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Authors
Pierce, Gregory
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Rippy, Megan A
et al.

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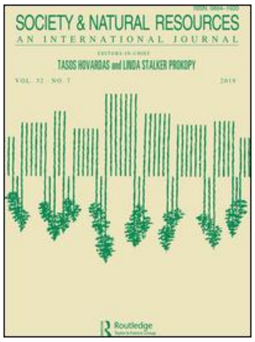

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Environmental Attitudes and Knowledge: Do They Matter for Support and Investment in Local Stormwater Infrastructure?

Gregory Pierce[a], Kyra Gmoser-Daskalakis[b], Megan A. Rippy[c], Patricia A. Holden[d], Stanley B. Grant[c], David L. Feldman[e], and Richard F. Ambrose[f]

[a]UCLA Department of Urban Planning, UCLA Luskin Center for Innovation, Los Angeles, CA, USA; [b]Center for Environmental Policy and Behavior, University of California Davis, Davis, CA, USA; [c]Occoquan Watershed Monitoring Laboratory, Virginia Polytechnic Institute and State University, Manassas, VA, USA; [d]Bren School of Environmental Science and Management, University of California, Santa Barbara, CA, USA; [e]Department of Urban Planning and Public Policy, School of Social Ecology, University of California, Irvine, CA, USA; [f]Department of Environmental Health Sciences, Jonathan and Karen Fielding School of Public Health, University of California, Los Angeles, CA, USA

ABSTRACT

Stormwater infrastructure substantially impacts water quality and supply. In the U.S., local agency investments rely on public support from taxes or fees. Assessing individuals' knowledge and willingness to pay helps inform potential pathways to funding and green infrastructure implementation. Using a 2018–2019 survey of 868 University of California students and staff, we analyze stormwater knowledge and willingness to pay or support public fund allocation for green infrastructure, especially natural treatment systems (NTS). Results of three separate regression models, each with a one-campus random sample and an all-campus convenience sample, show the majority of respondents supported allocating personal and campus funds for NTS. Preexisting environmental attitudes (on the New Ecological Paradigm scale) were the most common driver in nearly all models, but with inconsistent results and low explanatory power across models. Harnessing public support to increase stormwater investment may require tailored benefit messaging or other motivational frameworks, particularly in semiarid environments.

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Introduction

Local public agencies face increasingly stringent mandates for stormwater runoff and pollution control as urban development increases impervious surface area which, combined with changing precipitation, alters natural hydrology and degrades water supply and quality. While cities in the United States and elsewhere must address water pollution and flooding from stormwater runoff, in semiarid regions many are considering runoff as a water resource (Mankad, Walton, and Leonard 2013; Grant et al. 2012). U.S. cities adhere to stormwater permits issued through the National Pollutant Discharge Elimination System (NPDES) for Municipal Separate Storm Sewers (MS4s) (US EPA 2015).

CONTACT Gregory Pierce gspierce@ucla.edu UCLA Department of Urban Planning, UCLA Luskin Center for Innovation, 3323 School of Public Affairs Building, Los Angeles, CA 90095, USA.

Public attention to stormwater has increased in recent years from education programs and water quality and flooding concerns (Derkzen, van Teeffelen, and Verburg 2017; Pradhananga and Davenport 2017; Gao et al. 2018). Due to lack of other funding sources, municipalities in the U.S. and internationally increasingly create stormwater utilities, which charge fees akin to other public services, or ask voters to support stormwater taxes (Tasca, Assunção, and Finotti 2017; Campbell 2018).

Green infrastructure is an increasing investment focus, can provide multiple environmental benefits (Askarizadeh et al. 2015; McPhillips and Matsler 2018; Keeler et al. 2019), and includes natural treatment systems (NTS)—engineered systems employing natural materials and processes to manage stormwater (Grant et al. 2012, 2013; Levin and Mehring 2015; Askarizadeh et al. 2015; McPhillips and Matsler 2018; Keeler et al. 2019).

This paper assesses individuals' support for public funding of improved stormwater management, and measures its connections to stormwater knowledge, sociodemographic factors, and environmental attitudes, in the context of large public universities in California, which are "non-traditional" MS4 permittees. University campuses must comply with many of the same stringent requirements as larger municipalities (US EPA 2015). While the relationships between attitudes, knowledge and investment support have been investigated in many parallel environmental management realms, they have not for local stormwater planning, particularly in semiarid environments.

Our previous work studying university campus stormwater governance found that stormwater management practices and infrastructure land allocation are constrained vis-à-vis municipalities due to financing constraints and a lack of accountability or decision-making transparency to campus residents, which presents obstacles to permit compliance (Pierce et al. 2020). This study expands upon our prior research by examining financing opportunities and campus stakeholder views and knowledge on stormwater infrastructure. We conducted a survey at five University of California (UC) campuses and developed regression models to understand drivers of knowledge, willingness to pay, and willingness to support natural treatment systems (NTS) in semiarid environments. Universities present unique opportunities to pilot green infrastructure like NTS, given their dense development, associated stormwater management challenges, and role as policy influencers and formulators of environmental knowledge. Identifying campus populations' knowledge of and support for NTS informs opportunities for investment and action while contributing to the broader scholarly conversation on drivers of pro-environmental behavior and financial support.

The Value of Studying Campus Stormwater Management and Population Attitudes and Knowledge

Our research fills a current gap in the literature regarding drivers of stormwater-specific knowledge and willingness to pay by utilizing data from university campus populations: staff and students. This focus is valuable for at least four reasons.

Scale

University campuses present a useful scale of analysis for stormwater management because they are large, developed areas that in some ways operate like cities within cities and are subject to Phase II MS4 permits with similar requirements to cities (SWRCB. 2013). Three of the five campuses in our sample have disproportionately large populations or land areas compared to their surrounding municipalities and three contain or discharge runoff to environmentally sensitive, protected habitat (UC Santa Barbara 2014; UC Irvine 2018; UC San Diego 2019). Our previous research found that, like municipal Public Works Departments, campus Environmental Health and Safety (EHS) offices shoulder the burden of responsibility for urban runoff compliance (Pierce et al. 2020). Campuses can serve as pilot areas for innovative green infrastructure approaches.

Control

Universities' control over campus development decisions means they constitute a unique and contained unit of analysis for stormwater impacts and response. UC campuses have Long Range Development Plans and need not comply with the zoning regulations of surrounding cities (UC Irvine 2007). They also represent a controlled environment for studying resident (i.e., student, staff) support and opportunities for green stormwater infrastructure adoption.

Funding

Campuses are more constrained than cities in funding stormwater infrastructure because they cannot levy taxes on residents, but they can levy fees on students; understanding support for fees can inform the viability of this funding stream for stormwater infrastructure. Students have opinions that can influence university development and funding decisions, despite the current lack of transparency or opportunities for meaningful student involvement (as found in). While staff could support campus infrastructure financing through paycheck deductions, student fees are the most direct campus funding source akin to municipal fees or utility user charges.

Education

Students and staff are a relevant population because campus Phase II MS4 permits require educational components; examining the present state of campus populations' stormwater knowledge assesses the success of these efforts. Students can learn about stormwater through coursework and on-campus educational experiences; they can exercise this knowledge as future city residents deciding whether to support progressive municipal stormwater management or funding measures and to influence peers and neighbors. Students living off campus and current staff members vote on such measures in their home municipalities.

Literature Review: Environmental Attitudes, Knowledge, and Behaviors

We next synthesize relevant literature on the influence of environmental attitudes and knowledge on pro-environmental behavior. Review of this literature, including behavioral theories and surveys that test those theories, informed our survey development.

Models of Pro-Environmental Behavior

Since the 1970s, environmental psychology and education scholars have studied the link between environmental knowledge, attitudes, and behavior using multiple frameworks. Initially, literature supported an information deficit model that assumed a direct correlation between increased environmental knowledge and increased pro-environmental behaviors (Kollmuss and Agyeman 2002). However, Blake (1999) identified a "value-action gap" where strong pro-environmental support does not translate to strong pro-environmental behaviors or actions. Current models hypothesize various roles (or lack thereof) for environmental knowledge and environmental attitudes governing individual behaviors (Kollmuss and Agyeman 2002; Levine and Strube 2012).

