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Homeowners' Willingness to Adopt Environmentally Beneficial Landscape Practices in an Urbanizing Watershed

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Streams in urbanizing watersheds often experience low flows in summer due to increased water use for residential landscaping and decreased base flow as impervious land cover limits aquifer recharge. Environmentally beneficial landscape practices that save water and infiltrate runoff have the potential to provide multiple ecological benefits including reducing stress on urban streams, but can face opposition by local homeowners. Thus, this study explored attitudes toward landscape water conservation including the barriers and motivations that exist to adoption of water conserving landscape practices by residents in the Ipswich River watershed north of Boston, Massachusetts (USA) that experiences seasonal water shortages. The study used a mail-out and on-line survey with images of different water conserving landscape practices (including rain gardens and native plantings) and questions about homeowners' watering practices, likelihood of adopting these landscape practices, and attitudes towards environmental issues in the region, including existing water policies to restrict use. The results showed that residents (n=265) were aware of existing water shortages and supportive of water conservation policies. Their willingness to adopt water conserving landscape practices was influenced by aesthetic preference with more support for practices that appeared neat rather than those that appeared unkempt. Barriers to residential adoption of these landscape practices included concern about disease-carrying pests and the perceived cost of landscape change. Knowledge about the environment, as operationalized by membership in a local watershed association, as well as educational attainment and income were statistically significant variables in predicting aesthetic preferences and willingness to adopt landscape practices. Promoting widespread adoption of water conserving landscape practices could benefit from local community support and educational initiatives about the multiple-benefits of these practices, including potential long-term cost savings for homeowners. Residential landscape design and management, however, are only part of overarching policy changes that could address water conservation in urbanizing watersheds.

Keywords

residential landscaping, water conservation, stormwater management, homeowner attitudes, Ipswich River watershed, Massachusetts, suburban landscape preference

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INTRODUCTION

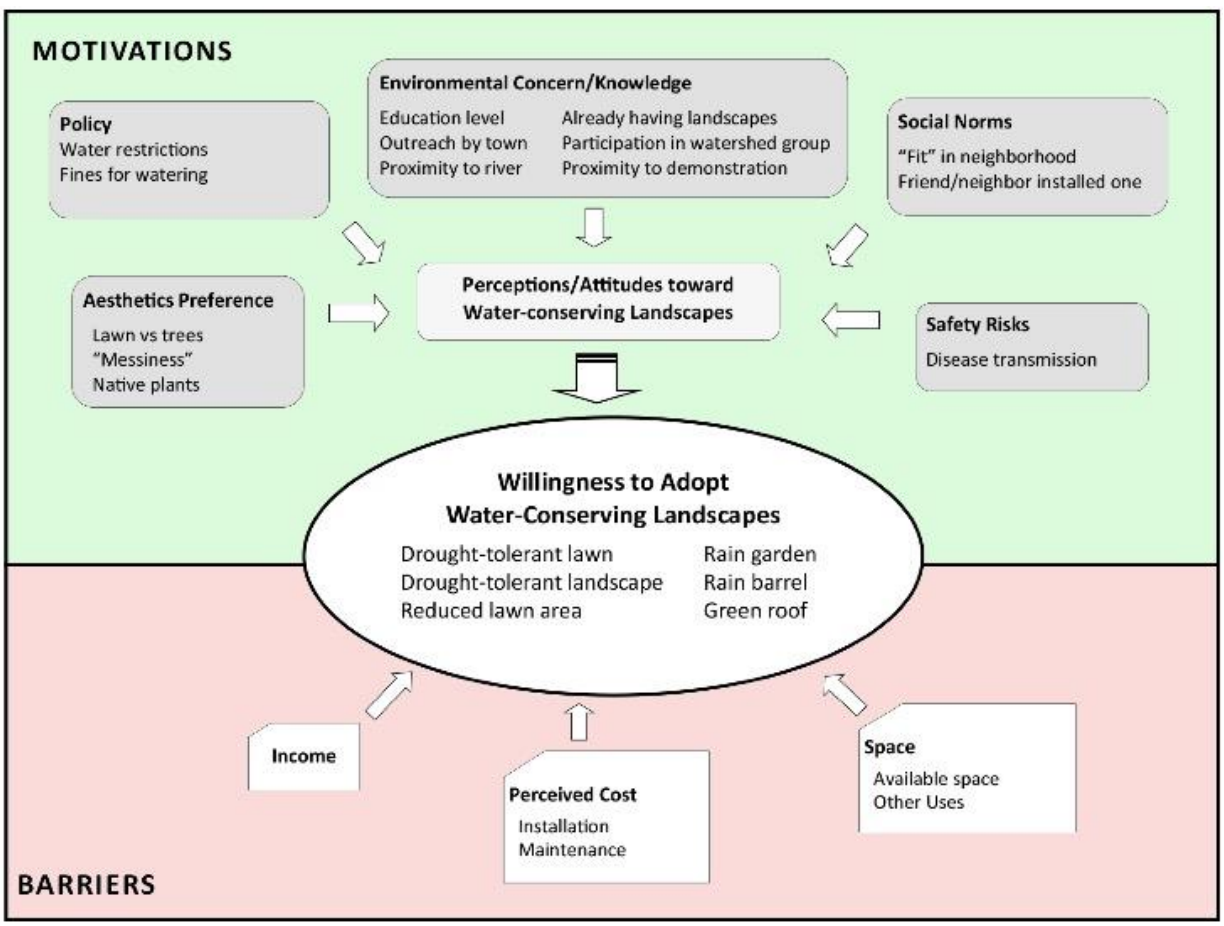
Suburban and exurban residential landscapes comprise a growing proportion of the land in the United States (U.S.) and around the world (Hamidi et al. 2015, Barrington-Leigh and Millard-Ball 2020). These landscapes typically have extensive impervious surfaces (e.g., roads, rooftops, driveways, parking lots), resulting in increased runoff and reduced infiltration relative to natural areas (Arnold and Gibbons 1996; Wilson and Chakraborty 2013), with various consequences on base flows (Bhaskar et al. 2016). Suburban landscapes also have large areas of lawn, which can have high seasonal water demand (Grimm et al. 2008; Bowling and Mackin 2003; Runfola et al. 2013). In fact, according to recent estimates of land cover data, turf grass has surpassed corn in area of irrigated 'crops' in the U.S. (NASA 2014). Collectively, impervious surfaces and water use, coupled with climate change and more frequent droughts, have potential to greatly impact water resources at local and regional scales (Bates et al. 2008).

