

## Research paper

# Understanding urban-suburban adoption and maintenance of rain barrels



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## HIGHLIGHTS

- Economic cost and lack of knowledge are factors limiting practice adoption.
- Economic benefits are a more important motivator than environmental benefits for practice adoption.
- No significant difference exists between Full Maintainers and Partial Maintainers.

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## ABSTRACT

Stormwater best management practices (BMPs) can help local communities alleviate water runoff and reduce pollution in a cost-effective way. However, few researchers have examined the adoption of stormwater BMPs in urban-suburban communities. The purpose of this study was to explore the factors influencing adoption and maintenance of rain barrels, a commonly promoted urban-suburban BMP, in two watersheds in Indiana. The resulting analysis of quantitative survey data, qualitative interview data, and practice assessment field data indicated that: (1) People with more positive attitudes towards the environment and higher level of knowledge about practices are more likely to adopt practices; (2) Gardeners with the intention of reducing water use in their yard were the most prevalent adopters and should be targeted for future stormwater conservation practices; (3) Between 25% and 35% of practices were discontinued within five years of their adoption; and (4) Informational signage stating adopters' commitment to practices and support for the environment is a potential strategy for fostering practice maintenance over time.

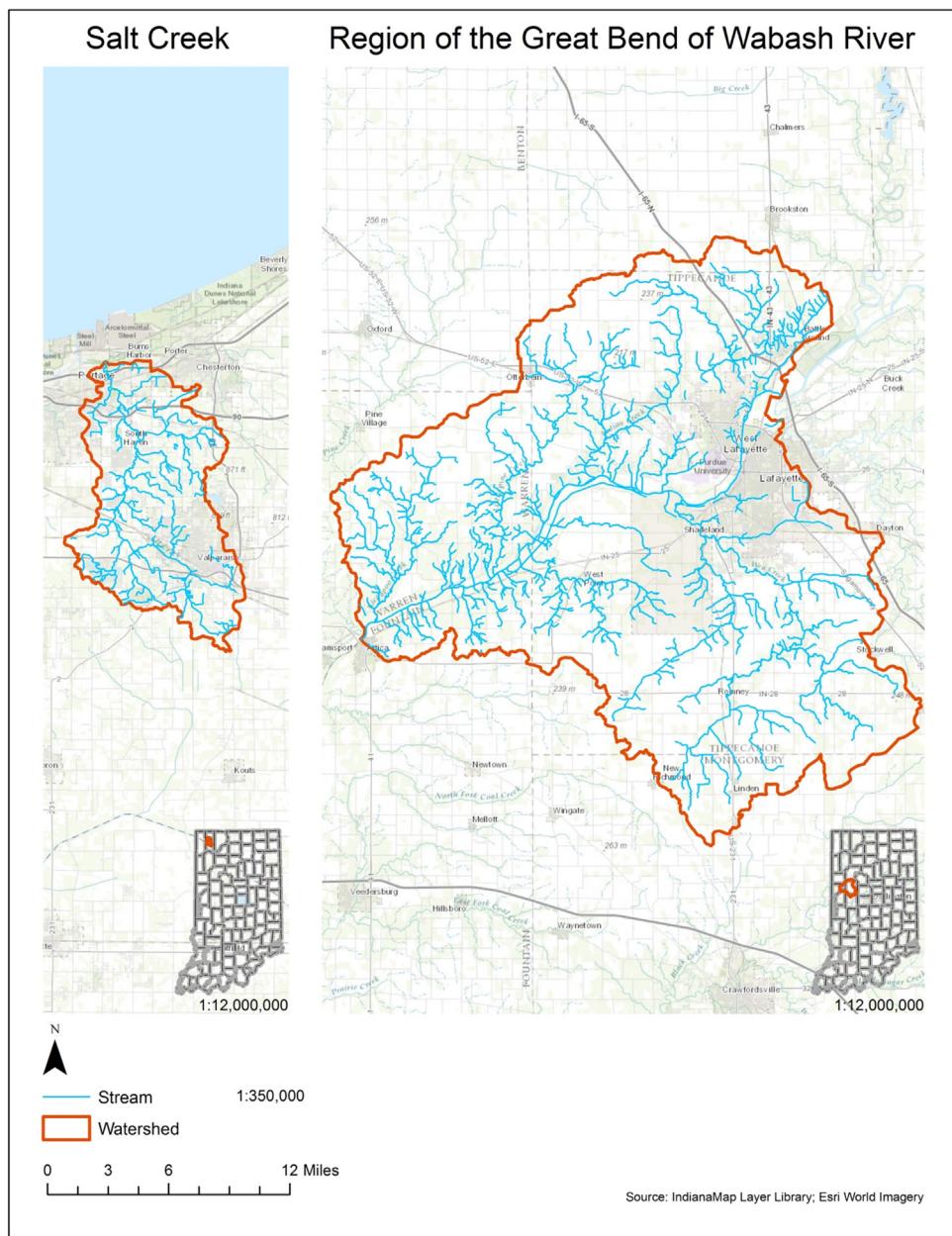
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## 1. Introduction

Stormwater management, including the infrastructure for water conveyance, drainage and treatment, is an increasing water problem for communities of all sizes. Urban expansion has changed the landscape of the United States at a dramatic pace. In the previous decade, the amount of impervious surface coverage in the contiguous United States has exceeded over 43,479 mi<sup>2</sup>, an approximate area the size of the state of Ohio (Elvidge et al., 2004). It is also predicted that United States public and private sector construction will contribute approximately one million single-family

homes and 10,000 miles of new roads per year (Elvidge et al., 2004). In Indiana, more than 404,685 ha of farmland were converted to urban uses between 1992 and 2002, a trend that has continued through the present day (Thompson & Prokopy, 2009). Urbanization increases stormwater volume and decreases infiltration capacity due to the impact of added impervious surfaces and reduced vegetation. According to a U.S. Census Bureau projection U.S. population will increase from 320 million to almost 400 million, by 2050, an increase of 25% (USGS, 2013). Without improved urban planning, increases in the population may demand more land for public infrastructure development and private construction, which could aggravate the problem of stormwater management. At the same time, the predicted increased prevalence of extreme weather events such as floods and droughts due to global climate change will have wide-ranging impacts on the ability of these sys-

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**Fig. 1.** Salt Creek watershed & Wabash watershed.

tems to continue to provide stormwater management functions and services at acceptable levels (Wuebbles, Hayhoe, & Parzen, 2010). An imbalance between development and existing infrastructure has led to older combined sewer systems (CSSs) being frequently overloaded with relatively small rain events, which results in the direct release of untreated wastewater to receiving streams in overflow events. Separated sewers can reduce water quality problems associated with overflow events, but still result in the direct flushing of pollutants accumulated on paved surfaces into receiving streams. Urban stormwater runoff as one source of non-point source (NPS) pollution carries accumulated pollutants, such as “fertilizer, herbicides and insecticides from lawns and gardens, oil, grease and toxic chemicals from motor vehicles, viruses, bacteria and nutrients from pet waste” (USEPA, 2003) into local water bodies. As a result, urban streams are among those with the lowest water quality in the country, with concentrations of fecal coliform bacteria commonly exceeding recommended USEPA standards for water-contact recreation (USGS, 2001).

