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Doing the Hard Work Where it's Easiest? Examining the Relationships Between Urban Greening Programs and Social and Ecological Characteristics

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Abstract In this paper we examine the performance of formal programs associated with tree plantings in Washington, D.C. and Baltimore, MD to understand the relationships between the implementation of urban greening programs and the social and ecological characteristics of a city. Previous research has examined variations in patterns of existing and possible tree canopy cover relative to different social theories. Less attention has been paid to the processes of how the current patterns of tree canopy cover have developed. The goal of this paper is to address this gap by examining current programs to increase tree canopy. This paper utilizes public records, administrative data, a geodemographic market segmentation database, and high-resolution land cover data to assess where programs work, who participates in these programs, and whom the programs fail to reach. Recruiting households to plant trees can be hard work. In this paper, we find that programs might be most successful where it is easiest but have the lowest need. Free or reduced-cost programs for tree planting on private lands were most effective in the most affluent neighborhoods of Washington, D.C. and Baltimore, MD. These areas tended to also have the most existing tree canopy on both private residential lands and the public right of way. An outcome of this research is a framework for further testing which land management strategies are most effective, where, and with whom in order to improve the ability to plan and enhance urban sustainability and resilience through urban forestry.

Keywords Adoption · Urban sustainability · Tree canopy · Geodemographics Baltimore, MD · Washington, D.C

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Introduction

Municipalities' sustainability plans contain several interrelated social, economic, and environmental goals (Brundtland 1987; ICLEI 2009). Reaching these goals may require a number of practices associated with land management. Examples of these land management practices include increasing tree canopy cover on public and private lands, stormwater mitigation through rain barrels and gardens, and stream restoration.

Several cities have ambitious urban forestry campaigns; often as a component of their sustainability plan because the well documented benefits of trees (ACTrees 2012; Forest Service Northern Research Station 2008) are increasingly well recognized. In some case these campaigns are to plant a target number of trees, such as million tree programs in New York, Los Angeles, Shanghai, and Denver (City of Los Angeles 2007; City of New York 2007, 2011; Shanghai Roots & Shoots 2009; The Mile High Million 2013). In other cases, the urban forestry campaign goal is to achieve a level of tree canopy cover, such as tree canopy goals in Baltimore, MD, The District of Columbia, and the entire state of Maryland (Baltimore Sustainability Plan 2009; District of Columbia Urban Tree Plan 2013; Governor O'Malley 2013). In the case of the City of Philadelphia, the City has established both a tree planting and tree canopy goal (Greenworks - City of Philadelphia 2009; Plant One Million 2013). There is one constant in all of these cases. Urban forest campaigns cannot meet their canopy goals without tree planting and conservation on private residential lands (Grove 2014). Thus, it is critically important to understand the ecological and social factors that affect planting and conservation on private residential lands so that urban forest campaigns can meet their goals.

Ecological and social processes affect the distribution and quality of urban vegetation. Ecological processes include natural regeneration from seed dispersal and clonal growth. Social processes include both informal and formal practices. People may plant trees on their own initiative. Alternatively, people may participate through formal programs such as organized plantings in public parks or on their own properties. To date, there has been substantial research to understand the social-ecological factors associated with uneven patterns in the distribution of urban tree canopy (Cook et al. 2011). In these cases, the processes or mechanisms that produce uneven patterns in the distribution of urban tree canopy have been hypothesized, but not directly measured. In this paper, we make an initial attempt to directly measure and understand the process relationships between urban greening programs and the social and ecological characteristics of a city by examining the performance of formal programs associated with tree plantings in Washington, D.C. and Baltimore, MD.

Theoretical and Practical Rationales for this Research

Theory: from Patterns to Process

A growing body of research utilizes high-resolution land cover maps (sub-meter) to test social and ecological theories about variations in the distribution patterns of vegetation on public and private lands in urban areas. There are five predominate theories in this body of work: 1) human population density; 2–4) social stratification; and 5) reference

group behavior. Human population density is presumed to drive vegetation change through development and the subsequent loss of space for existing trees and growth of new trees (Smith et al. 2005; Marco et al. 2008 in Cook et al. 2011). However, the empirical relationship between human population density and canopy cover is mixed. In Baltimore, MD, human population density and tree canopy are *negatively* correlated at the Census block group (Troy et al. 2007) and tract scales (Boone et al. 2010). Similar negative associations were found for tree canopy on private land in Montreal, ON (Pham et al. 2012b). In Raleigh, NC, population and household density are *positively* and significantly correlated with more abundant tree canopy on private residential lots (Bigsby et al. 2013). These mixed results suggest that there may be additional local conditions to be considered in addition to human population density.

The next three theories are interrelated and based upon theories of social stratification to understand variations in vegetation cover on private urban lands. The first social stratification theory focuses on social and spatial mobility afforded through higher economic status and neighborhood turnover (Roy Chowdhury et al. 2011). Wealthier families may choose to live in neighborhoods that provide a richer package of attractive amenities, including greener areas (Logan and Molotch 1987). A second social stratification theory posits that differentiated power and income differences among neighborhoods influence varying levels of public investment in green infrastructure (Grove et al. 2006b). Members of some socio-economic groups are better able to attract public investment in local greening initiatives (Logan and Molotch 1987: 39; Perkins et al. 2004).