Water conserving landscapes offer a potential solution to reduce the impact of suburban development and improve water quality and quantity. In this paper, we use water conserving landscapes broadly to describe a range of green infrastructure practices (Benedict and McMahon 2006) focused on water conservation, including low impact development (LID) (US EPA 2020), water sensitive urban design (WSUD) (Donofrio et al. 2009), xeriscaping (Sovocool et al. 2006), and other residential practices that reduce demand on potable water (Rostad et al. 2016). For example, rain barrels and cisterns harvest stormwater runoff from roofs, reducing stormwater volume, and, if stored, water is used to replace potable water, reducing water demand (Steffen et al. 2013). Another water conservation practice is replacing lawns with rain gardens, which not only reduces the need for lawn maintenance and watering, but also promotes infiltration of runoff from upslope areas (Jennings et al. 2015). Simply landscaping with trees and appropriate native plants can reduce outdoor water use and increase stormwater infiltration (Calkins 2012).

While water conserving landscapes offer numerous benefits, widespread adoption of such landscapes is limited (Rector and Obropta 2016; Coleman et al. 2018) due to a variety of motivations and barriers that influence attitudes toward water conserving landscapes, as outlined in Figure 1. Lack of adoption may be due to homeowners' attitudes toward water conserving landscapes, which is influenced by aesthetic preferences and social norms, among other motivational factors. Environmental psychologists, such as Stephen and Rachel Kaplan (1989), have proposed that humans across many different cultures have an innate preference for smooth ground cover and lawn with widely spaced trees. The traditional suburban lawn is deeply imbedded in U.S. cultural norms (Jackson 1982). Neighborhood characteristics (i.e., the type of dominant landscaping and vegetation cover) further influence the types of landscape practices that homeowners maintain (Larson et al. 2010) and homeowners' acceptance of native landscaping (Nassauer et al. 2009). The few studies that have explored homeowners' preference for native plantings emphasize the importance of intentional design cues, such as masses of flowering plants edged with lawn or other borders, for widespread acceptance (Nassauer 1995; Ryan 2010). For practices such as rain gardens and rain barrels, aesthetics was also found to be an important factor in homeowners' willingness to install (Beery 2018; Baptiste et al. 2015). These aesthetic preferences may also be related to the landscape context and whether these practices are socially accepted in the neighborhood (Nassauer et al. 2009; Larson et al. 2010).

Knowledge and awareness about environmental issues also likely influence attitudes toward and adoption of water conserving landscapes, an assumption that is supported by the literature and which guides our study (Fan et al. 2017; Larson et al. 2010; Nassauer 1995; Nassauer et al. 2009; Ryan 2010). Several studies suggest that if homeowners understood the efficacy of environmentally beneficial practices, they would be more motivated to adopt them (Baptiste et al. 2015; Bowman et al. 2012). For example, homeowners who are more knowledgeable about natural ecosystems are more likely to support using native landscaping (Nassauer 1995; Nassauer et al. 2009; Ryan 2010). Thus, informing and educating landowners of the benefits of water conserving landscapes may positively affect willingness to implement these practices and adoption rates (Baptiste et al. 2015). Demonstration projects are one strategy for developing knowledge about water conserving landscapes, as illustrated by a study of the educational impacts of rain gardens and bioswales in Portland, Oregon (Church 2015). Many outreach programs are explicitly designed to address the idea that lack of knowledge limits adoption; however, few studies have assessed whether outreach improves attitudes toward water conserving landscapes (Church 2015; Beery 2018).

Figure 1: Motivations and Barriers to Willingness to Adopt Water-Conserving Landscapes



Concerns about safety risks and policies aimed at deterring water use also influence attitudes toward water conserving landscapes. Homeowners' adoption of water conserving landscapes may be influenced by health and safety concerns that raingardens and other water storage techniques are breeding grounds for mosquitoes and other insects (US Geological Survey 2015). In the northeastern United States, ticks that harbor Lyme disease are a major concern in tall grass and brushy areas (CDC 2019). With concerns about drought, many places adopt regular or weather-driven water restrictions and fines for outdoor watering (Jedd 2019). These restrictions may raise awareness about water shortages and create the need to transform existing water-thirsty landscapes into those that can survive on limited supplemental water (Rector and Obropta 2016; Brownlee et al. 2014).

Even if homeowners have positive attitudes toward water conserving landscapes, they may not adopt the practices. One of the challenges of behavior change is that there can be a disconnect between homeowners' stated attitudes and their actions (Larson et al. 2010). Homeowners may state that they want to conserve water but do not adopt water conserving practices due to barriers such as cost, time, and space. The economic cost of landscape change and installing stormwater management, coupled with the relatively inexpensive cost of water (i.e., limited economic burden of current landscapes), may be a barrier to change (Espey et al. 1997; Olmstead and Stavins 2007; Baptiste et al. 2015; Beery 2018; Thurston et al. 2010). Larsen and Harlan (2006) found that income was a significant factor to adopting water conserving landscapes, with those in higher income brackets more willing to adopt xeriscaping in Arizona than lower-income homeowners, who preferred to maintain traditional lawns. Nassauer et al. (2009), on the other hand, did not find a difference in stated preferences toward "ecologically-beneficial" landscapes between income groups. In addition to installation costs, concerns about maintenance may also negatively influence adoption (Baptiste et al. 2015). Change can take a lot of initiative—financial and behavioral—and homeowners can be averse to changing the landscape, particularly if professionals created it (Larsen and Harlan 2006). Finally, available space on one's property for water conserving practices and opportunity costs of using the property for other purposes also likely affect actual adoption (Coleman et al. 2018), even if homeowners have positive attitudes toward water conserving landscapes.

While studies indicate that homeowners' willingness to adopt water conservation strategies may be influenced by a variety of motivational factors and barriers, these studies are geographically dispersed with few to date in the northeastern U.S., which is the focus area of our study. The northeastern U.S. is dominated by both temperate and continental climates with consistent precipitation (Bartels et al. 2020; NOAA 2020) and is not generally thought to have the water shortage concerns common in arid regions (Flicklin et al. 2015); however, changing climates have influenced precipitation patterns in the northeast causing more frequent droughts (Vose et al. 2016) and suburban areas such as the Ipswich River Watershed north of Boston, Massachusetts (MA) have experienced human-exacerbated drought in rivers in the last couple decades (Bowling and Mackin 2003; Quintana 2016). Regional assessments of homeowners' willingness-to-adopt water conserving landscapes are needed to identify motivations and barriers to adoption. Through a written survey, we assessed motivations and barriers to adoption of water conserving landscapes directly through questions about willingness-to-adopt specific practices and what factors would influence willingness-to-adopt, and indirectly through rating of pictures of different landscapes and associated free-form comments. The study was designed to assess whether willingness-to-adopt varies based on homeowners' (1) knowledge about water conservation, exposure to outreach efforts and concern for the environment; (2) residential proximity to demonstration projects or nearby waterways; (3) income and education level; and

(4) perceptions about the aesthetic appearance of different landscape practices. We specifically hypothesized that homeowners that would be more willing-to-adopt environmentally beneficial practices if they had 1) more knowledge about water conservation (as measured by living in towns with education program and membership in local watershed association) and concern for the environment; 2) live near (within 400 m) demonstration projects or waterways; 3) higher income and education levels; and 4) more acceptance of messier appearing landscape practices, such as taller grass and overgrown rain gardens. Increased understanding of motivations and barriers could help managers focus on strategies that are most likely to improve water conservation.