In response to the low capacity of older CSSs to reduce intensive runoff and its pollution, stormwater BMPs are identified as a cost-effective way to delay or prevent stormwater from reaching piped systems in the first place. Stormwater conservation BMPs, such as rain gardens, rain barrels and permeable pavement, offer a means to decrease stormwater volumes and reduce water quality impacts of predicted increases in intense rainfall events that result from climate change. Local-level stormwater BMPs have been proven to have a positive effect on the urban environment and are a promising strategy for adaptation to climate change (Semadeni-Davies, Hernebring, Svensson, & Gustafsson, 2008). While these stormwater conservation practices offer real potential to reduce impacts, they generally have low adoption rates, especially rain gardens and rain barrels (Newburn, Alberini, Rockler, & Karp, 2013). However, there have been few efforts to understand why low adoption rates persist, and as a result, there is little information regarding the adoption and maintenance of stormwater BMPs by urban residents. This lack of knowledge on stakeholder motivations contributes to

a high level of uncertainty and reluctance among organizations to promote urban BMPs through cost share programs (in a cost-share arrangement, the individual landowner shares the cost of a practice with another entity, such as a municipality or an environmental program run by a non-profit organization.).

There are many potential factors that may influence an individual's decision to adopt urban stormwater BMPs. The Theory of Reasoned Action Approach assumes that a person's behavioral intention results in action—the intention is influenced by their attitudes towards the behavior, subjective and descriptive norms, and perceived behavior control (Fishbein & Ajzen, 2010). In the environmental behavior field, Hines, Hungerford, & Tomera (1987) identified associated variables especially relevant for predicting environmental behavior, which included knowledge of the issue and potential action strategies, the locus of control of the issue, attitudes related to the issue, verbal commitment to the issue, and the individual's sense of responsibility towards the issue. In the agricultural context, researchers have explored factors that motivate farmers to adopt BMPs (Baumgart-Getz, Prokopy, & Floress, 2012; Knowler & Bradshaw, 2007; Prokopy, Floress, Klotthor-Weinkauf, & Baumgart-Getz, 2008). However, less information is available on what motivates urban residents to adopt BMPs. Recent studies have found that in urban areas, predictors of BMP adoption include broad knowledge of BMPs (Brehm, Pasko, & Eisenhauer, 2013), proximity to distribution points and information campaigns (Ando & Freitas, 2011), households with flower or vegetable gardening, and strong attitudes toward protecting local water resources (Newburn et al., 2013). Given the limited body of research from urban areas, these findings need confirmation.

The effectiveness of urban conservation practices should be evaluated not only by adoption rates, but also by the rate of maintenance of the practice over time. Just as there is scant literature on why urban residents adopt BMPs, there is even less literature focusing on what motivates urban residents to maintain BMPs. The little evidence from the agricultural sector suggests that structural practices are more likely to be maintained than management practices, and practices that are cost-shared are more likely to be maintained than those that are not (Jackson-Smith, Halling, de la Hoz, McEvoy, & Horsburgh, 2010). Other factors influencing the discontinuance of certain agricultural practices or technologies include profitability (Sofranko, Swanson, & Samy, 2004), prevalence of university extension visits (Oladele, 2006), and the degree to which farm production is orientated towards commodity versus specialty markets (Acharya and Sharma, 2013). However, since urban BMPs generally have fewer economic benefits to users compared to agricultural practices, these findings are of limited relevance to understand urban BMPs maintenance.

This study explores the adoption and maintenance of rain barrels, one of the stormwater conservation BMPs most widely promoted by local watershed groups in urban-suburban communities. Rain barrels connect to a house's gutter system, collecting and storing rainwater for future use that would otherwise contribute to stormwater runoff. This study aims to answer the following two research questions: First, what motivates urban-suburban residents to adopt and subsequently maintain their stormwater conservation practices? Second, what is the maintenance condition of practices? A comprehensive understanding of what factors influence the adoption and maintenance of urban conservation practices in the study area will contribute to better promotion of practices by local water management organizations. Using the case study of two Indiana urban-suburban regions, one in a sub-watershed of Lake Michigan and the other in a sub-watershed of the Mississippi River, this study assessed both property owners and the condition of their practice through social indicators surveys, interviews, and practice assessments. The surveys and assessment results test the following hypotheses: (1) Adopters will be different from non-

adopters in their awareness about local water quality issues, their attitudes towards the environment and their knowledge about conservation practices. (2) Full Maintainers (people who maintained their practices excellently with a full assessment score) will be different from Partial Maintainers in their awareness about local water quality issues, their attitudes towards the environment and their experience about maintaining conservation practice. (3) The use of informational signage showing adopters' use of practices and support for the environment will have a positive impact on maintenance of practices over time.

The goal in investigating the difference between adopters and non-adopters in their knowledge about BMPs, their attitudes toward the environment and their specific constraints are to provide information on factors influencing adoption of practices. If there is a relationship between these factors and adoption of practices, then these results can be used to develop outreach strategies such as the use of targeted educational programs, specific social norms in marketing, or particular economic incentives (McKenzie-Mohr, 2011). Finally, assessing the current maintenance condition of the practices as absent or unacceptable, acceptable and excellently maintained and relating these conditions to respondents' stated knowledge, attitudes and constraints provides useful information for targeting unacceptably maintained practice adopters in order to prevent potential future discontinuance of the practices.

## 2. Methods

### 2.1. Research area

The research focused on two urban-suburban regions located in two watersheds in Indiana, known as the Salt Creek watershed and the Region of the Great Bend of the Wabash River watershed (hereinafter referred as the Wabash watershed) (see Fig. 1). The two watersheds both experienced water quality issues due to urban population growth in the previous decade. Local environmental organizations in each region have initiated BMPs cost-share programs to tackle water quality issues addressed by their watershed management plans.

#### 2.1.1. Salt Creek watershed

The Salt Creek watershed is a Lake Michigan watershed—one of the most industrialized and populated areas in the state, covering 19% of Porter County in northwestern Indiana (Salt Creek Watershed Management Plan, 2008). Porter County's population is projected to increase by 24% from 2014 to 2050 (calculated by STATS Indiana Tool from Indiana Business Research Center using U.S. Census Bureau 2014 data). Like many similar communities with considerable population growth across the country, the area is struggling to deal with increasing urban impacts to local water quality. As a result, Salt Creek has been listed on the impaired water bodies list for E. coli since 1998 and impaired biotic communities since 2002 (Salt Creek Watershed Management Plan, 2008). In 2006, the Indiana Department of Environmental Management (IDEM) contracted with the Save the Dunes Conservation Fund (SDCF) to develop the Salt Creek Watershed Management Plan (SCWMP). The SCWMP addresses non-point source pollution problems and other identified issues in Salt Creek. In 2008, the SDCF started to administrate a cost-share program to implement the SCWMP, which allowed a portion of the cost to implement urban BMPs. The cost-share programs, which ran between February 1, 2009 and January 31, 2013, funded households, businesses and municipalities in the installation of over 350 practices including rain barrels, rain gardens, bioswales, pervious pavement, green roofs, critical area tree planting, and stream stabilization. Rain barrels were offered for \$10 by the cost-share program in partnership

**Table 1**  
Source of data.

Watershed	Method			
	Survey of adopters	Survey of urban residents	Interview	Practice Assessment
Salt Creek	2014	N/A	2014	2014
Wabash	2014	2014	N/A	2014 & 2015

**Table 2**  
Assessment index of rain barrel.

Category Name	Category Index Score	Criteria
Excellent	3	Rain barrel installed, fills with water, and is able to be used to its full potential
Acceptable	2	Rain barrel installed and does fill with water, but cannot be used to its full potential
Unacceptable	1	Rain barrel installed, but does not fill with water
Absent	0	Rain barrel not installed

with the Porter County Community Foundation, the IDEM and the City of Valparaiso from 2009 to 2013, and \$20 by the City of Valparaiso's Municipal Separate Storm Sewer (MS4) program in 2012.