The last social stratification theory variation is the so-called "luxury effect" (Hope et al. 2003, 2006; Martin et al. 2004). Proponents explain that wealthier households have more disposable income and may therefore spend more money on all consumer goods and services, including environmentally relevant expenditures such as landscaping. There is abundant and growing evidence that more abundant tree canopies in urban areas are often associated with higher incomes (Iverson and Cook 2000; Hope et al. 2003, 2006; Martin et al. 2004; Grove et al. 2006a, b; Tratalos et al. 2007; Kirkpatrick et al. 2007; Boone et al. 2010; Landry and Chakraborty 2009; Luck et al. 2009; Zhou et al. 2009; Pham et al. 2012a,b; Romolini et al. 2013; Grove et al. 2014), which may support the ideas that mobility provided through affluence and the luxury effect are viable theories.

The fifth social theory, reference group behavior theory, acknowledges the roles of human population density, mobility, uneven access to power, and the effect of additional discretionary income on private land management decisions and outcomes. However, this fifth theory also recognizes neighborhood differentiation based upon reference group behavior theory and the potential for households' land management activities to be influenced by a desire to uphold the appearance and exhibit membership in their neighborhood (Logan and Molotch 1987: 107–8; Grove et al. 2006a, b; Troy et al. 2007; Grove et al. 2014). This lifestyle and lifestage explanation for the distribution of existing tree canopy and lawns has been termed the "The Ecology of Prestige," based upon the idea that, "household patterns of consumption and expenditure on environmentally relevant goods and services are motivated by group identity and perceptions of social status associated with different lifestyles" (Zhou et al. 2009: 746). In this view, nearby households (Hunter and Brown 2012) may feel inclined to create an outward appearance to increase chances of acceptance and inclusion in the

social group of the neighborhood by upholding the status of the community (Nassauer et al. 2009; Mustafa et al. 2010). The role of outward displays of neighborhood identity and belonging may not be limited to residential landscaping.

This summary indicates the extensive body of research examining *variations in patterns* of existing canopy cover on public and private lands relative to different social theories. A crucial gap is to examine the *processes that produce or maintain variations* in patterns over time. In other words, previous work has been largely descriptive, with mechanisms theorized and inferred. By examining the programs that may lead to particular tree canopy pattern outcomes, the research presented in this paper moves closer to understanding the processes that lead to the observed patterns of urban tree canopy cover.

Practice

A number of cities have developed and begun to implement ambitious urban forestry initiatives, as we noted earlier. Further, a shared characteristic among these cities is that it is nearly impossible to achieve their urban tree canopy goal by planting only on public lands. In the case of Baltimore, the city's urban tree canopy (UTC) goal of 40 % is not attainable by planting exclusively on public lands. Even if the entire public right of way and every part of each public park were beneath tree canopy–a socially unrealistic proposition–the city would achieve only ~10 % of its 40 % canopy goal. Thus, a more inclusive, "All Lands, All People," approach is needed that involves public, private, community, and abandoned lands to reach the remaining 30 % of its tree canopy goal (Galvin et al. 2006; O'Neil-Dunne 2009; Grove 2009; Locke et al. 2013).

The shift from an exclusive public lands focus to an "All Lands, All People" approach can be extremely challenging. "Foresting public lands often means convincing a few public officials of the importance and benefits of planting trees. Foresting private lands requires persuading hundreds or thousands of residents—people whose backgrounds rarely include ecology, economics, or tree plantings" (Summit and McPherson 1998: 89). Because reaching most urban tree canopy goals cannot be achieved with public land management alone, it is important to understand the diverse motivations, capacities, and interests of all resident particularly residential landowners.

Currently, the motivation and interests of urban residential landowners to care for their land to advance local sustainability goals is poorly understood. In this paper, we address this practical need by adopting a geospatial, demographic approach (Weiss 2000; Holbrook 2001; Grove et al. 2006a, b; Troy 2008) to examine tree planting participation rates by location on private residential lands in Washington, D.C. and Baltimore, MD. Analyzing program performance by location enables urban natural resource managers to assess how effectively their programs are reaching different types of neighborhoods and achieving urban tree canopy goals and priorities (Locke et al. 2013). It is important to note that not all households across the different types of neighborhoods will be interested in urban forestry programs. Some of the reasons for objecting to tree plantings have been previously documented (e.g. Braverman 2008; Kirkpatrick et al. 2012, 2013; Rae et al. 2010; Conway and Bang 2014; Battaglia et al. 2014).

Method

Site Descriptions

This paper focuses on efforts to plant trees in Baltimore, MD and Washington D.C. from 2007 through early 2013. These two cities share numerous social and ecological characteristics that make them an ideal comparison. Both are similar in geographic size, age, and human population density. They are both coastal cities with direct connections to the Chesapeake Bay. Both cities are in the same climatic zone and are similar in total population, racial composition, and percentage of the population living below the poverty line. Both cities are in violation of air and water quality regulations and depend upon increasing tree canopy to improve air and water quality (Table 1).

