organization. These intersecting forces lead to varying outcomes in terms of the types of trees planted, the variety of neighborhoods involved, monitoring, and program resilience. Through the lens of urban forests as social-ecological systems (SESs) (Vogt et al., 2015), we discuss here potential linkages between biophysical, social and institutional factors and the observed program outcomes. Specifically, we organize this discussion by examining outcomes related to the programs' strategies to meet their goals and remain resilient.

4.1. Program goals

Originally, all five programs were spurred by municipal tree planting or canopy cover goals, in part conceived to capitalize upon the ecosystem services of urban forests which are maximized in large, mature trees (McPherson et al., 1997; Ko et al., 2015b). As described, this suggests that the programs' most direct and expedient tasks were to plant large canopy trees, ensuring and monitoring their survival, growth, and contribution to canopy cover change. Per their missions to distribute trees to private residences, staff

needed to 1) recruit private individuals as tree recipients, and 2) to ensure they planted and cared for the trees they were given. Given the PAR problems herein – to recruit agents in the short-term to request and plant trees, and for the long-term, to care for those Trees – programs developed a variety of strategies (institutional arrangements) including involving community partners, providing tree stock that aligned with recipients' aesthetic norms and practical needs, educating recipients, moderating required investments by recipients, and follow-up monitoring of tree performance. Some of these strategies were more common than others, and strategies varied in terms of transaction costs to the programs. Transaction costs can pose challenges for environmental governance (Paavola and Adger 2005) and although difficult to measure, can be applied on a comparative basis to analyze the implications of various governance arrangements (Williamson, 1985); thus we use these concepts to compare the strategies of the tree distribution programs studied.

A common social strategy, and one with seemingly high payoffs for the programs, was to invest in involving community groups to supplement staffing and provide social capital for their efforts. The five programs studied displayed a spectrum of staffing levels but the smaller programs, TreeBaltimore's program and Trees 2020, were both staffed by less than one full-time employee and both remarked on their inability to perform consistent outreach. Staff at the giveaway-based programs (i.e., all except Trees 2020) fostered greater capacity for outreach through community and non-profit partners who were also likely better able to connect with tree recipients at the neighborhood scale given their social connections to individual residents. While this strategy required the initial time and energy of program staff, it reduced their work load overall as community groups recruited residents and provided volunteer time at giveaway events. In using this strategy, the giveaway programs were leveraging resources across scales, which is critical to modern urban environmental stewardship networks (Connolly et al., 2013). The programs were also involving locals, reflective of behavioral theory that social incentives can adjust individual behavior (Baden and Noonan, 1998) and the principle that sustainable natural resource management strategies should fit local environmental and social conditions (Ostrom, 2005). An additional benefit of collaborating with community partners is that this institutional arrangement may help meet the needs of diverse constituencies and low canopy areas, and more equitably distribute trees. Indeed, our findings suggest that the outreach strategies involving community groups used by TreePhilly appear to be associated with relatively evenly-distributed trees within Philadelphia; this is critical due to environmental justice concerns with tree planting programs (Heynen et al., 2006; Locke and Grove, 2016). However, strategies to target low-canopy neighborhoods must also recognize biophysical limitations to planting due to small yards or even complete lack of yards. For example, many older neighborhoods with attached housing (e.g., row houses) may not have space for new trees (Hayward et al., 1999). Program staff noted that smaller stature trees are more appropriate for smaller yards (which relates to program shifts in species palettes), yet this has implications for overall canopy gains in those neighborhoods. The level of owner vs. renter-occupied housing in low-canopy neighborhoods may also have implications for outreach strategies and feasibility of recruiting residents to plant trees, as renters may not have the same incentives and/or may lack the authority to invest in property management activities, including tree planting, when compared to homeowners (Zhou et al., 2009; Landry and Chakraborty 2009; Meléndez-Ackerman et al., 2014).