### 2.1.2. The Wabash watershed

The Wabash watershed is a Mississippi River watershed that covers 70% of Tippecanoe County in north-central Indiana ([Region of the Great Bend of the Wabash River Watershed Management Plan, 2011](#)). Tippecanoe County's population is projected to increase by 23% from 2014 to 2050 (calculated by STATS Indiana Tool from Indiana Business Research Center using U.S. Census Bureau 2014 data). The Greater Lafayette communities spanning the banks of the Wabash River in Tippecanoe County account for 56% of the total population in Tippecanoe County ([U.S. Census Bureau, 2014](#)). Urban impacts to the Wabash River include combined sewer overflows (CSO) from five cities upstream of Greater Lafayette and 20 CSO points within Greater Lafayette. As a result, the Wabash River has been listed on the impaired water bodies list for nutrients, pH, E. coli, dissolved oxygen, and impaired biotic communities since 2002 ([Wabash River Watershed TMDL Report, 2006](#)). In 2008, the Wabash River Enhancement Corporation (WREC) contracted with the IDEM to initiate the development of a watershed management plan for the Greater Lafayette Region. In 2011, WREC initiated the cost-share program for promotion of BMP adoption throughout the Wabash watershed, with grants awarded from the Environmental Protection Agency and other smaller funders. Beginning in January 2012, the cost-share program funded households, businesses and municipalities in the installation of practices including rain barrels, rain gardens, bioswales, pervious pavement, green roofs, critical area tree planting, native plantings and urban infrastructure retrofits. Rain barrels were available for \$5 through grant funds from the local university and for \$77 through the Soil and Water Conservation Districts (SWCD) in 2010 and 2011. Rain barrel packages (barrel, stand, diverter) have been offered for \$25 by the WREC in partnership with the SWCD in 2012, with City of Lafayette since 2012 to present, and with City of West Lafayette since 2015 to present.

To understand what motivates the adoption and maintenance of rain barrels in the two watersheds, assessments of both the property owner/manager and the actual practice were conducted. This was accomplished through surveys and interviews of urban residents, as well as fieldwork assessment of rain barrels (see [Table 1](#)).

### 2.2. Survey

In the summer of 2014, a social indicator survey was mailed to rain barrel adopters in the Salt Creek watershed and the Wabash watershed. The addresses were comprised of all 205 rain barrel adopters from the SDCF and all 461 rain barrel adopters from the

WREC. In addition, a similar survey was mailed to 1100 urban residents in Tippecanoe County in late 2014, which the data could be extracted to compare between adopters and non-adopters about their awareness, attitudes and perception towards the environment and BMPs. The non-adopters were selected from the 2014 Wabash Urban Residents survey by excluding respondents who answered that they have installed a rain barrel. These addresses were compiled from a mailing list purchased from Survey Sampling International. The [Dillman, Smyth, & Christian \(2014\)](#) Tailored Design Method was used to contact all survey recipients up to five times (advance letter, 1st mailing of paper survey, reminder postcard, 2nd mailing of paper survey, 3rd mailing of a paper survey with a final notification postcard). The response rate was 53.3% (number of respondents: n = 90) in the Salt Creek Rain Barrel Adopters survey, 70.0% (n = 294) in the Wabash Rain Barrel Adopters survey, and 27.4% (n = 278) in the Wabash Urban Residents survey, excluding the bad addresses, duplicated responses, and invalid responses.

The surveys were designed according to parameters based on the Social Indicators Planning and Evaluation System (SIPES) ([Genskow & Prokopy, 2011](#); [Prokopy et al., 2009](#)) as well as through discussions with staff at the SDCF and the WREC. The indicators are grouped into four categories: awareness, attitudes, constraints and behaviors. Social demographic information was also collected.

Awareness about local water quality was determined by asking questions about perceptions of water impairments, sources of water pollution, and consequences of poor water quality (4-point Likert scale: 1 = not a problem, 4 = severe problem). All these awareness questions included a "don't know" answer option next to the 4-point Likert scale separating by a bold dark line, which would be an important indicator for measuring the knowledge of respondents about water quality ([Hu and Morton, 2012](#)). Attitudes about the environment were measured by questions related to their agreement or disagreement with specific statements (5-point Likert scale: 1 = strongly disagree, 3 = neutral, 5 = strongly agree). Practice constraints were measured by asking how much given factors complicate continued use of a rain barrel. Behaviors were measured by their experience with rain barrels, including questions about why a rain barrel was obtained, how it was paid for, what the water was used for, and how they learned about the practice, as well as their experience with various other BMPs. Social demographic information included gender, age, income, and education as well as property aspects such as lot size, years in residence, proximity to water bodies, and landscape environment.

Analysis included descriptive statistics (average and frequencies) of social demographic information and closed-end responses as well as Chi-square test to compare the nominal variables (social demographic variables, experience about rain barrels and other BMPs) between adopters and non-adopters, and between Full

**Table 3**  
Survey respondents' demographic profile.

		Salt Creek	Wabash
Gender	Female	62.10%	57.40%
	Male	37.90%	42.60%
Age	Mean	58.7	55.1
	Range	34–91	25–92
Education	High school	15.90%	8.60%
	Some college	13.60%	12.90%
	2-year college degree	6.80%	9.70%
	4-year college degree	36.40%	30.50%
	Graduate degree	27.30%	38.40%
Residential Lot Size (unit: acre)	1/4 or less	47.20%	63.70%
	More than 1/4 but less than 1	34.80%	23.00%
	1 to less than 5	12.40%	10.10%
Home Property	5 or more	5.60%	3.20%
	Own	96.60%	97.90%
	Rent	3.40%	2.10%

Maintainers and Partial Maintainers. Independent *t*-test were used to compare the mean of other ordinal variables (Likert-scaled questions: perceptions about water quality, opinions about environment) between different groups.