There are important differences between the two cities, however, that offer unique opportunities for the questions we propose. Washington D.C. can be considered a "pull" city due to its current and projected growth, while Baltimore can be categorized as a "push" city due to its declining population and high rates of vacancy (Gottdiener and Hutchison 1994). For instance, from April 1, 2010 to July 1, 2011, Washington D.C. ranked 15th in terms of absolute growth among cities in the country with the addition of 16,273 residents. Baltimore City experienced the third largest decline in population across the United States, losing an estimated 1468 people (United States Census Bureau 2011). According to the Census Bureau's 5-year rolling average

Table 1 A summary and comparison of key social and ecological characteristics for Washington, D.C. and the City of Baltimore, MD

Data	Washington, D.C.	City of Baltimore, Maryland	Source
Land area (km^2)	176.98	210.88	1
Population	599,100	616,065	1
Persons / km^2	3385.1	2921.4	1
Population change (2010–2011)	+ 16,273 residents	−1468 residents	2
African-American alone (2013)	49.5 %	63.3 %	2
White alone (2013)	43.4 %	31.6 %	2
Households	269,057	250,319	1
Homeownership rate (2008–2012)	42.4 %	48.8 %	2
Median value of owner-occupied housing (2008–2012)	$443,000	$161,300	2
Vacant Housing Units (2008–2012)	35,479	55,807	2
Median household income (2008–2012)	$64,267	$40,803	2
Person below poverty line (2008–2012)	18.5 %	23.4 %	2
Status of stormwater / sanitary system	Combined & Separate	Separated	
Status of stormwater runoff permitting	Consent Decree	Consent Decree	
Status of air quality permitting	Non-attainment for smog, soot	Non-attainment for smog, soot	
Urban Tree Canopy Goal	40 % by 2035	40 % by 2037	

1 ESRI 2010; 2 U.S. Census Bureau 2012a, b

estimates contained in the 2008–2012 American Community Survey, Washington's median value of owner-occupied housing ($443,000), was nearly three times greater than Baltimore's ($161,300; United States Census Bureau 2012a, b). Finally, Washington D.C. had an estimated 35,479 vacant housing units, which is approximately one-third fewer than the 55,807 vacant housing units in Baltimore City.

Data Sources

This paper uses a combination of tree planting administrative data from urban natural resource management organizations and a commercial market segmentation dataset. These administrative data are collected primarily for program management purposes and not for research. Once standardized, they contain categories indicating the type of tree planting program, year, and location or addresses indicating where trees were planted. In Baltimore, there are five types of tree-related administrative data to analyze. Among the tree programs in Baltimore, requests for street tree maintenance are made using the city's non-emergency government services hotline "311" and street tree requests to the Department of Recreation and Parks. These two programs operate only in the public right of way (or non-parcel area called the "PROW"). The other three programs in Baltimore work on private residential properties. In Washington D.C., there are three types of tree programs. Street tree planting requests are made using Washington D.C.'s non-emergency government services hotline called "311," representing the only PROW-focused tree program in Washington, D.C. Each program is described in further detail in Table 2.

In cases when administrative data included only an address, the addresses were geocoded using the free software package Open Refine[1] to access the Google Maps API and retrieve a latitude/longitude pair. The latitude/longitude coordinates were converted to points in a GIS in order to integrate with other spatial datasets. All points representing the location of tree plantings were counted in each Census block group using the spatial join tool in ArcGIS 10.1 (ESRI 2012).

ESRI's year 2010 Tapestry market segmentation data were used to examine program participation from a geodemographic and business analytics perspective.[2] Tapestry is a geodemographic market segmentation that uses year 2010 Census block group boundaries (ESRI 2010). Geodemographic market segmentation is the process of classifying neighborhoods into categories based on a combination of demographic, socio-economic, and lifestyle characteristics. These market categories do not correspond neatly to a single characteristic such as race/ethnicity, or the age distribution within a neighborhood. Instead each market segment captures a range of demographic and socioeconomic traits that might be predictive of consumer behaviors, preferences, and lifestyles. Each Census block group is categorized as belonging to a single "LifeMode" market segment in the Tapestry database (ESRI 2010). For example, the LifeMode *Metropolis* is associated with 105,361 (42.09 %) and 65,726 (24.43 %) of households in Baltimore and Washington, D.C., respectively, and is characterized by households comprised of married couples and single parents with children living in older, single-family homes or

[1] http://openrefine.org/

[2] ESRI's methods and the description of each market segment can be found here: http://www.esri.com/library/brochures/pdfs/tapestry-segmentation.pdf

Table 2 Administrative data and program descriptions for used to examine participation in tree or rain barrel programs, by market segment, in Washington, D.C. and Baltimore, MD