At the same time, Fishbein and Ajzen (1975) developed a widely-cited behavior model, first as the Theory of Reasoned Action (TRA) and later the Theory of Planned Behavior (TPB). This theory posits that intention, largely determined by attitudes toward behavior and subjective norms, predicts behavior. A strand of empirical studies has since based their behavioral modeling on this theory, including for water resource decisions (Wolters 2014; Chang 2013).

Other models place more direct or indirect emphasis on knowledge; the Model of Responsible Environmental Behavior associates two knowledge variables with pro-environmental behavior: knowledge of issues and knowledge of action strategies (Hines, Hungerford, and Tomera 1987). Fietkau and Kessel (1981) developed a model where knowledge indirectly influences behavior by modifying attitudes and values. Some studies find that knowledge has a relatively small direct link to pro-environmental behavior (Kollmuss and Agyeman 2002) but may be necessary as a baseline for individual environmental support and actions (Jensen 2002).

Pro-Environmental Attitudes and Behavior

In this study, we hypothesize that attitudes may play a larger role than knowledge in determining direct and indirect support for stormwater NTS (as in Fishbein and Ajzen 1975; Kollmuss and Agyeman 2002). Particularly, we relate Dunlap and Van Liere (1978)'s New Environmental Paradigm scale (later updated as the New Ecological Paradigm) to measure pro-environmental orientation with 15 Likert-scale questions (Dunlap et al. 2000). Previous studies in different contexts find NEP strongly associated with or predictive of pro-environmental behavior (Tarrant and Cordell 1997; Arcury 1990; Pe'er, Goldman, and Yavetz 2007; Mobley, Vagias, and DeWard 2010). Studies examining the influence of environmental attitudes, as measured by NEP, on willingness to pay (WTP) for environmental protection generally find NEP significantly associated with higher WTP (Wolters 2014; Ntanos et al. 2019; Husted et al. 2014; Meyerhoff 2006; Choi and Fielding 2013; Aldrich et al. 2007). A survey of college students by Levine and Strube (2012) found explicit attitudes (including the NEP scale) most significantly correlated with intentions to or performance of everyday pro-environmental behaviors. The common use of NEP, particularly in studies of water resources behavior (Wolters 2014; Lucio et al. 2018) and individuals' support for on-site stormwater infrastructure (Turner et al. 2016), motivated its inclusion in our models to measure pro-environmental attitudes.

Studies of Stormwater Knowledge and Willingness to Pay

Finally, studies to assess public valuation and support of environmental goods and outcomes are common, but few focus on stormwater or green infrastructure (Baptiste 2014; Turner et al. 2016). Most studies addressing knowledge and support of stormwater and green infrastructure are descriptive (e.g., Giacalone et al. 2010; Ward and Winter 2016; Eckman and Walker 2008; Bartlett 2005; Mankad, Walton, and Leonard 2013) but contingent valuation (CV) surveys are also employed (Wang, Sun, and Song 2017; Chui and Ngai 2016; Cadavid and Ando 2013; Lindsey 1990). In a few studies, residents' stormwater knowledge is assessed alongside green infrastructure adoption (Baptiste 2014; Turner et al. 2016) or in polling for stormwater taxes or fees (Clark et al. 2002; Nemes et al. 2016; Wang, Sun, and Song 2017). Wang, Sun, and Song (2017) found a majority of surveyed urban Chinese residents knew about green stormwater infrastructure and supported funding it via a water bill surcharge. Baptiste (2014) found high experiential stormwater knowledge among Syracuse residents correlated with high willingness to implement green infrastructure. However, Clark et al. (2002) and Nemes et al. (2016) found that educating survey respondents about green infrastructure benefits did not significantly influence WTP.

Our review of the literature did not reveal any surveys on stormwater among campus populations, but did identify other CV studies of environmental goods conducted on campuses (see Attarana and Celik 2015; Campbell et al. 2014; Gossling et al. 2005). Our study assesses student and staff direct WTP via campus fees—one potential funding avenue for universities. We use a WTP question and a survey question on indirect support for campus spending on NTS via the reallocation of general campus funds, another main university funding stream. Our study thus complements existing literature examining links between environmental attitudes, knowledge, and behavior but fills a gap in the specific connections between attitudes, knowledge of and support for local, large-scale stormwater infrastructure, particularly in semiarid environments.

Materials and Methods

Survey Overview

Between August 2018 and April 2019, we administered a 15-minute long online survey of students and staff at the five southernmost UC campuses (UC Santa Barbara (UCSB), UC Los Angeles (UCLA), UC San Diego (UCSD),[1] UC Irvine (UCI), UC Riverside (UCR)). Researchers at UCLA and UCI developed the survey,[2] which was pre-tested in two graduate-level courses and an undergraduate engineering course. The subsequent five-campus survey deployment collected 868 complete responses out of 1,157 total responses[3] via the SurveyMonkey platform. The survey yielded complete responses from 434 undergraduate students, 224 graduate students, and 210 staff members (including faculty and administrators). We created separate WTP models for students and staff, since staff do not pay student fees.[4]

Response totals varied by campus, largely based on available deployment methods. Table 1 shows total responses by campus, and the percent of populations reached—percentages were low due to the limited financial or other incentive offered. Due to campus restrictions,

Table 1. Number of survey responses (percent of total student and staff population, by campus).[a]

	UCSB	UCLA	UCSD	UCI	UCR
Undergraduate	195 (0.8%)	59 (0.2%)	146 (0.5%)	32 (0.5%)	2 (0.01%)
Graduate	94 (3.2%)	63 (0.5%)	49 (0.6%)	8 (0.1%)	10 (0.3%)
Staff	24 (0.5%)	98 (0.4%)	25 (1%)	11 (0.2%)	57 (0.7%)

[a]Percent of total student population was calculated for undergraduates and graduates at each campus using University of California Fall 2018 enrollment numbers and for staff using Fall 2018 estimates from the National Center for Education Statistics IPEDS database.

we were only able to send solicitation emails to all UCSB students via the Registrar's Office. Other Registrar's Offices (UCSD, UCLA) sent emails to 5,000 randomly selected students while UCI and UCR did not allow campus-wide emails, severely restricting survey deployment. Only UCSB, which had the largest number of respondents, represents a random sample of students. The survey was also deployed via student governments, clubs, staff associations, and introductory environmental courses. The estimated response rate for the survey was 1%, this low rate is a study limitation but still provided a sufficiently large sample given the high number of initial contacts (including emails to roughly 34,000 students across UCSB, UCSD, and UCLA). Several measures within our budget were employed to reduce non-response bias in the survey (e.g., as per Saleh and Bista 2017), including (1) a lottery-based financial incentive (1 in every 200 participants received a free iPad), (2) reminder emails to boost response rates, and (3) assurance of anonymity (noted in the recruitment e-mail and online consent form).

The survey included a mix of open-ended and multiple-choice questions addressing stormwater and NTS, campus funding, demographics and environmental views.[5] Our study focuses on responses regarding:

- Stormwater Knowledge—assessed through multiple-choice questions on the definition of urban runoff and urban runoff challenges (true/false)
- Willingness to Pay (WTP)—asked respondents how much they would be willing to pay as a student fee or staff donation to construct NTS on campus (and if zero, an explanation of why)
- Willingness to Support (WTS)—asked respondents how supportive they would be (7-point Likert scale) of their university allocating general funds to NTS construction and what they would prefer to divert money from (open-ended question)
- Demographics—questions on race/ethnicity, gender, and age
- Environmental Views/Attitudes—assessed using 10 New Ecological Paradigm scale questions[6]

Similar to Baptiste (2014) and Mankad, Walton, and Leonard (2013), we created a composite stormwater knowledge score from multiple true/false and definitional questions. The score ranged from 0 to 4; one point was awarded for each correct answer to two true/false questions[7] and zero to two points were awarded for correct definitions of urban runoff (one point for each correct answer to the multiple-choice question[8]). Anyone who answered that they did not know what urban runoff was or selected the response "Tap water that flows through the drinking water distribution system" received zero points for this question.