### 2.3. Practice assessment

Practice assessments of the condition of adopters' BMPs were based upon established criteria and indicators for on-site assessments of BMP performance and maintenance (Bracmort, Engel, & Frankenberger, 2004; Lindsey, Roberts, & Page, 1992). In addition, collaboration with staff at the WREC and the SDCF led to the development of a checklist with criteria for evaluating the level of maintenance of rain barrels (see Appendix A in the Supplementary material for assessments sheet). Excluding the inaccessible locations, a total of 135 rain barrels in the Salt Creek watershed were successfully assessed between June 11 and July 15, 2014; 143 rain barrels in the Wabash watershed were successfully assessed between May 30 and June 10, 2014; and 480 rain barrels in the Wabash watershed were successfully assessed between May 18 and October 6, 2015.

The assessments documented the following conditions of rain barrels:

- if the rain barrel is present,
- if the rain barrel is connected to a downspout or roof overflow,
- if the rain barrel is installed on a stand,
- if the exit hoses are attached,
- if there are any non-essential holes on the screen or on the barrel,
- if the residents displayed informational signage (see Appendix D in the Supplementary material) about their rain barrel in their yard (only applicable in the Wabash watershed),
- and an approximation of how full the rain barrel was at the time of assessment.

The informational signage information was only recorded in the Wabash watershed. For 2010 and 2011 pre-WREC period adopters, the signs were installed by the WREC staff and volunteers after ascertaining adopters' willingness to display one. For 2012 adopters, the individual had to fill out a form stating that they will install a sign and indicating they allow access to their property at the time of purchase through the WREC. The signs were installed by the WREC staff and volunteers. For 2013 and current adopters, the signs were provided by the WREC at the time of purchase and the purchasers voluntarily install on their own.

Each rain barrel received a score on an index from 0 to 3 after completing the assessments. Table 2 displays the criteria to achieve an index score.

Rain barrels with a score of 0 are not installed. These rain barrels either are not present, or are present but not connected to a downspout or roof overflow.

Rain barrels with a score of 1 are installed, but do not capture rainwater. These rain barrels either are connected to a downspout diverter that runs uphill, or have severe holes or cracks that eliminate the barrel's ability to collect water.

Rain barrels with a score of 2 are installed and can capture rainwater, but limitations exist on the use of this water. For example, rain barrels that are not on a stand exhibit water pressure concerns, and rain barrels with damage to the screen on top of the barrel have the potential to attract mosquitoes. The rain barrels sold by the SDCF are designed so that they require the use of "exit hoses" to retrieve water from the barrel; therefore, Salt Creek rain barrels without "exit hoses" receive a score of 2. (see Appendix C in the Supplementary material for exit hose design difference.)

Rain barrels with a score of 3 contain all the necessary items to be used properly and without difficulty.

### 2.4. Interview

In-person interviews of adopters in the Salt Creek watershed were conducted in June and July 2014. All 205 rain barrel adopters in the Salt Creek watershed were contacted up to three times; 31 individuals agreed to participate in the interview. Of these 31 interviews, 30 were with homeowners and one was with a Porter County government official. The thirty homeowner interviews were coded using NVivo and used for analysis; the interview with the government official helped gain background on stormwater initiatives in the community, but it was not used for analysis since it was not based upon personal experience with rain barrel adoption. The interviews were semi-structured, following the interview guide presented in Appendix B in the Supplementary material, but occasionally adding, omitting, or changing the order of questions as the interview progressed.

Interviews included questions about where they learned about rain barrels, their motivation for installing a rain barrel, maintenance concerns, who they talked to about their rain barrel, and their knowledge of others who implemented rain barrels. Specifically, residents who said they had installed their rain barrel were asked what they use the water in their rain barrel for and how their rain barrel is working. Those who purchased a rain barrel but did not have it installed were asked about why they have not installed their rain barrel.

After a single researcher coded all thirty interviews with a systematic codebook, an inter-coder reliability test was completed. This reliability testing reduces the possibility that researcher bias resulted in the data to be coded overly consistent with the hypotheses. It will also increase confidence that the single coder's coding would be reproducible by other coders (Campbell et al., 2013). After two additional coders examined ten percent of the set of interviews, all three coders compared the results and reconciled areas of discrepancies or confusion. This process was repeated until the level of coding consistency reached a Cohen's kappa coefficient value of 0.7, which has been recommended as a satisfactory level of agreement (Bakeman & Gottman 1986; Gardner 1995).

## 3. Results

### 3.1. Demographics of rain barrel adopters in two watersheds

There was a higher percentage of female respondents than male in both watersheds. More than half of the respondents in both watersheds were aged between 50 and 69 (62.5% Salt Creek; 52.8% Wabash). A large number of the respondents in both water-

**Table 4**

Top five constraints to maintain a rain barrel.

Salt Creek	Wabash
Equipment malfunction (n = 70)	21.40%
Concerns with mosquitoes (n = 72)	15.30%
Water pressure issues (n = 71)	12.70%
Time required for maintenance (n = 71)	11.30%
Insufficient water in the barrel (n = 70)	8.60%
Equipment malfunction (n = 226)	18.10%
Water pressure issues (n = 227)	16.30%
The features of my property made it difficult (n = 226)	11.10%
Insufficient water in the barrel (n = 225)	11.10%
Time required for maintenance (n = 227)	8.40%

sheds earned a bachelor's degree or higher (63.7% Salt Creek; 68.9% Wabash). Most of the respondents owned their property rather than rented it in both watersheds (96.6% Salt Creek; 97.9% Wabash). See Table 3 for more details.

### 3.2. Adopters' experience with rain barrels

#### 3.2.1. Motivation for adoption and maintenance of rain barrels

Over half of the respondents in both watersheds reported that they received their rain barrels at a discounted price from the city, university, or local organization (64.7% Salt Creek; 73.0% Wabash). The majority of respondents in both watersheds said they installed their rain barrel and currently use it (70.5% Salt Creek; 77.9% Wabash). Over half of the respondents who installed a rain barrel (64.4% Salt Creek; 71.8% Wabash) stated they emptied their rain barrel within a week of filling.

When asked about motivations for installing a rain barrel, a high percentage of the respondents said they used it to "reduce water use for their yard and house" (91.9% Salt Creek; 90.7% Wabash). The second top reason reported was "to improve water quality in my area" (47.3% Salt Creek; 45.1% Wabash). Over half regarded reduction of water use for their yard and house as the most important single factor driving their acquisition of a rain barrel (62.9% Salt Creek; 65.8% Wabash), while only a small percentage of respondents saw improvement of water quality as the most important factor (12.9% Salt Creek; 10.4% Wabash). Most respondents in both watersheds said they used stored rain barrel water to irrigate a vegetable or flower garden (94.4% in Salt Creek; 95.6% Wabash).

All of the interviewees in the Salt Creek watershed, regardless of whether or not they installed their rain barrels, were flower and/or vegetable gardeners. Twenty-eight of the 30 interviewees mentioned gardening as a primary reason for purchasing a rain barrel. The two who did not mention gardening as a key motivator did not install their rain barrel. Four interviewees mentioned that having a rain barrel was convenient for them because the rain barrel was closer to their garden than the hose was, and made watering easier. Fourteen interviewees also saw cost as an important reason to purchase a rain barrel. Eight interviewees mentioned the rain barrel was inexpensive, while seven individuals noted that city water was expensive while rain barrels supplied free water.