City	Land use	Program	Description	Time	N	Cost to resident	Link to program
Baltimore	Public right of way (PROW)	Baltimore City Recreation and Parks street trees	Street trees planted by the city in response to citizen requests	2008–2012	4234	Free	Link
		311 Forestry Service Requests	All requests to the city's non-emergency services hotline pertaining to trees. This is used as a measure of citizen activity.	~2002–June 2013	35,483	Free	Baltimore 311 online
	Private residential properties	TreeBaltimore/ Blue Water Baltimore tree giveaways	Trees given to residents at farmers markets, school plantings and other events to be planted on private property	2008–2010, and 2012	1989	Free	TreeBaltimore GiveawayPage
		Volunteer Plantings	Trees planted by larger and highly professionalized organizations using volunteers. These groups include the Alliance for the Chesapeake Bay, Baltimore Orchard Project, Baltimore Tree Trust, Blue Water Baltimore, Jones Falls Watershed Association, Parks and People Foundation	2008–2012	1751	Free	Organized by various organization, no single site
	Mix	Neighborhood Plantings	Trees planted by localized, smaller community organizations, business improvement districts and faith-based groups including Downtown Partnership, Druid Hill Community Development Group, Ellerslie Public Housing, Episcopal Community Church, Gary Letteron, Labyrinth Sacred Space, Midtown Community Benefits District, Morgan State Delta Sigma Theta Sorority, Mt Vernon Business Association, New Cathedral Cemetery, Reservoir Hill Improvement Council, The Samaritan Women's Rain Garden, Windsor Hills Elementary, Windsor Hill Trail Committee	2008–2012	425	Free	Organized by various organization, no single site
Washington, D.C.	PROW	Requests for street tree planting from 311	Residents request street trees through the District's non-emergency hotline. Note that these requests may or may not have been met due to available space or other planting constraints.	2009–2012	4741	Free	Washington, DC 311 online

Table 2 (continued)

City	Land use	Program	Description	Time	N	Cost to resident	Link to program
	Private residential properties	RiversSmart Homes Trees	District Department of Environment responds to citizen requests for land management practices that reduce storm water runoff. One of the options includes trees. The non-profit Casey Trees sends a second auditor to determine along with the resident the species and location of the tree(s) to be planted by Casey Trees.	2007–2012	1959	$50	RiverSmart Homes Shade Tree Planting Request
	Private residential properties	Tree Rebates	Receipts for trees purchased by a resident are submitted to Casey Trees for either a $50 or $100 reimbursement depending on if it's a small ornamental or a large shade tree. The program is funded by District Department of Environment.	2007–2012	1978	$50 to $100 depending on tree size	tree rebate program from Casey Trees and DDOE

row houses built in the 1940s or earlier, and who tend to own fewer vehicles and rely more on public transportation (ESRI 2010).

Applications of geodemography are seen in several disparate fields from both research and practice (Holbrook 2001). For example, epidemiologists use geodemographic profiles to examine health care service utilization among different populations (Tao et al. 2013), or for service planning, social marketing, and benchmarking in public health (Abbas et al. 2009). School performance has also been benchmarked and evaluated within geodemographic segments (Gibbs et al. 2010). Recently, these methods for understanding people and place have increasingly been used in urban and community forestry research to understand spatial patterns (Grove et al. 2006a, b; Troy et al. 2007; Zhou et al. 2009; Boone et al. 2010; Bigsby et al. 2013; Grove et al. 2014). This article is the first known to use geodemographic techniques to answer urban forestry questions about processes of participation in land management-based sustainability programs.

Spatial and Statistical Analyses

An overall adoption rate was created by dividing the counts for each program by the total number of households for each city. An expected adoption rate was calculated for each market segment by multiplying the overall adoption rate, or initial fraction, and the number of households per LifeMode group in each city for each market segment (Eq. 1). The expected value is the proportion of trees that would be expected in a LifeMode group if they were equally distributed with respect to the number of households in each LifeMode group. Next, the adoption rate per LifeMode group, or counts of each program type in each LifeMode group, were divided by each group's expected value to create a group-specific fraction representing market adoption as a standardized rate or odds ratio (Eq. 2). This is illustrated using a fictitious example in Fig. 1. Using the pois.exact() function in the epitools package in the free R Programming Language, 95 % confidence intervals were computed (Aragon 2010; R Development Core Team 2013). While it may be unlikely that program adoption rates for households in each market segment are near the expected values (i.e. have an odds ratio equal to 1), the purpose of this paper is to understand *by how much* does participation deviate from a scenario of equitable distribution. Odds ratios are easy to interpret measures of association.

$$ExpectedValue_{LifeModeGroup} = \frac{\sum GreeningProgramCounts}{\sum households} \times population_{LifeModeGroup} \quad (1)$$

$$OddsRatio_{LifeModeGroup} = \frac{\sum GreeningProgramCounts_{LifeModeGroup}}{ExpectedValue_{LifeModeGroup}} \quad (2)$$

Participation rates in the land management-based sustainability practices of interest were then visually compared to existing and possible tree canopy. Existing tree canopy is "the layer of leaves, branches, and stems of trees that cover the ground when viewed from above" (O'Neil-Dunne 2009: 1). Possible tree canopy is the area that is non-road,

