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Differences in Opinions about Surface Water Quality Issues in the Southern United States: Implications for Watershed Planning Process

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ABSTRACT Public participation in a watershed planning process involves reaching out to social groups with very diverse opinions and perceptions about environmental issues. Using responses to a nationwide survey of public attitudes and perceptions related to water issues, we examined the effects of socio-demographic and residence characteristics on opinions about water quality, agricultural and urban pollution sources, and nutrients and pathogen pollution issues in the southern United States. Significant differences were identified among respondents of different age groups, genders, and educational levels. Opinions also differed significantly among urban and rural respondents and between states. These results can be used by state and local agencies, universities, and extension services involved in the design of collaborative watershed management processes and water resource educational efforts.

Public participation in the development of watershed management plans has been recommended or required by several state and federal programs (e.g., USEPA, 2012a, 2012b). In addition to the potential benefits provided by the "process" of participatory decision-making (such as the educational benefits for citizen participants and decision makers, political persuasion, citizen empowerment, breaking decision gridlocks, and litigation avoidance), it is estimated that public participation can result in better "outcomes," namely improved decisions that better reflect public preferences for environmental policies (Irving and Stansbury, 2004; Beierle, 1998). However, the preferences can vary significantly among the citizens, and finding a consensus decision can be difficult, requiring significant time and budgetary commitments (Steelman and Ascher, 1997). Existing studies recommend selecting the method of public participation in the decision-making process depending on the heterogeneity of the target community. For example, in small, homogeneous communities, direct participation can be effective and relatively quick since just a few volunteer citizen participants are needed to represent the interests of the whole community. In contrast, in large and heterogeneous communities, capturing the environmental policy opinions and preferences of diverse socioeconomic and interest groups requires a large group of citizens engaged in the decision-making process. Finding citizen representatives, motivating them to stay engaged in (often lengthy) decision-making process, and finding a consensus decision given their diverse preferences can be time-consuming and costly, and in some cases, may not be possible at all. Heterogeneous communities may require alternative methods of public involvement, such as soliciting information through surveys, focus groups, or elections of public representatives. If a community is large and diverse, while an environmental issue is relatively non-controversial, then the traditional, agency-dominated, decision-making process may be a more effective and less costly method of decision-making (Irving and Stansbury, 2004).

Given that the heterogeneity of the community can have significant implications for the participatory decision-making process, existing studies have examined the factors influencing the degree of heterogeneity, with several of those studies identifying socio-demographic characteristics among key determinants (Vigdor, 2004). For example, compared with older residents, younger citizens are generally more likely to have eco-centric worldviews, that is, to believe that there are limits to economic and population growth and that development should comply

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Abbreviations: ROC receiver operating characteristic; TMDL, total maximum daily load.

with sustainability principles (Hamilton et al., 2010; Kahn, 2002; Klineberg et al., 1998; Scott and Willits, 1994; Arcury and Christianson, 1990). Hence, finding a consensus environmental management decision will require more time and effort if stakeholders participating in the decision process represent diverse age categories. Since younger residents are generally more idealistic and less integrated into existing economic systems, they may be more open to changes and more motivated to address environmental problems (VanLiere and Dunlap, 1980). Similarly, higher levels of education are usually associated with more concerns for environmental issues and higher support for eco-centric worldviews (VanLiere and Dunlap, 1980; Hamilton et al., 2010). Furthermore, women assess family dangers (including environmental risks) higher than do men, whereas men report fewer environmental concerns and higher confidence in their knowledge than do women (e.g., Hamilton et al., 2010).

The composition of urban or rural land uses can also influence the degree of community heterogeneity. Several studies have shown that urban residents may share more concerns about environmental issues than do rural residents, although the difference depends on the measure of environmental concern used by the researchers (e.g., Arcury and Christianson, 1990; Morrissey and Manning, 2000). Those residing in rural areas generally perceive their water to be of better quality and less affected by such sources of pollution as farming and timber harvesting (Hu and Morton, 2011). This difference in perceptions can be explained by the more pronounced exposure to environmental degradation in urban areas. Urban residents are also more involved in activities that include the environment in appreciative or recreational ways. In contrast, rural residents are generally more likely to be engaged in extractive uses of natural resources (such as mining) that can lead to a more utilitarian orientation toward the environment. Furthermore, more tenuous economic conditions in rural areas may lead to supporting economic growth over environmental protection. Freudenburg and McGinn (1987) offered an additional explanation of the differences in opinions: agricultural producers understand the resiliency and adaptability of nature better than do urban residents, and they perceive human activities as supporting natural productivity (as opposed to impairing it). Finally, in metropolitan areas, socialization can lead to favorable perceptions of group solutions to environmental problems (Lowe and Pinhey, 1982; Freudenburg and McGinn, 1987; VanLiere and Dunlap, 1980).

