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Know your watershed and know your neighbor: Paths to supporting urban watershed conservation and restoration in Baltimore, MD and Phoenix, AZ

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ABSTRACT

Stormwater run-off is an important component of the hydrologic cycle of urban watersheds. There is increasing concern with the water quality of stormwater run-off, in addition to the effects of flooding. Changes in the structure of watersheds and in human behavior are important to improve stormwater quality. These changes often require support for government programs and voluntary actions. Environmental knowledge and social cohesion may be two important factors that affect support for urban watershed improvements. We compared temperate Baltimore, MD and arid Phoenix, AZ to examine the relationships among watershed knowledge and social cohesion and support for taxes or voluntary actions to improve local urban watersheds. We also test two social concepts—the "crowding out" and "snowball" effects. Crowding out effects suggest that government activities will crowd out a willingness to volunteer. Snowball effects suggest that voluntary actions are more likely when they complement existing government activities. Using a telephone survey (n = 3,273), we find that watershed knowledge is positively associated with both taxes and volunteering in Baltimore and had no relationship in Phoenix. Social ties are negatively associated with support for taxes and positively associated with volunteering in both cities. We found evidence for the snowball effect: participants who supported a tax were twice as likely to support volunteering. These findings are relevant to the long term dynamics of urban watersheds because the deterioration or improvement of urban watersheds is critically tied to the willingness and capacity of social actors to intervene.

1. Introduction

Stormwater run-off is an important component of the hydrologic cycle of urban watersheds. As more people move to urban areas (United Nations, 2014), the complexity of the urban social-hydrological interface will continue to increase (Groffman et al., 2003; Hager, Belt, & Stack, 2013; Lim, 2016). Management of urban hydrology in the United States has historically focused on the effects of stormwater run-off on flooding and risks to human life and property (Hale, 2016). However, the Federal Clean Water Act in 1972 expanded management concerns to include water quality of urban watersheds and downstream receiving waters and created standards for regulatory compliance.

To comply with the Clean Water Act, there have been physical improvements in infrastructure such as reducing point source pollution discharge from industrial and commercial areas; repairs and enhancements to sanitary systems and water treatment plants; and new design requirements for different land uses that incorporate environmental site design and green infrastructure. Cities' stormwater systems are regulated through the National Pollutant Discharge Elimination System managed by the Environmental Protection Agency. To address nonpoint source pollution that enters the stormwater system, cities have been encouraged to adopt changes to physical, biological, and built structures on the urban landscape and behavioral changes through programs such as education, citizen water monitoring, and stream cleanups via Municipal Separate Storm Sewer System permits (known as MS4 permits) (Kinchy, 2017).

Although there has been improvement in the water quality of urban watersheds (Melosi, 2008, Lefcheck et al., 2018), considerable work remains, including continued improvements to public infrastructure systems, changes in private residential landscape design and management practices, and opportunities to incorporate nature-based designs in both cases (Liao, Deng, & Tan, 2017). Sweeping changes associated

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with stormwater require political champions within government and policymaking (Hopkins, Grimm, & York, 2018) along with public support and knowledge about the issue.

In this paper, we examine the relationships among watershed knowledge, support for policy instruments (fees for watershed improvement), and willingness to volunteer to improve watersheds. We explore whether these relationships vary between temperate, Baltimore, MD and arid Phoenix, AZ. These urban areas host the Baltimore Ecosystem Study (BES) and the Central Arizona-Phoenix (CAP) long term ecological research (LTER) sites, where a comparative telephone survey was conducted in 2011. We consider whether social ties, an important component of social cohesion and perceptions of collective efficacy, are related to support for public policy or willingness to volunteer. We examine the question of whether there may be trade-offs between government programs to improve watersheds and voluntary behaviors that may produce a "crowding out" effect or, alternatively, whether government programs and voluntary projects are complementary and may lead to a "snowball effect".

2. Background

Linking individuals' knowledge and social ties to their support for policy preferences and environmental behaviors has a rich literature in the social sciences, as described below. We focus our attention on research regarding social ties, cohesion, and efficacy and their linkages to policy support and voluntary action for urban watershed management. Our first question is whether knowledge about environmental issues may lead to support for policy interventions and willingness to engage voluntary behavior. Secondly, we examine whether social ties, and thereby cohesion and efficacy, may influence support for policy intervention and willingness to volunteer.