The programs also strategized to educate private individuals as a means to address PAR problems in terms of recruiting them as tree recipients and then influencing their tree care behavior. There are relatively low transaction costs associated with developing or sourcing educational materials, thus two of the programs invested in overcoming concerns about trees with positive messaging and "myth busting" to attract potential recipients. Some of the concerns that staff reported hearing from residents are reflected in literature about disservices of urban greening (Lyytimäki et al., 2008; Conway and Yip, 2016). Indeed, such disservices can be rooted in genuine problems caused by trees, as well as misconceptions, and disservices must be carefully integrated into successful arguments for urban greening programs (Lyytimäki and Sipilä 2014; Handel, 2016). Programs also invested staff and volunteer time in communication and demonstrations at giveaway events, meant to promote proper tree planting and care. While this likely represents relatively higher transaction costs (compared to creating educational materials) for the programs, these training sessions operated not only as educational tools but also as requirements for tree recipients (time investments) functioning to motivate tree care (discussed further below), thus they served multiple purposes. Trees 2020′s unique approach had staff individually educating each tree recipient on their property, offering highly site-specific information, but at very high transaction costs for programs. Overall, educational strategies are warranted under a broad theory of human behavior and its effect on decision-making – "individuals rarely have full and complete information [. . .] but they do learn" (Poteete et al., 2010). Thus, relatively moderate investments in educational outreach (e.g., flyers regarding tree benefits and maintenance, standard short lessons about proper planting technique) seem beneficial, particularly when they serve multiple functions.

All programs attempted to balance minimizing the costs of program involvement for residents, in order to garner participation, while still requiring some investment that would incentivize long-term tree care, although strategies varied. While Trees 2020 charged a fee for trees, arguing that the fee signaled an important investment and motivation for long-term tree care, that program balanced the fee by consistently providing tree delivery and one-on-one planting and care instruction. While not requiring a fee, the other four programs required other forms of investments from participating residents; namely, some form of time investment (opportunity cost) for recipients including tree pick-up and/or required training about tree planting and care. Moderating costs to participants would seem to be a sound strategy by all programs because "when actions involve high costs, the monetary and time constraints facing individual actors are important constraints [which] may eliminate all but a very narrow band from the feasible set of some actors" (Ostrom et al., 1994; 35). However, it is difficult to know whether fees as opposed to training or pick-up requirements yield more participants and/or better long term care of trees given the confounding factors associated with the many differences between Trees 2020 and the other programs. What is clear is that the strategies employed by Trees 2020 likely factored heavily into the lack of resilience for their program, which is discussed further below.

Perhaps the most interesting strategy utilized by programs was to provide smaller-statured, ornamental tree stock through giveaways in order to match the normative desires of many tree recipients, which involved the interaction between social and biophysical factors. The fact that respondents noted that many tree recipients opted away from shade trees, instead choosing smaller, ornamental, or fruiting trees, is consistent with findings from previous research that aesthetics drive residential tree planting (Summit and McPherson, 1998; Locke et al., 2015b). The program response – to provide more of those small-statured trees over time – appears to have helped recruit tree recipients by meeting their desires, arguably supporting program goals associated with high numbers of trees given away as well as potentially meeting social goals of growing people's sense of connection with and appreciation for trees. Moreover, in the cases that smaller-statured trees were

necessary given biophysical constraints of yard space, few drawbacks of this strategy can be identified. However, as an overarching strategy, there was a potentially high cost to the programs in this species palette shift, given small trees' relatively low contributions to increasing canopy cover – the original primary goal of most programs. Indeed, respondents linked this strategy to an informal shift in goals and definitions of success (i.e., mission statements were not rewritten yet staff reported that their goals shifted internally). Combined with the difficulty in monitoring tree survival, the strategy to match residents' aesthetic norms has led to programs emphasizing social definitions of success: spreading a positive message about trees and urban greening. Spreading positive messages about trees also aligns with the mention of stewardship, awareness and advocacy in program mission statements, yet distributing primarily small trees conflicts with canopy cover and ecosystem services-oriented goals, suggesting possible trade-offs between attainment of biophysical and social goals.