In this article, we use the responses to a nationwide survey of public attitudes and perceptions related to water issues (Hu and Morton, 2011; Borisova et al., 2012a; Mahler et al., 2004, 2013) to explore the heterogeneity in attitudes and opinions about the critical environmental issue of nutrient and pathogen water pollution. We focus on the southern United States. According to the U.S. Environmental Protection Agency (USEPA, 2012c), nationwide, 54% of assessed river and stream miles, and 69% of assessed lake, reservoir, and pond acres are classified as threatened or impaired, with nutrients (nitrogen and phosphorus) and pathogens being among the top causes of impairment. A variety of sources, including agriculture, urban-related runoffs, and municipal discharges, contribute to the impairments (USEPA, 2012c). However, opinions about nutrient and pathogen impairments can differ among various stakeholder groups (e.g., Borisova et al., 2012b). In this article, we specifically examine the differences in opinions about nutrient and pathogen water pollution among respondents (a) living in rural and urban areas; (b) with different demographic characteristics based on age, gender, and education; and (c) supporting eco-centric or anthropocentric worldviews. Our results show that these demographic, residence, and attitudinal characteristics correlate with respondents' attitudes and opinions about water pollution issues and sources. In addition, significant differences in opinions are found among the residents of different states in the southern United States, possibly related to the differences in local environmental conditions and policies. These results can be used by agencies to evaluate the heterogeneity of the target community and select the appropriate degree and form of the public participation process.

DATA

Details of the development and administration of the nationwide survey of public attitudes and perceptions related to water issues are discussed in Mahler et al. (2013). In this article, we focus on responses to the survey from nine southern states (AL, AR, FL, GA, LA, MS, OK, TN, and TX), and examine the responses to the questions about surface water quality in general and pathogens and fertilizer pollution issues specifically, as well as point (wastewater treatment plants and industry) and nonpoint (agriculture, urban runoff, and septic systems) pollution sources. As stated in Mahler et al. (2013), each region had some flexibility to modify the questionnaire used in the survey to match the local issues. As a result, water quality questions were asked differently in various regions. The Southern region was surveyed last (in 2008–2010), and given that the southern states face similar environmental challenges, the water quality questions examined in this article were asked consistently from state to state.

This article focuses on the responses to the following survey questions:

In your opinion, what is the quality of surface waters (rivers, streams, lakes, channels, and wetlands) where you live? Answer choices were aggregated into three categories: "good or excellent," "fair," and "poor." "No opinion/I don't know" responses (15%) were omitted from the analysis conducted for this question.

Do you know of or suspect that any of the following pollutants affect either surface or groundwater quality in your area? A list of 12 potential surface and groundwater issues was provided. For each issue, the respondents were asked to select an answer from the choices, ranging from "Know it is NOT a Problem" to "Know it IS a Problem" and "Don't know." In this article, we focus on the responses related to the three pollution issues: pathogens, fertilizer/nitrates, and fertilizer/phosphates. A significant number of respondents answered "Don't know" to these questions (42–54%), and these responses were excluded from the analysis of opinions related to the potential water pollutants.

In your opinion, which of the following are most responsible for the existing pollution problems in rivers and lakes in your state? (Check up to 3 answers). A list of 13 potential pollution sources was provided. Those who did not select any of the potential sources or those

Table 1. Socio-demographic characteristics collected in the survey.

Variable (sample size)	Percent respondents (%)
What is your age? (N = 3025)	
20–34 years old	6.18
35–44 years old	11.74
45–64 years old	44.69
65 years old and older	37.39
What is your gender? (N = 3065)	
Male	64.18
Female	35.82
What is the highest level of education you have completed? (N = 3055)	
Less than high school / some high school education	0.06
High school graduate	0.18
Some college or vocational training	0.31
College graduate	0.24
Advanced college or other professional degree	0.21
Please place an X on the line below to indicate how you see yourself on environmental issues. (N = 3150)	
1 = total natural resource use;	9.56
2	0.38
3	1.49
4	3.81
5	9.11
6 = equal balance between use and protection†	34.32
7	15.84
8	15.52
9	7.94
10 = total environmental protection	2.03
The population of the city/town in which you live is: (N = 2860)	
More than 100,000 people	31.29
25,000 to 100,000 people	28.64
7,000 to 25,000 people	18.32
3,500 to 7,000 people	9.86
Less than 3,500 people	11.89
Where do you live? (N = 3068)	
Inside city limits	56.78
Outside city limits, not engaged in farming	37.58
Outside city limits, currently engaged in farming	5.64
State of residence: (N = 3163)	
Alabama	9.20
Arkansas	8.13
Florida	16.53
Georgia	16.44
Louisiana	7.94
Mississippi	8.98
Oklahoma	8.35
Tennessee	11.19
Texas	13.25

† Identified as "average American adult" in the survey.

who selected more than three sources were excluded from the analysis of opinions related to the pollution sources (17%). In this article we focus on the responses about the following sources that are identified as the probable sources of impairments for relatively large proportion of stream miles and lake acres (USEPA, 2012c): wastewater treatment plants, industry, agriculture (crops or livestock), septic systems, and urban sources (such as stormwater runoff, runoff from home landscapes, new suburban development, and erosion from roads and/or construction, repair). The other five potential sources (forestry; military bases; landfills; oil wells; and mining) were excluded from the analysis conducted for this question.