#### 3.2.2. Special constraints about maintenance of rain barrel

When asked about special constraints on the continued use of rain barrels, except for equipment malfunction and water pressure, over half of the respondents reported all the other listed constraints as "Not at all" in both watersheds. Respondents in both watersheds regarded equipment malfunction (4.4% Salt Creek; 4.4% Wabash) and water pressure issues (4.4% Salt Creek; 4.8% Wabash) as the factors influencing them "a lot". The cost of maintenance was identified as the least constraining factor ("Not at all": 97.2% Salt Creek; 92.9% Wabash). The top five factors respondents identified as constraints (aggregated percentage of "a lot" and "some") are shown in Table 4.

The interviewees in the Salt Creek watershed talked about diverse maintenance concerns as well. The most common maintenance issues mentioned include hoses clogging or breaking, water

overflowing, rain barrel cracking over the winter season, and low water pressure. Inconvenience was also a common concern. Six of the eight interviewees who received an assessment score of 0 mentioned inconvenience as a reason why they do not use their rain barrel. One person who used their rain barrel also mentioned inconvenience. As a result, this person discouraged a friend from getting a rain barrel because of the work required.

#### 3.2.3. Practice assessment

In the Salt Creek watershed, 135 rain barrels were assessed and assigned an index score. In the Wabash watershed, 143 rain barrels in 2014 and 480 in 2015 were assessed and assigned an index score (Table 5).

Notably, almost 35% of the Salt Creek rain barrels were absent after a maximum of five years in practice while 25% and 29% of the Wabash rain barrels were absent after two and three years of use, respectively. For the comparison of different locations, the Salt Creek watershed has a statistically significant lower average assessment score than the 2014 Wabash watershed average assessment ( $\text{Sig.} = 0.016$ ). For the comparison of different years, the WREC updated their rain barrel inventory in 2015. Although the average assessment score in 2015 is higher than that in 2014, the percentage of scored-3 records (Full Maintainers) in 2014 is higher than that in 2015 (67% in 2014; 47% in 2015).

In addition, in the Wabash watershed the impact of informational signage on adoption and maintenance of rain barrels was assessed (Table 6).

Residents who did not have informational signage about their rain barrel in their yards had a statistically significant lower assessment score than residents who displayed the signage on average ( $\text{Sig.} = 0.000$ , 2014;  $\text{Sig.} = 0.000$ , 2015).

### 3.3. Comparison between non-adopters, adopters and full maintainers

The non-adopters were selected from the Wabash Urban Residents survey by excluding respondents who answered they have installed a rain barrel. For the analysis of difference between adopters and non-adopters, the purpose is to test whether adopters will have more awareness of local water quality issues, more positive attitudes towards the environment, and more capabilities about using the practice than non-adopters. In order to see who is more likely to maintain their practices, another comparison is made between Full Maintainers and Partial Maintainers in the Wabash into analysis. There are a total of 226 Full Maintainers from the 2015 practice assessment result. After correlating Full Maintainers' assessment records with the 2014 survey data, 135 Full Maintainers received the 2014 Rain Barrel Adopters Survey and of these, 93 Full Maintainers responded to the survey. The comparison between different groups includes their social demographic profile, their awareness about local water quality issues, their opinion towards the environment, and their constraints and experience about various conservation practices.

**Table 5**

Summary of assessment scores, based on locations and years.

Category	Index Score	Salt Creek	Wabash 2014	Wabash 2015
Full Maintainers	Excellent (3)	70 51.90%	96 67.10%	226 47.10%
Partial Maintainers	Acceptable (2)	9 6.70%	7 4.90%	35 7.30%
	Unacceptable (1)	9 6.70%	5 3.50%	81 16.90%
	Absent (0)	47 34.80%	35 24.50%	138 28.80%
	Mean	1.76	2.15	2.42
	Median	3	3	3
	Mode	3	3	3

**Table 6**

Summary of assessment scores, based on informational signage.

Category	Index Score	No Sign Present		Sign Present	
		2014	2015	2014	2015
Full Maintainers	Excellent (3)	24 41.40%	172 41.50%	72 84.70%	54 81.80%
Partial Maintainers	Acceptable (2)	1 1.70%	31 7.50%	6 7.10%	4 6.10%
	Unacceptable (1)	2 3.40%	73 17.60%	3 3.50%	8 12.10%
	Absent (0)	31 53.40%	138 33.30%	4 4.70%	0 0.00%
	Mean	1.31	1.57	2.72	2.7
	Median	0	1	3	3
	Mode	0	3	3	3

**Table 7**

Survey respondents' demographic profile, Wabash.

		Non Adopters	Rain Barrel Adopters	Full Maintainers
Gender	Female	39.90%	57.40%	32.20%
	Male	60.10%	42.60%	67.80%
Age	Mean	60.3	55.1	56.2
	Range	24–96	25–92	25–92
Education	Some formal schooling	3.70%	N/A	N/A
	High school	18.40%	8.60%	11.40%
	Some college	16.30%	12.90%	4.80%
	2-year college degree	8.20%	9.70%	8.00%
	4-year college degree	20.40%	30.50%	30.70%
	Graduate degree	33.10%	38.40%	35.20%
	Residential	1/4 or less	66.80%	63.70%
Lot	More than 1/4 but less than 1	28.20%	23.00%	21.60%
Size	1 to less than 5	5.00%	10.10%	9.10%
(unit:	5 or more	0.00%	3.20%	0.00%
Home	Own	87.70%	97.90%	96.60%
Prop-	Rent	12.30%	2.10%	3.40%
erty	Less than \$24,999	N/A	4.80%	3.80%
	\$25,000 to \$49,999	N/A	24.20%	32.10%
	\$50,000 to \$74,999	N/A	22.60%	23.10%
	\$75,000 to \$99,999	N/A	17.50%	15.40%
	\$100,000 or more	N/A	31.00%	25.60%

### 3.3.1. Social demographic profile

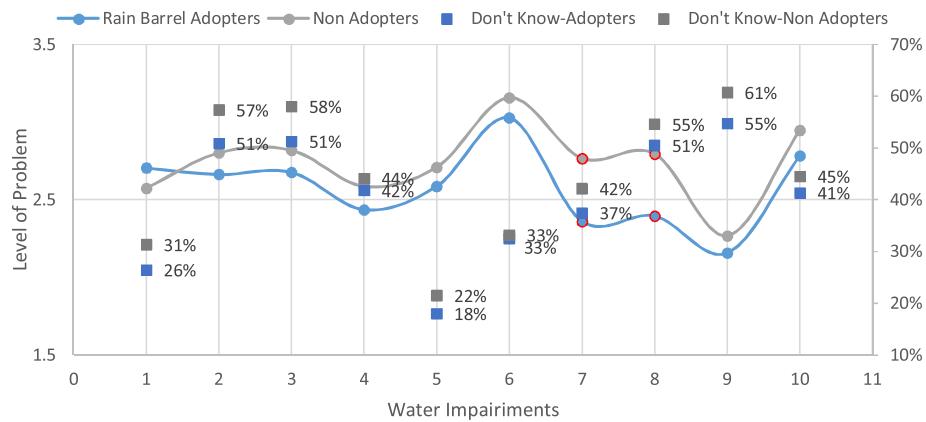
There was a higher percentage of female respondents in rain barrel adopters than non-adopters and Full Maintainers. For all the other demographic variables, there was no statistically significant difference between Full Maintainers and Partial Maintainers. The percentage of non-adopters with only a high school diploma and some formal school was significantly higher than that of rain barrel adopters and Full Maintainers (22.1% non-adopters; 8.6% rain barrel adopters; 11.4% Full Maintainers). The percentage of rain barrel adopters and Full Maintainers with a 4-year college degree was higher than that of non-adopters (20.4% non-adopters; 30.5% rain barrel adopters; 30.7% Full Maintainers). More rain barrel adopters and Full Maintainers lived on residential lots of greater than one acre (5.0% non-adopters; 13.3% rain barrel adopters; 9.1%

