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Water quality perceptions in the US

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Abstract

An integrated, place-based approach which brings local citizens and stakeholders into the agenda-setting, decision-making, monitoring and enforcement activities within their local watershed has proven to be effective in solving local water problems. A first step in creating effective local, watershed based deliberations is to discover agreement as well as differing viewpoints regarding the importance of and attitudes toward local water resources. Understanding public perceptions of water quality is important because the perceptions will essentially affect the extent to which the public takes action to support public policies and projects designed to solve water quality problems. The objective of this dissertation is to provide a framework for examining the various factors, including environmental attitudes, place of residence, and general state level characteristics that affect the perceptions of individuals about their local water quality. This research is based on a national water survey completed in thirty-six states of the fifty United States. Three papers focus on different aspects of water quality perceptions and environmental attitudes, place of residence, and other demographic variables associated with water resources. The findings offer policymakers a better understanding of the differences and common grounds regarding water quality issues and provide guidance in building concerted support for solutions to water quality problems. In addition, the study of "don't know" responses delineates populations which are more likely to say they have no opinion about their water quality. The revealed patterns about "don't know" responses provide valuable information for education outreach and the effective promotion of public awareness and knowledge about water quality.

Key words: water quality perception, environmental attitudes, place of residence and environmental management, don’t know responses

Chapter One General Introduction

Introduction

The degradation and pollution of water resources in the United States (US) poses significant environmental challenges nationally and to states and local communities (Heinz, 2008). The US Environmental Protection Agency (US EPA) classifies water pollution into two types based on polluting sources: point and non-point source pollution (US EPA, 2009). Point source water pollution mainly comes from stationary locations such as factories, sewage treatment plants, and ships. Non-point source pollution (NPS) is caused by more diffuse sources, such as agricultural runoff, mining activities, construction sites and road erosion (US EPA, 2009). Point sources of water pollution are easier to track and identify than non-point source pollution. The passage of the Clean Water Act in 1972 has effectively reduced point source water pollution in the US (Sharpley et al, 1997). However, NPS pollution of both surface and ground waters remains the largest source of water quality impairments.

In 1994, the US Environmental Protection Agency identified agricultural non-point sources as responsible for water quality problems in over 70% of surveyed rivers and lakes (US EPA, 1994). NPS continues to be one of the most difficult pollution problems the US faces (US EPA, 2002). Agriculture is a major source of several non-point source pollutants, including nutrients, sediment, pesticides, and salts (Ribaudo et al., 1999). In addition to soil and pesticide loss from agriculture, most water quality concerns center on non-point transport of nutrients - nitrogen (N) and phosphorus (P), which are considered essential inputs for optimum crop production. Excessive application of fertilizer and animal manure which provides more N and P than removed by crops can cause potential movement of N as NO_3 (nitrate) to groundwater and P in surface runoff.

The standard top-down regulatory methods which proved to be effective with point source water pollution are recognized as being less effective in reducing NPS pollution because of its diffuse nature. An emerging trend in environmental movements is to actively involve citizen groups and community based environmental organizations to work with regulatory agencies to tackle environmental issues and provide an alternative way to solve water quality problems. These local, community based groups bring citizens and stakeholders into agenda-setting, decision-making, monitoring, and enforcement activities. An integrated strategy is usually used to protect and restore water quality through three main elements: problem identification, stakeholder involvement, and integrated actions (Cline and Collins, 2003). USEPA and many other government agencies have endorsed greater citizen involvement and offered funding through competitive grants programs to encourage these new partnership arrangements (US EPA, 2002) in the hopes that they can do what government has been unable to fully accomplish.

The integrated approach, however, is not free from challenges. Because watersheds do not usually follow political boundaries, and because of the variety of socio-cultural issues and multiple stakeholders involved, watershed management is essentially management of people--with complexity that is often beyond the experience and expertise of scientists and managers (Barham, 2001). Although many scholars have argued for using the collaborative decision-making approach to watershed management and the importance of civic engagement (Wagenet and Pfeffer, 2007; Barham, 2001; Brezonik et al., 1999), one particular difficulty constantly encountered by the integrated approach is low public awareness of watersheds (O'Neill, 2005).

In addition, scholars have found that public perception of drinking water quality or water in general varies according to demographic characteristics such as gender, age, and education, etc. (Redfern and Wells, 2007; Williamson et al, 2006; Mahler, 2005).

A first step in creating effective watershed based deliberations is to discover agreement as well as differing viewpoints. Because water is visible and has so many functions in almost every aspect of people's life, it is one component of the environment on which most people have some opinions or attitudes. For this reason, when water quality issues involve multiple parties, individuals or groups, it is essential to understand the relative value of water to different groups of people, their perceptions and knowledge about the problems, and furthermore their intrinsic attitudes and beliefs about human relationship to the environment. Study of environmental attitudes and beliefs are critical because these attitudes influence how people approach the natural environment. Underlying these attitudes and beliefs are cultures, social norms, and paradigms that affect the way the whole society interact with nature (Lundmark, 2007). Understanding environmental beliefs can help all parties involved acknowledge differing ways of framing the functions and value of water resources and lead people to find common ground for concerted efforts to solving water problems.

