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Homeowner Willingness to Adopt Low-Impact Development Practices in the Ipswich River Watershed: Opportunities and Barriers

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HOMEOWNER WILLINGNESS TO ADOPT LOW-IMPACT DEVELOPMENT PRACTICES IN THE IPSWICH RIVER WATERSHED: BARRIERS AND OPPORTUNITIES

A Thesis Presented

By

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ABSTRACT

HOMEOWNER WILLINGNESS TO ADOPT LOW-IMPACT DEVELOPMENT PRACTICES

IN THE IPSWICH RIVER WATERSHED: BARRIERS AND OPPORTUNITIES

MAY 2015

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The Ipswich River watershed has experienced increasing urbanization in recent years. The river, which supplies water to over 300,000 residents (twice the watershed's population), was considered one of the 10 Most Endangered Rivers in the U.S. in 2003 due to seasonal low-flow and no-flow events. Seasonal outdoor water restrictions have curbed residential demand; however, impervious surfaces and municipal sewer systems direct much of the runoff outside the watershed. Low-impact development (LID) practices, specifically those that infiltrate runoff, have the potential to keep more water in the watershed, and increase baseflows in the river.

This study seeks to ascertain the barriers and motivations that exist to LID adoption. A paper survey including Likert-scale questions and a photo preference component was sent to 1,000 homeowners in the watershed. Analysis of responses employed factor analysis and means comparisons to compare responses between concerned homeowners (those who belonged to the local watershed association) and randomly-selected homeowners.

Income and educational attainment were significant variables in both aesthetic preferences and willingness to adopt LID practices. Perceived cost of landscape changes and concern about disease-carrying pests were also barriers to residential adoption. The findings emphasize alternate strategies for

land use planners, landscape professionals and environmental organizations to promote behavioral changes in the way residential landscapes are managed, and policies municipalities could adopt to implement more widespread use of LID practices. A broader understanding and appreciation of the multiple benefits of LID landscapes could also serve all three groups.

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INTRODUCTION: RESIDENTIAL LOW-IMPACT DEVELOPMENT FOR WATER CONSERVATION

1.1 The Ipswich River: Residential LID for Water Conservation

The Ipswich River is an important water source for residents of Boston's North Shore. This 45-mile river drains a densely-populated area of 155 square miles covering twenty-one towns (Massachusetts Executive Office of Energy and Environmental Affairs, 2014). Over 330,000 people and businesses rely on the river for drinking water even though only ~160,000 live within the watershed boundaries (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 river conservation non-profit named the Ipswich River the third most endangered river in the U.S. (American Rivers, 2003). Seasonal outdoor water use restrictions have been implemented by the state Department of Environmental Protection over the past ten years 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 introduce uncertainty to the river's flow regimes and subsequently to its health (Zhang, 2010). Some towns in the watershed are considering buying their tap water from another basin via the Massachusetts Water Resources Authority to further reduce withdrawal demands. These restrictions and alternative water sources may alleviate demand stress on the river, but the latter is not a feasible option for all watershed towns due to the financial burden of the permitting process, and infrastructure constraints (R. Danford, personal communication). Thus, additional water conservation measures are needed.

Water withdrawals from the river are complex, and include both groundwater withdrawals via wells adjacent to the river and surface-water withdrawals during spring and fall. While a 2000 USGS study found that surface water withdrawals do not significantly alter river discharge rates, groundwater withdrawals can greatly affect river flows (Zarriello, 2000). Surface water withdrawals are limited to times of the year when river discharge is greatest. Groundwater withdrawals, however, have a greater impact on the river, since they occur during the summer months when the river discharge is already low (Zarriello, 2000, p. 72). Development patterns across the watershed also result in significant impervious surface, which, in turn, affects groundwater recharge rates. The threshold for watershed impacts from impervious surfaces is noticeable at around 10% imperviousness (Brabec, 2002). According to MassGIS data, 12.4% of the watershed area is covered by impervious surfaces. In an effort to address both of these issues, the EPA and Massachusetts Department of Conservation and Recreation have adopted a two-pronged approach to reduce residential water use and to keep stormwater in the watershed. Plans to implement these ideas throughout the watershed include low-impact development implementation and water conservation education and outreach.

Low impact development (LID) is defined by the USGS as “a planning or design approach to development intended to reduce runoff by enhancing infiltration, thereby retaining or restoring natural hydrological characteristics” (Zarriello, 2010). For the Ipswich River watershed, LID is particularly useful as a way to reduce the effects of impervious surfaces, increase groundwater infiltration and keep more water in the river’s watershed.

In general, water conservation education has been geared towards outdoor water use, where demand is more elastic – watering the lawn and washing cars are generally perceived as less necessary than indoor uses such as cooking and cleaning. While water conservation may be viewed as a demand issue (i.e., raising awareness of low flows in the river, instituting outdoor watering restrictions, etc.), it can overlap with LID, especially at the watershed-scale. Landscape techniques such as adding organic matter to soil to increase water absorption, will reduce the required watering frequency for turf and ornamental plants. Likewise, using more drought-tolerant plants will also reduce watering requirements. LID applies more so to landscape installations, such as rain gardens and permeable paving, where rather than carry stormwater off-site to a storm sewer, the water stays on-site and is allowed to filter into the ground, where it eventually recharges the groundwater.

Demonstration projects designed to increase groundwater recharge were created in eight watershed towns; these range in scale from a low impact development subdivision to installation of rain gardens within an existing subdivision. Water harvesting and water-metering were also conducted in several towns to gauge their effect on water conservation.

The Massachusetts Executive Office of Environmental Affairs commissioned a study by the Horsely-Witten Group in the early 2000s titled 'Ipswich River Watershed Action Plan.' This study noted both the demand stress on the river, as well as the fact that 80% of the municipal water is sewered out of the watershed after it's been treated. Both are key contributors to low flows in the river and to the river running dry. That is, an estimated 23.5 million gallons per day enter the sewer system to be treated, and are not returned to the river (Horsley & Witten, Inc, 2003). The report further identifies reducing outdoor water use and reductions in water exported from the watershed as main goals to improve river flows. A USGS report studied the impacts of some of these LID installations and the results were favorable. Rain gardens and porous pavers installed in Wilmington reduced runoff to storm sewers by 50% for small storms (under .25 inches). A green roof installed in Ipswich retained 50% of water that fell during 70% of the storm events (Zimmerman, 2010). While the study found that the few existing LID installations would not significantly affect river flows in an area characterized by both developed and undeveloped land, more widespread application of LID practices to reduce imperviousness in more highly developed areas probably would positively affect river flows (2010). In a modeling study conducted in an urbanized watershed in Indianapolis, IN, 25% adoption of rain barrels and cisterns resulted in a 3-6% reduction in runoff; and 25% adoption of rain barrels and 25% adoption of porous pavement reduced runoff 7-8%. Streamflow increased between 1-4% for both scenarios (Ahiablame, L.M., et al, 2013).

LID practices may also reduce the outdoor water demand during summertime through reduced lawn areas (and the subsequent need for irrigation), drought-tolerant landscaping and water catchment systems (i.e. rain barrels, cisterns, etc.). The Massachusetts Department of Conservation and Recreation attempted to raise awareness of these practices through EPA-funded Low-Impact Development landscape projects on town properties in Wilmington, Topsfield and Hamilton (Zimmerman, 2010). Separate projects also funded by the EPA and coordinated by a local pond association include about a dozen rain gardens installed in North Reading (Environmental Protection Agency, 2013). Through anecdotal evidence, it appears that these projects raise awareness of LID practices; however, actual adoption and implementation of these practices at the residential scale is limited. Evidence of installed projects is difficult to find, either because there is no comprehensive system to track them, or because they simply don't exist. A telephone inquiry of five ecologically-oriented landscape contractors in the North Shore area revealed only a handful of installed projects, and many of these were not LID projects in a strict sense, but rather an attempt by the landscape contractor to integrate LID concepts into the design.

This dearth of landscape installations to address the water budget and supply issues in the Ipswich River are perplexing and raises a host of questions. Are homeowners in the watershed aware of the condition of the river? Are they aware that outdoor water use is one of the primary factors causing stress to aquatic species and necessitating summer water restrictions? Are homeowners aware that changing their behaviors could have a significant positive impact on the quantity of water in the river? How knowledgeable are they about LID practices and what are the perceived barriers to their implementation on a residential scale? Water use rates in this watershed are generally lower than the state-recommended average of 65 gallons per day (Massachusetts Executive Office of Energy and Environmental Affairs and Water Resources Council, 2012); however low flows continue to plague the river. Stream discharge rates under 5cfs were gauged in August and September of both 2013 and 2014 (US Geological Survey, Water Resources, 2014). These facts raise the question of how are residents using water, how willing are they to change their behavior and what barriers do they perceive to the adoption of these behaviors and practices.

1.2 Goals, Purpose and Objectives

This study presents the results of a survey sent to watershed homeowners during the summer of 2014. The survey asked a variety of questions related to outdoor water use, conservation knowledge and attitudes towards different water conservation policies. Specifically, the survey components drew from similar surveys conducted in other parts of the country, in an attempt to better understand homeowners’ perceptions of and willingness to adopt water-conserving landscape practices. . To better understand the relationship between knowledge and actions, the survey results are presented using the lens of Kaplan and Kaplan’s Reasonable Person Model. The survey was sent to a random selection of 150 homeowners in four towns throughout the watershed, as well as up to fifty homeowners who belong to a local watershed association in each town. The balance of participants were selected from homeowners who live near the river (Middleton and Topsfield) or near a publicly-accessible LID installation (North Reading and Wilmington). It is presumed that those who belong to the watershed organization will be more aware of water conservation issues and willing to reduce water use and implement LID practices. It is also predicted that those who live near the river may be more concerned about low flows, and thus more interested in conservation and infiltration practices. Understanding homeowner's behaviors and perceptions of water conservation measures, and identifying barriers to adoption of conservation behaviors will better enable town officials and water managers to create more effective and practicable water use and land use policies in their towns (Armstrong, 2012) (Corral-Verdugo, 2003). These policies may focus on public education, land use zoning and the nexus between natural resource planning and subdivision regulations.

1.3 Research Questions and Hypotheses

According to a recent news article (Salem News, August 2013), the Ipswich River has not run dry since 2006. However, flows in the river are still low during mid-summer, and an especially dry year could lead to very low flow or no-flow events. While all of the watershed communities may theoretically opt to purchase water from the Massachusetts Water Resources Authority, this is impractical due to water availability, the need for infrastructure connections and the lengthy and expensive MEPA and Environmental Impact Report process towns must go through to import water from outside of their basin (Drury). Thus, it is necessary to pursue the initial questions posed in this project – what are homeowners' motivations to adopt LID? What are their perceptions of LID practices and outdoor water conservation measures? And do homeowners understand the connection between LID practices, conservation measures and outdoor water use? An over-arching question in this study is how these findings differ between randomly-selected homeowners and environmentally-conscious homeowners (watershed association members and potentially river-buffer and LID-proximate homeowners); are more environmentally-aware homeowners more interested in adopting practices and willing to install LID? Existing research on residential LID adoption is sparse. Landscape preference research for water-conserving landscapes exists for drier areas of the country, such as the southwest (Harlan, 2006) (Larson E. C., 2010).

The first research question is whether people connect their own water use to the conditions of the river. This, in its most direct sense, is a complicated question to ask. The public water supply in many watershed towns is supplied by surface reservoirs and groundwater wells, which have hydrologic connections to the Ipswich River. Since, in most cases, they do not have surface connections to the river; the inferred link between tap water and the river may not be intuitive to watershed residents. As a proxy for understanding resident's local water knowledge, the survey asked about water use in general. Specifically, the survey attempted to obtain perceptions of relative water use – indoors versus outdoors, effectiveness of various water conservation practices, and about residents' actual practices (do they water in the morning/evening or mid-day). These questions indirectly assess residents' knowledge of general water conservation practices and whether their actual practices are contributing to water waste.

This topic relates to the question of perceived barriers to LID implementation. Do residents not implement LID because it's costly, because it's 'ugly' or because they don't think it will help? Conversely, does the cost of implementing LID outweigh the potential benefits to conserving this relatively inexpensive resource? If participants' responses to the initial question indicate that they are using water inefficiently and not necessarily concerned with conservation, then the answers for these questions will be more suspect. Assuming respondents are not apathetic towards conservation, I posit that homeowners are interested in and willing to adopt LID practices in the residential landscape. Joan Nassauer has studied landscape preference extensively in the context of how social norms affect landscape decisions and aesthetic preferences. A 2009 article highlights the 'neighborhood' effect, where homeowners' preferences are more influenced by their immediate neighbors than by larger societal norms for landscape appearance (Nassauer J. I., 2009). This study briefly explores whether homeowners would be more likely to install a rain garden on their property if their neighbor did. Lastly, Nassauer has studied the aesthetics of landscape design and the types of residential landscapes homeowners find most acceptable. Using photographs of LID practices, I seek to ascertain whether residents find rain gardens, smaller lawns, rain barrels and permeable paving attractive enough to install on their own property.

There is a common perception that landscaping is expensive. If this is a major obstacle to implementation, it is important for policymakers to know this; grants, volunteer-efforts and financial incentives may be easy solutions to these barriers. As a not-for-profit in North Reading has done, public funds may be obtained to install green infrastructure on private land because it serves a public good (reduced flooding).

A related question is how willing homeowners are the change their landscape. If residents have not added or removed lawn, there may be financial factors at play, but there may also be a lack of inertia – an acceptance of the status quo. The question of incentives to change also addresses a larger question of whether zoning regulations should dictate lower-input properties, rather than leaving these decisions to the developer and homeowner. Rather than suggest that zoning regulations dictate the specific plant species on a property, towns may choose (as Senate Bill 14-017 in Colorado proposes) to set a maximum area of lawn on a property

(Hanel, 2014), and encourage the use of native plants and drought-tolerant grasses where water resources are more scarce.

These factors can be combined to address barriers to LID adoption, where:

Hypothesis 1: Aesthetic, economic and awareness barriers exist to the adoption of LID in residential landscapes.

A second research question asks whether attitudes towards these barriers and toward water conservation in general, vary between the four towns and between the four interest-groups. I posit that those more aware of water conservation issues and express increased concern for water-related issues are more willing to adopt LID practices and reduce their water use. If there is a correlation between town policies and willingness to adopt, this may indicate that education can be a motivator for positive environmental change.

Hypothesis 2: Attitudes towards willingness to adopt residential-scale LID vary between the towns, depending upon their conservation policies, and between interest sub-groups, depending upon their environmental awareness.

A third question seeks to understand the socio-demographic barriers that exist between these groups, and whether the willingness to overcome these barriers vary by group. Specifically:

Hypothesis 3: Randomly-selected homeowners are less willing and less concerned about changing their home landscape to conserve water. Concerned homeowners (watershed association members and potentially river-buffer and LID-proximate respondents) are more willing to adopt practices to conserve water and implement landscape changes to conserve water on the landscape-scale.

1.4 Scope of Research and Organization of Study

1.4.1 Scope of Research

This research aims to address existing gaps in the literature related to aesthetics of low-impact development practices. As mentioned previously, many studies have been published about residential water conservation in more arid regions; however, few studies exist for similar research in more temperate areas of the U.S. Likewise, environmental behavior literature exists that analyze homeowners views on aesthetics of more naturalized landscaping in Michigan; literature related to the acceptability and implementation of xeriscaping exist for areas of the southwest. However, these two topics have rarely been combined to study the attitudes and perceptions of homeowners in the northeast towards water-conserving landscapes. Finally, LID evolved from stormwater management best practices in the 1980s, and over ten years of literature exists to support its effectiveness. However, little research has been undertaken or published that addresses the perceived barriers of homeowners in adopting and implementing these practices. This study aims to address all three gaps in the existing literature. Given this, the survey instrument is somewhat lengthy, and only addresses homeowners. Planning staff, developers and landscape architects would likely have different perspectives and their role in LID implementation is crucial to understanding the policy and practical barriers to implementation. These topics, however, are beyond the scope of this study.

1.4.2 Organization of Study

The following document presents a review of existing literature related to outdoor water conservation and landscape decisions of homeowners. The Methods section includes a description of the study area and a discussion of the survey itself. A description of the research methods employed to create and analyze the survey is also presented in the Methods sections. Results of the survey and data analysis are presented in the following chapter. Lastly, the analysis of the survey results will be discussed in a separate chapter. Future policy recommendations for outreach, development standards and retrofit programs that encourage reduced outdoor water use will be presented in the final chapter.

CHAPTER 2

LITERATURE REVIEW: ENVIRONMENTAL STEWARDSHIP, LOW-IMPACT DEVELOPMENT AND LANDSCAPE PREFERENCE

2.1 Overview

Landscape practices can affect seasonal water use significantly. According to estimates of land cover data, NASA researcher Cristina Milesi estimates that turfgrass has surpassed corn in area of irrigated 'crops' in the U.S. (NASA, 2014). Thus, how homeowners manage their lawns is significant. Building upon existing research in the fields of outdoor water conservation, landscape preference and low-impact development strategies, this chapter will synthesize findings to date that may be applied to water use in the Ipswich River watershed. Specifically, the results of this research could be especially useful to water policy makers. While there may be resistance to increasing water rates to fund infrastructure improvements, behavioral changes are often less costly. Policymakers interested in reducing water demand may look to create incentives that encourage certain landscape practices such as adoption of LID practices and possibly even embed these conservation practices in zoning regulations and town bylaws (lawn reduction, irrigation bylaws, permeable paving, etc.)

To find existing studies in the fields of outdoor water conservation, landscape preference and low impact development, several searches were conducted using the Web of Science database. The search term 'water use' generated hundreds of results, many of which are related to stormwater, drinking water systems or water politics, but largely irrelevant to the topic of landscape practices. Similarly, a search for 'water conservation' yielded over 3,000 articles, many of which are related to agricultural practices or indoor water use. Searching the topic 'water use + residential landscaping' is too narrow and yields few results. Similarly, the term 'green infrastructure' is not widely used in article titles, and only yielded 23 results. Many of the articles cited below were identified from the bibliographies of articles written by Joan Iversson Nassauer, Robert Ryan or members of the Center for Agriculture –Ipswich River Project research team (Colin Polsky (Clark University), Paige Warren (UMass), Craig Nicholson (UMass) and Alison Roy (UMass)).

2.2 Outdoor Water Conservation

Studies on homeowners' motivations and attitudes towards water conservation have yielded conflicting and inconsistent results. There are numerous potential socioeconomic factors that could influence whether a person conserves water and their level of environmental concern. In one study employing the Human-Exception Paradigm, socioeconomic status was a major factor in water use (Corral-Verdugo, 2003). Meanwhile, another study found little correlation between socioeconomic status (both income and education) and water use (deOliver, 1999). One might expect that those who are committed environmentalists would be more likely to conserve water. However, a study in the U.K. found little correlation between practiced water conservation behaviors and level of commitment to the environment; those more highly educated and with higher incomes did not differ statistically in their behavior from those who were less 'committed environmentalists' (Barr, 2006).