Stormwater Knowledge Model

We developed two sequential regression models to assess drivers of the composite knowledge score and examined three different participant samples: the total student sample from all five campuses, the random sample of UCSB students, and the total sample (including staff) from all five campuses. Comparison of the UCSB and all student populations allows us to determine how nonrandom sampling on other campuses might have affected study results.

Control variables were selected based on other studies and our sample population (students and staff), including age, race, gender, and student level (i.e., graduate or undergraduate). These demographic variables are typically included in other environmental knowledge studies (Dean, Fielding, and Newton 2016; Paço and Lavrador 2017; Arcury, Scollay, and Johnson 1987; McCright 2010; Oweini and Houri 2006; Baptiste 2014; Levine and Strube 2012; Frick, Kaiser, and Wilson 2004; Ramsey and Rickson 1976; Zsóka et al. 2013; Pe'er, Goldman, and Yavetz 2007; Huxster, Uribe-Zarain, and Kempton 2015), although studies find conflicting results on the magnitude and direction of these sociodemographic variables' influence on knowledge.

An ordinal NEP variable for environmental attitudes was constructed based on responses (7-point Likert scale) to ten statements from the NEP scale (Saphores, Ogunseitan, and Shapiro 2012). Following methods in the literature which convert NEP questions into a single scale (see Good 2007; Noblet, Anderson, and Teisl 2013), we reversed the values on even-numbered statements opposite the NEP view (Noblet, Anderson, and Teisl 2013) and averaged the resulting scores to create a mean NEP score (Erdogan 2009; Deuble and de Dear 2012). For the composite knowledge score, values of 0 and 1 were collapsed into one category, resulting in a final four-category knowledge variable.

We considered two model types to assess drivers of knowledge. An ordered logistic regression model used the composite knowledge score as the outcome. This regression (performed in Stata using ologit) operates under the proportional odds assumption that coefficients are identical for each step in the knowledge score (Williams 2016). Second was a generalized ordered logistic regression model, performed using gologit2 (Williams 2016). This model relaxes the proportional odds assumption and provides coefficients for each independent variable at each step of the knowledge score. Given the similar results and that the initial model proved more interpretable, we report ordered logistic regression coefficients here.

Willingness to Pay (WTP) Model

Next, three regression model specifications were compared to assess participant willingness to pay (WTP) for NTS on campus via a quarterly fee (students) or monthly paycheck donations (staff). The three models included ordinary least squares regression, a Tobit model with a censored lower limit of $0 and upper limit of $100, and a Heckman model with a selection equation of non-zero WTP. This manuscript presents results of the Tobit model because it accounts for censoring of the WTP from the payment card approach.

Table 2. Survey respondent demographics.

Demographics	Percent of respondents ($N = 868$)
Association	50% Undergraduates, 26% graduate students, 24% staff
Age	Average undergraduates: 19.97 (SD: 2.4), median: 20 Average graduate students: 27.33 (SD:6.0), median: 26 Average staff: 42.39 (SD:13.0), median: 39.5
Gender	60.6% Female, 32.9% male, 6.5% other/prefer not to state
Race/Ethnicity	40% White 27% Asian 20% Hispanic/Latino 7% Other Non-Hispanic[a] 6% Unknown

[a]Other Non-Hispanic includes Black/African American, Hawaiian/Pacific Islander, and American Indian/Alaska Native and those selecting Other but not selecting Hispanic/Latino.

We assessed our dependent variable, WTP, with a two-part survey question (see Appendix for the exact question). Similar to Chui and Ngai (2016) and Blaine et al. (2005), a payment card approach provided value ranges for respondents to select, which Donaldson et al. (1997) infer provides more valid results than open-ended questions. We included a follow-up question to ascertain reasons for no WTP responses (Blaine and Litchkoppler 2016). First, respondents selected a \$20 range from \$0 to \$100 or could indicate they were not willing to pay any fee. Subsequently, each respondents' \$20 range was narrowed into \$5 increments, and they again selected their range of WTP. For our analysis, we assigned respondents a WTP of the median value within the selected \$5 range, with \$0 assigned to those not willing to pay. Our WTP analysis included all independent variables used to assess stormwater knowledge in addition to the composite stormwater knowledge score itself.

Willingness to Support (WTS) Model

Finally, an ordered logistic regression, using the same independent variables as the WTP model, was developed to assess willingness to support (WTS) NTS for all three participant samples: the total student sample from all five campuses, the random sample of UCSB students, and the total sample from all five campuses. The dependent variable WTS used a Likert scale question (1 = strongly unsupportive to 7 = strongly supportive) to capture the degree to which respondents supported the reallocation of campus general funds to campus NTS construction. Respondents answering "I don't know" ($n = 18$) were excluded.

Results

Survey Descriptive Statistics

Table 2 reports the demographics for all survey respondents, the majority of which were female undergraduates. Table 3 shows the distribution of stormwater knowledge scores; graduate students and staff exhibit slightly higher levels of knowledge than undergraduates. All populations exhibited generally higher scores than in other environmental knowledge surveys (Dean, Fielding, and Newton 2016; Turner et al. 2016), similar to relatively high knowledge levels found in some stormwater studies (Baptiste 2014;

Table 3. Stormwater knowledge scores.

Composite stormwater knowledge score	Undergraduate student respondents ($N = 434$)	Graduate student respondents ($N = 224$)	Staff respondents ($N = 209$)
0	0.5% (2)	0.9% (2)	0.5% (1)
1	6.7% (29)	4.5% (10)	3.3% (7)
2	23.3% (101)	17.4% (39)	15.8% (33)
3	43.5% (189)	41.1% (92)	45.9% (96)
4	26.0% (113)	36.2% (81)	34.4% (72)

Table 4. Areas respondents support for funds diversion toward NTS construction ($n = 664$).

Funding area	Proportion of respondents
Athletics/Recreation	28.8%
Don't know (Don't have enough information)	13%
Construction/Housing	11.9%
Salaries	11.1%
Activities/Events	11.1%
Landscaping/Utilities	6.8%
Transportation	4.4%
Other	13%

Mankad, Walton, and Leonard 2013). Most respondents correctly answered the true/false questions about urban runoff challenges (85% for statement about untreated runoff discharges in California and 88.1% for runoff causing water pollution in the U.S.). Yet less than forty percent (38.1%) selected both correct definitions of urban runoff in the multiple-choice question.

Generally strong support for NTS adoption was evidenced by positive WTP in the form of student fees and staff donations. The average WTP of undergraduates ($n = 409$) was $26.55 per quarter ($106.20 annually) with only 9.4% of respondents not willing to pay a fee. Graduate student respondents ($n = 214$) had a similar WTP of $25.02 per quarter ($100.08 annually) with 7.6% of respondents not willing to pay a fee. Staff had a slightly higher average WTP than students ($114.12 annually; $9.51 per month) but a significantly higher proportion (39%) were not willing to pay any amount ($p < 0.001$; Chi-Square test). The vast majority of respondents supported reallocating UC general funds to construct NTS on campus (Table 4), with similar proportions across populations.