Full Maintainers). A higher percentage of rain barrel adopters and Full Maintainers lived on their own property than that of non-adopters (87.7% non-adopters; 97.9% rain barrel adopters; 96.6% Full Maintainers) (Table 7).

### 3.3.2. Awareness of local water quality

Local water quality awareness was measured by assessing perceptions about water impairments (Fig. 2), sources of water pollution (Fig. 3) and consequences of poor water quality (Fig. 4). By excluding "Don't know" responses, the analysis compared mean indicator values of awareness between non-adopters and rain barrel adopters, and between Full Maintainers and Partial Maintainers.

For all the 38 variables, Full Maintainers were not significantly different from Partial Maintainers. In addition, non-adopters had a

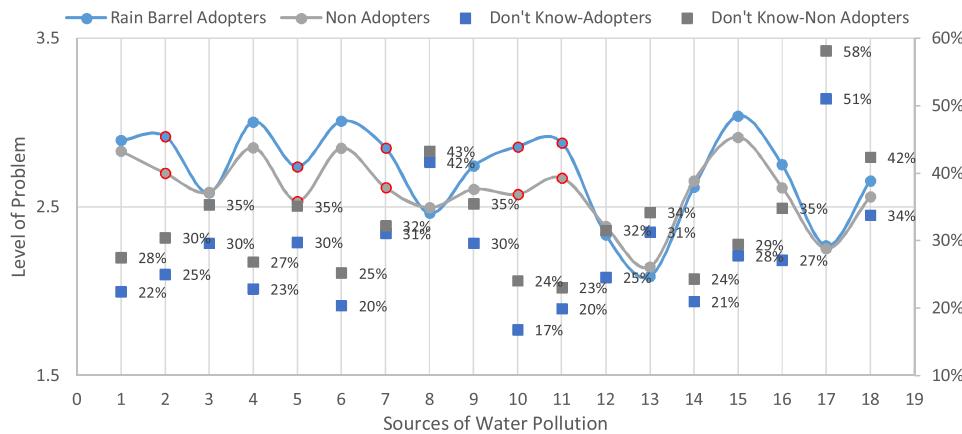
**Fig. 2.** Perceptions about water impairments.

Note: Red circle highlights variables that comparison groups are significantly different.

(Y-Axis) Level of Problem: from Not a problem to Severe problem[1,4].

(X-Axis) Water Impairments Categories:

1. Sedimentation (soil particles) in the water
2. Nitrogen
3. Phosphorus
4. Bacteria and viruses in the water (such as *E.coli*/coliform)
5. Trash or debris in the water
6. Pesticides, herbicides, fertilizers, and insecticides
7. Algae in the water
8. Not enough oxygen in the water
9. Flow alteration
10. Habitat alteration harming local fish

**Fig. 3.** Perceptions about sources of water pollution.

Note: Red circle highlights variables that comparison groups are significantly different.

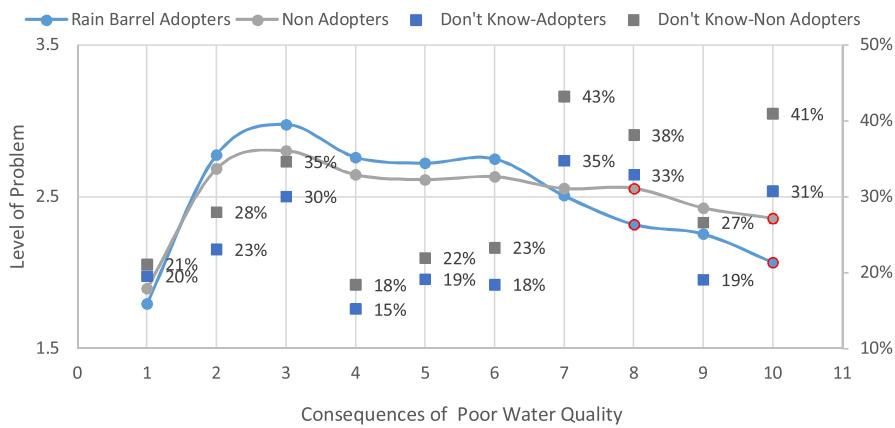
(Y-Axis) Level of Problem: from Not a problem to Severe problem[1,4].

(X-Axis) Source of Water Pollution Categories:

1. Discharges from industry into rivers and streams
2. Discharges from sewage treatment plants
3. Soil erosion from construction sites
4. Soil erosion from farm fields
5. Soil erosion from shoreline and/or streambanks
6. Excessive use of lawn fertilizers and/or pesticides on lawns
7. Improper disposal of lawn waste, oils, and chemicals into storm drain
8. Improperly maintained septic systems
9. Manure from farm animals
10. Stormwater runoff from rooftops, parking lots, and roads
11. Street salt and sand
12. Droppings from geese, ducks, and other waterfowl
13. Waste material from pets
14. Littering/illegal dumping of trash
15. Excessive use of fertilizers for crop production
16. Land development or redevelopment
17. Channelization of streams
18. Removal of trees and vegetation along streams

higher percentage of “Don’t know” responses in all the 38 variables than rain barrel adopters.

**Fig. 2** shows that non-adopters were more likely to recognize all the listed water impairments as a problem in their area than rain



**Fig. 4.** Perceptions about consequences of poor water quality.

Note: Red circle highlights variables that comparison groups are significantly different.

(Y-Axis) Level of Problem: from Not a problem to Severe problem [1,4].

(X-Axis) Consequence of Poor Water Quality Categories:

1. Contaminated drinking water
2. Contaminated fish
3. Loss of desirable fish species
4. Reduced beauty of rivers or streams
5. Reduced opportunities for water recreation
6. Reduced quality of water recreation activities
7. Excessive aquatic plants or algae
8. Fish kills
9. Odor
10. Lower property values

barrel adopters, except for “sedimentation in the water”. Among the listed water impairments, non-adopters were significantly different from rain barrel adopters in recognizing “algae” ( $\text{Sig.} = 0.000$ . Mean value: 2.77 non-adopters; 2.36 rain barrel adopters) and “not enough oxygen in the water” ( $\text{Sig.} = 0.003$ . Mean value: 2.80 non-adopters; 2.40 rain barrel adopters) as a problem.