While actual conservation behaviors may vary and be unpredictable, attitudes towards water conservation may also provide insights for future water policy. Many towns in the Ipswich River watershed have instituted restrictions on outdoor water use during the summer months (Ipswich River Watershed Association, 2014). These have kept water use in check, but do not, on their own, solve the problem. Additionally, it is unclear what residents' attitudes are towards these restrictions and whether some towns would resist the restrictions more than others. In Guelph, Ontario, survey respondents indicated a willingness to reduce lawn watering and employ rain barrels to reduce outdoor water use. Gender of respondents was a statistically significant factor in these results (Atwood, Kreutsweizer, & deLoe, 2007). Another similar survey in San Antonio, TX again found broad support for voluntary and mandatory water conservation measures, but was not able to make conclusive connections between particular socioeconomic characteristics (gender or education) and these attitudes (deOliver, 1999). Willingness to conserve water may be situational and may be difficult to predict. It may be necessary to look at the physical landscape of a property and what changes can be made that would reduce outdoor water usage.

2.3 Landscape Preferences and Decisions

The physical landscape of houses can be a significant factor in water use. Conventional lawns certainly require more water than naturalized areas. Thus, encouraging homeowners to reduce the amount of landscape cover that requires regular watering may be one solution for this watershed. Research on preference for water-conserving landscapes is more abundant for drier regions that regularly face water shortages. Again, however, the findings are inconsistent and sometimes conflicting. Several factors affect landowners' attitudes towards and maintenance of their home landscape, including income, education, gender, location, neighborhood aesthetics, and societal norms. The existing research indicates that there is often a disconnect between homeowners' stated attitudes and their actions (Larson, Cook, & Hall, 2010). For example, homeowners may state that they want to conserve water, but do not actively replace their lawn with xeriscaping or water less often. Instead, as several studies have found, other factors dominate. For example, the historic land use of an area likely plays a larger role in the types of landscape practices that homeowners maintain (Larson, Cook, & Hall, 2010). Change takes a lot of initiative–-financial and behavioral--and homeowners are often averse to changing the landscape installed by the contractor who built their house (Harlan, 2006). This information prompts the question of whether the onus for change should be placed on the homeowner, the developer, or planning boards who create the guidelines to which developers must adhere.

Another factor influencing homeowners' landscape decisions is how they use their property. Are homeowners with children more likely to have a large lawn that their children use for play? Do they have an above-ground pool that they fill each year? Do they have a fountain, or other water-intensive feature? Examining studies that identify how people in different types of developments use their yards could shed light on potential areas for landscape change. If homeowners have a large lawn because they think it looks nice, but they don't actually use it, they might be more willing to change some of the lawn to meadow than someone with small children who regularly play in the yard. In one small study (n=126), the most popular use of yards was as 'a place of beauty,' followed closely by a place to 'observe nature' (Clayton, 2007). Another found that while homeowners could identify their ideal landscapes, the landscape of their own house was not the one they identified as ideal (Harlan, 2006), suggesting that there may be latent motivation for landscape change. Alternatively, research using simulated photographs of front yards with increasing amounts of 'naturalized area' found that people were willing to remove a significant amount of their lawn to install shrubs and other more natural plantings (Nassauer, Wang, & Dayrell, 2009). The question in this research is whether homeowners in the suburbs of Boston would have similar aesthetics as those near Ann Arbor, MI. Also, what motivates homeowners to change their landscape – financial, altruistic, or practical incentives? Lastly, what level of incentives are needed for homeowners to change their landscape?

2.4 Economics of Outdoor Water Use

In each of these preference surveys, the questions asked were directed toward the aesthetics of landscape alternatives. There is often one significant hurdle for homeowners – the cost of altering their existing landscape. Despite the perceived high cost of landscaping, few studies have identified cost as a barrier to making more environmentally-sensitive landscape changes. While this barrier arose in the results of this study, the financial considerations of landscape maintenance is not a focal point of this survey. The low cost of water is also a disincentive to conservation. Several studies have explored this idea (Stavins, 2007) (M. Espey, 1997), and there is potential to add to an understanding of the economics of outdoor water in the New England region, but that research is another project unto itself, and is beyond the scope of this survey.

2.5 Low Impact Development and Water Use

Knowledge and awareness is another potential hurdle to adoption of more water-sensitive landscape decisions. Recent studies point to the potential for changes in residential land use to decrease outdoor water use (Runfola, Polsky, & Nicolson, 2013). This study models water use under existing development and future development scenarios, and finds that through application of town-wide smart growth development techniques, Ipswich, MA could reduce its residential water use by 5%. (Smart growth, in this case, refers to the idea of limiting future development to areas directly adjacent to existing development.) This is encouraging for water conservation, however, do homeowners like the look of smart growth? And if they do, are developers convinced enough to build smart growth and low-impact development subdivisions? Published studies to date suggest that barriers to smart growth implementation exist (West, 2008) (Bowman, Thompson, & Tyndall, 2012).

Many landscape changes proposed in the Ipswich River Conservation Plan (Ipswich River Watershed Management Council and Ipswich River Watershed Assocation, 2003), may be achieved through adoption of smart growth principles. While these principles are not easy to retrofit, faster-growing towns in the watershed (e.g., Middleton with 18% population growth since 2000, Reading with 9% population growth since 2000) (U.S. Census) may require these practices be applied to future development. This can be accomplished in two ways: homeowners can make changes to their landscape that will require less water (smaller lawn, more drought-tolerant plants, etc) or developers and cities can change the amount of lawn that residential developments install in new projects. Since it has been shown that homeowners usually do not alter the landscape of their home when they bought it (Harlan, 2006), the latter seems like the better route to pursue. It has also been shown that homeowners frequently apply more water to lawns than is required (Brewer, 2012); thus, if they had less lawn area, people would presumably use less water. Faced with water restrictions, homeowners have identified reduced lawn watering as a primarily option (Atwood, Kreutsweizer, & deLoe, 2007). This study will attempt to evaluate homeowners' perception of this alternative in the Ipswich River watershed.

Understanding the various motivations and attitudes of homeowners towards outdoor water conservation is a multifaceted and complex subject. Environmental attitudes, economics, and landscape preference are all factors which may influence residents' actual actions. While the studies conducted to date have yielded some insights as to the socioeconomic factors which most strongly predict certain behaviors, sufficient research to more accurately predict attitudes and behaviors on a regional scale does not exist. This project will attempt to apply similar research methods employed in the studies cited above to determine more regional trends and attitudes towards outdoor water conservation in suburban Boston.

2.6 Environmental Stewardship and Demographics

Other reasons that homeowners may not implement LID practices is that they may be unaware of them, or they may not feel that doing so would significantly affect the river. Numerous studies have been completed to assess the demographic and ideological characteristics of people who practice various conservation behaviors. A number of factors can influence homeowner's motivations to conserve water, including political ideologies, income, education and even gender. For instance, a study in Mexico grouped survey respondents into utilitarian and conservation-minded categories. Those in the utilitarian group tended to be middle-class, and were more likely to practice conservation behaviors than those grouped as 'conservation-minded' (deOliver, 1999). In a similar paradox, survey respondents in a 'green-certified' subdivision and a conventional subdivision self-reported their conservation activities; however, there was no difference in conservation focus or the extent of conservation activities between the two groups (Hostetler & Noiseux, 2010).

Many of these surveys ask questions related to demographic information and political beliefs. There may, however, be more practical reasons that people may adopt LID practices. If, for instance, sewer bills were to decrease due to the reduced amount of runoff from properties with rain gardens, this may be a motivation. Similarly, if residents noticed that flooding decreased in neighborhoods after rain gardens and infiltration trenches were installed throughout the neighborhood, this would be important to know. Likewise, if more people understand the positive impacts of LID practices, they may be more willing to implement them on their own property. One example is a survey of farmers and landowners on riparian parcels in Maryland, where landowners who were less knowledgeable about riparian buffers were less likely to implement them on their property (Stedman, 2012). Likewise, a focus group of developers, planners and homeowners indicated that homeowners have a more favorable view of LID principles when they understood the benefits (Bowman, Thompson, & Tyndall, 2012). These studies indicate that while results are inconclusive for some groups, informing and educating landowners of the benefits of low-impact design can positively affect adoption rates and willingness to implement these practices. This concept is based on Kaplan and Kaplan's Reasonable Person Model (2004), where there is a feedback loop such that homeowners who understand that there are water shortages take 'meaningful action' to conserve water, and this in turn leads to effective water use reduction.

CHAPTER 3

MEASURING LANDSCAPE PREFERENCE AND PERCEPTIONS OF LOW-IMPACT DEVELOPMENT: STUDY AREA AND RESEARCH METHODS

3.1 Study Area

Much of the Ipswich River watershed is densely populated and covered by suburban land uses, including large-lot subdivisions and residential development. 20% of the watershed is covered by residential land uses, with 2% in house lots over 1 acre. Approximately 56% of the watershed is forested and 19% is covered by impervious surfaces (MassGIS, 'Impervious Surface Mosaic' layer). In general, the upper watershed contains more development and impervious area than the lower watershed. The following table indicates land cover across the region for towns with over 50% of their land area in the watershed:

Table 3.1: Land coverage in towns with >50% land area in the watershed

Town	% Impervious[1]	% Forested[2]	% Residential[2]	Population Density (people/mi^2)
Boxford	6.6	40.5	8.2	341
Hamilton	6.9	35.1	11.9	565
Ipswich	6.2	20.9	7.3	412
Middleton	9.8	49.3	15.2	630
North Andover	13.6	32.5	11.6	1,042
North Reading	16.1	38.3	29.6	1,092
Reading	16	13.8	12.5	2,368
Topsfield	8	46.8	18.4	482
Wenham	7.9	36.2	16.1	619
Wilmington	21.8	26.2	25.8	1,306
MASSACHUSETTS	n/a	58	n/a	859

[1]Source: EPA, Regulated MS4 in Massachusetts webpage (2012)
[2]Source: Massachusetts GIS, Land use datalayer (updated 2005)

A combination of land use factors and drinking water withdrawal rates is blamed for the water shortages these towns have experienced over the past two decades (Ipswich River

Watershed Council and Ipswich River Watershed Association, 2003). Many watershed towns have adopted an array of conservation measures to reduce withdrawal stress on the river. Several towns have seasonal water restrictions, which either prohibit or severely restrict outdoor water use between May and October. Nine of the twenty-one watershed towns have become members of Greenscapes, a program of the USEPA, which promotes outdoor water conservation and provides outreach and education to member communities. The Massachusetts Department of Environmental Protection attempted to raise awareness of LID practices through EPA-funded Low-Impact Development landscape projects on town properties in Wilmington, Topsfield and Hamilton (Zimmerman, 2010). Separate projects also funded by the EPA and coordinated by a local pond association include about a dozen rain gardens installed in North Reading (Environmental Protection Agency, 2013). Additionally, many towns have irrigation bylaws requiring any irrigation system installed on a residential property to acquire a permit and to be moisture-sensitive. However, it is apparent that some watershed towns have been more proactive than others in promoting conservation measures.

Water use rates in this watershed are generally lower than the state-recommended average of 65 gallons per day (Massachusetts Executive Office of Energy and Environmental Affairs and Water Resources Council, 2012); however low flows continue to plague the river, and were recorded several times during the summers of 2013 and 2014 (U.S. Geological Survey, 2015). While it appears that significant efforts are in place to promote conservation, residential adoption and implementation has been minimal. Thus, towns with a wide range of conservation policies were selected to participate in this study.

3.2 Town Selection

Surveys were distributed to residents of four towns in the watershed. Since many of the LID practices included in the survey involve infiltration, only towns that had significant land area in the watershed were selected. Other key criteria for town selection include participation in town-sponsored water conservation programs, and rates of land use change and population growth. Town-sponsored water conservation programs include those which the municipality itself has become part of and which the town, presumably, advocates to the public. The Greenscapes program, water restrictions and irrigation bylaws were all considered town-sponsored programs to incentivize water conservation. Presence of LID installations in a town may also affect water conservation behavior, and was also a consideration. Rate of development was measured by population change. (Since the population is growing throughout the watershed, population growth was relative within the watershed.)

Using this criteria, four towns were chosen to satisfy each of the following criteria: High growth rate/low conservation endorsement, High growth rate/high conservation endorsement, moderate growth rate/low conservation endorsement, moderate growth rate/high conservation endorsement:

Table 3.2: Population Growth and Conservation Priorities in Selected Towns

	High growth rate (13 years)	Moderate growth (13 years)
Low conservation	Middleton (18%)	Wilmington (6%)
High Conservation	North Reading (9%)	Topsfield (1%)

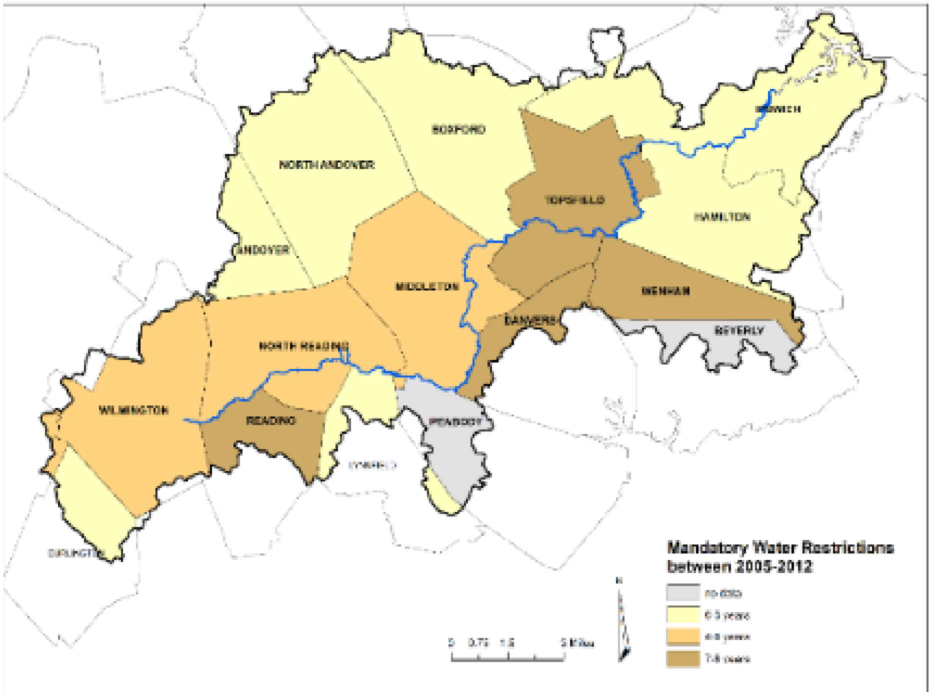
Several other factors were also considered in town selection:

1) Land area in watershed – since the installation of green infrastructure could affect flows in the river, only towns with significant land area in the watershed were considered. 'Significant' is defined as over 50% of land area.

2) Water source – Some towns in the watershed receive their water from the Metropolitan Water Resources Authority (i.e., outside of the watershed), or many of the homeowners have private wells. Since the water use of the former would not negatively affect the Ipswich River, these towns were removed from consideration. Since homes with private wells do not receive water bills, their financial incentive to reduce water use is less. Thus, towns whose residents' primary source of tap water was the Ipswich River were selected (N.B. Wilmington draws water from the Massachusetts Water Resources Authority during the summer only, and on an as-needed basis (Commonwealth of Massachusetts, Water Resources Commission, 2007)).

3) Conservation programs - Several towns have actively adopted policies and even bylaws to promote water conservation. The Massachusetts Department of Environmental Protection (MADEP) imposes outdoor watering restrictions on many towns in the watershed from May 1 to September 1 every year. In some towns, these restrictions have been in effect for over six of the eight years for which we had data. In other towns, restrictions have only been in place for a two to three of those years. The persistence of water restrictions likely affects public perception of the need to conserve water and, subsequently, water conservation awareness. Water restrictions are tiered, and their severity fluctuates during the season. Generally, the restrictions limit or prohibit automated outdoor water use altogether (but hand-watering is allowed). Also, both MADEP and USEPA have installed demonstration projects around the watershed, in an effort to promote awareness of LID practices to homeowners. Residents in towns with these installations are compared to residents in towns without these installations.

Figure 1: Mandatory Water Restrictions across the Watershed



Lastly, many towns in the watershed are members of the national Greenscapes program, which seeks to educate homeowners about environmentally-sensitive and water-conserving landscape practices. This fact was used as a potential indicator of willingness to adopt green infrastructure, where we expect to find that town Greenscapes membership predicts an increased willingness of residents to practice water conservation.

3.3 Study Towns

Table 3.3: Town Demographics and Source of Water

Town	% Public Water[1]	2000 Population[2]	2013 Population[3]	% Change	Area (mi^2)[4]	2013 Population Density (/mi^2)	2013 Avg Household Income[5]	2013 Median Age[3]
Middleton	65	7744	9131	118%	14.5	630	106,843	41.1
N. Reading	97	13,837	15,076	109%	13.5	1,092	121,607	42.4
Topsfield	79	6141	6211	101%	12.8	482	118,510	45.4
Wilmington	95	21,367	22,626	106%	17.2	1,306	107,893	41

Sources:

[1] Anita Millman, "Mass Community Water Public Water Systems"
[2] U.S. Census Bureau, DP-1 (2000, 5-year average)
[3] U.S. Census Bureau, DP-05 (2013, 5-year average)
[4] MassGIS Datalayers
[5] U.S. Census Bureau, S2503 (2013, 5-year average, Owner-occupied units)

3.3.1 Middleton

Located almost wholly within the watershed, this town has seen double-digit population growth in recent years (118% between 2000-2013 (U.S. Census, ACS)). 2013 household income for homeowners is $106,843 and per capita water use is ~52 gallons per day (gpd) ((Save Water North Shore, 2015). Numerous subdivisions have been built, resulting in over 100 new residential subdivision lots created between 2012-2013 (Town of Middleton, 2013). Many of these already have houses built on them. Since many people in Middleton are on septic systems, most lots in town are a minimum of 1-acre. First-hand observation suggest that these lots are primarily covered by lawn. Middleton's main water-conservation policy is a bylaw requiring irrigation systems to be moisture sensing (Town of Middleton, 2014). Middleton is not a member of Greenscapes, nor do they have many publicly-accessible LID projects in town. Approximately 65% of the town has public water while the remainder rely on private wells for residential tap water. The majority of properties in town have individual septic systems (Town of Middleton, 2014) (IPSWATCH, 2014). Mandatory water bans were in place for six summers between 2005 and 2012.