A total of 664 respondents (102 undergraduates, 50 graduates, 52 staff) answered the open-ended survey question, "What would you support your campus spending less money on in order to make funds available for NTS construction on campus?" We organized responses into nine categories,[9] with athletics the most common response (Table 5) and "I don't know" the second most common.[10]

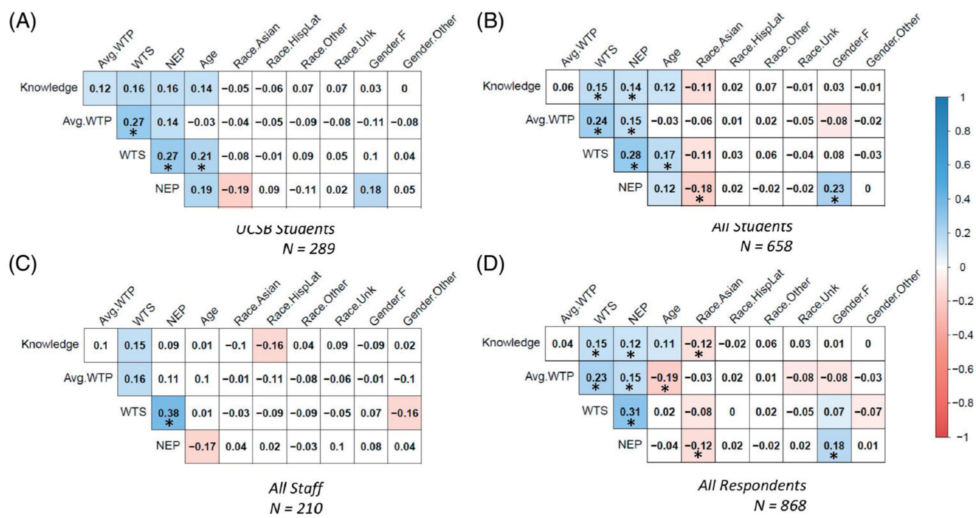
Model Results

Bivariate Correlations

Pearson's correlation coefficients were calculated between independent variables and the outcomes of interest (see Figure 1). NEP emerged as a master variable, being significantly and positively correlated with stormwater knowledge (all students and all respondents), WTP (all students) and WTS (all surveyed populations). Stormwater knowledge and age were also significantly positively correlated with WTS (knowledge

Table 5. Willingness to support use of campus funds for NTS construction.

	Undergraduates ($n = 425$)	Graduate students ($n = 221$)	Staff ($n = 207$)
7—Very supportive	42.8% (182)	51.1% (113)	39.6% (82)
6—Moderately supportive	27.5% (117)	26.7% (59)	30.9% (64)
5—Slightly supportive	18.6% (79)	13.1% (29)	13.0% (27)
4—Neutral	6.4% (27)	5.4% (12)	11.6% (24)
3—Slightly unsupportive	2.4% (10)	2.7% (6)	0.5% (1)
2—Moderately unsupportive	1.9% (8)	0.9% (2)	2.4% (5)
1—Not supportive at all	0.5% (2)	0% (0)	1.9% (4)



Numbers represent correlations between two variables with coloring to indicate strength and direction (red for negative, blue for positive) of correlation, a * represents a pairwise correlation of statistical significance (95% confidence or above).

Figure 1. Diagram of correlations among drivers variables of knowledge of, willingness to pay for, and willingness to support green infrastructure.

for all respondents, age for UCSB students, both for all students)—the two variables Baptiste (2014) found to correlate with willingness to implement green infrastructure. No independent variables were significantly correlated with WTP for the staff population. We note staff WTP may have been impacted by the use of paycheck donations as the payment vehicle; this method was employed since it is currently the only feasible way for staff to pay for NTS on campus. Significant correlations among independent variables with coefficients exceeding 0.3 were only detected for two independent variable pairs: "Asian" and "Hispanic/Latino" race and ethnicity variables and "prefer not to state" for race with "other" for gender (see Figure 1).

Regression Models

Tables 6 and 7 show regression coefficients for best-fit models of stormwater knowledge, WTP for NTS and WTS campus NTS funding for all three study populations. Consistent with our bivariate correlation results, NEP was the single most significant variable in all three models across all surveyed populations (random and nonrandom)—lending support to theories where environmental attitudes influence behavior and

Table 6. Ordered logistic regression models for stormwater knowledge and general fund support.

	Knowledge (score 0–4)			Support (for general fund NTS use)		
	UCSB students ($n = 262$)	All students ($n = 609$)	All respondents ($n = 788$)	UCSB students ($n = 259$)	All students ($n = 598$)	All respondents ($n = 769$)
Graduate student	0.540 (0.354)	0.337 (0.212)	0.242 (0.154)	−0.273 (0.368)	−0.224 (0.232)	0.272* (0.161)
Staff member	—	—	0.665 (0.528)	—	—	0.688 (0.607)
Race[a] (Non-Hispanic Asian)	−0.058 (0.299)	−0.285 (0.191)	−0.369** (0.170)	0.048 (0.288)	−0.192 (0.194)	−0.354** (0.171)
Race (Hispanic Latino)	−0.193 (0.331)	0.080 (0.201)	−0.078 (0.181)	0.161 (0.353)	0.061 (0.217)	0.019 (0.196)
Race (Non-Hispanic other)	0.649 (0.451)	0.447 (0.305)	0.396 (0.273)	1.223** (0.531)	0.358 (0.334)	0.006 (0.285)
Race (Unknown, decline to state)	1.263 (0.913)	−0.119 (0.602)	0.321 (0.441)	1.752 (1.184)	0.264 (0.629)	−0.099 (0.434)
Age	0.0049 (0.0276)	0.010 (0.019)	0.015** (0.006)	0.083** (0.035)	0.074*** (0.025)	0.005 (0.007)
NEP score	0.419** (0.165)	0.266*** (0.102)	0.249*** (0.084)	0.071*** (0.174)	0.698*** (0.113)	0.758*** (0.093)
Gender (female)[b]	−0.247 (0.260)	0.040 (0.165)	−0.010 (0.145)	0.297 (0.257)	−0.05 (0.171)	−0.105 (0.149)
Gender (other, decline to state)	−0.795 (0.664)	−0.209 (0.449)	−0.366 (0.411)	0.252 (0.733)	−0.212 (0.479)	−0.210 (0.451)
Knowledge (0–4 score)	—	—	—	0.215 (0.142)	0.224** (0.090)	0.239*** (0.081)
Pseudo R^2	0.0287	0.0167	0.0183	0.0644	0.0517	0.0513
Prob > Chi-square	0.0337	0.0030	0.0001	0.0000	0.0000	0.0000
LR Chi-square (degrees of freedom)	18.13	24.94	34.75	47.73	82.25	106.39

Asterisks correspond to the following *p*-values of statistical significance: *<0.1, **<0.05, ***<0.01.
[a]White is the reference condition for the Race variable in the models in Tables 5 and 6
[b]Male is the reference condition for the Gender variable in the models in Tables 5 and 6

Table 7. Tobit regression model for student willingness to pay.

	WTP (willingness to pay)		
	UCSB students ($n = 252$)	All students ($n = 581$)	All staff ($n = 148$)
Graduate student (=1)	4.511 (4.496)	0.174 (3.092)	—
Race (Non-Hispanic Asian)	−2.545 (3.831)	−3.560 (2.756)	−2.352 (5.659)
Race (Hispanic Latino)	−6.549 (4.423)	−1.850 (2.944)	−9.483 (6.775)
Race (Non-Hispanic Other)	−9.243 (5.854)	1.397 (4.492)	−10.926 (9.214)
Race (Unknown, decline to state)	−13.110 (10.899)	−18.733** (8.985)	−2.907 (10.469)
Age	−0.628* (0.358)	−0.406 (0.281)	0.244 (0.178)
NEP score	5.837*** (2.196)	6.815*** (1.518)	5.153** (2.408)
Gender (female)	−9.740*** (3.290)	−6.915*** (2.374)	−0.612 (4.717)
Gender (other, decline to state)	−15.732* (8.986)	−5.849 (6.819)	−8.797 (21.621)
Knowledge (0–4 score)	3.632** (1.829)	1.394 (1.282)	0.986 (2.748)
Constant	24.490*** (9.314)	25.644*** (7.291)	−15.407 (13.255)
Pseudo R^2	0.0121	0.0067	0.0126
Prob > Chi-square	0.0034	0.0002	0.2964
LR Chi-square (degrees of freedom)	26.27	34.32	10.71

Asterisks correspond to the following *p*-values of statistical significance: *<0.1, **<0.05, ***<0.01.

literature finding NEP correlates with WTP for environmental goods (Wolters 2014; Ntanos et al. 2019; Husted et al. 2014; Choi and Fielding 2013).