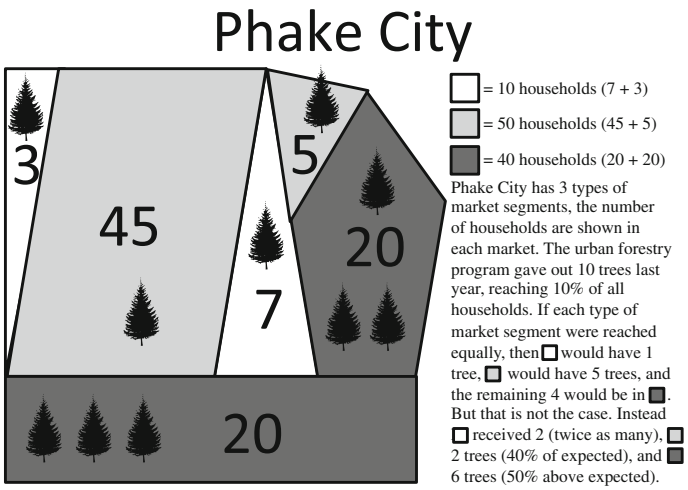

Fig. 1 This fictitious example shows how the standardized rates are computed. The fraction of all trees or rain barrels in a given market segment are divided by the proportion of households in that market segment type. Adapted from Locke (2014)

non-building, non-water, non-existing tree canopy and is used to estimate opportunities for additional tree canopy. The tree canopy estimates were derived from high-resolution (Washington, D.C., 0.6 m; Baltimore, 0.91 m) land cover maps using the Tabulate Area tool in ArcMap (ESRI 2012). Two estimates were derived, one for the public right of way ("PROW" or the non-parcel areas) within each LifeMode group for each city, and a second for only residential lands. These two estimates were needed to distinguish between and analyze differences between tree programs operating in the PROW and those on private lands. In each city, a parcel GIS database facilitated these analyses. The Object Based Image Analysis techniques and process for creating these maps are described by MacFaden et al. (2012) and O'Neil-Dunne et al. (2012), and the land cover maps are freely available online (Land Cover Washington, D.C. 2006 2009; Land Cover Baltimore 2007 2009)).

Results

Programs in the Public Right of Way

The results for participation in tree planting programs in the PROW, by market segment, are shown in Fig. 2. Market segments are arrayed from lowest income on the left to highest income on the right. The most affluent market segments shared two critical characteristics for this analysis. First, the most affluent market segments had the most existing tree canopy cover. Second, the most affluent market segments also participated the most in the reduced-cost tree programs. In contrast, some of the poorest market segments had the most opportunities for tree planting and the least participation in reduced-cost tree programs.

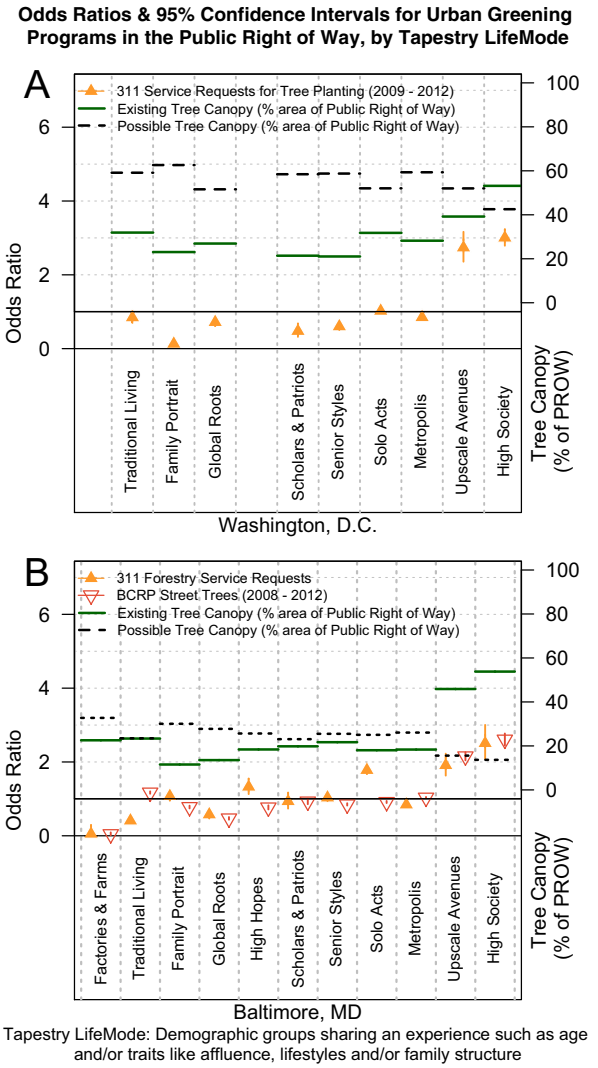

Fig. 2 Odds Ratios & 95 % Confidence Intervals for Urban Greening Programs in the public right of way, (PROW) by Tapestry LifeMode

Participation is quantified using odds ratios, abbreviated "OR". The symbols indicate the odds ratio, corresponding to the y-axis on the left. The horizontal line located at one on the y-axis indicates a situation where the ratio of households in that market segment to the proportion of service requests or street trees requests are equal. For example, people within the *Solo Acts* market segment in Washington, D.C. during the study period made 2341 requests (or 49.38 % of total) for new street trees using the non-emergency government service 311 system. The *Solo Acts* market segment is comprised of 130,062 households (or 48.34 % of all households), so the triangle in Fig. 2a is located at 1.02 on the y-axis (49.38 / 48.34=1.02=OR). Vertical lines span the estimated 95 % percent confidence intervals. The proportion of the PROW covered

with Existing Tree Canopy or Possible Tree Canopy are show with horizontal green or dashed black lines, respectively, and correspond to the y-axis on the right. These bars are not stacked and do not sum to 100 % because a portion of the PROW is not suitable for additional tree canopy because it is comprised of roads, railroads, buildings, or water.