2.1. Knowledge to action

Models of policy support often include socio-demographic variables such as income, education, race, and household age as factors associated with support for local policy responses (see for example York, Kane, & Clark, 2017). Knowledge is often critical in the policymaking process (Sabatier, 1987) and influences public response to environmental questions and willingness to support policies (Rauwald and Moore, 2002) or volunteer (Ellis & Waterton, 2004). General knowledge of watersheds (see Dean et al., 2016) and more specific hydrologic concerns such as flooding (e.g. Thieken, Kreibich, Müller, & Merz, 2007, Bubeck, Botzen, & Aerts, 2012, Milman, Warner, Chapman, & Short Gianotti, 2018), scarcity (Salvaggio et al., 2014), and nonpoint source pollution (i.e. Vrain & Lovett, 2016, Okumah, Martin-Ortega, & Novo, 2018) are associated with support for private or public action. Knowledge in and of itself is not the sole motivating force, but rather may be mediated by socio-demographic characteristics and community context, such as social cohesion.

2.2. Social cohesion to action

Social ties are considered to be the basis for forming social bonds and social trust, which may ultimately lead to greater social cohesion and collective action (Larsen, Harlan, & Bolin, 2004; Sampson, Raudenbush & Earls, 1997). In Phoenix research has shown that, "people who associate with their neighbors and trust their neighbors are more likely to take action" to solve community problems (Larsen et al., 2004: 74). Further, Baptiste, Foley, and Smardon (2015) argue that there are connections among knowledge about stormwater, perceived social efficacy, and willingness to support various management techniques. Social ties are often connected to perceived collective efficacy. Thus, social ties may be an important factor in explaining policy support or willingness to volunteer.

2.3. The "Crowding out" and "Snowball" effects

There are ongoing debates in the public choice and policy literature about the effect of new government programs on voluntary action by citizens or non-governmental organizations. Government involvement may lead to less private giving, volunteering, and general involvement from citizens: "crowding out." Empirical support of crowding out has been found with respect to charitable giving (Abrams & Schitz, 1978). Relatedly, cognitive psychologists use "cognitive evaluation theory" (Deci, Ryan, & Koestner, 1999), which explains that intrinsic motivation may be reduced once incentives are provided for voluntary activity. Thus, government policy or action may crowd out willingness for private individuals to engage in a voluntary activity.

A competing hypothesis is that government action may reinforce private action, as residents see increased efficacy of their own activities with those of complementary state-funded action, leading to a "snowball" effect. We borrow this phrase from the policy diffusion literature where adoption of a policy increases the likelihood of adoption of complementary policies (see for example Shipan & Volden, 2012). We examine evidence for crowding out or snowball effects for individual support for government action and willingness to engage in voluntary activity urban watershed issues (Fig. 1).

Hypotheses. Our dependent variables are support for government intervention (See Fig. 1, A) and willingness to engage in voluntary action (B) to support watershed conservation and restoration activities. We hypothesize that greater watershed knowledge (1) and more social ties (2) will be positively associated with both government intervention support (A) and voluntary action (B) when controlling for socioeconomic and demographic factors (3) income, education, race, and age and the environmental context, (4), as Baltimore (temperate) and Phoenix (desert), may lead residents' to have different experiences and, potentially, differences in support for urban watershed conservation and restoration (Fig. 1). In particular, we anticipate that environmental context (4) is likely to impact knowledge (1), as we anticipate that Baltimore residents will be more aware and more engaged in their watersheds because of the temperate conditions with semi-frequent rain, consistent presence of visible surface water, and its status as a major port city. In contrast, the arid nature of Phoenix and the diversions of significant waterways, such as the Salt River, may lead to misunderstandings about urban hydrology and basic environmental knowledge in Phoenix. Fig. 1 is used to organize and summarize our methods, findings, and discussion.