METHODOLOGY

Study Area

The Ipswich River is an important water source for residents of Boston's North Shore. This 45-mile (72.4 km) river drains 155 square miles (401.4 sq. km) covering 21 towns (Massachusetts Executive Office of Energy and Environmental Affairs 2014). More than 330,000 people rely on the river for drinking water through both surface and groundwater withdrawals, even though only approximately 160,000 live within the watershed (Ipswich River Watershed Association 2014). In the 1990s and early 2000s, the river ran dry several times and resulting fish kills prompted policy actions to address the over-withdrawals (Ipswich River Watershed Association 2014). In 2003, American Rivers (a non-governmental organization based in Washington, DC) named the Ipswich River the third most endangered river in the U.S. (American Rivers 2003). During the past decade, seasonal outdoor water use restrictions have been implemented by the state and local governments to curb water demand during summer months when river flows are lowest. While these restrictions have improved flows in the river, climate change and variable precipitation levels during dry years introduce uncertainty to the river's flow regimes, with low stream discharge (below 2 c.f.s./0.057 m^3/s) in summers 2013, 2014, 2016, and 2020 that have negatively impacted stream biota (US Geological Survey Water Resources 2021; Döll and Zhang 2010; Quintana, 2016). Thus, additional water conservation measures are needed to restore flows in the watershed.

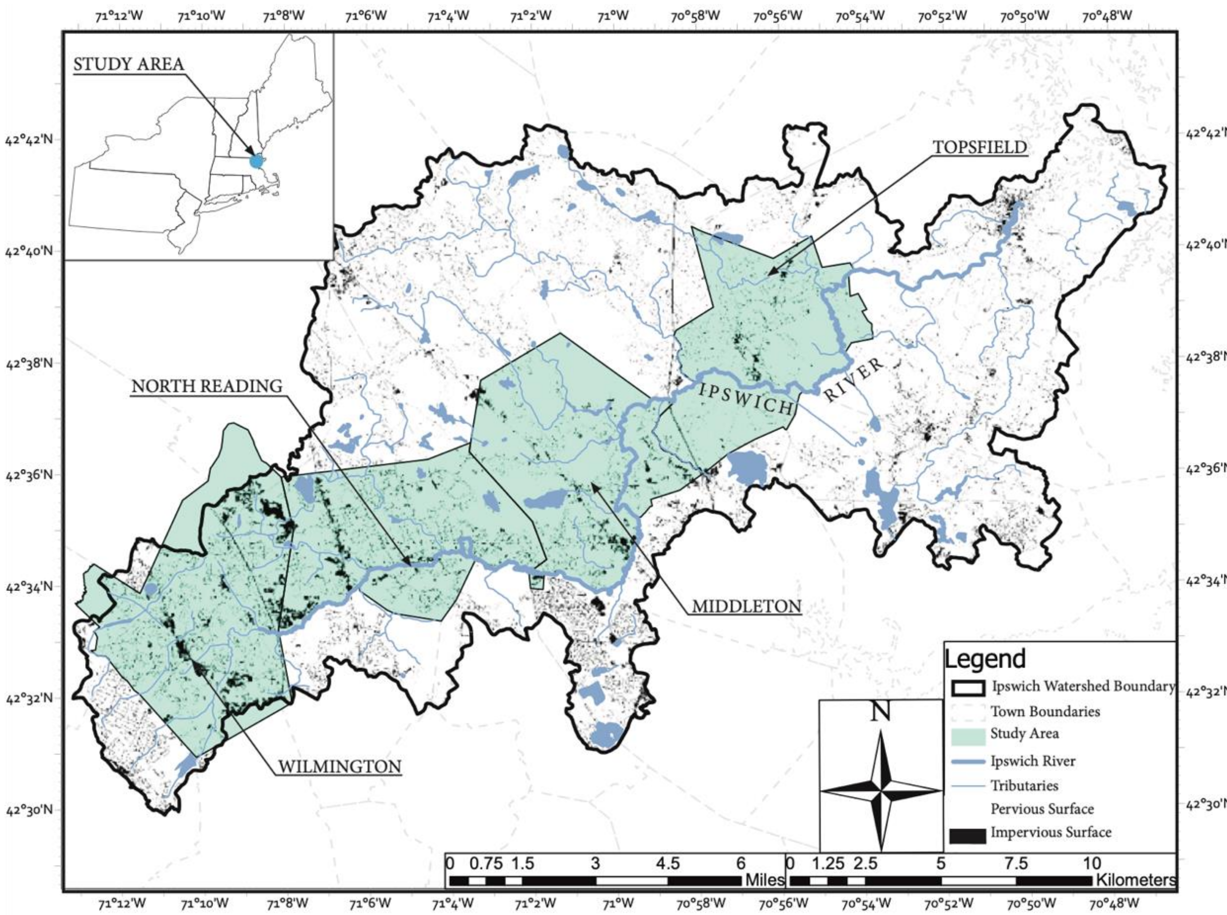
The U.S. Environmental Protection Agency and Massachusetts Department of Conservation and Recreation have adopted a two-pronged approach to reduce residential water use and to infiltrate stormwater in the watershed which includes implementing 1) landscape demonstration projects on town-owned and residential properties and 2) water conservation education programs through the non-profit Greenscapes Northshore Coalition (Zimmerman et al. 2010; U.S. EPA 2005; www.greenscapes.org). In addition, some towns in the watershed have adopted seasonal water bans to meet the state and federal water goals for the Ipswich River. These water bans have varied by town and the severity of the water shortages, and range from restricted days and times for watering to bans of all outdoor watering.

The study was conducted in four towns in the middle of the Ipswich River watershed that have experienced water bans in the past few years (Fig. 2): Wilmington (pop. 22,626), North Reading (pop. 15,076), Middleton (pop. 9,131), and Topsfield (pop. 6,211) (U.S. Census Bureau 2013). The towns varied from more developed towns with less new growth (Wilmington and

North Reading) to more rural, rapidly growing towns, such as Middleton which had an 18% population increase in the past decade. Two of the towns, North Reading and Topsfield are members of the Greenscapes program that run workshops and provide information to homeowners about environmentally-sensitive and water-conserving landscape practices (www.greenscapes.org). Also, two of the towns, Wilmington and North Reading have neighborhoods with water conserving demonstration projects with rain gardens and permeable paving. While most residents of the four towns are on public water supply, Middleton has approximately 35% of households that rely on private wells for drinking water.