As in the existing literature, inconsistent results were found for the influence of demographics on knowledge and behavior, including between the random sample at UCSB and the opportunistic sample across campuses (Dean, Fielding, and Newton 2016; Paço and Lavrador 2017; McCright 2010; Oweini and Houri 2006; Baptiste 2014; Levine and Strube 2012; Frick, Kaiser, and Wilson 2004; Zsóka et al. 2013; Pe'er, Goldman, and Yavetz 2007; Huxster, Uribe-Zarain, and Kempton 2015). Age was a significant predictor in knowledge among the all-respondent sample, as seen in other water and stormwater knowledge studies (Baptiste 2014; Dean, Fielding, and Newton 2016), but only predicted WTS and WTP among students (both for UCSB and WTS for all students). Race was typically insignificant, with the exception of Asian respondents in the wider sample (knowledge and WTS) and other race for WTS in UCSB students. Female gender predicted lower WTP among students (UCSB and all) but was otherwise insignificant.

Given that the literature has not validated the information deficit behavior model, it is unsurprising that knowledge predicts WTP and WTS less significantly than NEP in our models. Although, Baptiste (2014) did find high knowledge correlated with high willingness to implement green infrastructure, while Turner et al. (2016) found low WTP across a population with lower environmental knowledge. Knowledge was significant for WTS in our broader samples (all students, all respondents) but only among UCSB students for WTP. The high knowledge levels among all respondents makes drawing definitive conclusions on its influence difficult.

Effect magnitude (expressed as pseudo *R*-squared) was low across all models (0.007–0.06; see Tables 6 and 7) illustrating that while variables such as NEP, age, and knowledge significantly influence WTP and WTS for NTS on campuses, they are not in and of themselves strong predictors and there may be other factors at play. In short, our results point to a significant but small influence of environmental attitudes on knowledge of, willingness to pay for, and support of campus stormwater management. Results are more mixed for other driver variables, with age and stormwater knowledge emerging as typically influential.

Discussion

This study demonstrates that individuals' willingness to pay for and support green stormwater infrastructure are more commonly and significantly, though still weakly, predicted by NEP scores—an indicator of environmental attitudes—than factual knowledge. This finding suggests that preexisting attitudes influence actions and behaviors regarding stormwater management to some extent, echoing previous studies finding a link between environmental attitudes and WTP for other environmental goods.

Given that NEP statements relate to the balance of nature, human-nature coexistence, and potential ecological crises, promoting the biodiversity and climate adaptation benefits of green infrastructure may tap into these aspects of the public's pro-NEP values. At the same time, results across our models were generally inconsistent and explanatory power was low. Incorporation of other pro-environmental behavior and support theories besides NEP may add explanatory power to understanding stormwater infrastructure support. Particularly, norm activation models that motivate water conservation behavior in semiarid environments may be helpful (Landon, Kyle, and Kaiser 2017). Moreover, norms often reflect individuals' sense of community attachment and place identity; these factors have been shown to influence WTP for ecosystem services (Nielsen-Pincus et al. 2017). Future research should explore whether these behavioral models help explain varying levels of financial support for stormwater.

NEP scores were also significantly correlated with stormwater knowledge among students and staff, with knowledge itself less significantly influencing WTP and WTS. These results may be meaningful for campus stormwater managers. Can campus stormwater educational campaigns increase support for campus-based measures by increasing knowledge itself or by changing environmental attitudes? The results are unclear, given that factual stormwater knowledge was generally high; previous studies report lower environmental knowledge scores (Dean, Fielding, and Newton 2016; NEETF/Roper Survey 2000; Kempton et al. 1995). This high knowledge level could have made it difficult to consistently detect a significant influence of knowledge on WTP or WTS because there was no uneducated control group.

This weak effect might also be attributable to differences between the salience of experiential and factual knowledge, with the former being more salient especially in wetter contexts (Baptiste 2014). In areas with high precipitation, flood management and combined sewer overflows cause direct monetary and health harms (Feldman 2018; Sheikh 2020). The challenge of communicating the benefits of enhanced stormwater in semiarid contexts might be addressed in two ways, the tensions between which need to be further examined (Dagenais, Thomas, and Paquette 2017). On the one hand, green infrastructure such as NTS can provide environmental and economic benefits including biodiversity and drinking water supply in semiarid regions facing water scarcity (Porse et al. 2018), which provides opportunities to appeal to diverse populations already expressing general pro-environmental attitudes. Thus, advocates generally advise public agencies to communicate the broad range of green stormwater infrastructure benefits to enhance public support, especially in semiarid or arid environments where benefits are less obvious to the public (Diringer et al. 2020).

On the other hand, literature assessing how individuals become motivated to support environmental investments suggests that promoting specific benefits that work in individuals' functional self-interest, especially as property owners, may better motivate WTP and WTS (Gao et al. 2018; Diringer et al. 2020). Providing incentives for self-made investments may prove more effective than a tax or fee approach (Rissman, Kohl, and Wardropper 2017). Individuals are often more motivated to pay a fee when they see hyper-local benefits, such as stormwater infrastructure investments on or close to their property (Turner et al. 2016; Roque 2017), rather than communal infrastructure as on a publicly-owned campus. Emphasizing single, economic benefits of stormwater investments relevant to semiarid contexts, such as enhanced raw water supply, as opposed to diffuse benefits may thus be more successful. Outreach campaigns focusing on single, quantitative benefits may also be more effectively carried out given the culture of many local public agencies (Cousins 2017).

We found strong campus support for stormwater management and NTS. Average annual student WTP was $106 and $100 for undergraduate and graduate students respectively, more than double a typical annual student fee of $4–40. Staff exhibited a slightly higher average annual WTP than students ($114), but a significantly greater proportion were unwilling to pay any amount. This may be explained by the fact that students regularly pay fees for other campus improvements while staff do not. Furthermore, some parents pay students' fees (particularly for undergraduates), which may make students more "willing to pay" something, and some graduate students have research or teaching appointments that covers fees. WTP has limitations as a valuation technique, but enables assessment of fees as a potential funding source. Beyond fees, our study found the majority of students and staff support campus investment in green stormwater management.

In short, our study suggests untapped support for green stormwater management among opinion-shaping populations on university campuses in semiarid contexts. Future research should aim to provide additional guidance to campus and other local environmental managers on how to appeal to this untapped base to generate funds and political action for transformative investments. In semi-arid contexts, a multi-pronged strategy may be most effective, by deploying a range of stormwater infrastructure demonstration projects alongside resource security and economic pitches that cater to community-level, self-interested concerns (Roque 2017; Gao et al. 2018). Further research, however, must assess which behavioral frameworks, benefits, and communication approaches most effectively motivate public support for stormwater investments.

Conclusions

We found generally high levels of knowledge and support for NTS, perhaps due to our sample of University of California students and staff. Personal environmental attitudes (NEP scores) were the most significant indicator of knowledge, support (WTS), and willingness to pay (WTP) for green stormwater management, in the form of natural treatment systems, on university campuses. Environmental knowledge was correlated with but only weakly predictive of WTP and WTS, and demographics (age, race, and gender) were inconsistent, and often insignificant, drivers of these variables. Our findings lend support to previous work theorizing the relative importance of attitudes on

WTP for environmental goods (Wolters 2014; Ntanos et al. 2019; Choi and Fielding 2013).

Given the limitations of this study's explanatory power, future studies must draw on larger, general public samples, and tie support directly to individually-experienced benefits in order to draw broader conclusions that could inform the range of municipalities where students will eventually live and act as voters on stormwater measures. Future research can also examine how different methods and sample populations might change findings—the use of NEP to measure attitudes, a payment card approach for WTP, factual definitions and true/false questions for knowledge assessment, and the campuses' semiarid environments represent limitations of this study. For example, cultural backgrounds and exposure can impact respondents' awareness of specific terminology (e.g., "urban runoff"), limiting our ability to capture knowledge if respondents interpret terms differently.