3. Methods

3.1. Study areas

This research was conducted as part of the Baltimore Ecosystem Study (BES) and Central Arizona Phoenix (CAP), the two urban components of the U.S. National Science Foundation (NSF)-funded Long Term Ecological Research (LTER) network. Phoenix has an average annual temperature of 23.9 degrees Celsius with 20.4 cm annual rainfall on average; Baltimore has an average annual temperature of 12.8 degrees Celsius with 106.4 cm average annual rainfall (NCDC, 2014). Phoenix is the fifth-largest city in the USA with over 1.6 million residents within the city boundaries (Census Bureau, 2018a) and 4.7 million in the metropolitan statistical area (Census Bureau, 2018b). The Baltimore metropolitan area has 2.8 million (Census Bureau, 2018b) with approximately 611,000 residents within the city boundary (Census Bureau, 2018b. Phoenix is characterized by rapid population growth, a large service sector economy, and a young population (26.8% under 18 years old; Census Bureau, 2018b) with a government focus on managing and supporting growth (York, Feiock, & Steinacker, 2013). Phoenician water management is complex and varied (Hale, Turnbull, Earl, Childers, & Grimm, 2015). The study site includes Indian Bend

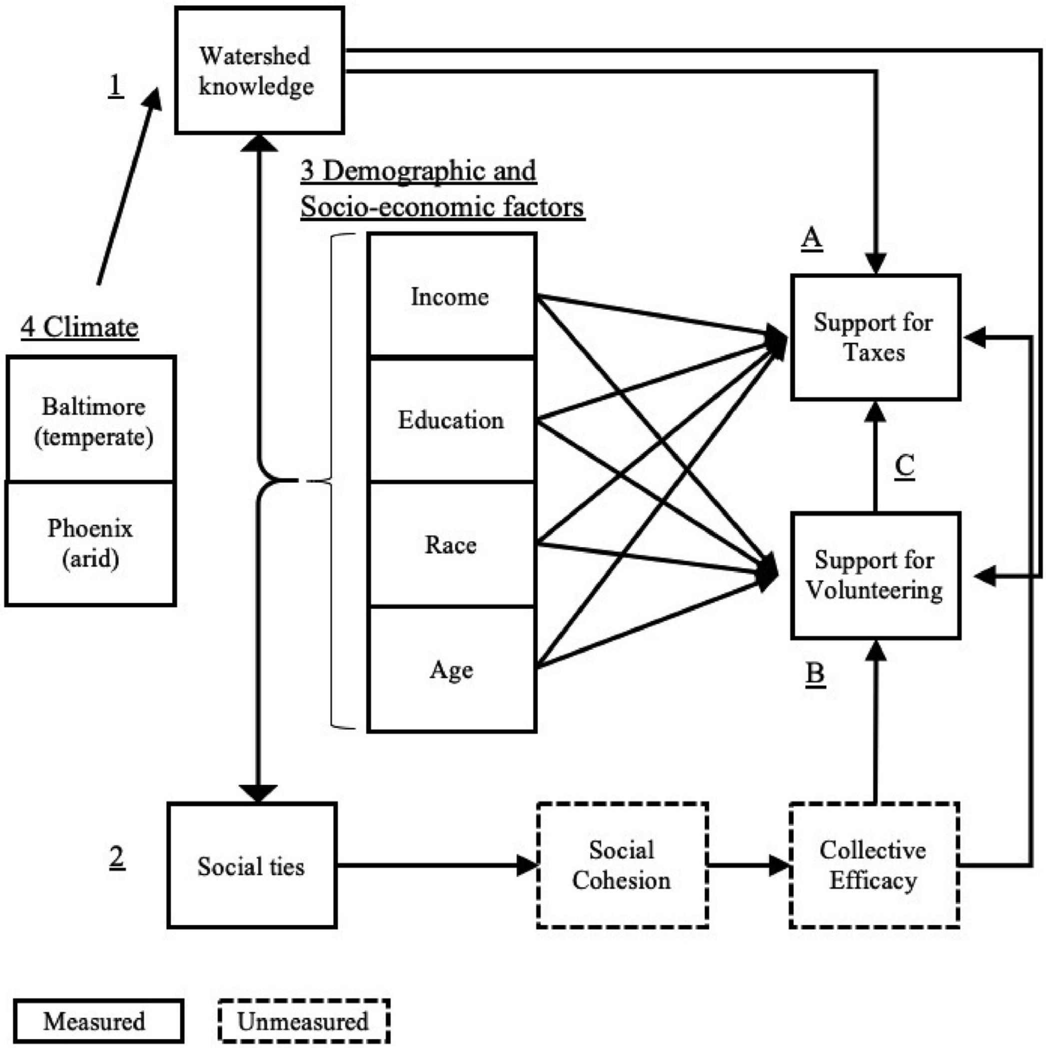

Fig. 1. Watershed knowledge and Collective Action Model for the Conservation and Restoration of Watersheds in the BES and CAP urban LTERs.