Figure 2. Ipswich River Watershed Study Area

The four study towns (shaded in green) are along the mainstem of the Ipswich River north of Boston, Massachusetts (USA)



Survey Questions

The survey was a six-page written survey (see Supplemental Information) that asked questions to assess motivations and barriers to adopting water conservation practices. Specifically, we asked survey participants about their opinions on effectiveness of water conserving practices/behaviors and their willingness to adopt them (Q14) and whether they had specific water-conserving landscape features and their willingness to implement them (Q15). Most willingness-to-implement questions used a 5-point rating scale (1=not at all to 5=extremely). We also asked what specific factors might encourage them to adopt a rain garden (Q16), to replace lawn with meadow or groundcover (Q20), and to reduce outdoor water use (Q21). For these questions, higher scores (i.e., closer to 5) indicated that these variables were more important for making decisions. To assess differences in responses based on study objectives, we collected information about awareness of water bans and concern for environmental issues (Q17–19; Objective 1), proximity to a waterway (Q6 and survey sample; for Objective 2), and income and education (Q25–26; Objective 3). We also asked several background questions to better understand the surveyed population and their properties, including age, gender, property size, property ownership, and water source (public or private).

To assess perceptions of aesthetic appearances of different landscape practices, the survey included a photo-questionnaire of 20 color scenes showing a range of water conserving landscape techniques that were grouped into eight labeled categories according to feature type (e.g., forest and lawn, driveway type, taller grass height, less lawn, rain gardens, rain barrels, naturalize lawn, and drought tolerant landscapes). Participants were asked to rate the photos according to how much they would like to have these landscapes in their own yard using a 5-point scale (1=not at all to 5=a great deal). At the end of the section, participants were asked to write comments next to their highest and lowest rated photos to help us understand factors that influenced their ratings.

The photo sampling methodology developed by Kaplan and Kaplan (1989) was used to select the images. Most photographs were taken in the watershed, including at demonstration projects, and care was taken to avoid showing cars or people in the image that would potentially bias the viewer. As described by Kaplan and Kaplan (1989), images were kept uniform for seasonality, lighting, and camera angle (eye level and 55-degree angle). All photos were taken during summer months on sunny days to show plants in bloom and green grass. Care was taken to focus images on the landscape rather than the houses, streets, or other distracting elements. For each of the eight labeled categories, a range of conditions was selected. For example, rain garden images varied by level of maintenance and vegetation composition, such as ratio of ornamental grasses to perennials. The less lawn category had images that varied from yards with about half lawn and perennials, which was the most preferred level in previous studies (Nassauer 1995; Ryan 2010), to entirely perennials and shrubs with no lawn. The final sample of 20 scenes was drawn from hundreds of images and reviewed by landscape experts and a sample of local residents as part of pre-testing the survey instrument. The pre-test of the draft survey by a small sample (n=8) of local experts (landscape professionals, agency, and non-profits), as well as residents included filling out a draft survey then commenting on issues related to understandability, survey length, and image selection. While we acknowledge that a larger number of scenes could have been used in the survey to increase the representation of the conditions portrayed, as Kaplan and Kaplan (1989) suggest, it was important to limit the survey length to make sure it was not too time-consuming participants to fill out. Thus, the photo preference section comprised three pages of the six-page survey (see Supplemental Information). For more details on photo sampling methodology see Stacy (2015).

Survey Distribution

A total of 1,000 households evenly divided between the four towns were selected to receive the study survey. The 250 residents per town were further divided between 150 randomly selected homeowners, 50 members of the local watershed association, and 50 residents who lived near (i.e., within 400 m) a demonstration rain garden (Wilmington/North Reading) or the main stem of the river (Topsfield/Middleton), with the assumption that members of these latter two groups had higher knowledge about water resource issues in the Ipswich than the randomly selected residents and, subsequently, might be more supportive of environmentally beneficial practices. While we acknowledge that the towns have different population sizes, the rationale for sampling them equally was that we were interested in exploring comparisons between the towns. Although the sample size was relatively small, it was still large enough to allow statistical comparisons (see Stacy 2015 for further details on sampling methodology).

A modified Dillman (2007) approach with reminder postcards and a follow-up survey to non-respondents was used to increase the response rate. In addition, an online version of the survey was created in Survey Monkey and sent to members of two local watershed associations. Of 1,000 surveys mailed, 265 were either returned via mail or completed online and four were returned undeliverable, for an effective response rate of 26%, which is typical for mail-out surveys (Babbie 2013).

Data Analysis

Numerical survey responses were analyzed using both Microsoft Excel and SPSS Version 19. Descriptive statistics were generated to determine the means, modes, frequencies, and standard deviations of the survey results. Next, factor analysis was conducted on individual multiple-item questions to create meaningful categories for dependent variables. Factor analysis is helpful for discerning patterns among large numbers of variables (Babbie 1990) and was used by Kaplan and Kaplan (1989) in their description of Category-Identifying Methodology for landscape preference studies. Factor analysis used principal axis factoring with varimax rotation and pair-wise deletion of missing data; eigenvalues greater than 1.0 were included and values under 0.4 were suppressed. Items that loaded on more than one factor were not included in subsequent scales. Cronbach's coefficient of internal consistency, alpha, was also used to determine the degree of fit between the items within each category (Cronbach 1951). The resulting categories of the factor analyses were used to create scales by calculating participant's average rating of the items that formed the category and named according to the common theme they shared. Each scale then became a dependent variable that was used in subsequent analyses.

Chi-square tests were run to assess the population distribution among sub-groups. Independent means t-tests and one-way analysis of variance (ANOVA) with Bonferroni post-hoc tests were used to compare groups based on membership in the watershed association, proximity to the river and demonstration projects, and socio-economic variables. We tested for unequal variance between groups using Levene's test. Qualitative data from participants' descriptions of their highest and lowest rated photos (Q21) were assessed using word counts for frequency and then grouped by emergent themes (Gaber and Gaber 2007).

RESULTS

Participant and Property Description

In general, the survey population showed a moderate tendency toward more highly-educated and older respondents than the adult population in the study area (US Census Bureau, 2013), which is consistent with previous landscape preferences surveys (Nassauer et al. 2009; Larson et al. 2010; Armstrong and Stedman 2012). About half of the sample was in the 45-64 age range (53.6%) and more than a third were 65 years or older (36.2%). The sample had a higher percentage of men (60%) than women, which reflects the original mailing list, where 65% of survey addressees listed a male as the property owner. Participants' household income mirrored that of the study area as a whole with the majority (56.3%) having above the median income of $100,000 USD (U.S. Census Bureau 2013). Most participants were college graduates (71%), which is representative of homeowners, but higher than the percentage of college graduates in the census areas as a whole (52%). Almost the entire sample were homeowners (99.2%) with only two renters (0.7%), which is not surprising since the survey was sent to property owners.