This study illustrates university campuses have an under-utilized pool of advocates for innovative stormwater management. The links between pro-environmental attitudes and support for natural treatment systems suggests campuses could demonstrate the multiple benefits of green infrastructure to solicit financial and political support for broader implementation. Assessing perceptions of green infrastructure benefits will help gauge public knowledge about and support for specific stormwater management practices. Efforts to elucidate common drivers of knowledge of, willingness to pay for, and willingness to support innovative stormwater management practices are necessary to motivate investment in local policy arenas.

Disclosure statement

The authors declare that they have no conflict of interest.

Notes

1. Due to the context in which some surveys were administered, UCSD responses to questions regarding natural treatment systems may have been affected, but those questions were not used in this study.
2. The survey received Institutional Review Board (IRB) approval for research with human subjects through UC Irvine (IRB Approval #2817-1).
3. The remaining 289 respondents each stopped completing the survey at certain points, leaving the remainder of the survey blank.
4. Staff WTP was assessed as a voluntary paycheck donation, the only feasible way for staff to contribute to the university.
5. Each campus deployed an identical survey with one WTP question for students and another for staff.
6. The 15 NEP scale measures agreement with 15 environmental value statements, e.g. "The earth is like a spaceship with limited resources" (Dunlap et al. 2000). A modified 10 question scale excluded NEP questions demonstrating low correlations in other studies (Saphores et al. 2012).
7. The first true statement was "In most California cities, urban runoff that enters a storm drain is discharged into the environment without treatment" and the second was "In developed countries like the United States, urban runoff is a leading cause of water pollution in urban environments."

8. This question asked, What is urban runoff? Respondents could select all that applied from: Water that soaks into the ground, Tap water that flows through the drinking water distribution system, Rain water or snowmelt that flows over impervious surfaces like paved areas or roofs, irrigation water that flows over impervious surfaces like paved areas or roofs, I do not know what urban runoff is. The correct definitions were: rain water, snowmelt or irrigation water that flows over impervious surfaces.
9. One author coded the responses, which another author reviewed, into subgroups which were combined into 9 larger categories based on the repeatedly listed types of expenses; the "other" category captured less common responses.
10. Variations coded "don't know" include "I'm not familiar with the budget," "I don't know what they spend it on now," and "I don't know enough about campus spending to answer that."

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ORCID

Kyra Gmoser-Daskalakis http://orcid.org/0000-0003-2305-0484

References

Aldrich, G. A., K. M. Grimsrud, J. A. Thacher, and M. J. Kotchen. 2007. Relating environmental attitudes and contingent values: How robust are methods for identifying preference heterogeneity? *Environmental and Resource Economics* 37 (4):757–75. doi:10.1007/s10640-006-9054-7.

Arcury, T. A. 1990. Environmental attitude and environmental knowledge. *Human Organization* 49 (4):300–4. doi:10.17730/humo.49.4.y6135676n433r880.

Arcury, T. A., S. J. Scollay, and T. P. Johnson. 1987. Sex differences in environmental concern and knowledge: The case of acid rain. *Sex Roles* 16 (9–10):463–72. doi:10.1007/BF00292481.

Arcury, T. A., T. P. Johnson, and S. J. Scollay. 1986. Ecological worldview and environmental knowledge: The 'New Environmental Paradigm'. *The Journal of Environmental Education* 17 (4):35–40. doi:10.1080/00958964.1986.9941424.

Askarizadeh, A., M. A. Rippy, T. D. Fletcher, D. L. Feldman, J. Peng, P. Bowler, A. S. Mehring, B. K. Winfrey, J. A. Vrugt, A. Agha Kouchak, et al. 2015. From rain tanks to catchments: Use of low-impact development to address hydrologic symptoms of the urban stream syndrome. *Environmental Science & Technology* 49 (19):11264–80. doi:10.1021/acs.est.5b01635.

Attaran, S., and B.G. Celik. 2015. Students' environmental responsibility and their willingness to pay for green buildings. *International Journal of Sustainability in Higher Education* 16 (3): 327–340. doi:10.1108/ijshe-04-2013-0029.

Blaine, T.W., and F.R. Litchkoppler. 2016. Factors affecting stakeholders' willingness to pay to prevent the spread of aquatic nuisance species. *The Journal of Extension* 54 (6):6FEA5.

Baptiste, A. K. 2014. 'Experience is a great teacher': Citizens' reception of a proposal for the implementation of green infrastructure as stormwater management technology. *Community Development* 45 (4):337–52. doi:10.1080/15575330.2014.934255.

Bartlett, C. 2005. Stormwater knowledge, attitude and behaviors. US EPA. https://cfpub.epa.gov/npstbx/files/NC_stormwater_survey_12506.pdf.

Blaine, T. W., F. R. Lichtkoppler, K. R. Jones, and R. H. Zondag. 2005. An assessment of household willingness to pay for curbside recycling: a comparison of payment card and referendum approaches. *Journal of Environmental Management* 76 (1):15–22. doi:10.1016/j.jenvman.2005.01.004.

Blake, J. 1999. Overcoming the 'value-action gap' in environmental policy: Tensions between national policy and local experience. *Local Environment* 4 (3):257–78. doi:10.1080/13549839908725599.

Campbell, J., R. B. DiPietro, and D. Remar. 2014. Local foods in a university setting: Price consciousness, product involvement, price/quality inference and consumer's willingness-to-pay. *International Journal of Hospitality Management* 42:39–49. doi:10.1016/j.ijhm.2014.05.014.

Campbell, C. W. 2018. Western Kentucky University Stormwater Utility Survey 2018. Western Kentucky University. https://www.wku.edu/seas/undergradprogramdescription/swusurvey2018.pdf.

Chang, G. 2013. Factors influencing water conservation behavior among urban residents in China's arid areas. *Water Policy* 15 (5):691–704. doi:10.2166/wp.2013.093.

Choi, A. S., and K. S. Fielding. 2013. Environmental attitudes as WTP predictors: A case study involving endangered species. *Ecological Economics* 89:24–32. doi:10.1016/j.ecolecon.2013.01.027.

Chui, T. F. M., and W. Y. Ngai. 2016. Willingness to pay for sustainable drainage systems in a highly urbanised city: a contingent valuation study in Hong Kong. *Water and Environment Journal* 30 (1-2):62–9. doi:10.1111/wej.12159.

Clark, D. E., V. Novotny, R. Griffin, D. Booth, A. Bartosová, M. C. Daun, and M. Hutchinson. 2002. Willingness to pay for flood and ecological risk reduction in an urban watershed. *Water Science and Technology* 45 (9):235–42. doi:10.2166/wst.2002.0247.

Cousins, J. J. 2017. Volume control: Stormwater and the politics of urban metabolism. *Geoforum* 85:368–80. doi:10.1016/j.geoforum.2016.09.020.

Dagenais, D., I. Thomas, and S. Paquette. 2017. Siting green stormwater infrastructure in a neighbourhood to maximise secondary benefits: Lessons learned from a pilot project. *Landscape Research* 42 (2):195–210. doi:10.1080/01426397.2016.1228861.

Dean, A. J., K. S. Fielding, and F. J. Newton. 2016. Community knowledge about water: Who has better knowledge and is this associated with water-related behaviors and support for water-related policies? Edited by Asim Zia. *PLoS One* 11 (7):e0159063. doi:10.1371/journal.pone.0159063.

Derkzen, M. L., A. J. A. van Teeffelen, and P. H. Verburg. 2017. Green infrastructure for urban climate adaptation: How do residents' views on climate impacts and green infrastructure shape adaptation preferences? *Landscape and Urban Planning* 157:106–30. doi:10.1016/j.landurbplan.2016.05.027.

Deuble, M. P., and R. J. de Dear. 2012. Green occupants for green buildings: The missing link? *Building and Environment* 56:21–7. doi:10.1016/j.buildenv.2012.02.029.