The programs varied in the extent to which follow-up with tree recipients and monitoring of trees was undertaken as a formal strategy to address the PAR problem of tree planting and maintenance. Among the five programs, four attempted ad hoc monitoring of tree survival which suggested a majority of the trees given away were planted and survived the first couple years. Monitoring efforts were challenging to conduct and incomplete, with possible nonresponse bias to survey instruments and private yard access difficulties for field observations, thus planting and survival rates reported in the results should be interpreted with caution. Moreover, these results are difficult to compare to tree giveaway survival monitoring conducted elsewhere due to differing sample designs and definitions of mortality (Roman et al., 2014). It is possible that lack of capacity to evaluate biophysical metrics of success (e.g., tree survival, tree cover change) may be part of what drove program staff to consider other means of defining success.

Overall, this suggests that monitoring efforts could be strengthened. Research in social-ecological systems has demonstrated the importance of monitoring both actors involved in the provision of natural resources as well as the resource itself for sustainable outcomes (Ostrom, 2005). In fact, research focused on neighborhood-planted trees demonstrated that neighbor-to-neighbor monitoring of tree watering positively moderated tree survival (Mincey and Vogt, 2014). Outcomes monitoring is also important for adaptive co-management in urban environmental stewardship (Silva and Krasny, 2014). In these cases, monitoring appears to produce accountability to follow through with agreements related to tree care as well as to provide important outcomes data. Indeed, for other urban tree planting programs, some funding agencies are beginning to require survival monitoring data, and robust planting records are critical as a baseline (Roman et al., 2013; Vogt et al., 2015). Two of the residential tree programs studied here mentioned good record keeping as being important to success (WTI and NYRP), although not all programs retained thorough information about species and resident addresses for some of the analyses we performed in this study.

4.2. Program resilience

While recruitment of tree recipients as well as tree planting and care were significant objectives toward meeting program goals, an alternative outcome of interest is the resilience of programs themselves (Acheson 2006; Helmig et al., 2013). The end of Trees 2020′s giveaway program coupled with its unique features relative to the other programs studied requires consideration. The other four programs persisted with shifting goals, which could arguably be viewed as demonstrating adaptive capacity and institutional resilience or alternatively, as a shortcoming of the programs to adequately address or measure their original goal of increased tree canopy on private lands. If one considers the hosting organizations as principles and the program staff as agents, a higher-level PAR and associated problems may exist, in terms of disconnects between organizational goals and staff members' evolved definitions of success. While we did not hear directly from staff that there was perceived misalignment between hosts and programs, it is, potentially, a point from which problems impacting program resilience might arise. As discussed above, this disconnect may relate to staff realizing that different strategies were needed to reach constituents. There may also be challenges in realistically achieving organizational program goals due to staffing capacity, funding and sociocultural considerations (seen through market segment groups).

Despite the fact that Trees 2020 appears to have remained most committed to distributing larger-statured trees and ensuring that trees got properly planted and thus, to a more direct path to increasing canopy cover, the program's cancellation points to several institutional arrangements that may have combined to overwhelm their capacity. These features include the program funding schemes, staffing, and operational model. Trees 2020′s funding scheme was based largely on a single foundation's support in addition to fees for trees. Given that the program was no longer viable once the foundation funding was gone, this demonstrates the need for diverse support and start-up fundraising for a program's endurance (Carroll 2009; Searing, 2015). Moreover, the program's single staff member was tasked with day-to-day tree delivery, planting and one-on-one resident education, which arguably prevented investments in other capacity-building activities for the program (e.g., grant writing, nurturing partnerships, volunteer coordination). Larger staff sizes may be able to offer program stability (Carroll, 2009) in this regard as well as allowing for increased capacity for outreach and education. That said, it is important to note that most of the programs were funded in some way by municipal or state governments; as such, political shifts could reduce funding and support for the programs since large-scale urban tree planting initiatives have not become institutionalized in local governments (McPherson & Young 2013). New mayors, for instance, may choose to endorse new programs as opposed to continuing the old. Additionally, the use of fees for trees in tree distribution programs must be carefully considered. Several interviewees hypothesized that the attractiveness of giveaway programs to funding agencies is predicated on free trees, suggesting that the fee-based model used by Trees 2020 was unsustainable.