About half of the survey respondents (49%) were randomly selected homeowners, and the other half was divided between members of a local watershed association (26%), and those who lived near LID demonstration projects (12.5%) or the mainstem of the Ipswich River (12.5%). The majority of respondents have property between ¼ - 1 acre (0.10-0.40 ha) in area, primarily covered by lawn (53% have more than half lawn, while 25% have more than half woods). More than one-third of respondents have a water body on or bordering their property, and most of these properties do not have irrigation systems or pools. In addition, a majority of participants (66%) reported that they currently did not water their lawn. The majority (82%) of participants have public water; respondents with private wells were primarily from the more rural towns of Middleton and Topsfield. See Stacy (2015) for more details on participant and study area population comparisons.

Knowledge and Concern for Environment

The results showed that study participants were aware of outdoor water restrictions and generally felt that they were both necessary (mean=4.08, S.D.=1.14 on a 5-point scale with "1=not at all; 2=a little; 3=somewhat; 4=a lot; 5=a great deal") and a relatively effective strategy to reduce water use (mean=3.80, S.D.=1.14). Furthermore, 93% of respondents indicated that their towns had water restrictions in the past year.

In terms of environmental concern, respondents indicated that the most serious concerns related to poorly planned development and having fewer fish in river and ponds. In general, participants were least concerned about there being too many environmental regulations. We were interested in testing whether people with higher concern for water-related environmental problems would more likely to be willing to implement low-impact development strategies, so we used factor analysis to develop a combined category (Table 1) that was used in subsequent analysis.

Membership in a local watershed association was used as a proxy for environmental knowledge. Watershed members rated the category of "water-related environmental problems," including items such as lack of drinking water and fewer fish in rivers and streams, to be significantly more concerning (mean=3.15, n=64) than did other randomly selected respondents (mean=2.52, $p<0.001$, $t=-2.85$, d.f.=178, n=114). These results support the first part of our hypothesis that watershed members and those living near demonstration projects would be more concerned about environmental issues; it will be interesting to see if this translates into more willingness to adopt environmentally-beneficial landscape practices. However, there were no significant differences in concern by those living near the river or demonstration projects.

Table 1: Perception of Environmental Problems

Environmental Problems:	Eigenvalue/ Loading	Mean	S.D.	α
Category: Water-related	**2.83**	**2.74**	**1.565**	**0.687**
Fewer fish in rivers and ponds	0.886	3.04	1.63	
Availability of drinking water	0.501	2.44	1.34	
Individual items				
Poorly planned development		3.02	1.38	
Climate change		2.91	1.38	
Flooding		2.74	1.35	
Too many environmental regulations		2.34	1.38	

Willingness to Adopt Environmentally-Beneficial Landscape Practices: Motivations and Barriers

In general, participants were more likely to have drought-tolerant landscapes or lawns than other practices in the list of survey items and more willing to adopt these practices in the future, including reducing their lawn area. Almost 20% of participants had rain barrels or other catchment systems; however, rain gardens were much less prevalent or likely to be adopted by participants. Factor analysis revealed one factor that characterized participants' willingness-to-adopt landscape practices (Table 2), which was used as the response variable when assessing factors influencing adoption.

Table 2: Willingness to Adopt Landscape Practices

Feature	Eigenvalue	Mean	S.D.	α
Category: Willingness to Adopt	**3.438**	**2.49**	**1.71**	**0.853**
Feature	Loading	Mean	S.D.	Have now
Drought-tolerant lawn	0.770	3.24	1.56	61 (23%)
Drought-tolerant landscape	0.782	3.18	1.58	59 (22%)
Reduced lawn area	0.740	2.70	1.63	67 (25%)
Rain barrel or catchment system	0.690	2.57	1.76	51 (19%)
Rain garden	0.695	2.23	1.60	19 (7%)
Green roof	0.494	1.11	1.00	2 (0.7%)

The highest rated motivation for installing a rain garden was a financial incentive, “not having to pay for it”. Respondents were mid-range in their perceptions of whether a rain garden would improve the look of their property. Receiving technical assistance and helping reduce flooding were also considered a somewhat important motivator for installing a rain garden. In contrast, social influences (“If a friend or neighbor installed one”) was rated significantly lower by the majority of respondents. The motivations to install a rain garden were combined into one factor (Table 3).

Table 3: Motivations to Install a Rain Garden

Factors that encourage installation of a rain garden	Eigenvalue/ Loading	Mean	S.D.	α
Category: Rain Garden Motivations	**3.262**	**2.84**	**1.06**	**0.853**
Not having to pay for it	0.703	3.71	1.53	
My property looked more interesting	0.731	3.10	1.34	
Reduction in my sewer and water bill	0.697	3.05	1.52	
Receiving technical assistance on how to construct one	0.741	2.90	1.49	
Decreased flooding in my neighborhood/on my property	0.441	2.72	1.53	
If a friend or neighbor installed one	0.701	1.68	1.11	

A little more than half of participants (57%) indicated that they would replace part of their lawn with meadow or groundcover. Participants were then asked to indicate the importance of different reasons for their decision (Table 4). A factor analysis of the list of reasons that influenced their willingness to replace their lawn revealed two factor categories– 1) ‘utilitarian,’ which includes concerns about costs, not having enough time, reducing water use, and ticks (i.e., disease causing insects that live in tall grass), and 2) ‘appearance,’ which grouped the two variables related to concerns about fitting in with the neighborhood aesthetic and the idea that meadows are perceived as messier/less tidy. The higher the rating on the 5-point scale the more participants considered this reason to be important in their decision, which allowed us to combine items that had both negative and positive connotations into the same category.

Table 4: Factors Influencing Willingness to Replace Lawn with Meadow/Groundcover

Importance of the following factors:	Eigenvalue/ Loading	Mean	S.D.	α
Category: Utilitarian Reasons	**3.445**	**3.39**	**0.99**	**0.82**
Landscape changes are expensive	0.771	3.75	1.24	
Concern about ticks	0.436	3.57	1.47	
Lack of free time to implement changes	0.720	3.43	1.36	
Cost of landscape maintenance	0.761	3.34	1.35	
Amount of time spent on maintenance	0.663	3.30	1.42	
To reduce water use	0.497	3.20	1.30	
Category: Appearance	**1.702**	**2.95**	**1.31**	**0.76**
Lawn is a better fit for my neighborhood	0.660	2.97	1.44	
Lawn looks neater than meadow	0.901	2.95	1.40	
Individual item				
Lawn is used regularly for outdoor activities		2.63	1.34	

Generally, utilitarian concerns were considered more important than how the meadow looked. However, it is important to note that a substantial portion of the population considers appearance to be important (39% and 35% respectively, rated these as 'very' or 'extremely' important). These results suggest that there are economic and perceived pest concerns discouraging homeowners from replacing lawn areas, but that aesthetic acceptance also plays a role. The use of lawn for outdoor activities was rated the least important item, receiving a mid-range rating (2.63 on a 5-pt scale), which suggests that participants were less influenced by the opportunity cost of losing space for outdoor activity when replacing lawn with meadow or groundcover.