**Fig. 3** shows that rain barrel adopters were more likely to identify most of the listed sources of water pollution as a problem in their area than non-adopters are. Among the listed sources of water pollution, rain barrel adopters were significantly different from non-adopters in identifying the following as local problems: “discharges from sewage treatment plants” ( $\text{Sig.} = 0.028$ . Mean value: 2.70 non-adopters; 2.92 rain barrel adopters), “soil erosion from shoreline and/or streambanks” ( $\text{Sig.} = 0.049$ . Mean value: 2.53 non-adopters; 2.74 rain barrel adopters), “improper disposal of waste, oils, and chemicals into storm drain” ( $\text{Sig.} = 0.020$ . Mean value: 2.62 non-adopters; 2.85 rain barrel adopters), “stormwater runoff from rooftops, parking lots, and roads” ( $\text{Sig.} = 0.002$ . Mean value: 2.57 non-adopters; 2.86 rain barrel adopters), and “street salt and sand” ( $\text{Sig.} = 0.018$ . Mean value: 2.67 non-adopters; 2.88 rain barrel adopters). Noticeably, both groups of respondents were less likely to recognize “waste material from pets” as a local problem (Mean value: 2.14 non-adopters; 2.09 rain barrel adopters).

**Fig. 4** shows that both groups of respondents did not see “contaminated drinking water” as a problem in their area (mean value: 1.89 non-adopters; 1.79 rain barrel adopters). Among the listed consequences of poor water quality, non-adopters were significantly different from rain barrel adopters in recognizing “fish kills” ( $\text{Sig.} = 0.031$ . Mean value: 2.55 non-adopters; 2.32 rain barrel adopters) and “lower property values” ( $\text{Sig.} = 0.015$ . Mean value: 2.36 non-adopters; 2.07 rain barrel adopters) as a problem in their area.

### 3.3.3. Attitudes towards the environment

Attitudes towards the environment were determined by asking respondents water quality related statements. Full Maintainers were not significantly different from Partial Maintainers in their

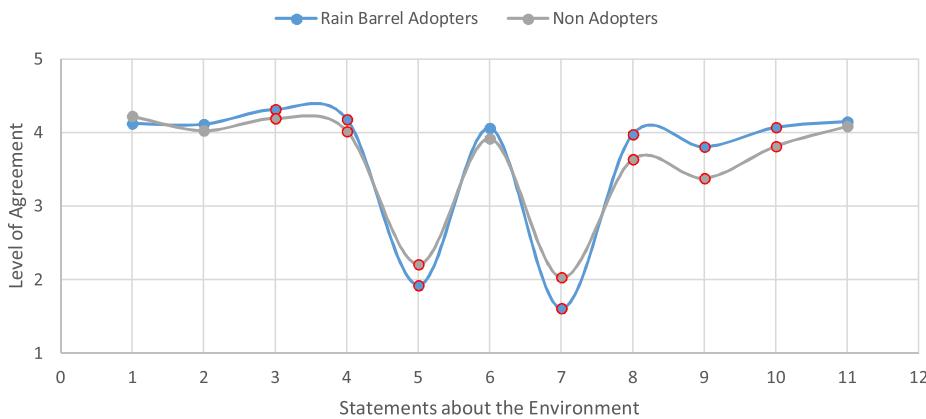
responses to these statements. Rain barrel adopters (both Full and Partial Maintainers) had more strongly positive attitudes towards the environment than non-adopters did (**Fig. 5**).

Rain barrel adopters were more likely to strongly disagree that “it is okay to reduce water quality to promote economic development.” ( $\text{Sig.} = 0.000$ . Mean value: 2.03 non-adopters; 1.61 rain barrel adopters), and more likely to strongly agree that “it is important to protect water quality even if it costs me more.” ( $\text{Sig.} = 0.000$ . Mean value: 3.64 non-adopters; 3.98 rain barrel adopters), “I would be willing to pay more to improve water quality.” ( $\text{Sig.} = 0.000$ . Mean value: 3.38 non-adopters; 3.81 rain barrel adopters) and “I would be willing to change the way I manage my stormwater runoff to improve water quality.” ( $\text{Sig.} = 0.000$ . Mean value: 3.82 non-adopters; 4.07 rain barrel adopters). Rain barrel adopters were also more likely to agree with the following statements: “It is important to protect water quality even if it slows economic development” ( $\text{Sig.} = 0.017$ . Mean value: 4.02 non-adopters; 4.18 rain barrel adopters) and “It is my personal responsibility to help protect water quality” ( $\text{Sig.} = 0.047$ . Mean value: 4.19 non-adopters; 4.32 rain barrel adopters). Rain barrel adopters were also more likely to disagree that “What I do on my land doesn’t make much difference to overall water quality” ( $\text{Sig.} = 0.001$ . Mean value: 2.21 non-adopters; 1.92 rain barrel adopters).

#### 3.3.4. Constraints and experience about conservation practices

Non-adopters identified “cost” (20.8%,  $n = 154$ ), “don’t know how to do it” (18.4%,  $n = 174$ ), and “time required” (18.0%,  $n = 161$ ) as the top three factors limiting them “a lot.” In addition, among non-adopters there was a high percentage of “don’t know” responses to “the features of my property do not support it (35.0%,  $n = 206$ )” and “insufficient proof of water quality benefit” (40.4%,  $n = 203$ ).

As section 3.2.2 showed, over half of rain barrel adopters indicated “not at all” to most of the listed constraints for using a rain barrel. A few of them identified “equipment malfunction” and “water pressure issues” as the factors influencing them a lot. “Cost of maintenance” was the least important constraint. In addition, Full Maintainers were less likely to identify “insufficient proof of

**Fig. 5.** Attitudes towards the environment.

Note: Red circle highlights variables that comparison groups are significantly different.

(Y-Axis) Level of Problem: from Strongly disagree to Strongly agree[1,5].

(X-Axis) Statements about the environment:

1. The economic stability of my community depends upon good water quality.
2. The way that I manage my stormwater runoff can influence water quality in local streams and rivers.
3. It is my personal responsibility to help protect water quality.
4. It is important to protect water quality even if it slows economic development.
5. What I do on my land doesn't make much difference to overall water quality.
6. My actions have an impact on water quality.
7. It is okay to reduce water quality to promote economic development.
8. It is important to protect water quality even if it costs me more.
9. I would be willing to pay more to improve water quality. (for example: through local taxes or fees)
10. I would be willing to change the way I manage my stormwater runoff to improve water quality.
11. The quality of life in my community depends on good water quality in local rivers and streams.

water quality benefit" as their constraint than Partial Maintainers ( $\text{Sig.} = 0.026$ . Mean value: 1.01 Full Maintainers; 1.10 Partial Maintainers).