Based on the existing literature, we hypothesize that the attitudes and opinions about water quality, pollutants, and pollution sources are correlated with the following characteristics of the respondents (Table 1):

Residence. We hypothesize that self-identified urban residents would be more concerned about water quality and nutrient and pathogen pollution than would self-identified rural and agricultural respondents; and that those residing in large cities would be more concerned about water quality problems than would those residing in smaller communities;

General Attitudes toward Environment. We hypothesize those with more eco-centeric worldviews to be more concerned about water quality issues. To explore the differences in respondents' worldviews, a scale question was used in the public survey to measure where each respondent's attitude might be placed in the continuum between extremes of total natural resource use (self-rating of 1) and total environmental protection (self-rating of 10).

Demographic Characteristics. We hypothesize female, younger, and more educated respondents to be more concerned about water quality issues.

State of Residence. Southern states differ from each other in their land use, type of industry, water quality standards, ambient water quality, and other characteristics. We hypothesize these characteristics to influence citizens' attitudes and opinions about water quality.

METHODS

Multivariate logistic regression analysis was used to examine the effects of various factors on the probability of respondents selecting specific answer choices. Separate regression models were constructed for each of the pollutants (Question 2), pollution source (Question 3), as well as overall opinion about surface water quality (Question 1).

Specifically, for the models related to potential pollution sources (Question 3), the dependent variable value for respondent i, y_i, is equal to one if the respondent selected a specific pollution source, and zero otherwise. It is assumed that the respondent i's true (unobservable) concern level, y_i^*, is a function of all the respondents' characteristics, $\mathbf{x}$, parameters α and β, and a disturbance e_i that has a standard logistic distribution (Wooldridge, 2009):

$$y_i^* = \alpha + \beta'\mathbf{x}_i + e_i \qquad [1]$$

Then, y_i, can be derived as follows:

$$y_i = 0 \text{ if } y_i^* \leq 0, \qquad [2]$$

$$= 1 \text{ if } y_i^* > 0$$

Given this specification, the probability of selecting a specific answer choice for Question 3 can be estimated as follows (Wooldridge, 2009):

$$\begin{aligned} \text{Prob}\,[y_i = 1 \mid \mathbf{x}_i] &= \text{Prob}\,[y_i^* > 0 \mid \mathbf{x}_i] \\ &= \text{Prob}\,[e_i > -(\alpha + \beta'\mathbf{x}_i) \mid \mathbf{x}_i] \\ &= 1 - F\,[-(\alpha + \beta'\mathbf{x}_i)] \\ &= F\,[(\alpha + \beta'\mathbf{x}_i)] \end{aligned} \qquad [3]$$

where F denotes cumulative standardized logistic distribution function (*cdf*). Then, the parameters α and β are estimated by maximizing the log-likelihood function:

$$\begin{aligned} \text{LogL} &= y_i \log(F\,[\alpha + \beta'\mathbf{x}_i]) \\ &+ (1 - y_i) \log(1 - F\,[\alpha + \beta'\mathbf{x}_i]) \end{aligned} \qquad [4]$$

In turn, for Questions 1 and 2, an ordered logistic regression model was estimated since the respondent was asked to select one of several sequentially ordered responses. The ordered logistic regression is a generalization of the ordinary logistic regression described above. It is important to note that the logistic distribution function F is nonlinear, and hence, the magnitude of coefficients α and β cannot be easily interpreted.

The parameters α and β for ordinary and ordered logistic regression models were estimated using *proc logistic* implemented in SAS 9.2 (SAS Institute, 2012a). Likelihood ratio tests were used to test the hypothesis that α and β are equal to zero. In turn, goodness of fit of the logistic regression model is evaluated using the area under the receiver operating characteristic (ROC) curve (c), which is based on the proportions of correctly and incorrectly identified responses, with $c = 0.5$, implying no predictive power in the model, and $c = 1$, implying absolute predictive power (SAS Institute, 2012b; UCLA, 2013).

RESULTS AND DISCUSSION

The majority of respondents believed their surface water is of good or excellent quality (53.9%) (Table 2). The majority of respondents also "knew" or "suspected" that pathogens, fertilizer/nitrates, and fertilizer/phosphates affect surface or groundwater quality in their areas (54.1, 67.5, and 67.4%, respectively). Given the significant correlation between responses about fertilizer/nitrates and fertilizer/phosphates (Cramer's V = 0.96), we used only the responses to the fertilizer/phosphates category in the regression analysis described below.

Overall, 42.7% of respondents identified "industry" as one of the top three river/lake pollution sources in their states. Although the percentage of respondents who selected other potential pollution sources is significantly smaller, overall, 66.2% of respondents selected one of the urban nonpoint sources (stormwater runoff, runoff from home landscapes, new suburban development, or erosion from roads and/or construction, repair), and 39.2% selected one of the agricultural nonpoint sources (agriculture–crops or agriculture–animals) among the top sources of pollution. The correlation among the responses about individual pollution sources was low, and hence, the responses about each potential pollution source were analyzed separately.