Wash, which is a well-studied stormwater management project that embraced alternative, often green, infrastructure in the 1960s, in order to manage the stormwater while providing the co-benefits of greenspace (Miller, Chester, & Muñoz-Erickson, 2018). The larger Phoenix context includes widespread utilization of retention basins for runoff (McPhillips & Matsler, 2018) and managed wetlands for sewage treatment as well as a major gray infrastructure system for storage and diversions of the region's rivers through an extensive canal system (Larson, Grimm, Gober, & Redman, 2005). Baltimore is a much older and diverse city (20% under 18 years old and 31.6% white) and areas within the city currently experiencing population loss and abandonment. Historically, the city's stormwater policy has focused on grappling with its aging infrastructure and the challenges of improving water quality in its streams and harbor (Hager et al., 2013). More recently, Baltimore has also embraced retention basins and green infrastructure, particularly low impact development (McPhillips & Matsler, 2018). Water quality is a dominant concern in Baltimore with documented impacts on land prices (Irwin, Klaiber, & Irwin, 2017). In Phoenix, water quantity, or supply, is a frequent issue raised in public discourse (Hirt, Snyder, Hester, & Larson, 2017), although there is widespread concern in the region about drinking water quality and utilization of expensive alternatives including filtration and bottled water (Gartin, Crona, Wutich, & Westerhoff, 2010; York, Barnett, Wutich, & Crona, 2011). Flooding is an issue in both regions, although Phoenix is characterized by "flashy," infrequent large-scale flooding events; historic floods affect 14% of the population, while Baltimore's typically smaller historic floods affect 4% of the population (National Academies of Sciences, Engineering and Medicine, 2019; Wing et al., 2018). Climate and the local environment may affect personal experiences (e.g. water contamination, scarcity, flooding) that may relate to knowledge, perception, and action.

3.2. Data

Data were collected using the BES Telephone Survey, which included Phoenix (CAP) in 2011. The BES Telephone survey collects information about recreation, perceptions of environmental quality, quality of life issues, and neighborhood desirability (Grove & Locke, 2018; Locke et al., 2019). The survey is stratified by population density, income, education, race, and life stage (see Vemuri et al., 2011; Polsky, Grove, & Knudson, 2014, and Groffman, Grove, & Polsky, 2016 for additional details).

Questions used for this analysis include 1) watershed knowledge, 2) social ties, 3) demographic and socio-economic factors, and 4) Climate and A) support for water quality-improvement taxes and B) volunteering to work on a cleanup (Fig. 1). During the telephone survey, the interviewer asks, "Now, I would like to ask you about areas called watersheds. A watershed is the drainage area to either a body of water itself or to its tributaries, such as the rivers & streams that eventually flow into it. Do you live in a watershed?" This question is an indicator of environmental knowledge and the correct answer is, "yes," because everyone lives in a watershed (1) (Fig. 1). The interviewer also asked (2), "About how many neighbors do you know by name?" with answer choices none, a few, about half, most of them, and all coded as 1 to 5, respectively. Finally, typical demographic and socio-economic control data were also collected (3), including participants' total annual income, educational attainment, race, and age. Because the survey in 2011 was conducted in both temperate Baltimore and arid Phoenix, (4) climate is implicitly included, and comparisons are made throughout. Participants were asked how likely they would be to (A) "support a modest (small) tax increase to be used for water quality issues" and (B) "volunteer to work on cleanup and/or pollution patrols?" Responses were collected as very likely, somewhat likely, somewhat unlikely, or very unlikely. Answers were later dichotomized into likely and unlikely categories for analyses. Relationship C is modeled below. The sample size was 1,637 for the Baltimore metropolitan region and 1,637 for Phoenix-Central Arizona metropolitan region. The data were freely accessed via Grove and Locke (2018).