3.3.2 Wilmington

Perhaps the most urban town in the study, Wilmington's population in 2013 was 22,626. The town is located in the upper watershed and is heavily developed. Per capita water use is 52gpd (Save Water North Shore, 2015) and the median household income for homeowners was $107,893 (US Census, 2013). Several of the town's wells were found to be contaminated in 2003 and the city sought to supplement its summer water supply from MWRA (Commonwealth of Massachusetts, Water Resources Commission, 2007). Population growth between 2000 and 2013 was slower at 106%, and the town itself is not a member of Greenscapes. It does, however, hosts several LID installations sponsored by the EPA and DEP, including a permeable parking area at the town beach, and several rain gardens installed in a nearby subdivision. Mandatory water bans were in effect for six summers between 2005 and 2012.

3.3.3 North Reading

Located east of Wilmington, and almost entirely within the watershed boundary, this town has also experienced significant population growth in recent years. The median household income for homeowners in 2013 was $121,607 (U.S. Census, ACS) and per capita water use was 65 gpd in 2010 (Save Water North Shore, 2015). North Reading is a member of Greenscapes, has had DEP-mandated water bans for four years between 2005 and 2012. It also had a rain barrel program for residents in the recent past (R. Danford, personal communication). An active local watershed association, the Martin's Pond Association, received a grant from the EPA to install rain gardens on residents' properties near the pond. The area around Martin's Pond experienced flooding in 2006 during heavy rain events, and town policy has sought to reduce impervious surfaces for new construction (Janet Nicosia, personal communication, 8/2/2013).

3.3.4 Topsfield

The easternmost town in this study, and also the least developed, it has a relatively stable population, with only a 101% change between 2000 and 2013. Median household income was $118,510 in 2013 (US Census) and per capita water use was 56 gallons/day (Save Water North Shore, 2015). It is relatively rural for this area, with the lowest population density of the four study towns. The town has been actively trying to reduce its water use. It is a member of Greenscapes, and has instituted mandatory water bans for seven summers between 2005 and 2012. The Water Department also sponsored a water meter program in 2007 and published a Water Conservation Plan in 2007. Approximately 21% of the town has private wells, which are not subject to the ban.

3.4 Survey Distribution

Paper surveys were sent using the Dillman method (1991). The first round of surveys was sent in early July 2014. About one month later, reminder postcards were sent to the same mailing list (minus those who sent back a completed survey). Two weeks later in late August, a subsequent mailing was sent to those who had not yet responded. Survey responses were accepted through the end of September. Over 160 surveys were returned for the initial mailing and 90^+ surveys were returned or completed online after the second mailing.

3.5 Survey Instrument

3.5.1 Paper Survey

The survey, which was six pages in length, primarily contained closed-ended questions designed to gather information on respondents' property characteristics, outdoor water use, attitudes toward green infrastructure, perceptions of the effectiveness of water conservation landscape practices, willingness to implement these practices on their own property and perceived barriers to implementation. A significant portion of the survey included a photo preference component, where respondents rated scenes of different water-conserving landscapes and how much they would like those landscapes on their own property. The text of the full survey is included in Appendix B.

Survey questions sought to address the following:

1) How people use water outdoors - These questions attempted to establish a baseline of how respondents use water outdoors and landscape features that might indicate greater or less water need and consumption. One question asked how much of the property was covered by lawn, meadow, garden and woods. Another question asked how often homeowners water their lawn and the time of day they water (thus assessing how efficient watering practices are). The survey also asked participants if they had an irrigation system and a pool, in an effort to establish how prevalent these significant water uses were. The survey also asked participants if the irrigation system was moisture-sensing and if their pool was filled with tap water or purchased water.

2) Perceptions of the effectiveness of different outdoor water conservation practices – These questions, which asked about several common outdoor water conservation practices such as adding organic matter to improve moisture-holding capacity, watering less

often, using a soil moisture meter and changing watering regimes, sought to assess general awareness and support for these practices. This question addressed practices that don't require physical changes to the landscape itself. We asked participants to rank how effective they thought these practices were and whether they would apply them in the future. Presumably, and according to the Reasonable Person Model (Kaplan, 2000 and 2003), if participants think the practice is effective and they understand the science that supports it, they would be more likely to practice it.

3) Landscape installations – Similarly, we were interested in how prevalent these practices are and whether homeowners perceive them to be effective enough to implement in the future. Using photographic examples of rain gardens, rain barrels, reduced lawn area, green roofs, drought-tolerant landscapes, the survey asked whether people already had these and how willing they would be to implement them in the future. A follow-up question assessed the obstacles to a common installation (rain gardens). Again, we didn't just want to know whether there were obstacles or not, but how great the respondent perceived them to be. We also asked about social, financial and aesthetic barriers that exist to homeowners changing their landscape from lawn to meadow. This question sought to gauge which variables were most significant. It also assumes that the primary land cover on the property is lawn.

4) The next series of questions asked about water restrictions in the town. Water restrictions have been in place seasonally for many watershed towns, and we both wanted to gauge the awareness of the restrictions, and the general sentiment towards the restrictions. Water restrictions can be a significant source of water conservation, but the political support needed to maintain them requires a level of understanding on the part of the consumer. Five Likert-scale questions asked participants about their sentiments towards the restrictions (how

necessary they are, how inconvenient they are, how much they are affected by them, and whether they understood the need to have restrictions.)

5) To gain an understanding of general environmental concern, one question was included that asked respondents to rate how serious various environmental problems were in Massachusetts; problems included land use issues (such as 'poorly planned development') as well as water-related issues (such as 'flooding,' 'fewer fish in rivers and streams,' and 'lack of drinking water.')

6) Lastly, to better understand motivations for homeowner water conservation, a question about the importance of water use factors was included. Stavins (2007) suggests that water is price inelastic, while Reynaud (2005) suggests that non-price policies have a greater effect on outdoor water use. These findings suggest alternative solutions: one that encourages non-cost policies such as educating homeowners about reduced outdoor water use, regulations governing outdoor water use and irrigation systems, and the amount of type of lawn that exists on their property, and another, which includes financial disincentives (higher water bill, surcharges or seasonal block rates) to reduce water use.

7) Basic demographic information was gathered in order to compare the sample population with the population of homeowners in each town. American Community Survey data was used as the baseline. Census data only includes homeowners in the categories of income, educational attainment, household size, age and tenure. Census data was not available for homeowner gender. For this piece of demographic information, we compared the names in the tax assessor's database with the respondents' identified gender. (In some cases, names were ambiguous, and so an 'educated guess' was necessary to determine the respondent's gender.)

8) Photo preference – One of the primary research goals was to ascertain whether watershed residents were interested and willing to implement water-conserving low-impact

development practices on their own property. Joan Nassauer (2009, 2006 and 2004) has used photo preference surveys to gauge similar questions related to landscape preference. Hundreds of photos of residential LID installations were taken from locations throughout the watershed during the summer if 2013. These include photographs of a range of residential and commercial installations. We expected to find many examples of these practices in the watershed due to the ongoing summer water restrictions that have taken place for the past ten-plus years, and the public education from both towns and the local watershed association. However, many installations were either on municipal property (playing fields, town hall, etc) and therefore did not provide a good representation of residential applications; or, they were on organizational properties (not belonging to homeowners, but to non-profits, etc.). For this reason, we expanded our search and the types of sites where we took photos to include installations outside of the watershed and those which had similar neighborhood features to towns in the watershed with the goals of incorporating photos in the survey that represented properties that were found in the watershed. Twenty photos included in the survey. Photos met the following criteria: 1) They did not show much of the house; 2) the primary focus of the photo was the green infrastructure installation.

One issue that arose in both identifying sites and choosing photos, was that the landscape practices for water conservation were not always evident in a photo. For example, a lawn planted with drought-tolerant grasses doesn’t look very different from a lawn planted with non-drought-tolerant grasses, especially in a photo that is not taken at a close range. Similarly, in contacting landscapers to identify properties with green infrastructure practices, many noted that the installation was purposely hidden from view (e.g. cisterns are buried underground, etc.); this presented a challenge in figuring out how to show visual examples of LID projects where the water conserving feature was clearly visible. Also included photos that offered as wide a variety as possible within each grouping. All photos were taken during summer months to show plants in bloom and green grass.

Finally, the following representative LID installations were included in the survey:

1) Land cover type – one primarily forest and the other photo primarily lawn

2) Driveway type (to allow for increased permeability over a paved driveway – granite cobbles and gravel);

3) Grass height – two photos, one with grass over 8” tall and the other with a mown apron and grass inside of that 1-2” taller (where taller lawn is thought to require less water);

4) Drought-tolerant landscape – also a range (one with lots of flowers, one with yucca and no flowering plants)

5) Reduced lawn area (included a range of photos from almost no lawn and lots of wildflowers to ½ lawn, ½ groundcover to some lawn and some wildflowers)

6) Rain barrels – showing two types (large barrels partially in the ground, and another of smaller barrel)

7) Rain gardens – gardens include a range of plantings from mostly grasses, some grasses and some wildflowers and all wildflowers and flowering shrubs. Some were well-manicured and some less so.

8) ‘Naturalized lawn’ - where shorter wildflowers and seed heads my appear in a lawn, and the lawn is not as manicured-looking, but includes a more varied plant palette – one that might occur naturally if not mown regularly.

Participants were asked to rate the photographs on a scale of 1-5 according to ‘how much you would like the following landscapes on your property,’ with 1 being ‘not at all’ to 5 being ‘a great deal.’ A follow-up question asked participants to write an explanatory word or two next to each photo they ranked very highly or very lowly. The purpose of the ranking system was to gauge how willing homeowners would be to adopting these practices themselves. The more open-ended question provided an opportunity for the participant to share their thought process and explain their choice. We could then use the ‘word count’ function in Microsoft Word to analyze how frequently certain words were used to describe the photos, to find general themes and trends.

3.5.2 Online Survey

A digital version of the survey was created and distributed via Survey Monkey. (The reminder postcards also included a link to the online survey.) The online version of the survey included the same content as the paper survey, and was formatted as similarly as possible to replicate the layout of the paper survey. An online version was created in an attempt to reach both younger homeowners, as well as provide an alternate means to respond to the survey. Also the paper survey response rate appeared to favor older homeowners, so the digital version created a venue to reach younger homeowners.

The data from the online survey was analyzed separately from paper-survey data for significant differences. Since the sample size was so small (n=14), online survey results were added to the paper survey results.

3.6 Study Sample Description

Participant recruitment was targeted specifically to homeowners. 250 participants were identified in each of the four towns. To measure the potential differences in attitudes and watering habits between the general public and more ecologically-minded individuals, the survey sample included 150 randomly-selected homeowners in each town from the property assessors' tax lists and 50 people in each town who were members of the local watershed association (Ipswich River Watershed Association). In two towns, Middleton and Topsfield, 50 homeowners who lived within a distance of ¼ mile from the river comprised the third sub-population. In North Reading and Wilmington, where there are several publicly-visible LID installations, homeowners with ¼-mile comprise the third segment of the sample population.

3.6.1 Selection Process

Randomly-selected: To select homeowners at random, names were chosen from the most recent assessor's parcel data, which was downloaded from the MassGIS datalayers. All parcels with a building value of $0 were removed. Property owners with non-local addresses were also removed. The remaining owners were then selected at random (dividing the list by 150 and selected each Xth name). (Note: The GIS database lists the first owner of a property.) For the first mailing, names were selected from the GIS database exclusively. The responses we received showed an overall gender bias of about 65% male and 35% female. For the second mailing, we sent the survey to the same households, but used the female owner's name, when available, for every other recipient (second-owner names were available on the town tax assessor's database for Middleton and Wilmington only). Topsfield and North Reading did not publish property owner information on their websites, so addressees' names were not changed in these towns for the second mailing. The following table shows the gender distribution by town for each mailing:

Table 3.4: Gender of Mailing List Recipients vs Survey Respondents

	Male – 1st	Female – 1st	Male – 2nd	Female – 2nd
Middleton	179	71	139	80
North Reading	189	61	158	56
Topsfield	199	51	152	48
Wilmington	185	65	108	114
TOTAL	752	248	557	298
Percentage	75%	25%	65%	35%

River Buffer: The river buffer addresses were also identified using GIS attribute table data. A ¼-mile buffer was applied to the portion of the Ipswich River that passed through each study town. Streets addresses were identified from the clipped buffer layer. Since this list included many more addresses than were needed, addressees were randomly selected from this parcel list street listing.

Watershed association members: The Ipswich River Watershed Association staff provided a list of member addresses for all four study towns. In two of the towns--North Reading and Wilmington--there were fewer than 50 members. In those two towns, additional surveys were sent to homeowners living near LID installations to make up the difference.

LID-proximate homeowners: Publicly-visible LID installations were mapped using GIS. ¼-mile buffers were drawn around each property and addressees within the clipped buffer were compiled. Again, more homeowners lived within these areas than were needed, so the needed number were randomly selected from the address list. The following table shows the survey population distribution of mailed surveys:

Table 3.5: Survey Distribution for Groups and Towns

	Random homeowners	Watershed association members	River buffer homeowners	LID-proximate homeowners
Middleton	150	50	50	-
North Reading	150	31	-	69
Topsfield	150	50	50	-
Wilmington	150	25	-	75

For the web survey, reminder postcards were mailed to participants who didn't respond to the first mailing. The reminder postcard included a weblink directing respondents to the online survey.

3.7 Data Analysis Methods

Survey responses were analyzed using both Excel and SPSS. Descriptive statistics were generated to describe the means, modes, medians, frequencies and standard deviations of both the survey population, and the responses for each question in Excel. Next, in SPSS, factor analysis was applied to individual questions that included Likert-scale responses in an effort to reduce overall responses to groupings. The resulting scales were analyzed by the researchers to determine why respondents grouped these answers together and were named according to the common theme they shared. Each scale then became an individual variable, which was used in subsequent t-test and ANOVA analyses.

Factor analysis was conducted using principal axis factoring with Varimax rotation, Eigenvalues greater than 1, cases excluded pairwise and values under .4 were suppressed. Variables that loaded on more than one factor were not included in either group on which they loaded.

Chi-square tests were run to assess the population distribution among sub-groups. T-tests were also run prior to other analysis to compare responses between genders and between subject groups (randomly-selected, watershed association members, buffer residents and LID-proximate homeowners). T-tests were run between two variables and ANOVA were run between three or more variables (namely to compare towns). These tests were conducted after the factor analysis to compare sub-groups' responses to photos and to the Likert-scale questions. For both ANOVAs and t-tests, a 95% confidence interval of 95% was used. Results of t-tests and ANOVAs yielded new insights for some variables, and subsequent tests were run to explore comparisons between subsets of these variables.

CHAPTER 4

MEASURING PERCEPTIONS OF LOW-IMPACT DEVELOPMENT: SURVEY RESULTS

4.1 Overview

The following chapter presents the results of the survey mailing and the statistical analysis conducted on the responses. A broad overview of response rates and population demographics is presented, followed by a general presentation of survey responses. A more specific presentation of the survey responses is then presented to test the hypothesis posed in the Introduction. As two hypothesis relate to variation between the sub-groups, a significant portion of the data analysis consists of comparisons between towns, between interest groups (random, watershed members, buffer and LID-proximate). Comparisons between demographic variables are also presented to better understand the underlying factors affecting water conservation attitudes and LID adoption.

Hypothesis 1: Social, aesthetic and economic barriers exist to residential-scale LID.

Hypothesis 2: Water conservation attitudes vary between towns and between interest groups.

Hypothesis 3: Unconcerned (random and possibly LID-proximate) are less willing than concerned homeowners (watershed association members and possibly river-buffer homeowners to overcome these barriers to adoption).

To study comparisons between sub-groups, exploratory data analysis results are presented. Factor analysis was first used to create scales from stem questions; t-tests were run to compare mean responses between different groups. Lastly, the data analysis process was iterative; as new insights came to light, further analysis was conducted to refine the differences between surveyed populations.

4.2 Survey Response Rates

Of 998 surveys mailed, 265 were either returned via mail or completed online and four were returned undeliverable, for an effective response rate of 26%. Two surveys were returned without a three-digit identifiers, so they are not included in the table below, but their responses are included in subsequent data analysis. Six additional surveys were completed online by members of a local watershed group in North Reading. Since this sample was so small, these responses were combined with the results obtained from the mailed survey. The responses rates varied widely between towns and between interest groups. While this supports the pattern that those with a stronger interest in a topic would be more likely to respond to the survey (Groves, 2004), previous landscape preference surveys have not consistently reached this conclusion. One study did not find a difference in response rates between homeowners in a conservation subdivision and those who weren't (Hostetler & Noiseux, 2010); Ryan also found mixed response rates between planners, developers and homeowners (2006). A complete table of response rates by town and group can be found in Appendix C.

Table 4.1 Response Rates by Town and Group

	Middleton (n=59)	N. Reading (n=65)	Topsfield (n=93)	Wilmington (n=46)	Total (n=263)
Random (n=128)	27	33	44	24	21%
Watershed (n=69)	18	11	30	10	44%
LID (n=33)	0	21	0	12	23%
Buffer (n=33)	14	0	19	0	33%
Total	24%	26.1%	37.2%	18.4%	

4.3 Survey Population Representativeness

To assess how well the survey population represents the general population, US Census data for Middlesex and Essex counties were compared to respondent demographics (Wilmington and North Reading are in Middlesex County, Topsfield and Middleton are in Essex County. Since the population of Middlesex County is more than twice that of Essex County, Middlesex averages were used in Table 4.2).

In general, the survey population shows a moderate bias towards more highly-educated and older respondents. This is consistent with previous landscape preferences surveys, where respondents were more likely to hold a college or graduate degree (Nassauer J. I., 2009) (Armstrong, 2012) and were older (Larson E. C., 2010) (Armstrong, 2012).

Table 4.2: Survey Population Demographics

AGE				GENDER		EDUCATION				INCOME			
n	Classes	Sample (%)	Census (%)	n	Classes	n	Classes	Sample (%)	Census (%)	n	Classes	Sample (%)	Census (%)
1	<25	0.4		138	Male	27	High school	11.7	21.3	24	<$50k	11.9	18.3
23	25-44	9.8	27.8	85	Female	40	Some college	17.3	19	64	$50-100k	31.8	27.1
126	45-64	53.6	49.1			75	Bachelors	32.5	26.6	58	$100-150k	28.9	27.9
85	65+	36.2	23.1			89	Graduate	38.5	25.5	55	$150k+	27.4	26.9
235	= Total			223	=Total	231	= Total			201	= Total		

SOURCE: American Community Survey, Middlesex County, 1-year averages for owner-occupied units unless noted (Tenure from B25038, Age from S2502, Education from S1501, Income from 2503 - 3 year average).

Age. Homeowners in this region are generally older and have owned their homes for many years. Since the survey sample over-represents those over 65 years old by more than 10%, this may affect interpretation of the results. Older residents likely had more free time to complete the lengthy survey, and are probably less likely to have children. Only 29% of the respondents reported having children under the age of 18 living at home. This fact may be important in considering how people use their yard, and whether they have safety concerns about LID practices (mosquitoes and ticks were mentioned several times in respondent comments). Conversely, it could be argued that younger people are be more open to new ideas and would be more likely to have a rain garden or rain barrel on their property. Age may also be a factor in maintenance – younger people may have less time to spend on yard maintenance, while older homeowners may have more time, but also more physical limitations. If time is a barrier to LID adoption, age may be an important factor to consider.