Diringer, S., S. Morgan, C. Heather, G. Madeline, W. Jennifer, and L. Sharlene. 2020. *Scaling green stormwater infrastructure through multiple benefits in Austin, Texas*. Oakland, CA: Pacific Institute.

Donaldson, C., R. Thomas, and D. J. Torgerson. 1997. Validity of open-ended and payment scale approaches to eliciting willingness to pay. *Applied Economics* 29 (1). doi:10.1080/000368497327425.

Dunlap, R. E., and K. D. Van Liere. 1978. The 'New Environmental Paradigm'. *The Journal of Environmental Education* 9 (4):10–9. doi:10.1080/00958964.1978.10801875.

Dunlap, R. E., K. D. Van Liere, A. G. Mertig, and R. E. Jones. 2000. New trends in measuring environmental attitudes: Measuring endorsement of the New Ecological Paradigm: A revised NEP scale. *Journal of Social Issues* 56 (3):425–42. doi:10.1111/0022-4537.00176.

Eckman, K., and R. Walker. 2008. *Knowledge, Attitudes and Practice (KAP) Survey Summary Report for the Duluth Lakeside Stormwater Reduction Project (LSRP)*. St Paul, MN: University of Minnesota Water Resources Center.

Erdogan, N. 2009. Testing the New Ecological Paradigm scale: Turkish case. *African Journal of Agricultural Research* 4 (10):1023–31.

Feldman, D. 2018. To live and drink in Los Angeles. *Nature Sustainability* 1 (6):271–2. doi:10.1038/s41893-018-0069-1.

Fietkau, H.-J., and H. Kessel. 1981. *Umweltlernen: Veränderungsmöglichkeiten des Umweltbewusstseins: Modelle, Erfahrungen*. Königstein/Ts.: Hain. Internationales Institut für Umwelt und Gesellschaft.

Fishbein, M., and I. Ajzen. 1975. *Belief, attitude, intention, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley Pub. Co.

Frick, J., F. G. Kaiser, and M. Wilson. 2004. Environmental knowledge and conservation behavior: Exploring prevalence and structure in a representative sample. *Personality and Individual Differences* 37 (8):1597–613. doi:10.1016/j.paid.2004.02.015.

Gao, Y., S. P. Church, S. Peel, and L. S. Prokopy. 2018. Public Perception towards river and water conservation practices: Opportunities for implementing urban stormwater management practices. *Journal of Environmental Management* 223:478–88. doi:10.1016/j.jenvman.2018.06.059.

Giacalone, K., C. Mobley, C. Sawyer, J. Witte, and G. Eidson. 2010. Survey says: Implications of a public perception survey on stormwater education programming. *Journal of Contemporary Water Research & Education* 146 (1):92–102. doi:10.1111/j.1936-704X.2010.00395.x.

Good, J. 2007. Shop 'til we drop? Television, materialism and attitudes about the natural environment. *Mass Communication and Society* 10 (3):365–83. doi:10.1080/15205430701407165.

Gossling, S., T. Kunkel, K. Schumacher, N. Heck, J. Birkemeyer, J. Froese, N. Naber, and E. Schliermann. 2005. A target group-specific approach to "green" power retailing: students as consumers of renewable energy. *Renewable and Sustainable Energy Reviews* 9 (1):69–83. doi:10.1016/j.rser.2004.01.005.

Grant, S. B., J.-D. Saphores, D. L. Feldman, A. J. Hamilton, T. D. Fletcher, P. L. M. Cook, M. Stewardson, B. F. Sanders, L. A. Levin, R. F. Ambrose, et al. 2012. Taking the "waste" out of "wastewater" for human water security and ecosystem sustainability. *Science* 337 (6095):681–6. doi:10.1126/science.1216852.

Grant, S. B., T. D. Fletcher, D. Feldman, J.-D. Saphores, P. L. M. Cook, M. Stewardson, K. Low, K. Burry, and A. J. Hamilton. 2013. Adapting urban water systems to a changing climate: Lessons from the millennium drought in Southeast Australia. *Environmental Science & Technology* 47 (19):10727–34. doi:10.1021/es400618z.

Hines, J. M., H. R. Hungerford, and A. N. Tomera. 1987. Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *The Journal of Environmental Education* 18 (2):1–8. doi:10.1080/00958964.1987.9943482.

Husted, B. W., M. V. Russo, C. E. B. Meza, and S. G. Tilleman. 2014. An exploratory study of environmental attitudes and the willingness to pay for environmental certification in Mexico. *Journal of Business Research* 67 (5):891–9. doi:10.1016/j.jbusres.2013.07.008.

Huxster, J. K., X. Uribe-Zarain, and W. Kempton. 2015. Undergraduate understanding of climate change: The influences of college major and environmental group membership on survey knowledge scores. *The Journal of Environmental Education* 46 (3):149–65. doi:10.1080/00958964.2015.1021661.

Jensen, B. B. 2002. Knowledge, action and pro-environmental behaviour. *Environmental Education Research* 8 (3):325–34. doi:10.1080/13504620220145474.

Keeler, B. L., P. Hamel, T. McPhearson, M. H. Hamann, M. L. Donahue, K. A. Meza Prado, K. K. Arkema, G. N. Bratman, K. A. Brauman, J. C. Finlay, et al. 2019. Social-ecological and technological factors moderate the value of urban nature. *Nature Sustainability* 2 (1):29–38. doi:10.1038/s41893-018-0202-1.

Kollmuss, A., and J. Agyeman. 2002. Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research* 8 (3):239–60. doi:10.1080/13504620220145401.

Landon, A. C., G. T. Kyle, and R. A. Kaiser. 2017. An augmented norm activation model: The case of residential outdoor water use. *Society & Natural Resources* 30 (8):903–18. doi:10.1080/08941920.2016.1239294.

Levin, L. A., and A. S. Mehring. 2015. Optimization of bioretention systems through application of ecological theory: Application of ecological theory to bioretention systems. *Wiley Interdisciplinary Reviews: Water* 2 (3):259–70. doi:10.1002/wat2.1072.

Levine, D. S., and M. J. Strube. 2012. Environmental Attitudes, knowledge, intentions and behaviors among college students. *The Journal of Social Psychology* 152 (3):308–26. doi:10.1080/00224545.2011.604363.

Lindsey, G. 1990. Willingness to pay for stormwater infrastructure. In *Water resources infrastructure: Needs, economics, and financing*, ed. J. F. Scott and R. M. Khanbilvardi, 176–9. Fort Worth, TX: American Society of Civil Engineers. doi:10.1080/00224545.2011.604363.

Londoño Cadavid, C, and A. W. Ando. 2013. Valuing preferences over stormwater management outcomes including improved hydrologic function. *Water Resources Research* 49 (7):4114–25. doi:10.1002/wrcr.20317.

Lucio, M., R. Giulia, and C. Lorenzo. 2018. Investigating attitudes towards water savings, price increases, and willingness to pay among Italian University students. *Water Resources Management* 32 (12):4123–38. doi:10.1007/s11269-018-2049-7.

Mankad, A., A. M. Walton, and R. Leonard. 2013. Public attitudes towards managed aquifer recharge and urban stormwater use in Adelaide. https://researchdirect.westernsydney.edu.au/islandora/object/uws%3A41312/.

McCright, A. 2010. The effects of gender on climate change knowledge and concern in the American public. *Population and Environment* 32 (1):66–87. doi:10.1007/s11111-010-0113-1.

McPhillips, L. E., and A. M. Matsler. 2018. Temporal evolution of green stormwater infrastructure strategies in three US cities. *Frontiers in Built Environment* 4:26. doi:10.3389/fbuil.2018.00026.

Meyerhoff, J. 2006. Stated willingness to pay as hypothetical behaviour: Can attitudes tell us more? *Journal of Environmental Planning and Management* 49 (2):209–26. doi:10.1080/09640560500507959.

Mobley, C., W. M. Vagias, and S. L. DeWard. 2010. Exploring additional determinants of environmentally responsible behavior: The influence of environmental literature and environmental attitudes. *Environment and Behavior* 42 (4):420–47. doi:10.1177/0013916508325002.