In Washington, D.C. and Baltimore, MD, two market segments dominated participation in the tree planting programs: *Upscale Avenues* and *High Society*. Residents in these market segments in Washington, D.C. were on average 2.74, 95 % CI [2.36, 3.16] and 3.00, 95 % CI [2.80, 3.23] times more likely to request a street tree using the 311 hotline, respectively (Fig. 2a). In Baltimore City, forestry-related service requests from 311 (not planting requests), and planting requests through the Department of Parks and Recreation were also high among the same market segments. *Upscale Avenues* households were 1.91, 95 % CI [1.63, 2.22] times more likely to request a street tree from the Department of Recreation and Parks, and were 2.15, 95 % CI [2.05, 2.26] more likely to request forestry services such as pruning or removal of downed limbs. Similarly, households in the *High Society* market segment in Baltimore City were 2.51, 95 % CI [2.08, 3.00] times more likely to request a street tree and 2.61, 95 % CI [2.45, 2.77] to call 311 for other municipal forestry services (Fig. 2b). It is possible that rates are slightly lower in Baltimore because there are more categories of programs for which data are available, and therefore fewer counts per category. Despite the larger confidence intervals, the signal is the same for both cities. In both cities, the market segments with the most abundant tree canopy in the PROW are also the most active in requesting trees and tree-related services, particularly in Baltimore.

Programs for Private Residential Lands

The patterns for participation on private lands were similar to the programs working on the PROW. For example, participation for households in Washington, D.C.'s *Upscale Avenues* and *High Society* Market segments were 4.91, 95 % CI [4.12, 5.80] and 5.06, 95 % CI [4.63, 5.53] times greater than expected for the RiverSmart Homes program which plants trees for a $50 copay (Fig. 3a). Rebates for $50 or $100 s, depending on tree size, were also popular among these two market segments. *Upscale Avenues* and *High Society* households participated 3.90, 95 % CI [3.21, 4.70] and 4.76, 95 % CI [4.34, 5.20] times greater than if participation were equitably distributed among households in all market segments relative to the number of households of each type. The RiverSmart Homes program is more popular than the "do-it-yourself" rebate program within the *Global Roots*, *Senior Styles* and to a lesser extent the *Metropolis* and *Traditional Living* market segments.

There were more programs analyzed in Baltimore because there were more tree planting organizations. Comparable data on the locations of volunteer plantings were not available for Washington, D.C. Therefore the error bars for the Baltimore estimates are larger than for Washington, D.C.. However, similar trends were present. Giveaways were most popular among *High Society* OR =5.25, 95 % CI [4.34, 6.29]) and *Upscale Avenues* (OR =3.48, 95 % CI [2.94, 4.10]), with higher than expected rates among *Scholars & Patriots* (OR =1.53, 95 % CI [1.16, 1.97]), and *Traditional Living* (OR =1.36, 95 % CI [1.23, 1.51], Fig. 3b). Volunteer plantings were most common in *Farms & Factories*, *Upscale Avenues*, and *High Society* market segments with

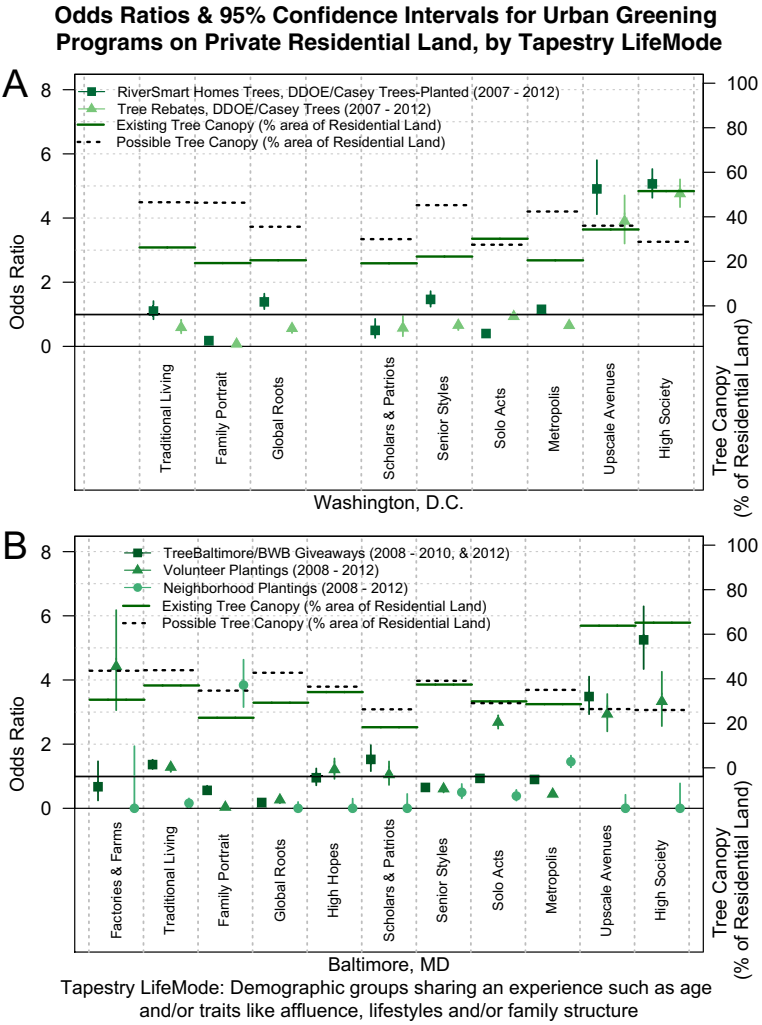

Fig. 3 Odds Ratios & 95 % Confidence Intervals for Urban Greening Programs on Private Residential Land, by Tapestry LifeMode