Table 1 presents the socio-demographic, residence, and attitudinal characteristics that were collected as part of the survey of public attitudes and perceptions related to water issues (Mahler et al., 2013). The majority of respondents were 45 years old and older, male, and had at least some college or vocational training education. The majority of respondents also resided in communities with populations larger than 25,000 people. Only 5.6% of respondents reported that they were engaged in farming. Responses from the four most populous states—Florida, Georgia, Texas, and Tennessee—accounted for almost 60% of the survey responses received from the region. Approximately one-third of respondents supported an equal balance between natural resource use and environmental protection (34.3%). More than one-third of respondents expressed some degree of support for environmental protection (41.3%), and they are hypothesized to have more eco-centric worldviews. Finally, 24.4% of respondents supported natural resource use (as opposed to environmental protection), and they are hypothesized to have more anthropocentric worldviews.

Table 2. Responses to the survey questions about surface water quality, water pollutants, and pollution sources.

Survey question (sample size)	Percent respondents (%)
In your opinion, what is the quality of surface waters (rivers, streams, lakes, channels, and wetlands) where you live? (N = 2585)	
Poor	15.24
Fair	30.91
Good or excellent	53.85
Do you know of or suspect that any of the following pollutants affect either surface or groundwater quality in your area?	
Pathogens (bacteria, viruses, germs) (N = 1351)	
Know it is NOT a Problem	8.73
Suspect it is NOT a Problem	37.23
Suspect it IS a Problem	44.49
Know it IS a Problem	9.55
Fertilizer / Nitrates (N = 1725)	
Know it is NOT a Problem	5.68
Suspect it is NOT a Problem	26.84
Suspect it IS a Problem	54.55
Know it IS a Problem	12.93
Fertilizer / Phosphates (N = 1687)	
Know it is NOT a Problem	5.63
Suspect it is NOT a Problem	26.97
Suspect it IS a Problem	54.36
Know it IS a Problem	13.04
In your opinion, which of the following are most responsible for the existing pollution problems in rivers and lakes in your state? (Check up to 3 answers) (N = 2619)	
Industry	42.65
Stormwater runoff	27.80
Agriculture–crops	27.68
New suburban development	26.42
Erosion from roads and/or construction, repair	26.38
Septic systems	21.76
Agriculture–animals	19.32
Wastewater treatment plants	17.33
Runoff from home landscapes	16.27

Table 3. Logistic regression analysis results: Effects of socio-demographics, general environmental worldviews, and residence characteristics on respondents' attitudes and opinions about surface water quality, pathogen and fertilizer pollution, and pollution causes.

Variable	Surface water quality in respondents' areas	Pollutants affecting either surface or groundwater quality in respondents' areas		Sources most responsible for the existing pollution problems in rivers and lakes in respondents' states								
		Pathogens	Fertilizer/ phosphates	Industry	Stormwater runoff	Agriculture–crops	New suburban development	Erosion from roads and/or construc-tion, repair	Septic systems	Agriculture-animals	Wastewater treatment plants	Runoff from home landscapes
Intercept	0.68†	−2.46†	−2.06†	−0.98†	−1.09†	−0.97†	−0.84†	−0.90†	−1.27†	−1.41†	−1.78†	−0.55*
		0.12	0.85†									
	2.29†	2.46†	3.16†									
Age (reference = 65 and older)												
20–34 years old	−0.43*	0.56*	0.31	0.26	0.46*	−0.50*	0.09	−0.08	−0.12	−0.72**	0.29	−0.60*
35–44 years old	−0.13	0.64†	0.39*	0.14	0.15	−0.15	0.17	0.15	0.04	−0.60†	0.14	−0.29
45–64 years old	−0.06	0.57†	0.51†	0.05	0.33†	0.02	-0.18	−0.16	0.04	−0.27*	0.31*	−0.30*
Male	0.15	−0.38†	−0.24*	0.09	0.25*	0.61†	−0.06	−0.29†	−0.37†	0.15	0.05	−0.09
Education (reference = advanced degree)												
Less than high school/ some high school	−0.34	0.30	−0.75**	−0.49*	0.09	−0.72**	−0.92†	0.61**	0.32	−0.35	0.40	−0.10
High school graduate	−0.04	−0.28	−0.75†	0.00	0.04	−0.66†	−0.63†	0.38*	0.28	−0.59†	0.45*	−0.25
Some college or vocational training	−0.18	0.04	−0.33*	−0.07	−0.12	−0.55†	−0.13	0.22	0.31*	−0.38*	0.45**	−0.36*
College graduate	0.03	−0.05	−0.20	−0.16	−0.13	−0.27*	0.19	0.18	−0.06	−0.09	0.15	−0.11
General attitudes toward environment												
	−0.07†	0.07*	0.16†	0.06**	0.03	0.06*	0.06*	−0.04	−0.05	0.03	−0.06*	0.03
Size of the community of residence (reference = more than 100,000 residents)												
25,000 to 100,000 people	−0.11	0.00	−0.10	−0.10	0.04	−0.01	0.34**	0.04	0.15	0.00	−0.31*	0.14
7,000 to 25,000 people	−0.10	−0.14	−0.03	−0.09	−0.10	0.15	−0.03	−0.01	0.11	0.05	−0.27	0.08
3,500 to 7,000 people	0.00	0.23	−0.11	−0.09	0.11	0.11	−0.24	−0.20	0.38*	−0.29	−0.24	−0.08
Less than 3,500 people	−0.20	0.30	0.13	−0.31	−0.09	0.35*	−0.42*	−0.20	0.32	0.39*	0.03	−0.31

(continued)

Table 3. Continued.