Environmental Attitudes

A central theme in this research on water quality is environmental attitudes. In this introductory chapter a brief overview of environmental attitudes is offered, followed by more details in subsequent chapters. The global nature of environmental problems became more evident in the 1970s with increased awareness of the problematic relationships between modern industrialized society and the physical environments (Stern et al., 1992). The relationships among human beings and nature can be broadly summarized by two systems of beliefs –

anthropocentrism and ecocentrism. Prior to 1970, anthropocentrism was a dominant view – one in which human beings are seen as separate from nature, more worthy than other organisms, and the central consideration in decisions about using and managing nature. Human beings are viewed superior vis-à-vis non-humans because of their developed capacity to use language, to reason logically, and to use advanced tools. Within this view, the values associated with nature are believed to be most instrumental in the sense that nature is expected to provide natural resources for human purposes and promote aesthetic satisfaction for human wants (Mathews, 1994; Fox, 1995). Furthermore, according to anthropocentrism, human beings are largely in control of the surrounding world and problems arising from modernity can be solved primarily through technological development (Attfield, 2003).

Ecocentrism views the natural environment as consisting of complex webs of ecological interdependence of which human beings are only one node. This view recognizes multiple effects on the ecosystems produced by pollution and other forms of human intervention, and casts doubt on the anthropocentric idea of an absolute divide between human and nature. Also, according to the ecocentrical view, there is intrinsic value of each individual living organism not just humans but all other species in the ecosystems (Lundmark, 2007).

At the end of the 1970s, an increasing number of people recognized that human activities were having huge impacts on the ecosystems and the urgent necessity to achieve a more sustainable form of development (Milbrath, 1984). Many scholars documented a trend of society reevaluating the anthropocentric worldview which had been the guiding principle of human relationship to the physical environment, and resulted in the creation of a more ecologically focused worldview (Milbrath, 1984; Dunlap and Van Liere, 1978). Empirical evidence of this shift in worldview has been guided by the question, ‘How do we measure people’s environmental beliefs, and furthermore, how shouldthe fundamental changes in their worldview be documented?' Originally, most attempts to study public environmental concern focused on single issues such as pollution, land use, or energy conservation (e.g. Weigel and Weigel, 1978). This was followed by the development of social paradigms and creation of scales to capture a more comprehensive system of ecological beliefs (Dunlap and Van Liere, 1978).

Pirages and Ehrlich (1974) were the first scholars to propose the concept of the Dominant Social Paradigm (DSP) as practiced by industrial nations. A DSP constitutes a worldview through which individuals, or a society, interpret the meaning of the external world (Pirages and Ehrlich, 1974). Pirages and Ehrlich see the following tenets as central toDSP: beliefs in progress and growth; faith in science and technology; materialism; and a view of Nature as a thing to be dominated by human beings. Values of DSP have evolved and reflect the shifts in human societies from agrarianism to industrialization. However, as industrialization brings prosperity to human society, it also brings along problems such as environmental degradation and natural resources depletion. Pirages and Ehrlich argue for a more realistic, pro-environment worldview to replace the current fundamentally anti-ecological DSP in order to avoid any further ecological catastrophes.

Meanwhile, new emerging ideas like limiting growth, the importance of preserving the balance of nature, the necessity of maintaining a steady, sustainable economy, and the need to reject the anthropocentric notion that nature exists solely for human use all posed a direct challenge to the DSP (Dunlap and Van Liere, 1978). Dunlap and Van Liere (1978) noted that these ideas together represent a systematic new worldview, which they termed the New Environmental Paradigm (NEP; later rephrased as New Ecological Paradigm). In contrast to the DSP, the New Ecological Paradigm makes the assumptions that there are limits to growth and the carrying capacity of the earth, that balance in nature can be easily upset and not quickly remedied, and that nature has its own right to exist rather than primarily for human use (Dunlap and Van Liere, 1978; Dunlap et al., 2000; Albrecht et al., 1982; Nooney et al., 2003). The perspectives about DSP versus NEP paradigms have had a tremendous influence on the development of environmental sociology, and in particular they have laid the fundament for study of environmental attitudes and concern.

To capture the shifting trend in views about the human-nature relationship, Dunlap and Van Liere (1978) introduced a 12-item scale, the first systematic measurement for the degree of acceptance of the two worldviews by the general public. The original NEP Scale consisted of 12 Likert items, measuring three facets of the NEP beliefs: balance of nature, limit to growth, and human domination of nature (4 items for each facet). The Scale was used to study environmental attitudes in the 1980s and has been widely used and treated as a measure of endorsement of a fundamental paradigm or worldview, as well as of environmental attitudes, beliefs, and even values. The first version of the NEP Scale focused on both sociopolitical and ecological domains, as it attempted to measure both DSP and NEP worldviews within the same framework (Dunlap, 2008). A framework of social-psychological theory was essentially missing at the creation of the Scale (Dunlap et al., 2000).