Education. The education level of survey respondents generally reflects homeowner population. It is notable that the results underrepresent those with a high school education. Of published surveys results in landscape preference, few incorporate education as a variable. One study found higher than average educational attainment among survey respondents (Nassauer J. I., 2009); this fact may speak to the idea that those with a college education are more likely to respond to a survey.

Income. The income distribution of the survey population also mirrors that found in the larger homeowner population – the lowest income bracket, <$50,000, is under-represented by over 6%. The median income for Middlesex County is $109,734 (2013, U.S. Census Bureau, S2503, 1-year estimate). Incomes in this region are significantly higher than the national median income of $52,250 (2013, U.S. Census Bureau, DP03, 1-year estimate).

Gender. The gender ratio is skewed towards men, though this reflects the original mailing list, where 65% of survey addressees were male. Other studies have included predominantly female respondents (Nassauer J. I., 2009) (Harlan, 2006), so the majority of male respondents provides an alternate point of view from the existing literature.

4.4 Overview of Responses

The survey was designed to address several topics, and questions related to these topics were grouped in the following manner (1's, 2's, and 3's = lower, 4's and 5's = higher):

1) How do homeowners use water outdoors?

Seven questions on the first page of the survey sought to obtain information about respondents' property and their landscape maintenance habits. Question 2 asked about property size, Question 3 asked whether an irrigation system was present and whether it was moisture sensing while Question 4 asked if the homeowner had a pool on their property and how they filled it (tap water or purchased water). Question 5 asked about the primary land cover on their property – lawn, woods, shrubs or garden beds, while another question asked whether a waterbody existed on or bordering their property. Question 11 asked how homeowners use their yard, with the hypothesis that people who used it for more socializing, entertaining and recreational purposes would have more lawn, while those interested is nature observation would have more wild landscapes. Those with less lawn and more natural landscapes may be more accepting of LID.

Four questions sought to understand both water sources, as well as how efficiently this water is used. Question 7 asked about tap water source, while Question 8 asked how many hours were spent on maintenance. Questions 9 and 10 asked how many times they watered their lawn during the summer and what time of day they watered.

Property Characteristic Responses. The majority of respondents have property between ¼ - 1 acre, primarily covered by lawn (53% have more than half, 25% have more than half woods). Over one-third of respondents have a waterbody on or bordering their property, and most of these properties do not have irrigation systems or pools. 60% of respondents reportedly use their yard frequently for appreciating nature/beauty, while 45% use it frequently for watching or feeding wildlife. Only 16% and 19% use their yard frequently for socializing and recreation, respectively.

The majority (82%) of participants have public water; the distribution of public vs private varies widely by town. In Middleton, 44% of respondents have wells, and 21% of Topsfield respondents have wells. In North Reading, only 6% have wells, and all Wilmington respondents have public water. A higher percentage of watershed members (23%) are on public water, versus non-members (16%).

2) What are the perceptions about outdoor water use and motivations to conserve water?

Conservation. Generally, half of respondents reported spending 2-3 hours per week on maintenance, while 66% report not watering their lawn at all. Of the 41 people who did report watering their lawn, only 5 water during the day, suggesting a general awareness of the most efficient times of day to water. One question also sought to assess the perception of the amount of indoor versus outdoor water use. While the EPA estimates that 30-70% of summer residential water use occurs outdoors, 61% of respondents thought more is used indoors (Environmental Protection Agency, 2013). This likely reflects that fact that most respondents don't water their lawn or use water outdoors in the summertime.

Question 19 sought to understand the general concern in survey respondents towards various environmental problems. The range of responses was fairly small, with means between 2.35 and 3.02. Singular water-related issues were neither high nor low on the list, though rated 49% of respondents rated "fewer fish in rivers and ponds" as a very or extremely serious concern. "Climate change" was also ranked as a serious concern by 47%, while "poorly planned development" was a serious concern for 41% (it also had the highest mean at 3.02). "Flooding" was next with 40% considering it serious (mean = 2.74), followed by "availability of drinking water" (serious = 37%, mean = 2.41). Too many environmental regulations was the least serious concern with a mean of 2.35 and 28% rating it a 4 or 5.

Table 4.3: Perception of Environmental Problems

Environmental Problem	Mean	S.D.
Poorly planned development	3.02	1.38
Fewer fish in rivers and ponds	3.01	1.32
Climate change	2.91	1.38
Flooding	2.74	1.35
Availability of drinking water	2.44	1.34
Too many environmental regulations	2.34	1.38

This ambivalence towards regulation also appears in Question 21, which asked about motivations to reduce outdoor water use. Options for "more restrictions" and "regulations limiting irrigation use" were rated lower (means = 2.65 and 2.63). Many of the top responses also received tepid ratings, with all six options having a mean rating between 2.52 to 2.97. Drought-tolerant lawn and financial disincentives (paying a $100 surcharge and water bill doubling) were the top responses, with means of 2.97, 2.84 and 2.69 respectively).

3) What are the barriers to adoption of LID – aesthetic, financial, perceptions of effectiveness?

The third group of questions sought to understand barriers to adoption of residential-scale LID practices. Question 14 asked about perceived effectiveness of water-conserving practices and how willing people would be to practice them in the future (scale 1 = not very likely to 5 = extremely likely). Responses rated 4's and 5's were considered most effective.

Effectiveness of Landscape Practices. In general, the practices that were rated both most effective, and which people were most likely to practice in the future are watering less often and watering during times of the day with lower evapotranspiration rates (early morning and evening). Practices that required either more labor or potentially-costly equipment (such as a moisture-sensing irrigation system) were less popular, and also rated less effective.

Table 4.4: Effectiveness of Landscape Practices

Practice	Effective?	Mean	Practice in future?
Watering the lawn less often	73%	4.04	84%
Watering the lawn at dawn/dusk	73%	3.96	90%
Using mulch in garden beds to reduce evaporation	68%	3.95	88%
Checking soil moisture and only watering when needed	68%	3.83	71%
Using a timer during watering	61%	3.62	80%
Adding organic matter to the soil to increase water retention	54%	3.6	66%
Installing a moisture-sensing irrigation system	48%	3.62	41%

Willingness to Adopt Landscape Practices. Questions 15 and 16 sought to assess how prevalent some landscape elements are throughout the survey area, and also to understand willingness to install various landscape elements on their property and motivations to install a rain garden.

Responses. Both of these questions received lukewarm responses. As with the previous questions, those actions which required less time and financial investment were rated higher. Respondents were both most willing to implement or had a drought-tolerant lawn and a drought-tolerant landscape. (While we did not ask respondents to explain their understanding of either, it's possible that many homeowners perceive themselves to already have these features if they do not water during the summer.) Rain barrels, rain gardens and green roofs were features respondents were least interested in installing. Rain barrels had the most variability in response, suggesting that some respondents were far more willing than other to adopt this practice.

Table 4.5: Willingness to Adopt Landscape Practices

Feature	Mean	S.D.	# Have
Drought-tolerant lawn	3.24	1.56	61
Drought-tolerant landscape	3.18	1.58	59
Reduced lawn area	2.70	1.63	67
Rain barrel or catchment system	2.57	1.76	51
Rain garden	2.23	1.60	19
Green roof	1.11	1.00	2

Motivations to Install a Rain Garden. Question 16 asked about motivation to install a rain garden. Financial incentives ("not having to pay for it" and "reduction in my sewer and water bill") topped the list, but also had the greatest dispersion. Respondents seemed divided on whether a rain garden would improve the look of their property; and given the 1.49 standard deviation, technical assistance was a more important factor for some than others. Social influences ("If a friend or neighbor installed one") was rated lowest by the majority of respondents (65% rated this 'not at all' a factor).

Table 4.6: Motivations to Install a Rain Garden

Factors that encourage installation of a rain garden	Mean	S.D.
Not having to pay for it	3.71	1.53
Reduction in my sewer and water bill	3.05	1.52
My property looked more interesting	3.10	1.34
Receiving technical assistance on how to construct one	2.90	1.49
Decreased flooding in my neighborhood/on my property	2.72	1.53
If a friend or neighbor installed one	1.68	1.11

Factors influencing lawn replacement. Question 20 asked if participants would consider replacing part of their lawn with meadow. While 57% said they would, cost of implementation, fear of ticks, and lack of free time were the most significant factors in the decision for all respondents. "To reduce water use" was only somewhat of a factor (possibly because such a small percent of the sample waters their lawn). Concern about appearances, including "Lawn is a better fit for my neighborhood," and "Lawn looks neater than meadow," were rated lower, though the standard deviation suggests that a significant portion of the population considers these more important (39% and 35% respectively, rated these as 'very' or 'extremely' important). These results suggest that there may be practical reasons not to install a meadow (financial and perceived pest problems), but that aesthetic acceptance may also play a role.

Table 4.7: Factors Influencing Willingness to Replace Lawn with Meadow

Importance of the following factors:	Mean	S.D.
Landscape changes are expensive	3.75	1.24
Concern about ticks	3.57	1.47
Lack of free time to implement changes	3.43	1.36
Cost of landscape maintenance	3.34	1.35
Amount of time spent on maintenance	3.30	1.42
To reduce water use	3.20	1.30
Lawn is a better fit for my neighborhood	2.97	1.44
Lawn looks neater than meadow	2.95	1.40
Lawn is used regularly for outdoor activities	2.63	1.34

Visual Preference for Landscape Practices. Lastly, photos were also chosen to elicit responses to a variety of low-impact design practices as well as mainstream landscapes to gain a sense of whether people were aesthetically accepting of alternative landscape practices, or whether there was a strong preference for more traditional landscapes. Of the 20 landscape photos included in the survey, most [include] some form of infiltration or water-conserving landscaping practice. The highest-rated photos (Photos 14 and 19) both included flowers and abundant healthy-looking vegetation and flowers, and were generally tidy and well-maintained. Photos that received lower ratings tended to be less-manicured or include less plant material (Photos 20 and 6). Low standard deviations suggest fairly consistent ratings.

Figure 2: Highest and Lowest-rated Photos

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

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

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

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

Photos were labeled on the survey and grouped into eight categories to offer cues to the characteristics tested. In general, mean ratings for photos were between 2 ('somewhat' like to have this landscape features on their property) and 4 ('a lot' like to have this landscape features). Standard deviations among photo ratings for all respondents were also within a relatively narrow margin, ranging from 1.11 to 1.46. More variation may appear in subsequent analysis between the four groups.

1) Forest and lawn – While many people had favorable ratings of the forested scene (49% rated this scene highly), they were less enthusiastic about the conventional lawn scene (42% rated as either not at all or somewhat likely to install on

their own property). While type of landscape is often considered an ideal, this data suggests a different norm in the survey area. Dispersion in ratings was moderate, suggesting some level of variability.

Figure 3: Forest and Lawn Photos

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

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

2) Driveway type – Gravel and permeable paving were shown as alternatives to more conventional impermeable driveways. Both photos included houses in the background. Over 50% rated the granite pavers very highly, while the gravel fared less well with only 32% rating it highly. 8 of the 41 comments alluded to a crushed stone driveway as difficult to maintain or not functional for snow removal. Some were not clear that it was gravel. The paver driveway had more variability in ratings than the photos of the gravel driveway, suggesting the gravel was more consistently disliked.

Figure 4: Driveway Type Photos

Photo 3: Mean = 2.86, s.d. = 1.26

Photo 4: Mean = 3.26, s.d. = 1.44

3) Taller grass – Grass that's allowed to grow taller requires less water to maintain its health due to a deeper root system. These two photos included a slightly taller lawn with lower mown edge, and another with a mown path through grass ~1 foot tall. 44% rated the shorter grass highly, while only 20% rated the tall grass highly. 9 of the 40 comments for Photo 6 mention ticks, while 13 comments included phases such as 'too messy' or 'not neat'. There was also more dispersion among responses for the taller grass, suggesting some respondents were more accepting of this practice than others.

Figure 5: Taller Grass Photos

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

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

4) Less lawn – Four photos displayed alternatives to a predominantly lawn landscape, as shown in Photo 2. They varied from yards with no lawn and taller wildflowers, to one that was part lawn and part wildflowers and another with part groundcover and part lawn. Of these, the one with both lawn and flowers was rated most highly, with 50% of respondents rating it either 4 or 5. The two yards with no lawn were in the middle with only 37% and 39% rating them highly. Interestingly, Photos 7 and 10 had higher rates of dispersion, suggesting that some people were more accepting of this 'messy' aesthetic than others. The last photo was rated low with 47% scoring it a 1 or 2; 6 of 24 comments including the words 'dull,' 'boring' or 'plain.'

Figure 6: Less Lawn Photos

Photo 7: mean = 2.85, s.d. = 1.43

Photo 8: Mean = 3.34, s.d. = 1.11

Photo 9: Mean = 2.63, s.d. = 1.15

Photo 10: Mean = , s.d. =

5) Rain gardens – There were several types of rain garden photos included – three were round gardens and one was linear. One included primarily grasses, two included flowers and the fourth a mix of plant types. The linear rain garden looked less maintained and had the lowest rating (mean = 2.8) and relatively low variation in ratings. The other three received higher ratings of 3.24, 3.39 and 3.6 respectively. The primarily grassy rain garden had the widest dispersion in ratings. There were also more negative comments about these photos than positive – many referred to amount of time required for maintenance, concern about bugs/mosquitoes (3), the general 'messiness' or that there were too many grasses.

Figure 7: Rain Garden Photos

Photo 11: Mean = 3.25, s.d. = 1.32

Photo 12: Mean = 3.40. s.d. = 1.09

Photo 13: Mean = 2.8, s.d. = 1.18

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

6) Rain barrels – Two photos showed alternative rain barrel uses in a residential setting – one included a smaller barrel camouflaged with the house; the other included partially-buried cisterns fed by a downspout. The cisterns were rated lower (mean = 2.64) 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 were uncertain how the water could be removed from them, others thought they would be too much work, or would be acceptable in a backyard but not a front yard. The single barrel received comments from several people who already had one, or had one but had not yet installed it. These photos had the highest rates of dispersion, indicating more conflicting acceptance of this practice. This variation is reflected in the mixed tone of the comments, which included some positive comments, such as "environmentally good" and "have it!" and "nice residential application."

Figure 8: Rain Barrel Photos

Photo 15: Mean = 2.64 , s.d. = 1.42

Photo 16: Mean = 3.03 , s.d. = 1.46

7) Naturalized lawn – Similar to the 'less lawn' photos, these sought to understand homeowners' perception of wildflowers interspersed with grasses – what might happen if their lawn were allowed to grow a few weeks between mowing. Both photos were rated relatively low.

Ticks and mosquitoes were cited for concern in 9 comments, while the word ‘messy,’ ‘unkempt,’ or ‘weedy’ were included in 27 comments.

Figure 9: Naturalized Lawn Photos

Photo 17: Mean = 2.46, s.d. = 1.34

Photo 18: Mean = 2.64, s.d. = 1.27

8) Drought-tolerant – Two photos were included that displayed more drought-tolerant landscapes. One, which included many flowering shrubs and perennials was rated much higher (mean = 3.36), than the other (mean = 2.25), which was more sparse and included plants such as yucca. The latter received many comments such as “looks unkempt/messy,” and several references to the Southwest and drier desert landscapes. Both photos had relatively moderate rates of dispersion, indicating that ratings were fairly consistent across the survey population.

4.5 Demographics of Towns

As one of the research questions asks whether the willingness and barriers to adopt LID vary between towns (and more specifically between towns that are members of Greenscapes and those that are not), a more thorough understanding of the survey population in each town is warranted. The table below highlights the demographics and property characteristics among towns.

Table 4.8: Key Town Demographic Variables

	Middleton	N. Reading	Topsfield	Wilmington
Gender:				
Male	59%	58%	62%	66.7%
Female	41%	42%	37%	33.3%
Age:				
<24	2%	0%	0%	0%
25-44	11%	10%	8%	9%
45-64	50%	62%	54%	51%
65+	38%	26%	37%	40%
Income:				
<$50k	13%	10%	11%	18%
$50-100k	32%	37%	24%	41%
$100-150k	21%	29%	30%	35%
$150+	34%	22%	34%	6%
Education:				
High school	11%	13%	8%	15%
Some college	20%	13.4%	16%	20%
Bachelor's	33%	33%	35%	25%
Graduate	35%	40%	40%	40%
Property Size:				
<1/4 acre	0%	12%	5%	15%
¼ = 1 acre	51%	70%	53%	76%
1+ acre	49%	19%	43%	9%
>50% in Lawn	37.5%	51%	54%	60%
% Public water	56%	93%	79%	100%
% adjacent to waterbody (Q6)	38%	30%	43%	28%

N.B.: Percentages may not equal 100 due to rounding. Percentages calculated based on number of responses for each question, which varied, but had at least a 70% response rate.

North Reading has the highest percent of people ages 45-64, indicating a lower median age, which likely correlates to the fact that it has the highest rate of households with someone under 18 (34%). Unlike the other three towns, woods are more prevalent in Middleton than lawn. The higher percent of homeowners with private wells in Middleton and Topsfield also reflect the more rural landscapes in these towns, whereas homeowners in the more urbanized areas of North Reading and Wilmington have primarily public water.

4.6 Demographics of Groups

Survey respondents were also divided into four groups, which were then used in subsequent analysis. These four groups include distinct populations that might have different motivations for adopting LID. Random homeowners should reflect the general population, watershed association members are a specific subset of the population who probably have more information and motivation to conserve water. Buffer residents in Middleton and Topsfield live within 1000' of the river, and thus may be more aware of river conditions; their water use actions and perceptions may reflect this more frequent interaction with the river (Kenwick, 2009) (Armstrong, 2012). Lastly, homeowners living near LID installations in North Reading and Wilmington may be more familiar with these landscape practices and thus more willing to adopt them.

Table 4.9: Key Demographic Characteristics by Sub-Group

	Random (n=128)	Watershed Assn members (n=78)	Buffer (n=33)	LID (n=29)
Response rate	21%	44%	33%	23%
% between 45-64	51%	57%	61%	48%
Male: female ratio	2:1	3:2	2:3	3:2
Income:				
<$50k	17%	14%	0%	8%
$50-100k	30%	26%	33%	56%
$100-150k	21%	36%	38%	28%
>$150k	31%	24%	29%	8%
Have graduate degree	39%	51%	33%	14%
¼ - 1 acre property size	59%	56%	55%	72%
Public water	83%	76%	58%	97%
Have children <18yo	29%	22%	32%	31%

4.6.1 Randomly-selected homeowners

128 respondents of this group answered the survey for a response rate of 21%, the lowest of the four groups. This group consisted largely of people between the ages of 45-64, who are fairly well-educated. 39% of these homeowners have graduate degrees, while 26% have

college degrees. The income distribution was also bimodal, with 30% earning between $50-100,000 and 31% earning over $150,000. 29% of these respondents have children under 18 living at home.