Variable	Surface water quality in respondents' areas	Pollutants affecting either surface or groundwater quality in respondents' areas		Sources most responsible for the existing pollution problems in rivers and lakes in respondents' states								
		Pathogens	Fertilizer/ phosphates	Industry	Stormwater runoff	Agriculture–crops	New suburban development	Erosion from roads and/or construc-tion, repair	Septic systems	Agriculture-animals	Wastewater treatment plants	Runoff from home landscapes
Residence (reference = inside city limits)												
Residence outside city limits, engaged in farming	−0.07	−0.23	−0.96†	−0.25	−0.36	−0.45	0.22	0.16	0.09	−0.42	0.59**	0.18
Residence outside city limits, not engaged in farming	0.14	−0.22	−0.41†	−0.08	0.09	−0.06	0.17	0.10	0.24*	−0.12	0.08	−0.42†
State of residence (reference = Florida)												
Alabama	0.28	−0.85†	−1.06†	0.89†	−0.28	−1.02†	−0.82†	0.14	0.09	0.09	0.03	−1.16†
Arkansas	0.94†	−0.97†	−0.98†	0.13	−0.60†	−0.06	−0.71†	−0.14	0.36	0.83†	−0.15	−1.16†
Georgia	0.12	−0.35	−0.82†	0.58†	−0.23	−0.95†	−0.04	0.79†	−0.26	−0.20	0.17	−0.70†
Louisiana	−0.60†	−0.19	−0.59†	0.81†	−0.84†	0.15	−0.97†	−0.18	0.58**	0.17	0.27	−1.12†
Mississippi	0.13	−0.76†	−1.30†	0.21	−0.51*	0.19	−1.04†	0.05	0.61†	−0.01	0.28	−1.40†
Oklahoma	−0.22	−0.45	−0.31	−0.08	−0.30	−0.69†	−1.13†	−0.21	−0.37	1.26†	0.24	−0.96†
Tennessee	−0.28	−0.69†	−1.03†	0.70†	−0.48**	−0.48**	−0.27	0.13	0.03	−0.03	0.17	−1.26†
Texas	−0.15	−0.47*	−0.84†	0.46†	−0.07	−0.60†	−0.33*	−0.16	−0.28	0.19	0.06	−0.73†
Model performance												
Likelihood ratio test (degrees of freedom = 23)	100.63†	84.16†	196.71†	86.10†	55.89†	170.57†	168.61†	86.65†	97.56†	120.36†	44.87†	106.42†
C	0.60	0.62	0.67	0.61	0.60	0.67	0.67	0.63	0.64	0.65	0.60	0.66

* Significant at the 0.05 level.
** Significant at the 0.01 level.
† Significant at the 0.009 level.

Residence. Results of the logistic regression analysis show that several respondents' characteristics were systematically correlated with answers about surface water quality and pollution causes and sources (Table 3). We found some support for our first hypothesis that urban residents are more concerned about environmental issues than are rural residents. Specifically, in comparison with city residents, those residing outside city limits (engaged in farming or not) were less concerned about fertilizer as a surface or groundwater pollutant in their areas. However, the responses about overall water quality in respondents' areas were not statistically different between self-identified urban and rural dwellers.

With respect to pollution sources, those residing outside city limits (engaged in farming or not) were more likely to identify septic systems and wastewater treatment plants among the top pollution sources than those living inside city limits. In addition, those engaged in farming were more likely to identify runoff from home landscapes as a top pollution source (as compared with respondents residing in the city). Septic systems are more common in rural areas and require at least occasional maintenance by the homeowner, possibly explaining the higher level of concern among rural respondents. In turn, wastewater treatment plants, unlike septic systems, are pretty much invisible to the urban homeowner, possibly explaining the relatively low level of concern of urban dwellers about this potential pollution source. Finally, runoff from home landscapes is usually associated with water quality impacts of urban areas, where lawns and gardens are connected to streams by streets and storm sewers, and hence, it is somewhat surprising that those living outside city limits and engaged in farming were more concerned about this potential pollution source than urban respondents.

Comparison of the responses by community sizes also shows that the opinions about the top sources affecting river and lake water quality in the respondents' states varied. Respondents residing in very small communities (less than 3,500 people) were more likely to identify agriculture (crops or livestock), and less likely to identify new suburban development among the top pollution sources (compared with those residing in very large communities). Very small communities are usually distant from urban areas and reliant on agriculture for their economy. This may explain higher concerns about agricultural water quality impacts among residents of small communities.