3.3. Analyses

First, cross-tabulations of support for taxes and volunteering were performed for each city to see the un-adjusted odds of stating support for each program and in each city. This shows how the dependent variables: support for taxes (A), and support for volunteering (B) relate to each other and vary by city without accounting for watershed knowledge (1), social ties (2), and demographic and socio-economic characteristcs (3). Then, watershed knowledge, social ties, and demographic and socio-economic factors were regressed against support for taxes, and support for volunteering, and for each metropolitan region, which results in four models. These models estimate the odds of program support while adjusting for watershed knowledge, social ties, demographic and socio-economic factors. Finally, versions of the volunteering regression model were fit with support for taxes as a predictor (C in the Fig. 1).

All statistical analyses were carried out with R version 3.4.4, 2018-03-15 (R Core Team 2018 using the tidyverse (Wickham, 2017), sjPlot (Lüdecke, 2018), MuMIn (Bartoń, 2018), lmtest (Zeileis & Hothorn, 2002), broom (Robinson & Hayes, 2019), and RColorBrewer (Neuwirth, 2014) packages.

4. Results

There are similar general patterns in terms of support for taxes and volunteering in Phoenix and Baltimore. Most people do not support either taxes or volunteering, which is followed by support for both taxes and volunteering (Fig. 2). But, almost 20% at each site support volunteering, but not taxes, and another almost 20% support taxes, but not volunteering. For both cities, the odds of supporting volunteering are ~2.5 times higher when the respondent also supports a tax (Fig. 2).

Watershed knowledge was substantially different, 11% and 41% of participants correctly answered the question in Phoenix and Baltimore, respectively (Table 1). Most reported knowing a few neighbors in Baltimore and Phoenix (Table 1). More than 80% of the sample had an annual income of > =$50,000, 59% had graduated from college. About 80% self-identified as white, and a plurality of participants were between the ages of 44 and 54 (Table 1).

4.1. Watershed knowledge

We found that increased watershed knowledge was positively associated with supporting both taxes (odds ratio: OR = 1.31, 95% CI [1.02, 1.67]) and volunteering (OR = 1.97, 95% CI [1.54, 2.53] in Baltimore. There were no significant associations between watershed knowledge and either taxes or volunteering in Phoenix.

4.2. Social ties

Knowing more neighbors by name was significantly and negatively associated with supporting water quality taxes (Fig. 3), and significantly and positively associated with the stated willingness to volunteer (Fig. 3). The odds of supporting water quality taxes were 15% and 12% lower when participants knew more neighbors by name, in Baltimore and Phoenix, respectively. Support for volunteering was ~13% greater in both regions when more neighbors are known by name (Fig. 3).

4.3. Demographic and Socio-economic factors

Although the overall patterns of support were similar for both Baltimore and Phoenix, the significant demographic control variables were different. In Baltimore, the odds of supporting the hypothetical tax were 13% and 30% higher with greater income and education respectively (Fig. 3). In Phoenix, white participants were 28% less likely to support the proposed tax, and older participants were 10% less likely to support the proposed tax for improved water quality (Fig. 3). Older residents in both regions were ~20–23% less likely to support volunteering to improve water quality (Fig. 3).

4.4. Crowding out versus snowball effects

We found support for the snowball effect thesis; households were more likely to join in and support volunteering when those households also support government action (Fig. 4). Households in Baltimore and Phoenix are more than twice as likely to support volunteering when they also support taxes for improving water quality. Further, the snowball effect is the second most likely scenario in the four types of choices for non/action among 1) no support for taxes or volunteering; 2) support for both taxes and volunteering; 3) support for volunteering but not taxes; and support for taxes but not volunteering (Fig. 2).

5. Discussion

Baltimore and Phoenix were strikingly different in watershed knowledge, with 41% of the participants in Baltimore correctly stating that they lived in a watershed and only 11% in Phoenix (Table 1). This may be attributable to a variety of factors, including environmental conditions such as climate and participants' experiences with water (hydrology) in their cities, connections to downstream features such as the Chesapeake Bay, environmental education, or outdoor recreation. This significant difference may also be due to Phoenix's arid climate with limited streamflow in major rivers through the city and complex water infrastructure, including massive retention basins, canals and dams, and traditional gray infrastructure. This gray infrastructure limits observable water flows, which may lead to incorrect ecological knowledge while the temperate climate in Baltimore, with its more-visible water flow and a critically important watershed for the regional economy, recreation, and ecology, may provide a backdrop for greater understanding. In Baltimore, watershed knowledge had a positive and significant relationship with support for taxes and volunteering and no relationship in Phoenix. In contrast, social ties had a similar relationship in Baltimore and Phoenix with support for taxes and volunteering, a negative relationship to taxes, and a positive relationship with volunteering. These results provide support for the idea that collective action increases within communities with more-established social ties (see for example Holahan & Lubell, 2016).