The majority have property between ¼-1 acre in size and lawn is the dominant land cover. 45 homeowners have irrigation systems, 45% of which are moisture-sensing. The overwhelming majority (83%) have public water, and more than one-third have a river, stream or pond on or bordering their property. 'Appreciating beauty/nature' was a popular use of their property (mean = 3.72), as was 'watching/feeding wildlife' (mean = 3.25).

4.6.2 Watershed association members

This group had the highest response rate at 44%. Age distribution for watershed members was similar to other groups, with the largest cohort aged 45-64, and the second largest aged 65+. Educational attainment was especially high for this group, with 51% holding a graduate degree and 36% holding a bachelor's degree. Income was slightly less than the random homeowner group, with 36% earning between $100-150,000, and 26% earning $50-100,000. This group was least likely to have children under 18 living at home.

Watershed association members generally had medium to larger properties, with 38% owning over 1 acre. Lawn again was a dominant cover type. 17 members have irrigation systems, [and surprisingly,] the majority of these are *not* moisture-sensing. Three-quarters have public water and 31% have a stream, pond or river on or bordering their property. Lastly, watershed members appear to value the natural features of their property by indicating that they use their yard often for 'appreciating nature/beauty' (mean = 3.8) and watching/feeding wildlife (mean = 3.56).

4.6.3 River buffer homeowners

33% of homeowners in the buffer category (n=33) participated in the survey. The majority of respondents are between the ages of 45-64. In contrast to other groups, women outnumber men (60% to 37%) and educational attainment and income are somewhat lower for this group than for other groups. 32% of households have children under 18 living in them.

Like other groups, the most common property size was ¼ to 1 acre with 33% having property over 1 acre. Only 6 respondents have irrigation systems, and most of these systems are moisture-sensing. Lawn is a dominant landscape cover, with woods being secondary. Unsurprisingly, almost half of respondents in this category have a stream, river or pond on or bordering their property. 58% of buffer homeowners are on public water. Respondents seem to value the natural attributes of their property, indicating that ‘appreciating nature/beauty’ is an activity they do regularly (mean = 4.00), as is ‘watching or feeding wildlife’ (mean = 3.34). Demographically, this group differs from the watershed association members, but property attachment and nature concerns are similar.

4.6.4 LID-proximate homeowners

The response rate for homeowners living near LID installations was 23%. Of these, 89% are over 45. There are more men (68%) than women (32%). Income and educational attainment are lower than the overall average, with 39% holding a bachelor’s degree and 29% having some college education. 31% of respondents report having a child under the age of 18 living at home.

LID-proximate homeowners live in two of the more urban towns in the watershed - Wilmington or North Reading. This more suburban landscape is reflected in the differences from buffer residents where 14% have property under ¼ acre. Also, a significant majority of respondents have property between ¼ - 1 acre where lawn is the dominant land cover, with 55% reporting that lawn covers more than half of their property. Few (n=5) have irrigation systems, and of those that do, only 1 is moisture-sensing. Consistent with a suburban area, 97% of the properties are supplied by public water.

4.7 Factor Analysis and Sub-group Comparisons

The above analyses highlight some of the variation between groups. To understand how these contribute to barriers to LID adoption, water conservation attitudes and willingness to overcome these barriers, t-tests and ANOVAs were conducted to compare mean responses between two or more groups for single questions. Nine questions on the survey contained stem questions. Factor analysis was run these questions to reduce the data and to better understand the underlying patterns. The following describes how the hypotheses were tested and present the resulting data.

4.7.1 Factor Analysis

Factors were extracted from six of the nine multi-stem questions. After examining common themes in the resulting factors, scales were labeled and grouping are identified in the table below. If a variable loaded on more than one factor, it was removed. Factor loadings were set at .4 minimum. A reliability test, using Crohnbach's alpha was run on each resulting factor. Acceptable alpha scores were >.6. A summary table of these scales, the sub-questions associated with each, Eigenvalues for each factor and the Crohnbach's alpha scores are listed below. Descriptions of each factor follow in the next section.

The scales that resulted from the factor analysis were used to examine how each group responded to the scales. T-tests were run to compare means for each scale between the following groups: Income (high and low), education, watershed association member vs not, Greenscapes town vs. not, water source (well vs public supply), river-buffer and LID-proximate homeowners. ANOVAs were run to compare more than two variables.

Factor analysis was run on nine questions (#11, 12, 14, 15, 16, 17, 18, 19, 20, 21 and for all photos). The results are presented below organized by topic.

4.7.2 Barriers to Adoption

Hyp1: Aesthetic, economic, and understanding/comprehension barriers exist to the adoption of LID on a residential scale.

Several questions sought to ascertain the social, aesthetic and environmental understanding barriers that might limit widespread adoption of these features. The first question (Q14) asked about the effectiveness of landscape practices to reduce water use and the willingness to implement these practices in the future. The factor analysis produced only one factor, which was called 'effectiveness.'

Table 4.10: Scale results: Effectiveness of practices

Category name	Items	Eigenvalue	Mean	S.D.	α
Effectiveness -All		3.665	3.782	1.80	.847
	Watering the lawn at dawn/dusk		3.96	1.77	
	Water the lawn less often		4.04	1.85	
	Installing a moisture-sensing irrigation system		3.25	1.83	
	Using mulch in garden beds to reduce evaporation		3.94	1.69	
	Using a timer during watering		3.62	1.86	
	Checking soil moisture and only watering when needed		3.82	1.78	

Generally, the mean responses for each practice fell between ‘somewhat’ and ‘very’ effective, with the exception of installing a moisture-sensitive irrigation system. The standard deviations are somewhat large, suggesting that there is wide variation between ratings, and varied viewpoints on how effective these practices are. This variation may be due to a difference in understanding how these practices reduce water use, or an implicit disbelief in how much water they actually save. The alpha score suggests very good reliability

Q15, which asked how willing homeowners were to implement certain landscape practices, also resulted in only one factor called ‘willing to implement.’

Table 4.11: Scale results: Willingness to Implement

Category Name	Items	Eigenvalue	Mean	S.D.	α
Willing to implement		3.438	2.495	1.71	0.853
	Rain garden		2.26	1.7	
	Rain barrel		2.63	1.9	
	Reduced lawn area		2.72	1.82	
	Green roof		1.16	1.03	
	Drought-tolerant lawn		3.23	1.91	
	Drought-tolerant landscape		3.2	1.92	

While respondents were least interested in adding a green roof on their property, many of the other features also received lukewarm responses. Respondents were most interested in installing drought-tolerant lawns and landscapes, these features had only moderate support and wide dispersion, suggesting that subpopulations may have very varied views towards these measures.

Question 16, which asked about financial, technical and social incentives to installing a rain garden on a person’s property produced one factor, onto which all variables loaded.

Table 4.12: Scale results: Rain Garden Incentives (Practical)

Category Name	Items	Eigenvalue	Mean	S.D.	α
Practical		3.262	2.844	1.72	0.853
	Technical assistance		2.88	1.76	
	Not paying for it		3.71	2	
	Reduce sewer/water bill		3.08	1.85	
	Property looks interesting		3.14	1.73	
	Reduce flooding		2.74	1.76	
	Friend/neighbor installed		1.72	1.22	

That all of the sub-questions loaded onto one factor would seem to suggest consistency in how these were rated individually. However, most of the standard deviations are relatively large, suggesting that there was a fair amount of dispersion in ratings. The influence of friends and neighbors is low, and this is one variable upon which most respondents agree. Even the most highly-rated variable 'not paying for it' has the widest dispersion, indicating that this may be a significant factor for some groups, but for others, cost is not an issue.

Question 20, which also produced only one factor, asked respondents to rate nine factors as to how important they were in their decision to replace part of their lawn with meadow. Two factors were extracted – 'utilitarian' which includes concerns about costs, ticks, and not having enough time. The second factor, 'appearance,' 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. Generally, utilitarian concerns were more important than how the meadow looked. However, both factors had significant variability in the ratings, again suggesting that different sub-groups may rate these variables very differently.

Table 4.13: Scale results: Factors Affecting Willingness to Replacing Lawn with Meadow

Category Name	Items	Eigenvalue	Mean	S.D.	α
Utilitarian		3.445	3.382	1.82	0.821
	Amount of time spent on maintenance		3.25	1.82	
	To reduce water use		3.21	1.75	
	Concern about ticks		3.55	1.91	
	Landscape changes expensive		3.77	1.84	
	Lack of free time to implement changes		3.42	1.81	
	Cost of landscape maintenance		3.33	1.79	
Appearance		1.702	2.979	1.735	0.76
	Lawn looks neater than meadow		2.95	1.72	
	Lawn is a better fit for my neighborhood		2.97	1.75	

4.7.3 Water conservation attitudes

Questions 19, which asked respondents to rate how serious a series of environmental problems are, produced two factors. The second factor had multiple double-loadings, and was thus eliminated. The means for both variables is neither high nor low, and the standard deviation suggests some variability in responses. (Flooding loaded on the second factor. Climate change and poorly planned development loaded on both factors, and were removed.)

Table 4.14: Scale results: Seriousness of Environmental Problems

Category Name	Items	Eigenvalue	Mean	S.D.	α
Water-related		2.83	2.74	1.565	0.687
	Availability of drinking water		2.44	1.5	
	Fewer fish in rivers and ponds		3.04	1.63	

Q21 asked respondents how much they agree the following statement: I would reduce water use if…" and resulted in only one factor. Doubled water bills, $100 surcharge, town limiting irrigation use, having less lawn, and having a drought-tolerant lawn all loaded on one factor; this scale was called 'conservation' (α = .839). Again, the means were all within a relatively narrow range, but the standard deviations were broad. This might suggest more polarized responses among sub-groups.

Table 4.15: Scale results: Motivations to Reduce Outdoor Water Use

Category name	Items	Eigenvalue	Mean	S.D.	α
Conservation		3.582	2.713	1.92	0.839
	My water bill doubled		2.76	2.03	
	There were more restrictions on outdoor water use		2.71	1.78	
	I would pay a $100 surcharge		2.88	1.96	
	My town adopted limits on irrigation		2.69	1.93	
	My property had less lawn		2.56	1.84	
	Had drought-tolerant landscape		2.98	1.99	

Questions 18, "How well do the following statements reflect your general opinion of the outdoor water use restrictions," did not produce any factors after 25 rotations, though respondents generally felt that they were both necessary (mean = 4.08) and a relatively effective strategy to reduce water use (mean = 3.76).

4.7.4 Photo-ratings

One question on the survey used photos to assess the aesthetic acceptance of various water-conserving landscape practices. The photos include scenes of infiltration practices such as permeable driveway paving and rain gardens, catchment practices such as rain barrels, non-conventional yards with taller grasses, no lawn and taller lawn with wildflowers. Two photos also depicted drought-tolerant landscapes. The photos attempt to both raise awareness of LID practices and display a variety of different types of installations to offer alternatives to preconceived ideas of these features. Factor analysis was conducted on all of the photos and five factors were generated. Photos 1 and 4 did not load on any factors. Photos 13, 17, and 19 loaded on more than one factor, and were thus removed. The following describes each scale and the photos that loaded onto that factor.

‘Messy landscapes’ – Photos 6, 7, 8 and 10 all loaded onto the first factor. These photos all depict taller some bare patches of lawn. P8 had the highest mean score of 3.34, while the other three all had means plants, P6 and P8 include a combination of lawn and flowers, while P7 and P10 include only flowers, with less than 3. A less-kept appearance seems to be the theme. The mean for this scale was 2.831 with a standard deviation of 1.31.

Figure 10: Messy Landscape Photos

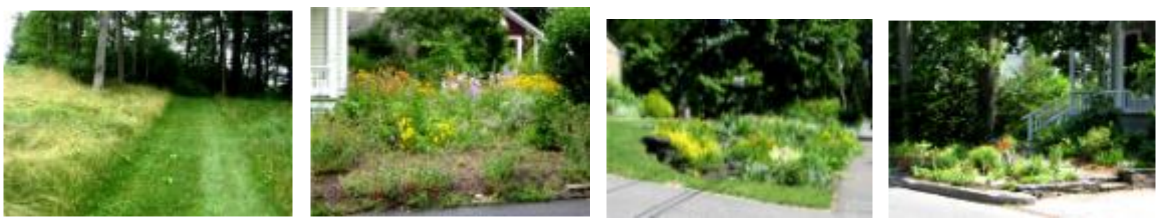


Photo 6 Photo 7 Photo 8 Photo 10

Table 4.16: Scale results: Messy Landscapes

Category Name	Items	Eigenvalue	Mean	S.D.	α
Messy landscapes		5.516	2.831	1.31	0.761
	Photo 6		2.23	1.31	
	Photo 7		2.84	1.43	
	Photo 8		3.34	1.124	
	Photo 10		2.8	1.379	

‘Rain gardens’ – Photos P11, P12 and P14 all loaded onto the second factor. These photos are grouped together in the survey under the heading ‘rain gardens.’ A fourth photo, P13, also loaded onto this factor, but had multiple loading, and was thus removed. These photos all had relatively high average ratings (between 3.24 and 3.61) for a mean of 3.403, α = .737.

Figure 11: Rain Garden Photos (factor)

Photo 11

Photo 12

Photo 14

Table 4.17: Scale results: Rain gardens

Category Name	Items	Eigenvalue	Mean	S.D.	α
Rain gardens		2.406	3.40	1.16	0.737
	Photo 11		3.24	1.299	
	Photo 12		3.40	1.062	
	Photo 14		3.61	1.106	

'Conventional landscapes' – Photos P2, P3, P5, and P9 all loaded onto one factor. These photos depict more conventional landscapes with lawn as the dominant landscape cover, and some amount of road or driveway. P2 and P4 include portions of the house. Photo ratings ranged from 2.67 for P9 to 3.26 for P5. P9 included more shade than the other photos in this cohort, which may explain its lower rating. The mean for all photos was 2.908. With Crohnbach's α = .572, this was not reliable, and was not studied further.

Figure 12: Conventional Landscape Photos

Photo 2

Photo 3

Photo 5

Photo 9

Table 4.18: Scale results – Conventional Landscapes

Category Name	Items	Eigenvalue	Mean	S.D.	α
Conventional		1.476	2.91	1.22	0.572
	Photo 2		2.78	1.336	
	Photo 3		2.87	1.264	
	Photo 5		3.26	1.147	
	Photo 9		2.67	1.134	

'Miscellaneous landscapes' – Photos 18 and 20 loaded onto another factor. Both photos had low mean ratings or 2.65 and 2.26 respectively. It's not entirely clear what the commonality between these photos is, other than that respondents did not like them. The Crohnbach's α of .499 also indicates that this factor has a low scale reliability.

Figure 13: Miscellaneous Landscape Photos

Photo 18

Photo 20

Table 4.19: Scale Results: Miscellaneous landscapes

Category Name	Items	Eigenvalue	Mean	S.D.	α
Miscellaneous landscapes		1.294	2.442	1.36	0.499
	Photo 18		2.65	1.27	
	Photo 20		2.26	1.237	

'Rain barrels' – Photos 15 and 16, which both include different types of rain barrels, comprised the last factor. The rain barrels appear to be the consistent theme between the two photos, which had a mean rating of 2.827. Reliability was relatively high for this factor (α=.767), indicating that this scale is a reliable grouping.

Figure 14: Rain Barrel Photos (factor)

Photo 15

Photo 16

Table 4.20: Scale results: Rain Barrels

Category Name	Items	Eigenvalue	Mean	S.D.	α
Rain barrels		1.12	2.827	1.43	0.767
	Photo 15		2.65	1.408	
	Photo 16		3.03	1.448	

4.8 Sub-group Comparisons

The initial research questions generated three hypotheses. The results discussed in Section 4.7 introduced some of the key barriers to residential-scale LID adoption (addressing Hypothesis 1), and included safety concerns (ticks and mosquitoes), varied acceptability of 'messier' landscapes, and low concern for water-related abundance issues. The following data analysis seek to test the remaining two hypotheses:

Hypothesis 2: Attitudes towards water conservation vary between four groups: those living near an LID installation (+), watershed association members (+), those living near the river (+), and those chosen at random (-).

Hypothesis 3: 'Unconcerned' (i.e., Random and possible LID-proximate) homeowners are either unwilling or uninterested in changing their landscape to implement LID. Concerned (Buffer, watershed members) homeowners may be willing to overlook the above barriers because they either understand the benefits or find the cause sufficiently compelling.

4.8.1 Attitudes towards water conservation

Two questions on the survey asked about factors that would influence homeowner to install a rain garden (Q16) and replace part of their lawn with meadow (Q20). Responses related to financial costs ('not paying for it' for rain garden question, 'landscape changes are expensive' for meadow question) rated highly (means = 3.71 and 3.75, medians = 4). Regarding replacing lawn with meadow, the most significant factors were concern about ticks and the fact that landscape changes are perceived to be expensive. Lack of free time to implement changes (mean = 3.43, median = 4) and time spent on maintenance were also significant factors (mean = 3.30, median = 4). Concern about appearance ('lawn is a better fit for my neighborhood,' mean = 2.97) and use of outdoors for activities rated lowest (mean = 2.63).

4.8.2 Towns

For the rain garden question, other factors varied more by town; North Reading residents were very interested in receiving technical support for a rain garden installation. North Reading and Wilmington residents cited reducing sewer and water bills as a significant factor. For residents with more private wells, this was not a significant factor (Topsfield and Middleton, mode =1). All towns were interested in installing a rain garden to 'make their property look more interesting' (mean = 3.14, median = 3). Wilmington was the town most motivated by the ability of rain gardens to reduce flooding. Respondents were not motivated by a neighbor or friend to install a rain garden (mean = 1.72).

For the questions about willingness to replace lawn with meadow, answers were fairly consistent across all towns. One notable exception was that homeowners in Wilmington were least likely to replace lawn with meadow. These residents were also more concerned about appearance ('lawn is a better fit for my neighborhood,' median = 3, somewhat agree) versus all other towns, where the most common response was 1 (not at all).

4.8.3 Groups

Regarding factors that influence rain garden installation, many groups responded fairly consistently. Random homeowners were less interested in receiving technical assistance (mode = 1), while the other three groups were more interested, with modes =4. Other factors were somewhat consistent the groups. All groups rated 'not having to pay for it' highly (medians = 4's and 5'). Buffer homeowners and those living near LID rated 'reduced sewer and water bills' more highly than random and watershed members (this may reflect the income disparities between these groups). This is somewhat surprising, considering that 42% of buffer respondents have private wells, and presumably do not have to pay for their tap water. All groups rated 'property look more interesting' on the high side (3's and 4's). The only group that seemed concerned about flooding were those living near LID installations (mean = 3.16). None of the group claim to be influenced by a friend or neighbor (means <2).