Landscape Preference

We used photograph ratings to elicit participants' willingness-to-adopt a variety of LID practices, using more traditional landscapes for comparison. The highest-rated of the 20 photos (Photos 14 and 19) both included flowers and abundant healthy-looking vegetation, and were generally tidy and well-maintained. Photos that received lower ratings for adoption tended to be less manicured or include fewer plants and more mulch (Photos 6 and 20) (Fig. 3). It is interesting that both Photo 19 and 20 came from the pair labeled 'drought tolerant landscapes' but had very different appearances and ratings by the respondents.

Figure 3. Highest and Lowest Rated Photos (top and bottom rows respectively)

Photo 14: Mean:3.63, s.d.:1.12

Photo 19: Mean:3.39, s.d.:1.24

Photo 6: Mean: 2.21, s.d.:1.32

Photo 20: Mean: 2.26, s.d.:1.25

Another interesting pair comparison were the two photographs labeled 'taller grass' (Fig. 4). Lawns and meadows that are allowed to grow taller require less water to maintain than short grass due to the deeper root system (Blankenship et al 2020). The image with a slightly taller lawn with lower mown edge (Photo 5) received significantly higher ratings (mean=3.26) than the adjacent photo (Photo 6) of a mown path through taller grass (appx. 1 ft. in height) (mean=2.21). The clean edge in Photo 5 could also have increased preference for this scene. Nine of the 40 comments for the taller grass photo (Photo 6) mention ticks, while 13 comments included phrases such as 'too messy' or 'not neat'.

Figure 4: Taller Grass Photos

Photo 5: Mean: 3.26, s.d.:1.16

Photo 6: Mean:2.21, s.d.:1.32

Another labeled pair, 'forest and lawn' had a forested front yard scene and a traditional lawn front yard (Fig. 5). Participants rated the forested front yard (Photo 1: mean=3.20) significantly higher than the more traditional lawn (Photo 2: mean=2.77), suggesting that participants would like to retain at least some forested areas in their lot and are less supportive of simply having a manicured lawn dominated front yard. In addition, the view of the home through the trees in Photo 1 which adds more privacy could also have increased preference for this scene.

Figure 5. Forest and Lawn Scenes

Photo 1: Mean: 3.20, s.d.:1.40

Photo 2: Mean: 2.77, s.d.:1.36

To further explore the data, we conducted factor analysis on the entire set of 20 landscape preference photos. As further discussed in the methods section, the rationale for conducting factor analysis was to explore cross-cutting themes and categories that could be used for dependent variables in further analysis (Kaplan and Kaplan 1989). The factor analysis derived categories varied somewhat from the a priori categories given by the researchers when organizing the photos in the survey instrument. While the factor analysis resulted in five categories, two of these categories had low Cronbach alpha scores and were not used in further analysis. Two photos did not load on any factor and were analyzed as individual scenes (Photo 1 and 4), while three photos loaded on more than one factor, and were thus removed from further analysis (Photos 13, 17, and 19).

The highest rated category included three of the four scenes from the 'rain garden' section with a category mean of 3.42, which included the highest rated scene in the photo set, Photo 14 (Fig 6). There were several types of rain garden photos included – three were circular gardens and one was linear. The linear rain garden looked less maintained and had the lowest rating (mean = 2.80), and was the one photo omitted from the rain garden factor because it loaded on two categories. Despite the overall high ratings, there were also more negative comments about the rain garden photos in this category than positive – many referred to amount of time required for maintenance, concern about bugs/mosquitoes, or too many grasses.

Figure 6: Rain Gardens Category

Mean:3.42, S.D:0.94, Eigenvalue: 2.40, α: 0.74

Photo 11: Mean:3.24, s.d:1.29 Loading: 0.643

Photo 12: Mean:3.40, s.d:1.06 Loading: 0.614

Photo 14: Mean:3.61, s.d:1.10 Loading: 0.729

Another category, which we labeled, 'messy landscapes' were three scenes of tall perennial plantings (labeled in the survey, 'less lawn') along with the tall grass scene (Fig. 7). With a Cronbach's alpha of 0.75 there is a strong internal reliability indicating that these photos are highly related to one another. The category mean for these four photos was below the mid-point of the 5-point scale (mean=2.83) indicating less acceptance by residents for these more unkempt appearing scenes. Comments from participants supported these observations.

Figure 7. Messy Landscapes Category
Mean: 2.83, S.D: 0.99, Eigenvalue: 5.51, α: 0.75




Photo 6	Photo 7	Photo 8	Photo 10
Mean:2.23, s.d:1.31	Mean:2.84, s.d:1.43	Mean:3.34, s.d:1.12	Mean:2.80, s.d.:1.38
Loading: 0.584	Loading: 0.813	Loading: 0.428	Loading: 0.613

Another category included the two rain barrel scenes – one with a smaller barrel camouflaged with the house; the other with partially-buried cisterns fed by a downspout (Fig. 8). The cisterns were rated lower (mean = 2.65) than the single rain barrel (mean = 3.03), with many of the 66 comments citing that they were 'ugly,' 'unattractive,' or 'too industrial.' Some respondents thought rain barrels and cisterns would be too much work or would be acceptable in a backyard but not a front yard. The single barrel also received some positive comments, such as 'environmentally good' and 'have it!' and 'nice residential application.'

Figure 8: Rain Barrels Category
Mean: 2.85, S.D: 1.30, Eigenvalue: 1.12, α: 0.76


Photo 15: Mean: 2.64, s.d.:1.42
Loading: 0.680

Photo 16: Mean:3.03, s.d.:1.46
Loading: 0.792

Factors that Influence Willingness to Adopt Innovative Practices

In general, watershed membership resulted in more significant differences in willingness-to-adopt water conserving landscape practices than any other category, which supports our research hypotheses. Watershed members were more likely to rate their willingness-to-adopt the 'messy landscape' photograph category (Fig. 7) higher (mean=3.18) than were the randomly-selected participants (mean=2.69, t=1.66, d.f.=170, $p<0.05$) using t-tests. They were also less concerned about appearances for reducing their lawn area (mean=2.61) than were other participants (mean=3.23, t=-2.57, d.f.=163, $p<0.05$). Watershed members were also less concerned about the economic costs for reducing their lawn area, such as "landscape changes are more expensive" (mean=3.24) than were other homeowners (mean=3.92, t=2.47, d.f.=163, p<0.05). In addition, watershed members were less concerned about maintenance costs (mean=2.84) than were other homeowners (mean =3.45, t=2.94, d.f.=161, p<.005), despite the fact that the income distribution was fairly similar for both groups. These findings suggest a much stronger environmental mindset with regard to water issues and a willingness to engage in more innovative water conserving practices by watershed members then the general public.