Regardless of the differences in relationships between watershed knowledge and support for taxes and volunteering for the two cities, however, the outcome is nearly identical. The distribution of participants' support for taxes and volunteering to improve water quality was nearly the same for Baltimore and Phoenix (Fig. 1). These findings raise a provocative question about the marginal significance of

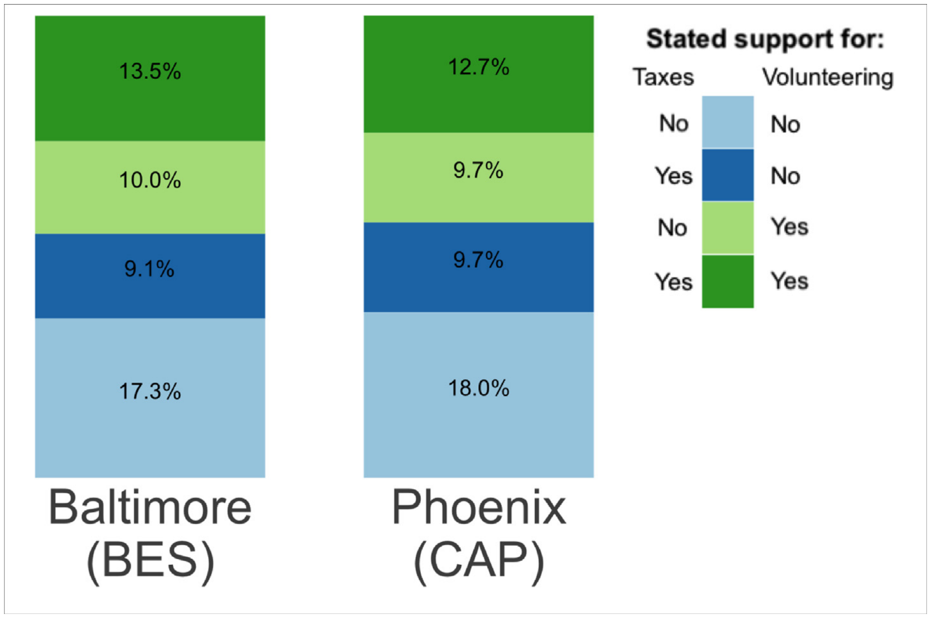

Fig. 2. Stated support taxes (A) and volunteering (B) to improve water quality among telephone survey participants $N_{BES} = 1{,}636$ and $N_{CAP} = 1{,}637$. Letters refer to Fig. 1.

Table 1
Descriptive statistics from telephone survey participants. Bold values indicate median.

		Central Arizona-Phoenix (CAP) (N = 1,637)	Baltimore Ecosystem Study (BES) (N = 1,636)
Do you live in a watershed?	**No**	**81%**	**52%**
	Yes	11%	41%
	Don't Know	8%	7%
About how many neighbors do you know by name?	None	3%	1%
	A few	**48%**	**40%**
	About half	23%	27%
	Most of them	20%	26%
	All of them	6%	6%
Total annual income of all members of household	< $15 K	3%	2%
	$15 K to $25 K	4%	2%
	$25 K – $35 K	4%	3%
	$35 K – $50 K	11%	8%
	$50 K – $75 K	**29%**	**23%**
	$75 K – $100 K	20%	21%
	$100 K – $150 K	17%	22%
	> $150 K	12%	20%
What is the highest grade of school you have had the opportunity to complete?	Less than High School	5%	2%
	High School Graduate	13%	17%
	Some College	25%	20%
	College Graduate	**35%**	**37%**
	Postgraduate Work	21%	24%
Race	All other categories	17%	14%
	White	**83%**	**86%**
Age	under 35	8%	10%
	35 to 44	19%	19%
	45 to 54	**28%**	**26%**
	55 to 64	23%	25%
	65 or over	23%	21%

environmental knowledge to produce support for watershed improvements under different social-environmental conditions. Does increased environmental knowledge lead to support for pro-environmental behavior and policy? In the case of our study, it appears that knowledge has either no effect (Phoenix) or positive impact (Baltimore) on support for pro-environmental preferences. Thus, stormwater programs addressing behavioral changes may consider the importance of education programs in the broader environmental context of a community.