Willingness to replace lawn varied between the groups. Random, watershed members and buffer homeowners were most willing to replace lawn, while those living near LID installs were not. For all groups, 'concern about ticks' and 'landscape changes are expensive' were the most influential factors, with medians of either 3 or 4. Time was another major consideration, with groups indicating that 'amount of time spent on maintenance' and 'lack of free time to implement changes' were 'very' important factors. This varied somewhat by group with those near LID installations less concerned about time spent on maintenance, and random homeowners indicating that lack of free time to implement changes was an only 'somewhat' important factor. Generally, buffer respondents rated these two factor more important (medians 3 and 4, respectively). Reducing water use was only 'somewhat important to random and LID-proximate respondents, while it was more important to watershed association members and buffer homeowners (medians =4 and 3).

4.9 Trends in Conservation Practices

4.9.1 Towns

An ANOVA was conducted comparing responses of each of the four towns to Question 14: how effective are the following practices (watering less often, watering at dawn/dusk, using mulch, checking soil moisture, adding organic matter, using a timer, installing a moisture-sensing irrigation system). There was no statistically significant difference among the four towns.

4.9.2 Groups

An ANOVA was conducted comparing responses of the four subgroups to Question 14. In general, all groups thought that these practices were 'very' or 'extremely' effective at conserving water. Notable exceptions were that LID-proximate homeowners rated 'adding organic matter to the soil' as only 'somewhat' effective. Buffer residents were also more likely to rank 'using a timer' as 'somewhat' effective. With the exception of 'installing a moisture-sensing irrigation system,' buffer homeowners were generally willing to practice all of these measures, though the results were not statistically significant (p=.131).

4.10 Trends in LID adoption

The following analyses test Hypothesis 3, that unconcerned (random and possibly LID-proximate) are less willing than concerned homeowners (watershed association members and possibly river-buffer homeowners) to overcome these barriers to adoption:

The survey asked respondents to indicate whether they had any of these features on their property. Overall, 19 respondents indicated that they have a rain garden, 51 have rain barrels, 66 have reduced lawn area, 61 that they have drought-tolerant lawns and 59 that they have drought-tolerant landscapes. (The last two seem high, and there may be a question as to whether the landscapes were intentionally drought-tolerant, or if they were so by default (i.e. water restrictions prohibited owners from watering their lawn, so the lawns were considered 'drought-tolerant).) Towns with the most 'reduced lawn area' respondents were North Reading and Topsfield, which are both Greenscapes towns. Those with the most drought-tolerant lawns was Topsfield, and the most drought-tolerant landscapes were Middleton and Topsfield (both less densely populated, and with higher incomes; these towns have both had many years of outdoor water restrictions).

4.10.1 Towns

An ANOVA was conducted comparing willingness between towns to adopt a variety of site-scale LID features, including rain gardens, rain barrels, reduced lawn areas, green roofs, drought-tolerant lawn and drought-tolerant landscapes. In general, homeowners were most willing to install drought-tolerant lawns and landscapes, with the medians for Topsfield, Middleton and North Reading = 4. Wilmington was the exception, indicating the median answer to install drought-tolerant lawn and landscape at 3/somewhat willing. The majority of respondents were willing to reduce lawn areas, except again, for those in Wilmington, where 51%

were not. Installing rain gardens was generally unpopular in Middleton, North Reading and Wilmington, but more attractive to Topsfield residents, with 35% indicating that they would be very willing (4's and 5's). Topsfield, Middleton and Wilmington residents were most interested in using rain barrels (35%, 37% and 47% indicating they would be 'very' or 'extremely' willing). Residents in North Reading were less interested (25% were very or extremely willing).

4.10.2 Groups

An ANOVA was conducted to compare willingness between groups to adopt a variety of site-scale LID features, as listed above. Random homeowners' responses were similar to LID-proximate homeowners with medians for drought-tolerant lawn and drought-tolerant landscapes at 3. Watershed association members and buffer residents were slightly higher (median = 4). Buffer homeowners were most interested in installing rain gardens (median = 3). Random homeowners, watershed association members and those near LID installations were less interested (medians = 1, 2 and 1.5, respectively). Green roofs were not popular at all (median =1), possibly due to the perceived cost or lack of familiarity.

4.10.3 Demographic barriers to residential LID adoption

There may be several barriers that affect homeowners' adoption of LID features. Questions #15, 16, 20 and all of the photos seek to identify these barriers, including financial considerations (such as cost of installation and savings to sewer/water bills) and aesthetics and concern for property appearance, time required to make changes, and knowledge and understanding of the benefits of LID. Question 16, "How much would the following factors encourage you to install a rain garden on your property?" sought to understand these barriers by identifying motivating factors to rain garden installation. Questions 20 asked "Would you consider replacing part of the lawn on your property with a meadow or groundcover." By running t-tests for three demographic categories, we attempted to understand the significance of each variable.

Income. To understand whether installing a rain garden was perceived to be an expensive undertaking or something more wealthy homeowners were inclined to do, t-tests were conducted to compare responses of high income participants (>$100,000) to low income participants (<$100,000). (Note: median household income throughout the watershed is over $100,000 (U.S. Census Bureau, 2013, DP03, 1 year average)). Of the 80% of respondents that disclosed their income range, 44% fell into the lower income category, and 56% into the higher income category. Income was a significant factor to several of the scales:

1) "Willingness to Implement" scale (p= .06). This scale, derived from Question #15, grouped several water-conserving landscape installations. Those in the higher bracket were more willing to implement this group of landscape installations than those in the lower bracket (2.74 vs 2.18). The list of installations ranged from relatively inexpensive (such as rain barrels and reduced lawn area) to more costly installations (rain gardens and drought-tolerant landscapes).

2) "Motivation to build a rain garden" scale (p=.033). Higher-income respondents were also more motivated by incentives than lower-income. High income respondents averaged a mean of 3.07 on the suite of rain garden incentives compared to lower income respondents (mean of 2.7). Incentives included financial ones such as 'not having to pay for it' to non-monetary incentives, such as 'receiving technical assistance on how to construct one.'

3) Question 20, which asked about replacing lawn did not yield statistically significant results when high and low incomes were compared in t-tests.

These results suggest that income level of participants and perceived cost may be a barrier to implementing LID; thus the incentives offered to create LID installations may vary by income of the target demographic group.

Water source. Residential water source may be another factor affecting adoption, in that those who have private wells may be less interested because they both don't pay for their water, nor do they necessarily associate their water use with the health of the river. To study this relationship, t-tests compared respondents with private wells (n=48) to those with public water (n=218) for each of the scales generated by the factor analysis. Water supply was a statistically significant factor in three of the scales:

1) "Willingness to Implement" scale – There was no significant difference between means for those with private wells and those on public water.

2) "Messy landscape" scale (p = .008). Those on private wells ranked these photos significantly higher (mean = 3.2) than those on public water (mean = 2.75). There may be a confounding factor, in that those on private wells may live in more rural areas, and be more accustomed to less-conventional landscapes.

3) 'Incentives/disincentives to reduce water use' (p=.00). Those with public water supply were more motivated by disincentives to reduce water than private well users were (2.9 vs 1.87). It may be that the financial savings was the motivator, but it may be that private well users feel they are entitled to their water and are less inclined to

conserve it. Private wells are not bound to the water restrictions that public water users are and private well users may feel they are immune to the disincentives.

4) "Motivation to build a rain garden" scale (p=.006). Those on public water had a higher mean score (2.93) than those with private wells (2.38), suggesting that there is a greater incentive to those who pay for their water; conversely, a disincentive exists to those who have a water source on their property.

Education*.* Level of education may be a factor in willingness to adopt. Those with a college degree may be more aware of environmental issues or have a broader understanding of the interconnections between the river and groundwater levels. The participants were divided into two groups – those with a college degree and above, and those with either a high school diploma or some college. Education proved to be statistically significant for two scales that measure willingness to adopt:

1) "Willing to Implement" (p = .001). Those with college degrees rated the suite of landscape installations a mean of 2.71 compared to a lower score for those without a college degree (mean = 2.02). While watershed association members were most likely to have college degrees, and also most likely to be interested in adopting these practices, they don't explain all of the difference between these groups.

2) "Messy landscape" photos (p = .000). Again, those with a college degree rated this series of photos higher (mean = 3.01) than those without a college degree (mean = 2.44). Does a college degree mean a higher acceptance of less-manicured landscapes? And what factor related to higher education increases this acceptance of 'messier' landscapes? (Interestingly, the scale regarding reducing lawn for appearance reasons, was not statistically significant between the two groups. It would seem that if

appearance was a significant factor in LID adoption, that this latter scale would also produce a difference between average means for the two groups.)

While not statistically significant, two additional scales are worth noting:

1) "Rain garden motivation" ($p = .084$) – Those without a college degree were somewhat less interested (mean = 2.62/5 in incentives to install a rain garden than those with a college degree (mean = 2.92).

2) "Neat rain gardens" ($p = .057$) – Here again, those with a college degree appear to be more accepting of rain gardens than those without a college degree. The three photos showing tidier rain gardens were rated higher (mean = 3.48) by those with a college degree than those without (mean = 3.21). While neither of these results are statistically significant, they do support the trend that a college degree is a good indicator of willingness to adopt non-traditional landscape practices.

4.10.4 Barriers to LID adoption among interest-groups

Demographic variables may explain some of the economic and aesthetic barriers to LID adoption, as presented above. Another variable to consider, is whether participation in an interest groups such as being a member of the watershed association or living in a town with more conservation policies, also affects acceptance of these landscape practices. The following analyses examine three variables that may affect willingness to implement and attitudes towards water conservation: living in a town that is a member of Greenscapes, being a watershed association member and living near the river.

Greenscapes Towns vs. Non-Greenscapes Towns

Respondent data was also divided into two groups – towns that were members of Greenscapes (North Reading and Topsfield) and towns that were not (Middleton and Wilmington). While town membership in Greenscapes alone is not an endorsement of water conservation practices, it might be a proxy for greater conservation awareness and policies in that town. Membership in Greenscapes was significant for two scales, including:

1) 'Messy landscapes' – Greenscape member towns rated these photos higher than non-Greenscape member towns (2.96 vs 2.63) (p = .018).

2) 'Reducing lawn for appearance reasons' – The difference in means between groups was also statistically significant (p=.019) for this scale. Non-Greenscapes members rated appearance factors as more important reasons for reducing lawn than Greenscapes members (3.24 vs 2.82). This supports and corroborates the finding that watershed members are more willing to accept messy landscapes than non-watershed members. A public education component may be linking these two scales, where those who understand the importance of water conservation are more likely to be willing to change.

3) Water-related environmental problems' – Greenscapes towns also rated water-related environmental problems as more serious than those in non-Greenscape member towns (2.84 vs 2.58). While the significance is doesn't meet the 95% confidence interval, it is notable (p=.094).

Watershed Members vs. Non-Members

A chi-square test found that the distribution of members to towns was not significant (p=.96). A one-way ANOVA was used to better understand the variation between the four groups (randomly-selected, watershed association members, LID-proximate and river buffer residents) for all of the scales. This ANOVA compared the resulting scales created in the factor analysis (which had a Crohnbach's $\alpha > .6$) across the four groups. A Bonferroni post-hoc test was also done. The following scales were statistically significant:

1) "Messy landscapes" photos ($p=.016$). Most significant were the ratings between the randomly—selected and the watershed members ($p = .012$), where random homeowners rates these photos of a mean of 2.69, while watershed members rated them higher at 3.18.

2) "Reduce lawn – appearance" ($p = .009$). Again, the most significant difference ($p = .019$) was between random homeowners and watershed members, where the former rated appearance factors more highly (mean = 3.23) than watershed members (mean = 2.61).

3) Cost-related factors in reducing lawn. Looking at specific individual variables influencing homeowners' willingness to reduce lawn, there were several statistically significant differences between random homeowners and watershed association members. "Landscape changes are expensive" was significant ($p=.024$), with random homeowners rating this a more important factor (mean = 3.92) than watershed members (mean = 3.24). "Cost of landscape maintenance" also was a statistically significant factor, with random homeowners more concerned (mean = 3.45) than watershed members (mean = 2.84). This is an interesting finding, given that the income distribution for these two groups is fairly similar (random homeowners have a slightly higher overall incomes).

4) "Water-related environmental problems" ($p = .002$). Again, the most significant difference ($p = .001$) exists between random homeowners and watershed

members, where the former rated these issues lower (mean of 2.50) compared to watershed association members (mean = 3.15). LID-proximate homeowners rated these issues similar to random homeowners (mean = 2.52), though the results were not statistically significant ($p = .067$).

While it is not surprising that watershed members are more concerned about water-related issues such as lack of drinking water, and fewer fish in rivers and streams, their acceptance of 'messier' landscapes for the sake of water conservation supports the idea that they are willing to practice their implicit beliefs.

Proximity to a Waterbody

This question was addressed in two different ways in the survey. First, 99 surveys were sent to homeowners who lived within ¼-mile of the Ipswich River in the towns of Middleton and Topsfield. When an ANOVA was conducted for all four groups, homeowners in this 'buffer' area differed significantly from randomly-selected homeowners regarding one variable:

1) 'Reduce lawn_neighborhood fit' – Random homeowners were more concerned (mean = 3.27) about whether a meadow would fit with their neighbor's properties than watershed members (mean = 2.58, $p = .017$) or those in the buffer area (mean = 2.44, $p = .047$). Since many watershed members as well as buffer residents live in Topsfield and Middleton (the two most rural towns in the study), there may be a confounding factor in that these homeowners may be more accustomed to more wild-looking landscapes that those in more suburban towns.

We also tested the effect of proximity to a waterbody by asking specifically if there was a "pond, river, or stream on or bordering your property" (Question 6). When survey respondents who answered ‘yes’ were compared to those who answered ‘no,’ one set of scale means was statistically significant:

1) ‘Effectiveness of Practices’ – Non-adjacent property owners rated these practices higher than adjacent property owners (3.88 vs 3.59) (p=.023). It is unclear why this difference exists; adjacent property owners are more likely to live in either Middleton or Topsfield, and may perceive that these practices are not as useful in a rural setting as they would be in a more urban setting.

2) Interestingly, there was no statistical significance between the adjacent and non-adjacent property owners regarding the seriousness of water-related problems. Proximity to the river did not influence this scale.

4.11 Summary of Findings

Several recurring themes emerge from the above analyses:

1) The scale ‘messy landscapes’ is a persistent theme among demographic variables (private well users, education and income), where more highly educated, wealthier homeowners with private wells are more accepting of less-conventional landscapes than their counterparts. Interest groups were also a more accepting of these landscape types. Greenscapes towns, watershed association members and private well users all rated this suite of landscapes higher than their counterparts. While an education component or deeper understanding of water conservation issues may exist for watershed association members and Greenscapes town residents, this connection is not be as clear for the private well-users. One potential explanation is that well-users are more likely to live in less-developed areas where societal landscape norms are different, and thus may be more accepting of non-traditional landscapes. Cross-references

to existing studies in this field might shed light on this theme (Armstrong, 2012) (Nassauer J. I., 2009) (Kenwick, 2009).

2) Another persistent theme is the perception that landscape changes (and to some extent LID) are expensive. Those with higher incomes were more willing to build rain gardens, and to implement a suite of LID practices, including less expensive actions such as installing rain barrels and reducing lawn area to more expensive landscape changes. The cost of landscape changes and maintenance were also top concerns when respondents were asked about replacing lawn with meadow. 'Not paying it' was a significant motivator to install a rain garden, as was 'reducing sewer/water bill.' Despite the higher incomes throughout this area, financial factors are an important consideration.

3) Third, safety concerns were a recurring theme in both the photo rating analysis and in the replacing lawn with meadow question. Despite the fact that rain gardens are designed to drain before mosquito larvae can hatch, and the fact that wide mown paths through meadows can curb the opportunity for ticks to reach humans, there still seems to be widespread concerns about these issues. Broader public education might allay some of these fears.

4) Beyond the sub-group differences in acceptance of messy landscapes, there are also recurring patterns between those who are more environmentally-conscious (Greenscapes and watershed association members) and those in the random category. While an educational component may be playing a role in the differences between these groups, it's unclear whether this explains all of the differences between these groups. Demographically, these are varied with respect to education and income, so the story seems more complex, which underlines the role of environmental awareness in willingness to adopt LID practices. To complicate this question, one wonders why aren't those near LID installations more interested in adopting those practices. Rain gardens in Wilmington are identified by signs, as are some in North Reading, so an education

component exists. Are those in more suburban areas less willing to give up some of their lawn because their properties are smaller? Do they doubt the effectiveness of these measures? Landscape preference studies on landscape preference (Larson, Cook, & Hall, 2010) (Armstrong, 2012) may highlight similar findings in other areas of the country.

The following chapter will explore the connections between variables acting as barriers to adoption of LID, and between attitudes towards water conservation. It will also re-examine the literature cited in Chapter 2 to connect the results of this study to those elsewhere in the U.S.

CHAPTER 5

DISCUSSION OF FINDINGS

5.1. Overview

Several findings presented in the previous chapter support existing landscape preference research, though many results are contradictory. The population surveyed included a mix of suburban and semi-rural homeowners. The survey population is generally more educated than the state population. An active watershed association and frequent press about the state of the river likely contribute to a greater awareness of water conservation issues. While explicit support for outdoor water conservation was lukewarm throughout the population, it was stronger in populations who were more conservation-minded (watershed association members), or lived closer to the river. Despite this support, several barriers exist to adoption of LID on a residential-level. First, respondents perceive landscape changes to be costly – both for installation and maintenance. Second, they are concerned about safety; despite design standards that exist to reduce standing water and address pest control, many responses express health concerns about adopting LID practices (especially taller lawn and rain gardens). An education and awareness component seems to underline the differences between watershed members (who have a higher acceptance of messy landscapes) and randomly-selected homeowners. However, this should not be the only solution presented; increased awareness of other aesthetic and cost benefits of LID, policies to promote and integrate LID-adoption into existing and proposed developments, and design standards which incorporate landscape aesthetics and 'cues to care' are other potential solutions.

The following discussion compares the findings in published literature with the results of this study. It also seeks to identify the underlying factors influencing these differences. Thirdly, it identifies opportunities for policies and design to positively influence LID adoption and promote more widespread behavioral practices to reduce outdoor water use.