#### 4. Discussion

This research finds that rain barrel adopters are different from non-adopters in their attitudes towards the environment and knowledge about conservation practices as hypothesized, but not in their awareness about local water quality issues. In other words, positive attitudes and good knowledge about urban conservation practices are most positively associated with adoption, which aligns with findings from other urban BMP researches (Brehm et al., 2013; Newburn et al., 2013) and other attitude-behavior literatures (Barr, 2007; Hines et al., 1987; Stern, 2000). The results regarding awareness about local water quality issues are inconsistent across the groups studied: adopters are more likely to identify sources of water pollution, while non-adopters are more likely to identify water impairments. However, non-adopters have a higher percentage of "Don't know" responses in all of the 38 variables measuring their awareness about local water quality. It implies non-adopters' knowledge about local water quality issue is lower than adopters' knowledge (Hu & Morton, 2012). Additionally, all of the interviewees from the Salt Creek watershed who installed their rain barrels mentioned being engaged with environmental or community issues; this indicates a high awareness towards the environment and commitment to community among these interviewees. It is also consistent with previous research on the diffusion of BMPs: individuals who actively participate in community activity are more likely to share information with others (Martini, Nelson, & Dahmus, 2014).

Socioeconomic and demographic variables, such as age, income, education, and related experience, which are proxy indicators for human capital formation, do influence landowners' capacity to adopt agricultural conservation practices (Prokopy et al., 2008). Importantly, this research shows that adopters and non-adopters

of urban BMPs are significantly different with respect to certain human capital variables. Residents who have at least a 4-year college degree, who own their property rather than rent, and whose residential lot size is greater than one acre, are more likely to adopt urban conservation practices. People with higher education levels tend to feel more responsibility about the environment outside their neighborhood (Hines et al., 1987; Syme, Nancarrow, & Jorgensen, 2002), which could explain the higher percentage of adopters with at least a college degree. Most of the adopters owned their property in the study area, confirming that people who own their land have more autonomy for making changes (Baptiste, Foley, & Smardon, 2015). People who live on residential lots greater than one acre are more likely to adopt the practice; one explanation for that might be that people with larger residential lots want to reduce water use in their larger yard. However, few studies of urban conservation practices have shown this association between residential size and adoption of practice, and as such it deserves further study.

The research finds that economic cost and lack of how-to knowledge related with the practice are important factors limiting adoption in the Wabash watershed. This implies that the partial cost share and installation assistance provided by the cost-share program are important for promoting the adoption of rain barrel, which is consistent with evidence from the Washington DC area (USEPA, 2008), Chicago (Ando & Freitas, 2011), and Syracuse (Baptiste et al., 2015). In addition, the economic benefits are a more important motivator for adopting a rain barrel than the environmental benefits. More adopters indicated that "reducing water use in their yard" was a more important motivation than "improve water quality". From another perspective, adopters care more about water quantity than water quality issues, this might explain the inconsistent and conflicting results of adopters and non-adopters with respect to awareness of water quality issues. Moreover, most adopters said they used the stored water to irrigate a vegetable or flower garden and all of the interviewees were gardeners. This characteristic of adopters identifying as gardeners is consistent with

previous research (Newburn et al., 2013). It should be noted that while water quantity was not classified as an environmental issue in the humid Midwest, it may very well be considered an environmental issue in other regions, especially in the arid western United States.

In contrast to our hypothesis, this research finds no significant difference between Full Maintainers and Partial Maintainers in their awareness about local water quality issues and attitudes towards the environment. The only significant difference between the two types of Maintainers is their view of "insufficient proof of water quality benefit", which Full Maintainers are less likely to see as a constraint. Therefore, little evidence from this comparison could be drawn on to make strong predictors for motivation of good maintenance. However, the interview data found that six out of eight adopters who received an assessment score of 0 mentioned "inconvenience" as their concern for using the practice, which is a common factor influencing discontinuance.

Differences in maintenance conditions between the two different watersheds could imply the impact of other exogenous factors. For example, the Salt Creek watershed has a statistically significant lower average assessment score than the Wabash watershed. This could be explained by the fact that the cost-share program in the Salt Creek was implemented in 2008, while in the Wabash it was implemented in 2012. The longer time lapse in the Salt Creek also allowed for more changes in home ownership: at least 10 of the 47 addresses in the Salt Creek received a score of 0 because the residents who had purchased and installed the rain barrel had moved away. Also, in the Wabash watershed, stands are usually sold alongside rain barrels. This was not the case in the Salt Creek watershed. The absence of the stands may explain why the Salt Creek rain barrels received more scores of 2 and fewer scores of 3, as some homeowners might be unaware that they need to elevate their rain barrel. What's more, because the design of the Salt Creek rain barrels requires the use of exit hoses and the design of the Wabash rain barrels does not, the Salt Creek rain barrels had to overcome an additional assessment criterion to receive a score of 3. Finally, informational signage was displayed only in the Wabash watershed, where a higher average assessment score was observed in adopters with signs than those adopters without signs in the area.

This result could be explained by the "commitment" phenomenon, where those who performed a small initial action were much more likely to agree to a subsequent larger action. This finding has been observed numerous times, such as in written commitments for recycling (Pardini & Katzev, 1984), public commitment for conserving energy (Pallak, Cook, & Sullivan, 1980), and stickers on curbside recycling containers indicating commitment for sustainable action (McKenzie-Mohr & Schultz, 2014). In this case, the initial action was installing the rain barrel and agreeing to display an informational sign. Having the sign clearly displayed subtly alters residents' views on watershed management: they begin to see themselves as someone who is an "Eco-Champion" and is "protect[ing] the Wabash River," as the sign reads. Signs publicly shown on their properties also have social diffusion effect, as friends and neighbors of the adopters will learn about the practice when the sign is visible.

## 5. Conclusion

Understanding the social and human dimensions of water resources management is an essential component to the design, promotion and management of successful local and regional water projects. This research explored the social and human factors motivating urban-suburban residents to adopt and maintain rain barrels in two Indiana watersheds. The results of measurement of social indicators, including awareness, attitudes, constraints, and behav-

iors over time, can assist resource managers in making informed decisions and implementing effective practices that ultimately lead to water quality improvement and protection.

This study found that people with more positive attitudes towards the environment and higher levels of knowledge about practices are more likely to adopt practices. This implies that it is necessary for practitioners to conduct education programs that spread knowledge of conservation practices, especially emphasizing the economic benefits of the practice as well as the environmental benefits. Additionally, gardeners with the intention to reduce water use in their yard could be the most likely potential adopters in the future. Moreover, for good maintenance of the practice, it is recommended that only well designed practices together with all related accessories are sold to adopters. Finally, it is strongly recommended that adopters are encouraged to display informational signage stating their use of the practice and support of the local environment. While future research should attempt to carefully control attributes of people with signage and people without signage in order to better understand the relationship between signage display and practice maintenance, the significant difference between average assessment scores of people with signs and that of people without signs implies a potential strategy for improving practice maintenance over time.

Most importantly, further investigation on the differential influences of economic versus environmental benefits for promoting adoption of conservation practices is needed. Future research should also focus on the factors influencing discontinuance of practices over time, as 35% of the Salt Creek rain barrels were discontinued after only five years of use and 25% and 29% of the Wabash rain barrels were absent after two and three years of use, respectively. It appears that over time certain "inconvenience" factors, which were mentioned repeatedly by the interviewees in the study area, make rain barrel maintenance unfeasible or undesirable.

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.landurbplan.2016.04.005>.

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