The socio-demographic characteristics of participants were similar for Baltimore and Phoenix in terms of income, education, age, and race (Table 1). However, the relationships among these control variables and support for taxes and volunteering were different. Income and education were positively associated with support for a tax in Baltimore. In Phoenix, white residents and older residents were negatively associated with support for a tax. In both cities, older residents were less likely to volunteer, fitting into national trends associated with youth and volunteering (Gaby, 2017). At the same time, as mentioned previously, the distribution of participants' support for taxes and volunteering to improve water quality was nearly identical for the two cities. Thus, the profiles of "likely supporters" appear very different for potential coalitions for watershed improvements in Baltimore and Phoenix to achieve similar support. In Baltimore, for instance, voluntary programs appear to appeal to young, well-connected residents who are knowledgeable; while taxation is supported by more affluent, educated, and knowledgeable residents in Baltimore and young, minority residents in Phoenix. Our analyses help point to the importance of understanding the "right demographic mix" or subpopulations with whom different types of interventions may be more popular (Locke & Grove, 2016).

Lastly, we tested the idea of crowding out and snowball effects. In both cities, we found support for the idea of the snowball effect. Households who supported a tax were twice as likely to volunteer. Thus, watershed programs may consider a "yes-and" approach to watershed improvement through both government programs and volunteering, rather than concern for "either-or" tradeoffs between relying on only government programs or volunteering. Instead of worrying about whether government intervention reduces volunteering, this finding provides support for the idea that there may be opportunities for complementary policies to increase perceptions of efficacy in volunteer behavior.

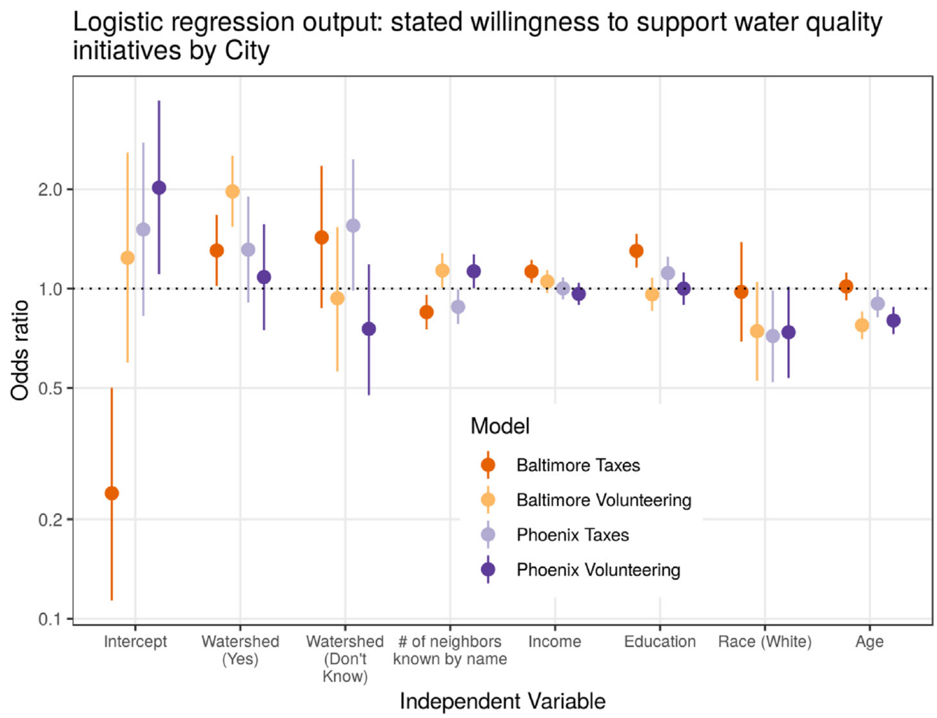

Fig. 3. Logistic regression for stated willingness, "To support a modest (small) tax increase to be used for water quality issues?" and, "to volunteer to work on cleanup and/or pollution patrols?" in Baltimore (BES) and Phoenix (CAP) in 2011.