corresponding odds ratios of 4.42, 95 % CI [3.06, 6.18], 3.33, 95 % CI [2.57, 4.25], and 2.94, 95 % CI [2.40, 3.56]. Neighborhood plantings as a program type had the lowest adoption rate. No neighborhood plantings occurred in either the *Upscale Avenue* or *High Society* market segments.

Discussion and Conclusion

A number of urban sustainability goals are difficult or impossible to achieve with public land management alone. This is particularly true for tree canopy and water quality goals. It is necessary therefore to understand the motivations, capacities, and interests of private land managers. Using the paired cases of Washington, D.C. and

Baltimore, MD, we employed geodemographic market segment analyses to evaluate where formal attempts to increase tree planting programs were working, who they were reaching, and by extension who they were failing to reach. Geodemography is a strategic platform for operationalizing a business analytics perspective and for linking to other social ecological approaches and databases. Despite the key similarities and differences between these push and pull cities, participation in land management-based urban sustainability practices by geodemographic segment displayed similar patterns.

Our results are less consistent with some of the five social theories discussed previously than with others. With respect to theories of human population density, we would expect to observe trees being planted in areas where there is the most space for tree plantings, termed possible tree canopy. This was not the case. We found that the highest rates of tree planting occurred in areas with the lowest percent area for possible tree canopy and the highest percent area of existing tree canopy: the *Upscale Avenues* and *High Society* market segments (Figs. 2 and 3, Table 3). Given the luxury effect theory, we would expect that less-affluent neighborhoods would have high rates of participation once the cost of tree planting was minimized because trees were provided free or at a reduced cost. We found that this was not the case. Our results indicated that the two most affluent market segments, *Upscale Avenues* and *High Society,* were the most likely to participate in the free or cost-share programs to increase tree canopy on private lands. Further, if the luxury effect were to play a strong role, the free or heavily reduced cost for trees would result in tree planting program activities to be more uniformly or equitably distributed across a wider range of neighborhood types with varying levels of household income. But our data do not support this notion either. The existing outreach strategies are extraordinarily effective in affluent neighborhoods; but as Table 3 shows, these market segments comprise just 3.18 % of households in Baltimore, and 6.53 % of households in Washington, D.C.. In contrast, the *Metropolis* LifeMode group contains a plurality of households (42.09 %) in Baltimore. Almost half (48.34 %) of all households in Washington, D.C. belong to the *Solo Acts* market segment, yet the upper limit of the confidence intervals for participation odds ratios was always below 1 (Fig. 3a) for these market segments. Finally, our findings corroborate previous research using reference group behavior theory (Grove et al. 2006a, b; Troy et al. 2007; Zhou et al. 2009; Boone et al. 2010; Grove et al. 2014), which found that different sub-populations in urban areas may have different social and ecological values for trees (Kirkpatrick et al. 2012; Rae et al. 2010), indicating the importance of lifestyle and lifestage concepts associated with an ecology of prestige for explaining variation in these urban forests. Furthermore, not all residents will be persuaded to plant and steward trees (Braverman 2008; Kirkpatrick et al. 2012, 2013; Rae et al. 2010; Conway and Bang 2014), a point urban foresters and program managers may occasionally forget. In Baltimore, recent research demonstrates how attitudes towards tree plantings may vary both within and across ethnic groups, by country of origin, and other culturally meaningful identifiers. Lived experiences by individuals appear to strongly influence their attitudes for or against tree planting initiatives in the neighborhoods investigated (Battaglia et al. 2014).

It is of practical importance to understand public and non profit service delivery as it relates to urban environmental quality. This paper utilized public records, administrative data, a geodemographic market segmentation database, and high-resolution land cover data to assess where programs worked, who participated in these urban

Table 3 Descriptive statistics of households and tree canopy, by Tapestry LifeMode