Study participants who indicated more environmental concerns for water-related environmental problems (Table 1) were also more willing to adopt landscape practices to benefit the environment (Table 2, mean=2.87) than those who were less concerned about these issues (mean=2.21, t=4.34, d.f.=212, p<.000), which supports our study hypotheses and research by others (Larson et al. 2010).

Participants who lived in towns that had the Greenscapes program (North Reading and Topsfield) were significantly more likely to rate the 'messy landscape' photograph category (mean=2.96) as landscapes they would like to see in their own yard than did those living in the other towns (mean=2.63, t=-2.29, d.f.=227, p<0.05). They were also less concerned about the appearance in their willingness to replace their lawn category (mean=2.82) than were those living in the other towns (mean=3.24, t=2.22, d.f.=220, p<0.05). This result suggests that having programs to promote environmentally beneficial landscapes may increase environmental awareness and the likelihood to adopt these landscapes in one's own yard, which supports our hypothesis regarding the role of education to promote adoption.

The study found few significant differences regarding homeowners who lived near the river (i.e., buffer residents), which did not support one of our study hypotheses. Randomly selected homeowners were more concerned about whether a "lawn was a better fit for (their) neighborhood" (mean=3.27) than were buffer residents (mean=2.44) and watershed members (mean=2.58, F=2.93, d.f.=3, 213, p<0.05). Since buffer residents lived in the more rural towns of Topsfield and Middleton, there could be a confounding factor that they are more accustomed to wilder looking landscapes than their suburban neighbors. This insight is supported by the fact that residents who lived in more rural areas that relied on private wells did not differ in their willingness to implement different strategies, except in the case of the 'messy landscape' photograph category which they rated significantly higher (mean=3.20, p<0.01 than did those on public water (mean = 2.75, t=2.53, d.f.=227, p<0.05).

Income and education proved to be the most significant demographic variables affecting willingness to adopt environmentally beneficial practices, which supported our research hypotheses. Education and income were correlated (Pearson's r=0.41, p<.01) but were analyzed separately as in some cases, they revealed different results. Higher income participants (>$100,000) were more likely to indicate that they would adopt landscape practices, such as rain barrels and reduced lawn area (Table 2) that had water conservation and environmental benefits (mean=2.74) than were those in the lower income brackets (mean=2.18, t=3.72, d.f.=185, p<0.001). Higher income participants were also more likely to be motivated by the incentives to build a rain-garden scale items (mean=3.07), such as 'receiving technical assistance' (Table 3) than were lower income respondents (mean=2.70, t=2.32, d.f.=178, $p<0.05$). There were no significant differences based on income for the replacing lawn category.

Respondents with college degrees were more willing to adopt the set of water conserving landscape practices, such as rain gardens (Table 2) (mean=2.71) than were those without a college degree (mean=2.02, t=3.20, d.f.=215, $p<0.005$). In addition, those with college degrees also rated the set of 'messy landscape' scenes higher (mean=3.01) than did those without a college degree (mean = 2.44, t=3.73, d.f.=221, $p<0.001$). The fact that those with more education were more accepting of the messy landscapes that can have higher ecological value is important when considering which sub-groups may be willing to implement less traditional water conserving landscapes.

DISCUSSION

There is a long history of drought in the Ipswich River watershed and residential water restrictions during summer months (Bowling and Mackin 2003; Quintana 2016; US Geological Survey Water Resources 2021). While residents were aware of water shortage issues and supported water restrictions as necessary, many expressed only moderate willingness to adopt water conserving landscape practices. This study revealed a set of factors that influenced adoption, including socio-economic variables of income and education, aesthetic appearance of practices, and environmental awareness, which supports our research hypotheses based on the literature. However, surprisingly, landscape context (i.e., living near the river) and living near low-impact demonstration projects made little difference in willingness-to-adopt water conserving landscape practices, although our sample size was small for these sub-groups (n=33 each respectively), which points to the need for a larger-scale study to further evaluate support these study conclusions. However, membership in a watershed association did make a difference with regard to willingness to adopt water conserving landscape practices which suggests outreach efforts need to be targeted.

Factors Influencing Willingness to Adopt

This study focused on stated willingness to adopt environmentally beneficial features rather than actual adoption, except in the case where participants indicated which practices they already had now (Table 2). By focusing on barriers to adoption and motivations, we hoped to build the connection between stated willingness and actual adoption, while still acknowledging that these are not always the same thing (Larson et al. 2010).

Cost was a significant factor for willingness to adopt rain gardens and replacing lawn with meadow. In general, respondents were more willing to adopt less expensive and less time-consuming changes (e.g., watering less) than costlier and more time-intensive changes (such as rain gardens). Income-level of participants positively influenced willingness to adopt these water conserving practices, which supports previous research about adoption of xeriscapes (Larsen and Harlan 2006), but differs from the Nassauer et al. (2009) study in which income was not significant. Our results suggest that outreach efforts could include the actual costs of installation of these practices and maintenance as they may be less expensive than homeowners perceive. In some cases, even small financial incentives are helpful to implement rain gardens and lawn reductions on a wider scale (Thurston et al. 2010, Baptiste et al. 2015). Furthermore, future research that explores differences between homeowners and renters along with relative resident income levels is an important area for future study.

Landscape appearance emerged as a key variable influencing willingness to adopt water conserving landscape practices. The photo ratings clearly showed that appearance made a difference with more neat-appearing landscapes rating significantly higher than those that appeared messier or unkempt. These results are supported in the literature about landscape preference for neater, more managed residential landscapes with native plantings that exhibit "cue to care" (Nassauer 1995; Nassauer et al, 2009; Ryan 2010).

Environmental concern also appeared to influence perceptions. Those who are members of a local watershed association were more accepting of water conserving landscape practices such as meadows, rain gardens, and rain barrels than the general population. Several studies indicate that increased understanding about the benefits of water conserving landscapes increases willingness to implement these landscapes (Bowman et al. 2012; Blaine 2012; Atwood et al. 2007). Landscape preference research has also shown that environmental knowledge can influence preference for otherwise less preferred, unkempt native landscapes (Kaplan and Herbert 1987; Ryan 2005); however, the challenge is to instill this knowledge in the general public. Additionally, the landscape preference section of the study relied on a small number of photographs representing a wide number of landscape practices from rain barrels to rain gardens. A more focused landscape preference study on individual elements, such as rain gardens, could help researchers tease out the design features that most influence preference and adoption.