5.2 Population Influences

The socio-demographics and environmental awareness of survey respondents affect their responses. While some variables analyzed in this study are consistent with the results of other studies, some variables vary significantly, and might reflect the social mores and public outreach efforts present in the region. Massachusetts is one of the most densely populated states in the country (859 people/square mile, U.S. Census 2013); however a disparity exists between those living in more rural towns and those in more suburban towns. The surveyed towns included Topsfield and Middleton, which have densities less than the state average (~470 and ~620 people/mi^2, respectively) and have less impervious area (8% and 9.8%, respectively) than other towns in the region. North Reading and Wilmington are more densely populated (~1100 people/mi^2 and ~1300 people/mi^2, respectively), and also have a higher percentage of impervious land area (16.1% and 21.8% respectively) (Environmental Protection Agency, 2012). This difference was apparent in homeowners' willingness to adopt landscape practices, and also their aesthetic acceptance of LID features. Also, while the regional income is high compared to national averages, perceived cost and time involved in maintenance were significant factors across towns and groups. Lastly, an aggressive public education effort related to tick and mosquito-borne illnesses such as Lyme and West Nile Virus have likely affected public perception of landscape practices that include any standing water or taller grasses. Middlesex and Essex counties have had some of the highest rates of West Nile Virus in the past few years (The region saw 18 of the state's 55 mosquito infections in 2014. 2014 data includes 1 human infection in

Essex County and 5 in Middlesex County, an increase from 2013 figures of 2 infections in Essex County, 1 infections in Middlesex County) (US Geological Survey, 2015). Given this public health concern, education about safety issues (or lack thereof) would be an important measure to allay these fears. Also, promoting measures that are associated less with standing water and taller vegetation may be more popular.

5.3 Barriers to Adoption

The three main challenges to LID adoption identified in this survey were the financial costs and perceived landscape costs associated with LID implementation, the importance of landscape aesthetics appeal and a willingness to bridge the gap between environmental awareness and actual action. These topics, and opportunities to overcome them, are explored below.

5.3.1 Economic Factors

The first hypothesis posits that economical, aesthetic and knowledge barriers to adoption exist. In general, willingness was higher to adopt less expensive and less time-consuming changes (watering less, watering at down or dusk, installing drought-tolerant lawn) than more costly and more time-intensive changes (such as rain gardens, moisture-sensing irrigation systems and green roofs). Cost was a significant factor for adoption of both rain gardens and replacing lawn with meadow. Larsen (2006) also 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 were more attached to traditional lawns. The latter was reflected in Wilmington residents who were least willing to replace lawn. Wilmington residents were most likely to have smaller lawns and earn less. Smaller properties may mean that there is less expendable outdoor space or thus less willingness trade lawn for another land cover.

Nassauer (2009), on the other hand, did not find a difference in stated preferences between income groups. This fact might point to the fact that financial incentives are necessary to implement rain gardens and lawn reductions on a wider scale.

5.3.2 Landscape Aesthetics

While not an explicit research question, the survey sought to understand how respondents viewed the aesthetics of water-conserving and LID practices. Landscape appearance emerged as a very significant variable ('Messy' landscape photos had the highest Eigenvalue of all scales at 5.516). While the aforementioned safety concerns likely result in lower acceptance of taller vegetation and less-manicured landscapes, the reason for these photo ratings is more complex. The interesting aspect of the 'appearance' factor was the way in which it was expressed in the survey. Question 20 ('what factors are important in your willingness to replace lawn with meadow') included several references to appearance – which were generally rated lower than other concerns. However, there was wide variation between those who are more environmentally aware (watershed members and residents of Greenscapes towns) and their counterparts; more concerned homeowners were more accepting of these 'messier' landscapes, and also less concerned about appearance. While one study (Larson E. C., 2010) found that stated environmental beliefs do not necessarily translate to actual practices, several studies (Bowman, Thompson, & Tyndall, 2012) (Blaine, 2012) (Willis, 2011) (Atwood R. K., 2007) indicate that increased understanding about the benefits of LID and ecological design practices increases willingness to implement landscape practices. Thompson also posits that increased ecological understanding may boost both acceptance and willingness to implement more sustainable land-use practices (Thomspon, 2004). This idea is reflected in the results indicating a higher level of concern for water-related issues (among watershed members) and less concern about appearance of lawns versus meadows (for both WSA members and Greenscapes towns). These groups may be more willing to look beyond the aesthetics of a landscape to address broader issues of sustainability.

5.3.3 Awareness

Implied knowledge was also hypothesized to be a factor in LID adoption. However, those with potentially more awareness and knowledge of water conservation issues and landscape practices to address them (as a result of living in a Greenscapes town, or being a watershed member), were not necessarily more willing to implement these practices than non-watershed members and residents of non-Greenscapes towns. Both groups, however, rated water-related environmental problems higher than their counterparts.

Safety concerns of LID practices was an unforeseen barrier expressed in the results. The fact that cost is a concern adds complexity to how homeowners weigh the benefits versus the perceived risks of implementing LID; if they perceive cost to be a significant factor, then they may be less likely to install a landscape that they also perceive will introduce health issues. Safety of LID wasn’t an explicit variable in the survey, but it was included in the question about factors involved in replacing lawn with meadow. Many comments were made in the photo portion of the survey that suggested concerns about ticks and mosquito-borne illnesses were widespread. Outreach and education about pest habitats and life cycles may again address these concerns and increase homeowners’ understanding of how rain gardens and rain barrels function.

Existing research on the perceived health risks of LID is scant. There are articles in trade publications that address these concerns, but few peer-reviewed articles exist connecting this perception with rain gardens, meadows, etc. This may be one point where ecological design and public health concerns are at odds. While many sources have cited the conflict between zoning codes which hinder alternative designs (Ryan R. L., 2006) (Bowman, Thompson, & Tyndall, 2012)and a parallel movement to incorporate LID, the literature is young and limited. Public education about how rain gardens function and how design standards ensure that LID practices such as rain gardens, vegetated swales, meadows are both designed and maintained to minimize creation of pest habitat would address this concern.

The third hypothesis posits that those with more understanding of water issues and concern for water conservation and LID practices were willing to overcome these barriers. Specifically, watershed members were statistically more concerned than random homeowners (p=.001) regarding these water-related issues. Buffer residents were also more concerned. These results suggests a pattern that those who either live near the river or have pro-environmental attitudes towards the river are both more aware of the issues and more concerned about them. Watershed members were more accepting of messy landscapes than random homeowners. They were also significantly less concerned with appearance than random homeowners. This is consistent with existing findings (Bowman J. T., 2009) (Armstrong, 2012) that those with more knowledge and understanding of the practice are more willing to implement it. While it is difficult to make a concrete link with the existing data, watershed membership correlates to acceptance of 'messier' landscapes, as well as greater acceptance of alternative landscape practices such as meadows, rain gardens and rain barrels. Further research into the components of membership that influence this acceptance is needed.

Homeowners in Greenscapes towns are both more accepting of 'messy landscapes' and less concerned about appearance. These findings corroborate the fact that watershed association members are also more accepting. This result also supports the hypothesis that more knowledge may influence willingness to implement. This is particularly notable, since this trumps the previous finding that income is a significant predictor of willingness to adopt; North Reading is a Greenscapes town, yet it has a lower overall income than Middleton (a non-Greenscapes town).

Several respondent comments about the rain garden and rain barrel photos also support this hypothesis; three asked how the rain barrels worked, and two commented that they would like to have or just installed a rain garden on their property. That homeowners seek information about these practices and aren't dissuaded by their 'look, speaks to an interest in water conservation and a willingness to practice non-traditional measures on their property.

This question of environmental awareness versus education raises the question: is this awareness an inherent trait, or can it be learned? A subsequent question is whether it is easier or better to promote LID adoption among those who already have pro-environmental attitudes (i.e. watershed association members and those who live near the resource), or whether it is more important to focus efforts on increasing more widespread understanding and knowledge about these practices in hopes of increasing widespread adoption through a combination of education and economic incentives.

Lastly, the town variation in willingness to adopt different practices is interesting. While Wilmington residents were less interested in giving up a portion of their yard to rain gardens or meadow, they were the most interested in installing a rain barrel (47% were very or extremely interested, while 25 respondents already have a rain barrel). There may be a few contributing factors to explain this: rain barrels don't take up much space, and thus would not compete with lawn for usable yard space. Secondly, Wilmington had mandatory water restrictions for every year between 2007 and 2012; thus they may be interested in a practice that allows them to water their lawn (and garden), when their outdoor water use is otherwise limited. Also, rain barrels are one of the least expensive measures to install, and thus the economic tradeoff may seem worth it.

5.3.4 Landscape and Social Contexts

In addition to an educational component, landscape context appears to play a role. Those living in more rural areas (specifically those with private wells, who also have less economic incentive to implement these practices) are also more accepting of 'messier' landscapes. This observation is mirrored by Nassauer (Nassauer J. I., 2009), who found that homeowners were willing to accept more 'wild/natural' landscapes if their neighbor had a similar landscape. One study found that alternative subdivision designs were acceptable when features associated with rural character (i.e., those similar to nearby landscapes such as open space, farm fields and natural features) were visible from the road (Ryan R. L., 2002); this finding emphasizes that if alternative landscape practices fit with the surroundings, they might be more acceptable. This idea could extend to the LID practices included in this study – if the practice fits the scale and general design of nearby land uses, they might be more acceptable to the local homeowners. While the messier landscapes were more acceptable to those in rural areas (likely because they are more familiar with this aesthetic (Ryan R. L., 2002)), rain gardens were acceptable to all respondents because they were generally well-maintained and situated in suburban settings, which tend to favor neatly-kept lawns and clean edges. While many comments for these photos referred to concern about mosquito breeding habitat, the general ratings appeared to override this fear, supporting previous research that well-maintained landscapes, despite looking less cared-for, are more acceptable (Nassauer J. I., 1995).

Social influence was a surprisingly insignificant factor in homeowner willingness to build a rain garden. Though only a couple questions in the survey addressed this topic, other studies have found that the local political climate and neighbors' yard management practices affect homeowner choices and attitudes (Blaine, 2012) (deOliver, 1999). Nassauer (2009) found quite the opposite phenomena in her research, where neighborhood norms outweighed more traditional landscape norms. Despite the apparent low concern for appearance when explicitly asked about this factor, there was an implicit concern about appearance that arose in the photo comments. Greenscapes, watershed association members and those with college degrees were significantly more accepting of messy landscapes. While there is likely overlap between these groups (i.e. watershed association members are more likely to have a college degree), the fact that all three groups consistently exhibit a willingness to devalue appearance suggests an education or awareness component that outweighs social norms. Two of these groups (watershed association members and Greenscapes towns) may have more access to information on water conservation and the benefits of LID practices, thus contributing to increased willingness; however, those with a college degree are not necessarily more environmentally-conscious, though they may have a broader understanding of ecological issues.

5.4 Opportunities for LID Implementation and Adoption

5.4.1 Economic

Survey responses focused on the costs (both time and financial) of implementing LID, but there was also indication that financial incentives to implement these practices are significant, too. Reduced sewer and water bills was a strong motivator to both reduce outdoor water use and to install a rain garden. There may be financial incentives that weren't included in the survey that could further tip the economic tradeoffs in favor of installation; one study (Neimiera, 2009) found that property values can rise over 10% with colorful, well-planned planting. As many respondents indicated an interest in installing a rain garden to make their property look more interesting, landscape features such as rain gardens and colorful, drought-tolerant plantings may have an added benefit of boosting property values. One preliminary study found that properties in Seattle with LID installations sold for 3.5-5% more than properties without these features (Ward, 2008). In addition, property owners who value their yard for its wildlife-viewing and nature appreciation opportunities may also be more interested in implementing rain gardens and meadows for the potential experiential benefits they provide.

5.4.2 Aesthetic

One interesting result identified in this study was the discrepancy between how willing homeowners were to install LID features (rain gardens, rain barrels, drought-tolerant lawns all had means between 'a little' willing and 'somewhat' willing) when these photos were accompanied by text descriptions versus photos. When asked to rate the photos as to 'how much they would like the following features…in [their] own yard," many of these installations were rated more highly ('neater' rain garden photos were rated a full 1 point over willingness to adopt; the small rain barrel photo was rated 3.03 versus 2.65 for willingness to implement). This finding suggests that pictures may be more influential than words, and that education and knowledge may be secondary to how the appearance of these features.

As an extension of this idea, regardless of demographic variables and groupings, landscapes that are well-maintained, colorful and reflect more traditional New England vegetation types were rated highest. The four photos rated highest all include colorful flowers, and three of them include some amount of healthy, green lawn. The fourth photo, though it focuses on a drought-tolerant landscape, includes clumps of flowers, a small tree and lush groundcover. Its rating (mean = 3.39) contrasts significantly with the other drought-tolerant photo (mean = 2.26) which shows a sparser landscape with mulch, yucca and browner grasses. This variation in photo ratings emphasizes that fact that the ratings are based less on the function of the landscape than the appearance of the landscape. A landscape may be designed to meet certain conservation goals, but it is more likely to be appealing if it also meets aesthetic goals of landowners. Choosing plants that are both drought-tolerant, colorful and green can make these installations more attractive. Likewise, choosing rain garden plants that have strong aesthetic appeal (such as grasses and flowers) may encourage homeowners to be more interested in these installations.

5.4.3 Awareness and Knowledge

While there appear to be very distinct differences between more concerned and environmentally aware homeowners and randomly-selected homeowners in willingness to adopt LID, the responses also suggest that there may be many misconceptions about these practices. The results indicate that perceived costs of landscape change, safety concerns and questions about the benefits are educational opportunities.

The perception that landscape changes are expensive raises the question of whether income alone is the main determinant. To look specifically at Wilmington, this appears to be the main distinction as compared to other towns; while it has slightly fewer college graduates, it has the same percentage of respondents with a graduate degree as North Reading and Topsfield. Both gender and age percentages are comparable to other towns. Income is the one category that differs significantly, where 41% of respondents earn more than $100,000, versus other towns where 51-64% earn more than $100,000.

Rain garden installation costs can vary from $5-45/square foot depending upon sitework needed, plants installed and labor costs (http://nemo.uconn.edu/raingardens/calculator.htm). This can add up quickly if the amount of impervious surface the rain garden is expected to treat is sizeable. Other measures, such as rain barrels, are less costly ($100-200 for a small barrel and installation materials such as hoses, downspout connection, etc) (Low Impact Development Center, Inc., 2015). Behavioral changes are even less costly, as practices such as watering during dawn or dusk, watering less often, and allowing lawn to grow taller (thus shading the soil and reducing evaporation rates) require no cost. The first two practices were considered very effective and also had high rates of willingness to practice (84% and 90% respectively); they may be more easily achieved goals. Education and outreach campaigns that focus on less-costly behavioral changes might be more effective. Likewise, homeowners may be motivated to adopt these practices if they understand that they can make a difference without expending money. Outreach efforts that raise awareness of how effective these strategies are (through water bills, PSAs in the newspaper, etc.) may produce results equivalent to more limited rain garden and rain barrel implementation.

Next, several studies have pointed toward the positive influence of volunteer participation in scientific research on increased environmental concern and knowledge (Toomey, 2013) (Jordan, 2011). The survey response rate alone (especially among watershed members – 44%) suggests an active and concerned citizenry. Pride in conservation practices and ecological knowledge was also prevalent (Sample comments include: “My lawn has over 40 species of plants!” and “I use the water from my dehumidifier to water my plants”). Building on this base of enthusiasm and awareness, citizen science can be used as a tool to increase both awareness of low-cost landscape practices and to also increase adoption rates for those motivated by altruism, collectivism and principlism (Batson, 2002).

5.4.4 Landscape and Social Context

Lastly, landscape context appeared to be a significant factor in the willingness to adopt LID, and which installations were more preferred. Promoting LID practices that are context-sensitive could be an effective strategy. Those in more rural areas appear more willing to implement larger-scale installations such as rain gardens, and reducing lawn area. Suburban homeowners are more interested in smaller installations such as rain barrels. Land use policies that incorporate these distinctions and reflect the income levels and property attachment of residents are likely to be more widely accepted.

5.5 Summary

Several themes emerge from the data. Barriers to residential adoption of low-impact development practices do exist. Income, educational attainment, and environmental awareness and concern are the primary factors that affect willingness to implement practices such as rain barrels and rain gardens. While the perception of cost (and that landscape changes are expensive) pervades many homeowner's hesitations, water source (well vs public water), landscape context (rural vs suburban) and public health concerns are also significant factors. While some of these variables, such as water source and landscape context cannot be changed, future policies and land use practices can address those more flexible variables.

Lastly, the results identify several areas for future research, including ways to explore the interactions between variables, and other methods to employ to understand the most significant variables in LID adoption. While willingness to adopt and implement LID on residential lots returned mixed results, behavioral changes are less expensive and may be easier to promote. Similarly, the appearance of LID practices is significant, where well-maintained and attractive landscapes (with flowers, different textures of plants, etc.) were more appealing – if the aesthetic appeal of a landscape promotes its adoption over its function, LID installations designed for aesthetic benefits may be a significant impetus to more widespread implementation. Similarly, increased awareness of the numerous other benefits of LID, may promote more widespread adoption. Specific land use policy recommendations and outreach efforts will be explored further in the next chapter.

CHAPTER 6

CONCLUSION

6.1 Overview

These findings of the aesthetic, financial and awareness barriers and motivations for LID adoption have many implications for practitioners as well as for those interested in pursuing research in this area. Landscape architects may alter their approach to LID design by emphasizing the aesthetic appeal of installations and promoting the potential financial benefits of LID adoption. Planners may try to integrate LID into new development projects and existing stormwater regulations as a way to reduce flooding, limit impervious surface impacts and cut costs associated with gray infrastructure maintenance. Non-profit advocates and extension educators may focus on the safety concerns and perceptions homeowners have about these practices, and promote the financial and reduced maintenance cost of LID practices over traditional landscapes. Lastly, students and researchers may use the results of this study to identify new areas of research, or topics to explore in greater depth.

6.2 Policy and Design Implications

6.2.1 Planning Policy

The findings of this research could be applied to several aspects of land use planning, including natural resource conservation, development standards and stormwater management strategies. One recurring and contentious issue among survey respondents was the fact that private well users are exempt from the water restrictions. In other communities with water restrictions, both well users and public water customers are both subject to the restrictions.

While ample case law protects the resources on and under a landowner's property (i.e. groundwater), outreach and education efforts may attempt to encourage well users to also limit outdoor water use. Numerous survey respondents noted that their water doesn't come from the Ipswich, even though hydrologically, their groundwater is connected to the river. Increased awareness of this common resource may prompt homeowners to do their part to improve seasonal flows in the river.

Second, while retrofitting existing properties with more sustainable practices such as LID can be a challenge, standards for new development may be easier to implement. Communities facing water restrictions, or with significant impervious surface areas might adopt zoning standards and subdivision regulations that require more compact development to preserve the ecological functions of undeveloped areas. One rent study found that a smart-growth approach to future development in Ipswich, MA could result in a 5% water savings (Runfola, Polsky, & Nicolson, 2013). Development pressures exist throughout the watershed and one way to minimize the impact of development is to limit its effect on hydrology. Partridgeberry Place, a 20-lot open space residential subdivision designed by Randall Arendt, was built in Ipswich, MA in 2006. The subdivision features narrower roads (18') and a large, centrally-located rain garden to treat road runoff. Houses have smaller setbacks, shorter driveways and small lot sizes, thought the latter is not apparent when visiting. 74% of the development is preserved as open space, and properties are connected to a single septic system and two leachfields that serve the whole development, thus eliminating the need for large-lots to serve individual septic systems (State of Massachusetts, 2015). Such development practices may serve as a model for other towns, especially those facing strong development pressures. Adopting zoning ordinances and bylaws that limit impervious surfaces and encourage more compact development would be the first step.