Tapestry LifeMode market segment*	# of households		% of households		Amount of land (Square miles)		Percent of land		Existing tree canopy (% of area)		Possible tree canopy (% of area)	
	Baltimore	DC	Baltimore	DC	Baltimore	DC	Baltimore	DC	Baltimore	DC	Baltimore	DC
High Society	2804	13,749	1.12	5.11	2.47	9.47	3.03	13.86	56.43	61.18	29.55	27.66
Upscale Avenues	5166	3834	2.06	1.42	3.95	1.22	4.85	1.79	49.05	36.40	37.21	42.23
Metropolis	105,361	65,726	42.09	24.43	31.71	16.40	38.95	24.00	25.78	28.77	41.66	49.08
Solo Acts	36,718	130,062	14.67	48.34	5.61	17.37	6.89	25.42	21.94	35.44	35.16	34.99
Senior Styles	25,916	14,070	10.35	5.23	8.78	3.34	10.78	4.89	27.12	26.41	47.51	47.89
Scholars & Patriots	4869	3578	1.95	1.33	0.46	4.83	0.56	7.07	18.88	9.35	32.52	62.45
High Hopes	7260	–	2.90	0	2.77	–	3.40	0	23.20	–	45.22	–
Global Roots	11,083	13,374	4.43	4.97	2.52	3.66	3.10	5.36	25.99	31.13	49.29	42.16
Family Portrait	16,866	16,809	6.74	6.25	3.55	3.95	4.36	5.78	17.93	29.94	45.93	48.38
Traditional Living	33,153	7855	13.24	2.92	12.52	2.68	15.38	3.92	32.64	34.77	42.13	45.44
Factories & Farms	1123	–	0.45	0	0.48	–	0.59	0	34.17	–	46.08	–
Undefined	24	22	0.01	0.01	6.60	5.40	8.11	7.90	13.53	24.76	62.75	53.46
Total	250,343	269,079	100	100	81.42	68.33	100	100	–	–	–	–

* Descriptions of each LifeMode description can be found here: http://www.esri.com/library/brochures/pdfs/tapestry-segmentation.pdf

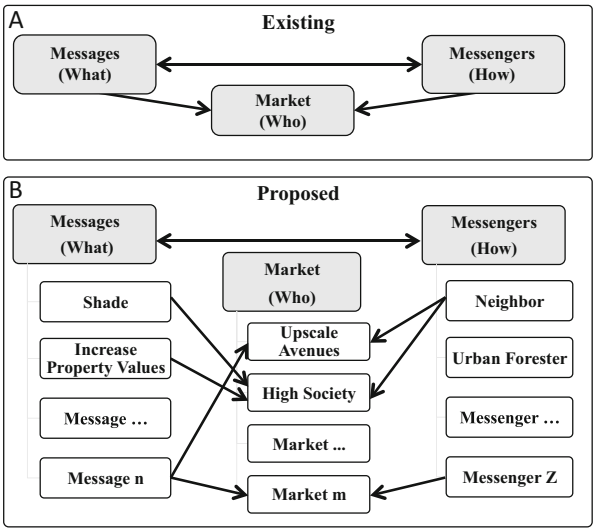

Fig. 4 Market Diversity for Urban Residential Land Management and Sustainability Practices. Existing approach assumes only one combination of market, messages and messengers for the entire population. Proposed approach hypothesizes that there are sub-population markets and that one or a combination of messages and markets may be needed to increase adoption of residential land management practices to enhance local sustainability. In the hypothetical example shown, the messages of shade and increase property values resonate well and are successful among households in the *High Society* market segment, when communicated by neighbors – the messenger

sustainability programs, and who the programs failed to reach in different markets. Because we found differences in participation by geodemographic segment, future work grounded in adoption of innovation and diffusion of knowledge (Rogers 2010) could test whether there are different types or combinations of messages and messengers for different market types. For instance, households who are renters or have fixed incomes–either retirees or on public assistance–may not be interested in the message that trees increase property values if increasing property values cause them to be displaced because they can not afford higher rental rates or property taxes. Certain types of "messengers" might not be effective. For instance, tree coupons sent by postal mail service might be lost in the mix with other commercial mail and advertisements. It is also possible that the well-intentioned urban forestry organizations in our study are seen as outsiders in some neighborhoods. Distributing trees through known, local, established and/or trusted neighborhood groups might be more successful because these organizers are viewed as insiders and members of their reference group.

We propose that a new framework needs to be developed and tested for public and non-profit service delivery of sustainability practices that depend upon private land management. The traditional service delivery model for environmental programs has tended to rely upon a top-down approach based upon a singular set of benefits and communication method to influence, for instance, residents to plant a tree (Fig. 4a). However, in this paper we have found large differences in response to this approach by lifestyle group or "market segment:" in some cases a fivefold difference between market segments. We suggest that in areas where participation was high, an appealing message about the benefits of

adoption was combined with an appropriate means or messenger for delivering the message. In contrast to the traditional model, Fig. 4b suggests that for many market segments there may be a preferred blend of message and messenger that will be most successful in influencing the adoption of land management based sustainability practices. The pane on the bottom illustrates a shift from the traditional model with the question "which messages, delivered with which messengers, will be most successful in each market segment?" Essentially, we anticipate that outreach could be more effective when a locally appropriate type or combination of messages–content or the "what"–and messengers–means of message delivery or the "how"–are matched to the needs and perceptions of people in different market segments (Fig. 4b). While we recognize that there may be some groups who have no interest in planting trees, regardless of the combination of messages and messengers, this new framework could be more successful in doing the hard work in all places: achieving equitable rates of participation to enhance the sustainability of cites.

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Appendix 1

- Washington, D.C. Resources
  - RiverSmart Homes homepage

    RiverSmart Homes Application for Low Impact Development options including trees for DC residents

    Tree rebate form
- Baltimore Resources
  - TreeBaltimore homepage

    Free trees
  - 311 Service request

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