Safety concerns of water conserving landscapes was an unforeseen barrier that was not an explicit variable in the survey. Comments suggested that concerns about ticks and mosquito-borne illnesses were widespread. Participants' safety concerns for tall grass and standing water may be the result of public education programs related to tick and mosquito-borne illnesses such as Lyme disease and West Nile Virus (US Geological Survey 2015). Given this public health concern, education about how rain gardens and rain barrels function and how to properly maintain these features to minimize risk is important to allay these fears. Also, promoting landscape features that are not associated with standing water and taller vegetation may be more popular to some homeowners. Existing research on the perceived health risks of water conserving landscapes is scant, suggesting the need for more research to support outreach efforts.

Respondents who live in the towns that participate in the Greenscapes program (North Reading and Topsfield) were also more likely to adopt the "messy" landscapes of taller perennials and grasses than those living in towns without the program (Wilmington and Middleton). It is unclear whether the program's outreach efforts (Greenscapes 2021) are responsible for raising public awareness and acceptance for water conserving landscapes, or whether there are other factors such as news coverage, landscape context, and education that have contributed to this sentiment, but there appears to be a common factor between these two towns that has led to a greater tolerance of less traditional landscapes.

Landscape context, the type of neighborhood and setting, is another factor that was related to willingness to adopt. People living in more rural areas (specifically those with private wells) were more accepting of 'messier' landscapes. Landscape context also relates to the scale of strategies to adopt. Those in more rural areas appear more willing to implement practices that take more space such as rain gardens and reducing lawn area. Homeowners with small properties (e.g., <1 acre) (0.40 ha) are more interested in smaller installations such as rain barrels, potentially because reducing lawn area may provide a significant opportunity cost for homeowners with small properties. Tailoring the appropriate scale of features to the context is important for future outreach efforts for different neighborhood contexts (Larson et al. 2010).

Opportunities for Fostering Adoption of Environmentally-Beneficial Landscapes

In light of these factors that affect homeowners' willingness to adopt water conserving landscape practices, we suggest that municipalities and conservation organizations could consider incorporating the following strategies to their outreach efforts:

1. *Increase homeowner access to information about benefits of water conserving landscape practices.*

   Many of the water conserving landscape practices included in this survey provide multiple benefits – in addition to reducing water use, they also provide secondary benefits of improving wildlife habitat and reducing flooding. For homeowners interested in wildlife viewing, meadows and rain gardens provide opportunities to attract birds and butterflies and beneficial insects (Obropta and Sciarappa 2006). Many study respondents indicated a concern for a variety of different environmental issues and may therefore also be more likely to adopt a practice that addresses multiple environmental problems. Outreach materials promoting water conserving landscapes could highlight these additional benefits.

2. *Highlight financial value of water-saving landscape features.*

   The survey results point to homeowners' concerns about the cost of installing these landscape features. However, it is very likely that costs are not well understood by homeowners. Converting a small lawn to a meadow and installing rain barrels on existing roof downspouts has minimal cost ($0-$500 USD). While rain gardens and re-landscaping with native plants can be more costly, the costs range widely based on space converted. While conversion to water-conserving landscapes requires upfront costs, they are also associated with long-term cost savings to municipalities and homeowners (Roseen et al. 2011). A secondary economic benefit to homeowners is that landscape features such as rain gardens and colorful, drought-tolerant plantings may boost property values. Studies have shown that property values rose 3.5-5% (Ward et al. 2008) and more than 10% (Neimiera 2009) with water conserving landscapes compared to properties without these features.

   As mentioned previously, reduced lawn area generally means less time and resources spent mowing and maintaining turf. Use of rain barrels reduces summer water use, which saves costs for homeowners (especially those with tiered or seasonally adjusted water rates). Also, residential landscapes with higher infiltration capacity likely experience less flooding during storm events, and thus, potentially, less property damage. The upfront costs and long-term financial benefits could be emphasized in outreach materials.

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3. *Use photographs and tailor outreach materials to the target audience.*

   Our study along with previous research show that landscape preference and aesthetics play a key role that is often overlooked by environmental advocates (Nassauer et al. 2009; Kaplan et al. 1998). Participants rated the 'neater' rain garden photos significantly higher than their initial ratings of the written category with a generic image. This finding suggests that pictures may be more influential than words, and that education and knowledge may be secondary to the appearance of these features (Kaplan et al. 1998). Outreach materials that encourage rain gardens or drought-tolerant plants could include pictures of installations that have high aesthetic appeal – colorful and interesting plants that provide multi-season interest and are well-maintained to suggest that naturalistic landscapes can 'fit in' with more traditional residential landscapes. Similarly, our survey revealed that landscape preference can be tied to landscape context, where homeowners in more rural areas are more tolerant of 'messier' landscapes. Thus, outreach efforts to rural homeowners may differ from those to homeowners with smaller properties, with rural homeowners targeted for taller lawns and meadows, and homeowners in more dense residential settings targeted for rain barrels and small, tidy native landscapes. Accordingly, outreach efforts could include pictures that match the landscape context of the target audience.

4. *Provide technical support for homeowners interested in adopting these landscape practices.*

   Our survey results highlight several perceived barriers to adoption of water conserving landscapes. Aside from the perceived financial costs, homeowners indicated that receiving technical assistance might encourage them to install a rain garden (mean = 2.88). Since these features are generally not yet common or widespread in conventional neighborhoods, there may be a need to provide information to homeowners about maintenance of water conserving landscapes. Local watershed groups and private landscape contractors may play key roles in translating this information to the public. Volunteer opportunities can also be used to expand environmental knowledge and concern (Jordan et al. 2011; Toomey and Domroese 2013); citizen science has been shown to increase awareness and adoption of water conserving landscapes (Batson et al 2002).

   Technical assistance on installation and maintenance of water conserving landscapes might allay fears that they will be more effort than they are worth. Further, many survey respondents (22% of comments submitted) expressed concern about creating habitat for ticks and mosquitoes with water conserving landscapes. To address these concerns, technical assistance could address how proper maintenance of these features can ensure that they function as designed. For example, efforts to increase rain barrel use could be paired with an information campaign on how to avoid creating mosquito-breeding conditions.

CONCLUSION

In summary, this study showed the important influence of aesthetics and landscape preference on willingness to adopt environmentally-beneficial landscape practices that conserve water, promote infiltration, and reduce flooding. Water resource challenges exist globally, and in a time of less predictable precipitation patterns, increased urbanization may lead cities to seek ways to manage water resources to increase infiltration, reduce flooding, and retain water for drinking and habitat needs. Although the insights on which water conserving landscape practices homeowners are willing to adopt may be specific to the region and towns, our suggestions on how to address some potential barriers to adoption are universal. However, additional research is needed to explore the efficacy of outreach efforts to promote these practices with a focus on the multiple benefits that these strategies can provide to homeowners. In the face of changing climate and increased demand on limited water resources, reimagined residential landscapes that increase infiltration may help promote the long-term health of rivers and streams in urbanizing watersheds.

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