Those residing in communities of 3,500 to 7,000 people were also likely to be concerned about septic systems, whereas those in larger communities (25,000–100,000 people) were concerned about new suburban development (compared with those in larger urban areas).

Overall, although we lacked objective information about the actual sources of water pollution in respondents' areas, the survey reflects respondents' awareness of local water quality problems, with agricultural sources and septic systems dominating in small communities and suburban development in larger cities.

General Attitudes toward Environment. With respect to our second hypothesis, as estimated, those respondents with more eco-centric worldviews (as evaluated by the question about general environmental worldview) ranked overall water quality lower, and were more concerned about pathogens and fertilizer pollutants, in comparison with those with more anthropocentric worldviews. Those with more eco-centric worldviews were also more likely to select industry, agriculture, and new suburban development as the top sources affecting river and lake water quality in their states. Surprisingly, such respondents were less likely to be concerned about pollution from wastewater treatment plants. All respondents were allowed to select up to three top pollution sources, forcing a hard choice among potential pollution sources.

Demographic Characteristics. We also found some support for our hypothesis that younger respondents are more concerned about water quality issues. Those 20 to 34 years old had lower opinions of overall surface water quality, and were more concerned about pathogens as a surface or groundwater pollutant than did those 65 years and older. Those 20 to 34 years old were also more likely to consider stormwater runoff as a top river/lake pollution source and were less likely to identify agriculture (crops or livestock) as a top pollution source. Furthermore, such respondents were also less likely to identify runoff from home landscapes as a top pollution source (although they may have considered stormwater runoff as an all-inclusive category, or they may be less familiar with the runoff and home landscaping issues due to the lack of home ownership experience).

Comparison of the responses among the age categories also shows that those 45 to 64 years old are especially aware of fertilizer as a cause of surface/groundwater pollution, and they are more likely to select wastewater treatment plants among top pollutant sources (as compared with those 65 years old and older).

As expected, gender and education were also among the significant predictors of the responses. Other things being equal, males were less likely to be concerned about pathogens and fertilizers, and they were less likely to select septic system or erosion from roads/construction among their top three pollution sources, but males were more likely than females to select stormwater runoff and agriculture–crops as the top pollution sources.

Respondents' education was also important. Those without a college degree were generally less concerned about fertilizers as a surface or groundwater pollution issue and less likely to include industry, agriculture (crops and livestock), new suburban development, or runoff from home landscapes among their top three pollution causes (compared with respondents with advanced degrees). However, those less educated were more likely to identify erosion from roads/construction and wastewater treatment plants among their top three sources affecting rivers/lakes in their states.

State of Residence. Finally, responses were significantly different among the states. Table 4 summarizes some key characteristics of the states in the Southern region that can help explain the differences in responses. In comparison with Florida, respondents from all the other states were less concerned about pathogens and fertilizers, and less concerned about the urban nonpoint pollution sources of runoff from home landscapes, stormwater runoff, and new suburban development (although the differences between Florida and some of the other states were not statistically significant). This relatively high level of concern with urban nonpoint sources in Florida can be explained by rapid population growth in the state, the large proportion of the state's territory already devoted to urban land uses,

Table 4. Characteristics of the states in the southern United States.

State	Percent of state area that is water†	Population growth, 2000–2010 (%)‡	Percent of state area in cropland, 2007§	Percent of state area in grassland pasture and range, 2007¶	Percent of state area in urban uses, 2007#
Alabama	1.9%	7.5%	9.5%	8.0%	3.4%
Arkansas	2.1%	9.1%	24.1%	9.7%	1.8%
Georgia	1.8%	18.3%	12.4%	3.5%	6.5%
Florida	8.7%	17.6%	7.5%	14.9%	10.9%
Louisiana	9.5%	1.4%	17.2%	7.5%	4.3%
Mississippi	1.7%	4.3%	12.5%	4.7%	1.3%
Oklahoma	1.8%	8.7%	29.1%	42.5%	1.6%
Tennessee	2.2%	11.5%	22.3%	7.8%	5.9%
Texas	1.9%	20.6%	19.9%	59.4%	2.7%

† Source: USGS (2010).
‡ Source: Mackun and Wilson (2010).
§ Based on (1) 2007 (estimated) cropland area (USDA-ERS, 2007a) and (2) total land area in each state (StateMaster.com, 2013).
¶ Based on (1) 2007 (estimated) grassland pasture and range (USDA-ERS, 2007b) and (2) total land area in each state (StateMaster.com, 2013).
# Based on (1) 2007 (estimated) land in urban areas (USDA-ERS, 2007b) and (2) total land area in each state (StateMaster.com, 2013).

Table 5. Demographic characteristics of selected sub-samples of survey respondents.