Nemes, V., A. La Nauze, C. J. Walsh, T. D. Fletcher, D. G. Bos, S. RossRakesh, and G. Stoneham. 2016. Saving a creek one bid at a time: A uniform price auction for urban stormwater retention. *Urban Water Journal* 13 (3):232–41. doi:10.1080/1573062X.2014.988732.

Nielsen-Pincus, M., P. Sussman, D. E. Bennett, H. Gosnell, and R. Parker. 2017. The influence of place on the willingness to pay for ecosystem services. *Society & Natural Resources* 30 (12):1423–41. doi:10.1080/08941920.2017.1347976.

Noblet, C. L., M. Anderson, and M. F. Teisl. 2013. An empirical test of anchoring the NEP scale in environmental ethics. *Environmental Education Research* 19 (4):540–51. doi:10.1080/13504622.2012.704899.

Ntanos, S., G. Kyriakopoulos, M. Skordoulis, M. Chalikias, and G. Arabatzis. 2019. An application of the New Environmental Paradigm (NEP) scale in a Greek context. *Energies* 12 (2):239. doi:10.3390/en12020239.

Oweini, A., and A. Houri. 2006. Factors affecting environmental knowledge and attitudes among Lebanese college students. *Applied Environmental Education & Communication* 5 (2):95–105. doi:10.1080/15330150600648945.

Paço, A., and T. Lavrador. 2017. Environmental knowledge and attitudes and behaviours towards energy consumption. *Journal of Environmental Management* 197:384–92. doi:10.1016/j.jenvman.2017.03.100.

Pe'er, S., D. Goldman, and B. Yavetz. 2007. Environmental literacy in teacher training: Attitudes, knowledge, and environmental behavior of beginning students. *The Journal of Environmental Education* 39 (1):45–59. doi:10.3200/JOEE.39.1.45-59.

Pierce, G., K. Gmoser-Daskalakis, K. Jessup, S.B. Grant, A. Mehring, B. Winfrey, Megan A. Rippy, D. Feldman, P. Holden, R. Ambrose & L. Levin. 2020. University Stormwater

Management within Urban Environmental Regulator Regimes: Barriers to Progressivity or Opportunities to Innovate? *Environmental Management* 67, 12–25. doi:10.1007/s00267-020-01377-3.

Porse, E., K. B. Mika, E. Litvak, K. F. Manago, T. S. Hogue, M. Gold, D. E. Pataki, and S. Pincetl. 2018. The economic value of local water supplies in Los Angeles. *Nature Sustainability* 1 (6):289–97. doi:10.1038/s41893-018-0068-2.

Pradhananga, A. K., and M. A. Davenport. 2017. Community attachment, beliefs and residents' civic engagement in stormwater management. *Landscape and Urban Planning* 168:1–8. doi:10.1016/j.landurbplan.2017.10.001.

Ramsey, C. E., and R. E. Rickson. 1976. Environmental knowledge and attitudes. *The Journal of Environmental Education* 8 (1):10–8. doi:10.1080/00958964.1976.9941552.

Rissman, A. R., P. A. Kohl, and C. B. Wardropper. 2017. Public Support for carrot, stick, and no-government water quality policies. *Environmental Science & Policy* 76:82–9. doi:10.1016/j.envsci.2017.04.012.

Roque, R. 2017. Liquid gold: Communicating about stormwater in Los Angeles. UCLA Luskin Center for Innovation. https://innovation.luskin.ucla.edu/wp-content/uploads/2019/03/Liquid_Gold-Communicating_About_Stormwater_in_LA.pdf.

Saleh, A., and K. Bista. 2017. Examining factors impacting online survey response rates in educational research: Perceptions of graduate students. *Journal of Multidisciplinary Evaluation* 13 (29):63–74.

Saphores, J.-D M., O. A. Ogunseitan, and A. A. Shapiro. 2012. Willingness to engage in a pro-environmental behavior: An analysis of e-waste recycling based on a national survey of U.S. households. *Resources, Conservation and Recycling* 60:49–63. doi:10.1016/j.resconrec.2011.12.003.

Sheikh, V. 2020. Perception of domestic rainwater harvesting by Iranian citizens. *Sustainable Cities and Society* 60:102278. doi:10.1016/j.scs.2020.102278.

SWRCB. 2013. Water Quality Order No. 2013-0001-DWQ. https://www.waterboards.ca.gov/board_decisions/adopted_orders/water_quality/2013/wqo2013_0001dwq.pdf.

Tarrant, M. A., and H. K. Cordell. 1997. The effect of respondent characteristics on general environmental attitude-behavior correspondence. *Environment and Behavior* 29 (5):618–37. doi:10.1177/0013916597295002.

Tasca, F. A., L. B. Assunção, and A. R. Finotti. 2017. International experiences in stormwater fee. *Water Science and Technology* 2017 (1):287–99. doi:10.2166/wst.2018.112.

Turner, V., Kelly, K. Jarden, and A. Jefferson. 2016. Resident perspectives on green infrastructure in an experimental suburban stormwater management program. *Cities and the Environment (CATE)* 9 (1):4. https://digitalcommons.lmu.edu/cate/vol9/iss1/4.

UC Irvine. 2007. Long range development plan final EIR 4.8 land use. http://www.ceplanning.uci.edu/EnvironmentalPlanning/FEIRfiles/VolumeI/landuse.pdf.

UC Irvine. 2018. Storm water management plan. https://ehs.uci.edu/programs/_pdf/enviro/stormwater-mgmt.pdf.

UC San Diego. 2019. Storm water management plan. https://blink.ucsd.edu/_files/safety-tab/environment/ucsd-storm-water-management-plan.pdf.

UC Santa Barbara. 2014. Stormwater management program guidance document. https://www.ehs.ucsb.edu/files/docs/ec/2014-08-20_UCSB_Stormwater_Guidance_Document-Campus_Version.pdf.

US EPA. 2015. Stormwater discharges from municipal sources. Overviews and factsheets. US EPA. https://www.epa.gov/npdes/stormwater-discharges-municipal-sources (accessed November 2, 2015).

Wang, Y., M. Sun, and B. Song. 2017. Public perceptions of and willingness to pay for sponge city initiatives in China. *Resources, Conservation and Recycling* 122:11–20. doi:10.1016/j.resconrec.2017.02.002.

Ward, E. W., and K. Winter. 2016. Missing the link: Urban stormwater quality and resident behaviour. *Water SA* 42 (4):571. doi:10.4314/wsa.v42i4.07.

Williams, R. 2016. Understanding and interpreting generalized ordered logit models. *The Journal of Mathematical Sociology* 40 (1):7–20. doi:10.1080/0022250X.2015.1112384.

Wolters, E. A. 2014. Attitude–behavior consistency in household water consumption. *The Social Science Journal* 51 (3):455–63. doi:10.1016/j.soscij.2013.10.003.

Zsóka, Á., Z. M. Szerényi, A. Széchy, and T. Kocsis. 2013. Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students. *Journal of Cleaner Production* 48: 126–38. doi:10.1016/j.jclepro.2012.11.030.

Appendix

WTP Survey Question

You currently pay approximately $XX every quarter in student fees. This total includes many smaller fees that support programs, including $XX for club sports, $XX for student outreach and leadership programs, $XX for transit system fees, and $XX for the green initiative fund. None of these fees typically support natural treatment system construction, which can make these large (in some cases multi-year) projects difficult to fund.

Keeping this in mind, consider the questions below. Please also take into account:

- Your income
- That fees only go to the construction of natural treatment systems on campus
- That fees are added on a quarterly basis
- That fees represent money not available for other things you might want to buy or fund
- That fees impact all students on campus
- That you already pay about $XX per quarter in student fees

What additional amount (beyond the $XX you currently pay) would you be willing to pay each quarter to support the construction of natural treatment systems on your campus?

- $0–$20
- $21–$40
- $41–$60
- $61–$80
- $81–$100
- I'm not willing to pay an additional fee
- Prefer not to respond