4.3. Study limitations and future research

Our study is limited by lack of fine-scale data regarding tree recipients and their individual trees, including incomplete program records for resident addresses and species distributed. Improved record-keeping over multiple years and during turn-over in personnel would enable analysis of changes in species characteristics and geodemographic patterns over time, as they relate to changing outreach tactics. Future research might expand upon this study to investigate two metrics of success: 1) residents' attitudes and behaviors towards trees and 2) tree performance (e.g., tree mortality, growth, health). However, staffing and funding capacity for practitioner-driven monitoring of urban tree performance are scarce in general (Roman et al., 2013). Some programs in our study relied on residents' self-reported behavior and/or partial, often drive-by style monitoring to determine planting and mortality information; such data may be unreliable and biased. Yet monitoring is essential to the sustainable and adaptive management of natural resources such as urban forests (Ostrom 2009; Williams 2011; Roman et al., 2016). Without monitoring, programs cannot accurately assess their impact or fulfillment of their (original or adapted) goals, report back to funders, or adaptively adjust

management with new lessons learned (Doick et al., 2009; Silva and Krasny, 2014). Indeed, if tree planting initiatives aim to increase the overall number of trees in the landscape, increase canopy cover, or provide ecosystem services in the long-term, then tree mortality is an essential outcome of interest (Roman et al., 2016; Widney et al., 2016).

Since programs seem to be shifting towards social definitions of success – changing residents' attitudes about trees and generating excitement about urban greening – it needs to be determined whether or not tree distribution programs are the most effective way to do so across social groups. Furthermore, for the social outcomes of these programs, clear metrics of program impact should be developed, beyond counts of participating residents – such as documented changes in residents' values, norms and behaviors surrounding trees. There is a need to further understand who participates in these programs, and why, as well as who does not participate, and why not. Even though aesthetics are often cited as a reason for valuing urban trees (Avolio et al., 2015; Locke et al., 2015b; Conway, 2016) more research is needed to better understand how residents decide whether and what to plant based on aesthetics as well as perceived tree care and site suitability. Future studies could investigate the impacts of different program models on resident attitudes and stewardship actions, such as free vs. fee-based programs and varying outreach strategies to low canopy neighborhoods. Given the emphasis that some greening programs have on reaching out to under-served constituencies, equity in tree distribution could also be viewed as a metric of success. While some of the challenges that programs encountered in outcomes monitoring and reaching diverse constituencies could be addressed with additional funding, we think that more fundamental issues would exist at any funding level: trade-offs in biophysical and social goals, and devising effective strategies to convince residents to care for trees on their private land for the greater public good.

In effect, by aiming to build residential excitement about and affection for trees, these programs have hypothesized that the way to increase tree canopy is through people's hearts, suggesting tight linkages between these social and biophysical program goals, albeit with potential trade-offs as discussed above. Yards are an anthropogenically-constructed landscape (Cook et al., 2012) and teasing apart the pathways connecting programmatic outreach to residents' values and ultimately changes in land cover is a promising area of further investigation, and a research topic with direct relevance to urban greening programs.

Acknowledgements

The research was supported by the US Forest Service Philadelphia Field Station's Science Sustainability Fellowship (VDN and DHL). We extend our deepest thanks to SC Low and JR McBride for their help in developing and implementing the surveys and interviews, all survey and interview participants for taking the time to contribute to this study, and L McKinley for her assistance with qualitative analysis. We are also grateful to all the present and former UEC members who provided a vibrant community for exchanging ideas and practices in urban greening. We extend tremendous appreciation to the many program staff, volunteers and private residents who make these yard tree programs possible and provided valuable feedback throughout our study. Lastly, we thank two anonymous reviewers for their thoughtful critiques on an earlier version of this manuscript.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ufug.2017.01.007.

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