					Proportion of respondents by educational levels					
Groups	Group description	No. of respondents†	Avg. age (years)	Male (%)	Less than high school	High school	Some college of vocational training	College degree	Advanced degree	General attitudes toward environment
1	Agricultural	148	56.5	81.8%	8.8%	28.4%	36.5%	14.2%	12.2%	5.5
2	Rural	664	59.3	66.3%	6.7%	24.1%	33.7%	20.5%	15.0%	6.0
3	Urban	997	57.9	67.0%	4.0%	13.9%	27.1%	29.0%	26.0%	6.3

† Note that the number of responses used in the analysis of specific survey questions can be smaller, since respondents can skip some of the survey questions.

and significant areas covered with water (which implies that much of the urban development is taking place in close proximity to water bodies).

Interestingly, in comparison with Florida, respondents from the other states (except Louisiana and Mississippi) were also less concerned about the impacts on river/lake water quality by agriculture–crops (although the difference between Florida and Arkansas was not statistically significant). Crops cover a relatively small percentage of Florida's territory, and hence, the significant level of concern of Florida respondents may be explained by the proximity of agricultural areas in relation to water resources, more intensive production practices used in Florida, and unique crops produced in Florida.

Respondents from Arkansas and Oklahoma were more concerned about the impacts of agriculture–animals on river/lake water quality (compared with Florida). Large areas in Oklahoma are devoted to pasture, while Arkansas is a leader in poultry production, which partially explain these results.

Finally, Louisiana and Mississippi respondents were more concerned about the impacts of septic systems on river/lake water quality, whereas Georgia respondents were more concerned about erosion from road/construction and repair (compared with Florida). Further analysis is needed to explain these results.

It is important to note that the overall explanatory power of the logistic regression models for Questions 1 to 3 is relatively low (i.e., *c* parameter for the model is below 0.70, see Table 3). This result implies that the demographic, residence, and attitudinal characteristics included in the regression models explain a relatively small proportion of the variability in the survey responses. However, as discussed above, the coefficients of several independent variables are statistically significant, and the effects of these variables on respondents' opinions are important. To illustrate the effect of the respondents' residence in urban or rural/agricultural communities category variable, we select three (self-identified) groups of respondents: those residing in rural areas and involved in agriculture (Group 1); those residing in rural areas not involved in agriculture, and living in communities with populations less than 25,000 people (Group 2); and those living in urban areas in communities with populations greater than or equal to 25,000 people (Group 3). It is important to note that those in Group 3 were on average more educated, more supportive of eco-centric worldviews, and included a higher proportion of females, in comparison with the other two groups (Table 5).

Opinions about water quality varied among the three residence groups (Fig. 1). Specifically, although close to 70% in Group 3 (urban residents) suspected that fertilizer and pathogens were affecting surface or groundwater in their areas, the overwhelming majority in Group 1 (rural residents involved in agriculture) knew or suspected that these issues were not affecting their local water resources. Furthermore, although the three groups generally agreed that industry should be a priority for water quality policy interventions, their opinions about the other sources diverged. For example, many in Group 3 (urban residents) indicated that new suburban development, stormwater runoff, and erosion from roads/construction were among the primary pollution sources. In contrast, Group 1 (rural residents involved in agriculture) were relatively more concerned about the impacts of wastewater treatment plans and septic systems on water quality. Finally, those in Group 2 (rural residents not involved in agriculture) were relatively more concerned about the impacts of agricultural sources.