Lastly, as towns grapple with new development (and increased impervious areas), they might employ a variety of methods to maintain and improve groundwater infiltration and minimize runoff. The North Reading Planning Board has prompted commercial applicants to incorporate LID practices such as permeable paving when possible (J. Nicosia, personal communication). Stormwater fees and utilities are another strategy municipalities across the county have adopted in an effort to both pay for existing municipal gray infrastructure maintenance, and to address stormwater pollution. While pollution isn't the main issue for the Ipswich, impervious surfaces lead to 'flashy' streamflow and reduced baseflow during the summer. Stormwater fees and utilities charge landowners for the runoff produced from their property; those with higher percent of impervious area are charged a much higher fee than those with more pervious coverage. Credit for efforts to reduce runoff may also be granted. This may be one means to incentive low-impact development practices on both commercial and residential properties. Over 400 communities in the U.S. have adopted such fees, and a couple of watershed towns are considering implementing such fees. (Ipswich River Watershed Association, 2015)

6.2.2 Design Strategies

The findings of this survey also hold many implications for the design field as well. Since aesthetic appeal of landscapes appears to be a significant motivator for LID installation, the planting design and site placement of LID features should be an integral aspect of their development. Rain gardens will function (if designed and installed properly) whether they are planted with grasses, flowering shrubs, or perennials. Tailoring designs to match homeowner preferences will likely increase their attractiveness and acceptability. This might be true for rain barrels, too. The photo in the survey that camouflaged the rain barrel with the house was rated higher than the one that showed large, black plastic barrels. Integrating rain barrels with the property design, or promoting more ornamental-looking rain barrels that look less utilitarian and more like complementary features may persuade broader homeowner adoption. The survey results appear to point towards a middle-ground; that the landscape feature itself may be functional, but it also needs to look attractive. As Buckminster Fuller stated "when I am working on a problem, I never think about beauty… but when I have finished, if the solution is not beautiful, I know it is wrong." Designers may need to more deliberately combine the functional with the beautiful to market LID practices.

Another marketing strategy designers could use to promote LID adoption, is to convey their multiple benefits. Each LID practice has a host of benefits beyond their ecological function. Meadows and taller lawns, which increase plant diversity and reduce water use, also look more interesting and save time and energy costs by requiring less frequent mowing. Weekly lawn maintenance can be both time-consuming and resource-intensive. Meadows, occasionally-mown lawns and lawns comprised of low-grow/no-grow grasses can significantly reduce both maintenance time, water requirements and costs; all important factors in landscape decisions. In addition to the practical advantages of incorporating LID features, many other benefits exist. For homeowners interested in wildlife viewing, meadows and rain gardens provide opportunities to attract birds and butterflies and beneficial insects (Obropta PhD, 2006). Several respondents noted the 'rich' and 'nice' look of permeable pavers in the photo section of the survey. As stated previously, landscaping also has the potential to increase property values; landscaping that serves dual purposes of water infiltration and aesthetic improvement can both boost property values and reduce flooding.

6.3 Areas for Future Research

While this study provided several insights to the barriers and motivations for residential LID adoption, it only alluded to a host of topics that could be explored further. Several unexpected findings present many prospects for future research. Economic tradeoffs and the opportunity costs associated with landscape decisions is a potentially large field of future inquiry. Additionally, there are numerous aspects of this data that were not analyzed during this study, and that may present additional insights to homeowners' willingness to adopt water-conserving landscape practices and implement LID.

The level of concern about mosquitoes and ticks and the perceived cost of landscape changes were two somewhat unexpected findings. Further investigation of how best to address the gap between homeowner perceptions and reality would be useful to both understanding how homeowners make landscape decisions, and also to larger efforts to change behaviors towards more sustainable practices/lifestyles. Citizen science projects in non-profit research efforts might offer one option to increase general awareness of ecological landscape practices. This practice has shown positive results among volunteers involved in wildlife counts and water quality monitoring. It may be an avenue to increase participation and encourage discussion about solutions. The next phase of this research study incorporates this idea by asking homeowners to meter their outdoor water use. A survey to homeowners as well as knowledge of their water use will seek to ascertain the extent to which homeowners alter their behavior based on knowledge, and to understand homeowner perceptions of the amount of water they use. This research may find that information does alter behavior, but it may also point to other avenues through which to alter water use behavior. Finally, there were indications that those who were watershed members or who lived in Greenscapes towns were more knowledgeable and aware of water conservation issues. Since correlation does not equal causation, further research into the link between responses and group members could strengthen the link between these respondents and how they ranked these issues – do they know more about LID? Did this information come from the watershed association or Greenscapes materials, or are these people intrinsically more altruistic? Are they more concerned as a result of town policies and outreach efforts?

Second, cost perceptions are a significant barrier to LID adoption. Future research to understand these perceptions, and how willing homeowners are to alter their perceptions include:

- What do people perceive the cost of a rain garden? Reduced lawn area? Drought-tolerant landscape?
- How does this perception compare to the actual cost of these installations?
- What do homeowners perceive to be the cost of maintaining their landscape as is? Are they surprised to find that there may be cost-savings and time savings by adopting alternative landscapes?
- What are the opportunity costs for replacing lawn with another, less-intensive landscape? Do people use all of their yard, or would they be amenable to converting 10% of their lawn to meadow, no-mow lawn, or another groundcover?
- What type of information or economic argument is necessary to encourage people to alter their behavior?
- How do these cost perceptions vary between towns and groups? Are those with large lawns more willing to adopt alternative practices to reduce time and energy spent on

maintenance? Conversely, are those with smaller lawns willing to make behavioral changes to maintenance that allow them to maintain their lawn, but use fewer inputs?

Lastly, there were many variables in this study that were not fully explored. Additional comparisons between respondents might further illuminate patterns and potential leverage points:

- Are those concerned about flooding, or those living in towns that have experienced recent flooding, more interested in adopting LID practices?
- Are those with children under 18 (who may have less free time), less inclined to adopt LID or change their behaviors than those who may have more time? And is time the main factor, or are there other safety issues related to the LID practices mentioned in the survey and having young children?
- How significant is age? The sample was older, and several photo comments indicate that older respondents perceive the energy required for maintenance of meadows and rain barrels to be beyond their abilities. In fact, some LID practices may be easier to maintain than traditional landscapes such as lawn. Rain barrels set up with a hose attachment simply require a turn of the spigot to use the water. Again, education as to how these elements function could address these concerns.
- Are there variables that would uncover the reason why respondents said they aren't particularly interested in installing a rain garden, reduced lawn area or rain barrel, though they rated these features higher as something they would like in their yard?

6.4 Alternate Study Organization

This study attempted to address several topics – from aesthetics to economic and time issues related to landscape decisions. It also sought to combine the two issues of water conservation and low-impact development. John Muir summarized the interconnectedness of natural resources/environ by saying "when we try to pick out anything by itself, we find it attached to everything else in the universe." It is tempting to address all of these inter-related topics simultaneously – economics, aesthetics and function. However, in doing so, breadth of understanding, rather than depth, results. A survey focused specifically on either LID adoption or on outdoor water conservation, might have resulted in a deeper understanding of either of those topics. Similarly, a survey aimed at understanding the aesthetic values of homeowners versus the practical priorities could have yielded more focused findings. That said, the breadth of this survey identifies several topics for future research and exploration.

6.5 Lessons for Future Researchers

6.5.1 Lessons for Planners and Landscape Architects:

- Designers - Aesthetics of LID installations are key to their adoption; in addition to functioning properly, their appearance and maintenance is important to homeowners acceptance;
- Designers - Promote the multiple benefits of LID – wildlife value, potential to increase property value, provide [multi-season] interest
- Designers - Address perceptions of safety issues in LID promotion – are they really mosquito-breeding habitat, or do their benefits outweigh any perceived concerns?
- Planners – Learn about the multiple environmental and economic benefits of LID (wildlife value, infiltration capability, less costly than gray infrastructure, etc) and promote them;

- Planners – Identify and adopt context-sensitive practices (considering incomes and political views of residents, surrounding land use – rural vs suburban, etc.)
- Planners – Incorporate appropriate LID practices into zoning and subdivision regulations; encourage and require development that results in lower runoff, less impermeable surface area and on-site stormwater treatment.

6.5.2 Lessons for Non-Profits and Outreach Efforts:

- Education – address concerns and realities of tick exposure and mosquitoes habitat creation when promoting LID. Are these concerns valid? Are there workarounds, or ways to mitigate these issues?
- Outreach – focus discussion on actual cost versus perceived costs; how do LID installations compare to traditional landscape regarding financial costs, opportunity costs, and level of maintenance required?
- Perceptions of benefits vs tradeoffs
- Tradeoffs – what LID practices are most cost-effective for different property types?

6.5.3 Lesson for Students Conducting Similar Research:

- For students new to the field of behavioral research and landscape aesthetics, focus on a unifying theme. The mixed methods approach in this study used photos as well as text to understand motivations and preferences. In attempting to address several topics simultaneously (aesthetics, financial considerations, perceptions of effectiveness, etc.), the results are more challenging to interpret. By focusing on one aspect, and using a mixed methods strategy to explore one topic, such as aesthetic acceptance, the results may be clearer and more straightforward.

- One limitation of surveys is that they are somewhat static. Despite attempts to interpret data by combining responses to multiple questions, or looking at data aggregated into groups, there is still a certain amount of interpretation that takes place, and some assumptions that are made about the survey population. Conducting focus groups of a subset of the survey population would allow researchers to assess these assumptions and confirm or refute these interpretations.

In summary, this study uncovered new insights for designers, planners, non-profit advocates, and local citizens who are concerned about river health and the future of urbanizing watersheds, such as the Ipswich River. By improving understanding of local residents' perceptions of water-conserving and LID landscapes, future outreach efforts and land use policies can continue to improve watershed functions and practices for insuring the health of urban rivers into the future.

APPENDIX

FULL TEXT OF SURVEY

Ipswich River Watershed Landscape Survey

Please help us better understand outdoor water use and residents' attitudes about water conservation in the Ipswich River watershed. This survey is part of a three-year research study in the Ipswich River watershed conducted by the University of Massachusetts-Amherst and funded by the Center for Agriculture. It should be completed by an adult member of the household.

We appreciate you taking the time to complete this survey and value your responses.

For the following questions, please circle your response:

1) Do you own or rent your home? OWN RENT

2) What is the size of your property? less than 1/4 acre ¼ to 1 acre more than 1 acre

3) Do you have an irrigation system on your property? YES NO
   If YES, is it moisture-sensing? YES NO

4) Do you have a swimming pool on your property? YES NO
   How do you fill the pool? Purchased water Tap water

5) How much of your property is covered by the following:

Woods	more than half	less than half	none
Shrubs, meadow or unmown grass	more than half	less than half	none
Garden beds (flower or vegetable)	more than half	less than half	none
Lawn	more than half	less than half	none

6) Is there a pond, stream, or river on or bordering your property? YES NO

7) The tap water for your home comes from: PRIVATE WELL PUBLIC WATER SUPPLY

8) How many hours do you spend *weekly* on yard maintenance during the summer? ≤1 2-3 4-5 ≥6

9) On average, how many times per week do you water your lawn during summer months? 0 1 2-3 ≥4

10) What time of day do you usually water? BEFORE 9am MID-DAY (9am-5pm) EVENING (after 5pm)

11) Please rank how often you use your yard for the following activities :

1 = not at all, 2 = a little, 3 = sometimes, 4 = a lot, 5 = a great deal

Socializing and entertaining	1	2	3	4	5
Recreation	1	2	3	4	5
Appreciating nature/beauty	1	2	3	4	5
Watching or feeding wildlife	1	2	3	4	5
Other: ____________________	1	2	3	4	5

12) How much information do you obtain from the following sources about landscaping?

1 = none at all, 2 = a little, 3 = some, 4 = a lot, 5 = a great deal

Landscape company or Garden center	1	2	3	4	5
Family, friends or neighbors	1	2	3	4	5
Environmental organizations (e.g, Greenscapes)	1	2	3	4	5
UMass Home Lawn and Garden website	1	2	3	4	5
Books and magazines	1	2	3	4	5
Internet	1	2	3	4	5

13) How much water do you think is used indoors versus outdoors in an average household during the summer months (circle one)? More indoors About the same More outdoors

14) In your *opinion*, how effective are the following practices at reducing outdoor water use and would you be willing to practice them in the future?

1 = not very, 2 = a little, 3 = somewhat, 4 = very, 5 = extremely

		Would practice in future
Watering the lawn at dawn or dusk	1 2 3 4 5	Y N
Watering the lawn less often	1 2 3 4 5	Y N
Installing a moisture-sensing irrigation system	1 2 3 4 5	Y N
Using mulch in garden beds to reduce evaporation	1 2 3 4 5	Y N
Adding organic matter to the soil to increase water retention	1 2 3 4 5	Y N
Using a timer during watering	1 2 3 4 5	Y N
Checking soil moisture and only watering as needed	1 2 3 4 5	Y N

15) The following images show landscape features that conserve water on-site or in the river:

Rain garden — a shallow depression in the ground that collects stormwater, and can be planted with shrubs or flowers

Rain barrel — a container that stores water for later use

Reduced lawn area — shrubs, flowers and groundcovers replace lawn

Green roof – one planted with vegetation that absorbs some of the rain that falls on it

Drought-tolerant lawn— one planted with grasses that requires less water to stay green

Drought-tolerant landscape— one that uses plants that require less water

Please indicate if you have any of these features on your property and your willingness to implement them:

1 = not at all, 2 = a little, 3 = somewhat, 4 = very, 5 = extremely, N/A = not applicable

		I have this
Rain garden	1 2 3 4 5 N/A	□
Rain barrel or catchment system	1 2 3 4 5 N/A	□
Reduced lawn area	1 2 3 4 5 N/A	□
Green roof	1 2 3 4 5 N/A	□
Drought-tolerant lawn	1 2 3 4 5 N/A	□
Drought-tolerant landscape	1 2 3 4 5 N/A	□

16) How much would the following factors encourage you to install a rain garden on your property?

1 = not at all, 2 = a little, 3 = somewhat, 4 = a lot, 5 = a great deal

Receiving technical assistance on how to construct one	1 2 3 4 5
Not having to pay for it	1 2 3 4 5
Reduction to my sewer and water bill	1 2 3 4 5
My property looked more interesting	1 2 3 4 5
Decreased flooding in my neighborhood/on my property	1 2 3 4 5
If a friend or neighbor installed one	1 2 3 4 5

17) Were there any outdoor water use restrictions in your town this past year? YES NO I don't know

18) How well do the following statements reflect your general opinion of the outdoor water use restrictions?

1 = not at all, 2 = a little, 3 = somewhat, 4 = a lot, 5 = a great deal

They are an effective way to reduce outdoor water use	1 2 3 4 5
They do not affect me significantly	1 2 3 4 5
They are necessary	1 2 3 4 5
They are an inconvenience	1 2 3 4 5
I don't understand why we have them	1 2 3 4 5

19) How serious are the following environmental problems in your part of Massachusetts?

1 = not a all, 2 = a little, 3 = somewhat, 4 = very, 5 = extremely

Availability of drinking water	1 2 3 4 5
Fewer fish in rivers and ponds	1 2 3 4 5
Climate change	1 2 3 4 5
Flooding	1 2 3 4 5
Poorly planned development	1 2 3 4 5
Too many environmental regulations	1 2 3 4 5
Other: ________________________	1 2 3 4 5

20) Would you consider replacing part of the lawn on your property with a meadow or groundcover? YES NO

Please indicate how important the following factors are in this decision:

1 = not at all, 2 = a little, 3 = somewhat, 4 = very, 5 = extremely

Amount of time spent on maintenance	1 2 3 4 5
Lawn looks neater than meadow	1 2 3 4 5
To reduce water use	1 2 3 4 5
Lawn is a better fit for my neighborhood	1 2 3 4 5
Concern about ticks	1 2 3 4 5
Landscape changes are expensive	1 2 3 4 5
Lack of free time to implement changes	1 2 3 4 5
Lawn is used regularly for outdoor activities	1 2 3 4 5
Cost of landscape maintenance	1 2 3 4 5
Other: ________________________	1 2 3 4 5

21) Please indicate how much you agree with the following statement: I would reduce my outdoor water use if…

1 = not at all, 2 = little, 3 = somewhat, 4 = a lot, 5 = completely, N/A = not applicable

…my water bill doubled (circle N/A if you have a private well)	1 2 3 4 5 N/A
…there were more restrictions on outdoor water use	1 2 3 4 5 N/A
…I would pay a $100 surcharge for excessive water use	1 2 3 4 5 N/A
…my town adopted regulations limiting irrigation use	1 2 3 4 5 N/A
…my property had less lawn	1 2 3 4 5 N/A
…the lawn on my property required little or no water	1 2 3 4 5 N/A

Please tell us a little about yourself.

22) Time at current residence:	0-4 yrs	5-9 yrs	10-14 yrs	15+ yrs
23) Age:	under 24	25-44	45-64	65 or over
24) Gender:	Male	Female	______	
25) Highest level of education:	High school	Some college	Bachelor's	Graduate
26) Household Income:	<$50,000	$50-100,000	$100-150,000	over $150,000

27) How many people live in your household? 1 2 3 4 5+

28) Does anyone under 18 live in your household? YES NO

Photographs: The next few pages show photographs of residential landscapes. Please rate how much you would like to have landscape features like those pictured in your own yard.

1 = not at all, 2 = somewhat, 3 = a little, 4 = a lot, 5 = a great deal

Forest and lawn:

1) 1 2 3 4 5

2) 1 2 3 4 5

Driveway type:

3) 1 2 3 4 5

4) 1 2 3 4 5

Taller grass height:

5) 1 2 3 4 5

6) 1 2 3 4 5

4

1 = not at all, 2 = somewhat, 3 = a little, 4 = a lot, 5 = a great deal

Less lawn:

7) 1 2 3 4 5

8) 1 2 3 4 5

9) 1 2 3 4 5

10) 1 2 3 4 5

Rain gardens:

11) 1 2 3 4 5

12) 1 2 3 4 5

13) 1 2 3 4 5

14) 1 2 3 4 5

5

1 = not at all, 2 = somewhat, 3 = a little, 4 = a lot, 5 = a great deal

Rain barrels:

15) 1 2 3 4 5

16) 1 2 3 4 5

Naturalized lawn:

17) 1 2 3 4 5

18) 1 2 3 4 5

Drought-tolerant:

19) 1 2 3 4 5

20) 1 2 3 4 5

21) For the photos you rated very high or very low, please use the margins next to the photos to add a word or two about why you did and didn't like the photos.

Thank you for your time!

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