6. Conclusion

The hydrologic function of urban watersheds, including stormwater quality, is increasingly important as cities work to reduce the risk of flooding and improve water quality while addressing changes in precipitation due to climate change (Rosenzweig et al., 2019). This importance has been encoded in the U.S. Clean Water Act, which specifies that all Americans, including urban residents, should be able to depend upon urban waterways as "drinkable, fishable, swimmable" resources. The drivers of urban watershed decline and rehabilitation are social, economic, and technological (McPhearson, Haase, Kabisch, & Gren, ??sa. , 2016). While initial improvements to urban watersheds occurred by addressing point sources of pollution, it has been increasingly clear that non-point sources of pollution need to be addressed. This expansion in focus has also involved enlisting a broader set of actors in urban watershed rehabilitation.

Previous urban LTER research has provided fundamental knowledge about the biophysical components of watersheds, including their

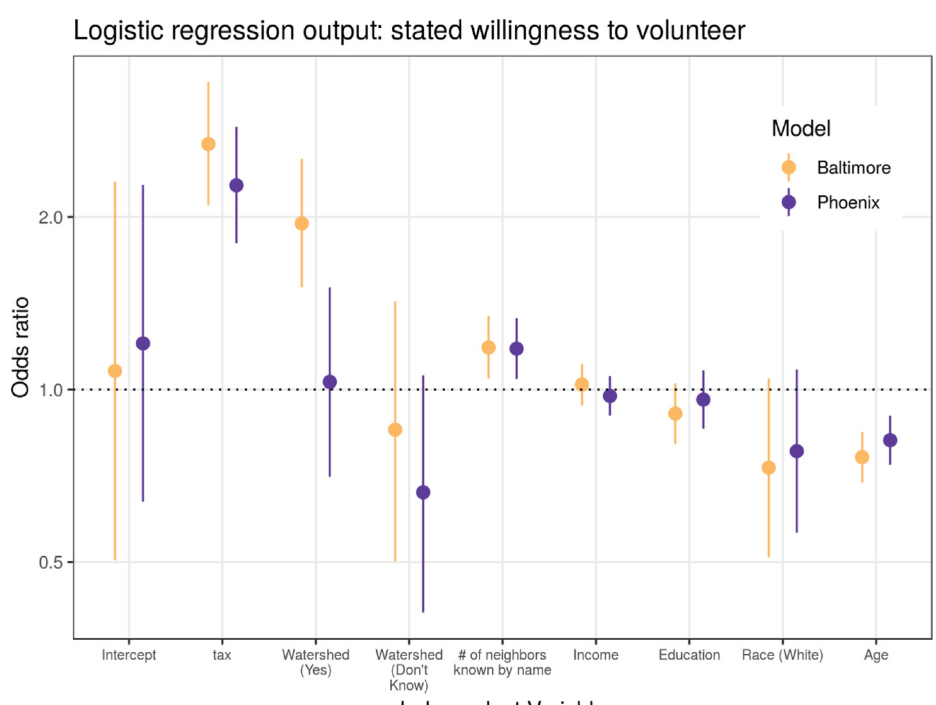

Fig. 4. Households who supported a tax were more than twice as likely to support volunteering, providing evidence for the Snowball Effect.

hydrology and ecology (Bettez, Duncan, & Groffman, 2015; Bird, Groffman, Salice, & Moore, 2018, Duncan, Welty, Kemper, Groffman, & Band, 2017; Hager et al., 2013; Kaushal & Belt, 2012). In this paper, we addressed some of the social and economic components of urban watersheds by comparatively examining the interactions among household knowledge, social ties, and support for urban watershed programs. In particular, we theorized and tested the crowding out and snowball effects for reaching a broader set of actors to rehabilitate urban watersheds. This paper provides findings that support a "yes-and" model of building coalitions for and participation in urban watershed rehabilitation by joining volunteer efforts and government action. As cities continue to work with limited resources to meet the goals of the Clean Water Act, it is increasingly important to understand the factors that affect broadened support and enhanced participation in urban watershed rehabilitation.

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Data Access

Data were accessed from Grove and Locke (2018).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.landurbplan.2019.103714.

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