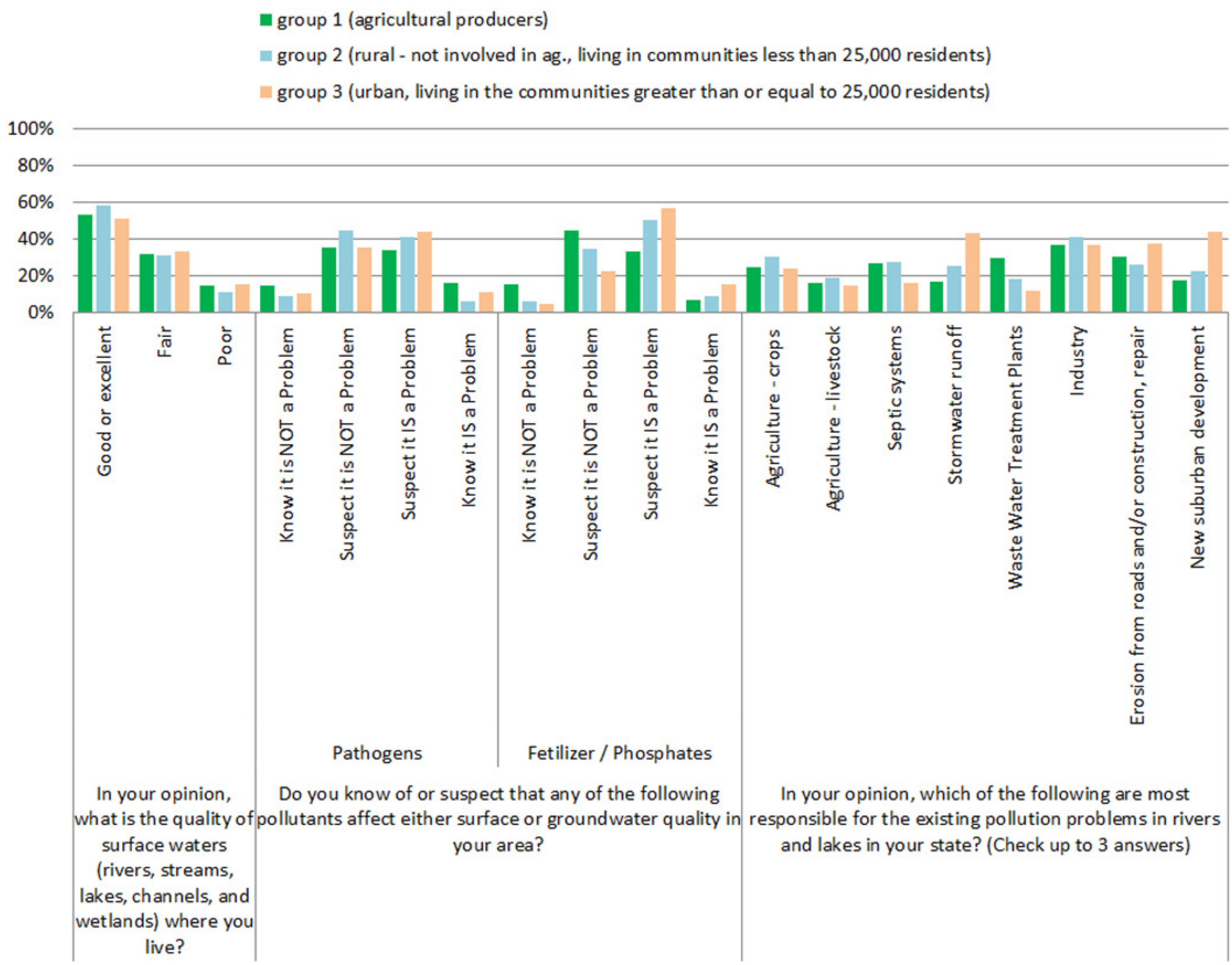

Fig. 1. Opinions about water quality and pollution issues and sources for survey respondents.

CONCLUSIONS

Nutrient and pathogen water quality problems are identified in many watersheds in the southern United States, and government agencies have been working with local communities to address the problems. To design an effective participatory watershed management process, government agencies need to account for the degree of the heterogeneity in opinions about water quality and pollution sources of the target community. This study shows that similar to the results reported for other regions (Hu and Morton, 2011), in the southern United States, the degree of the heterogeneity of citizens' opinions about the impacts of nutrients and pathogens on local water quality, as well as about the relative contributions of the potential pollution sources, depends on residency in urban or rural areas and involvement in agriculture, as well as on demographic characteristics. We found that younger, female, urban dwellers are generally more concerned about fertilizer and pathogen water quality issues than are older, male, rural dwellers (and those particularly involved in agriculture). We did not find any statistically significant difference in the perception of agriculture as a potential source of water pollution among self-identified urban and rural dwellers. However, those living in small communities were more likely to be concerned about agricultural water quality impacts. In turn, those residing outside city limits and currently engaged in farming were more likely to be concerned about the impact on water quality of wastewater treatment plants.

This study focused on just a few of the important stakeholder characteristics that can correlate with the opinions about water quality issues and sources. Correlations with other characteristics, such as occupation, ethnicity, religion, political views, and incomes (see Adeola, 2004; Morrissey and Manning, 2000; Kahn, 2002), should be explored in future studies. In addition, it is important to focus specifically on those citizens residing in close proximity to impaired water bodies and evaluate whether their opinions coincide with water pollution issues tentatively identified by state agencies leading watershed management plan efforts [such as total maximum daily load (TMDL), USEPA, 2012d]. The effects on public opinions of other factors, such as news media campaigns, educational interventions, or major policy initiatives (e.g., Genskow and Prokopy, 2008), should also be addressed in future research. Finally, additional questions can be included in future public surveys to further explore general environmental world-views of respondents and their impacts on attitudes and opinions about water quality specifically (Dunlap et al., 2000).

A significant number of survey respondents answered

"I do not know" to the questions about water quality and pollution issues. Given the significant amount of resources devoted by agencies and outreach organizations on public education about water quality, the significant proportion of "I do not know" responses is surprising. In this article we assumed that despite the significant proportion of "I do not know" responses (as well as non-responses), the systematic relationships we discovered between respondents' opinions and demographic and residence characteristics are representative of the true relationships in the population of a region as a whole. In the future, additional analysis of "I do not know" responses and non-respondents is required as recommended by Hu (2011).

Given that socio-demographic characteristics of the population in the southern United States are changing dramatically (in terms of the urban–rural split, racial composition, age, income, etc.), it would be interesting to project how water quality concerns will shift with changes in population (see Kahn, 2002). Periodic repeats of the nationwide survey of public attitudes and perceptions related to water issues can also help evaluate the dynamics of public concerns.

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