Over the years, the Scale has been revised several times and in the year of 2000, Dunlap et al. (2000) published a latest 15-item version of the revised NEP Scale. The revised Scale taps a wider range of ecological worldviews and two new facets were added. Based on Catton and Dunlap's argument about a human exemptionalism paradigm (1980), items measuring the degree to which respondents feel modern industrial society is exempt from ecological constraints were added. Also, in response to the growing awareness of global environmental problems, the authors added items dealing with the likelihood of eco-crises. Further, the authors addressed the unbalanced structure of pro- and anti-NEP items in the original version, making eight of the items worded as pro-NEP and seven anti-NEP. Every single facet was measured with items worded in both directions. While the original Scale used "strongly agree", "mildly agree", "mildly disagree", and "strongly disagree" response options for each item, in the revised version a neutral option of "unsure" was added to the options in order to avoid a forced, explicit position. The latest version of the Scale is solely aimed at measuring the degree of endorsement of an ecological worldview instead of mixing the measurement of both DSP and NEP in a single survey.

Since its first publication, the NEP Scale has been widely acknowledged as one of the most reliable multiple-item scales to measure people's beliefs towards the natural environment within quantitative research (Stern et al., 1995; Schultz and Oskamp, 1996). Since its 2000 revision, the NEP Scale has become the most widely used measure of environmental concern in the world and has been employed in hundreds of studies in dozens of nations (Dunlap, 2008). The NEP Scale has provided a very useful measurement for studying environmental attitudes, beliefs, concern, and the ethical positions on human-nature relations.

Organization of Dissertation

The primary goal of this dissertation is to find factors which help explain perceptions of water quality. The research conducted to answer this question is presented in three separate papers, each of which focuses on different aspects of this question. In chapter two, the first paper examines water quality perceptions and related issues in the Heartland Region. In the four-state Heartland Region (Iowa, Kansas, Missouri, and Nebraska) a dominant industry is agriculture, which is also a major source of NPS pollution (Ribaudo et al., 1999). This paper looks at the differing views of urban, rural non-farm, and farm residents regarding water quality. In chapter three, the second paper expands the scope of water quality perceptions to include thirty-six states of the US Many of the previous studies on water quality perceptions have been based on the assumption that responses are independent from one another. Recent findings, however, suggest that perceptions and attitudes about specific natural features are in fact related across space (Brody et al., 2004). Chapter three presents a multilevel modeling approach to studying the perceptions about water quality. The purpose of this chapter is to take into account the effects of location and natural and social settings of the states and use them to explain between-state variations in water quality perceptions. Chapter four, the third paper, focuses on non-substantive responses in water quality surveys. Non-substantive responses, responses of "don't know" and "no opinion" can reveal valuable insights about citizens' awareness and knowledge about their water quality. Finally, a chapter of general conclusion (chapter five) summarizes all three studies and gives suggestions for future research.

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Chapter Two Midwestern Residents' Perceptions of Water Quality

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Zhihua Hu and Lois Wright Morton

Abstract

The plurality of conservation and environmental viewpoints often challenge community leaders and government agency staff as they seek to engage citizens and build partnerships around watershed planning and management to solve complex water quality issues. The U.S. Midwest Heartland region (covering the states of Missouri, Kansa, Iowa, and Nebraska) is dominated by row crop production and animal agriculture, where an understanding of perceptions held by residents of different locations (urban, rural non-farm, and rural farm) towards water quality and the environment can provide a foundation for public deliberation and decision making. A stratified random sample mail survey of 1,042 Iowa, Kansas, Missouri, and Nebraska residents (54% response rate) reveals many areas of agreement among farm, rural non-farm, and those who live in towns on the importance of water issues including the importance and use of water resources; beliefs about water quality and perceptions of impaired water quality causality; beliefs about protecting local waters; and environmental attitudes. With two ordinal logistic models, we also found that respondents with strong environmental attitudes have the least confidence in ground and surface water quality. The findings about differences and areas of agreement among the residents of different sectors can provide a communication bridge among divergent viewpoints and assist local leaders and agency staff as they seek to engage the public in discussions which lead to negotiating solutions to difficult water issues.

Keywords: water quality perception; environmental attitudes; urban-rural differences

Introduction

The engagement of citizens in solving complex and persistent environmental issues such as water quality is value driven and influenced by beliefs about and perceptions of water resource issues. A number of scholars and practitioners suggest that environmental problems can be effectively addressed when scientific knowledge is linked to local knowledge and public deliberation [1-4]. The goal of convening diverse sectors of residents with a plurality of views is productive public discussions that lead to practical and positive actions [5]. However, fundamental differences in environmental ideologies can easily sidetrack conversations and result in polarized positions that paralyze community decision making [6]. Differences in experience with and knowledge about water also lead to further divergence in positions. A first step in creating effective place-based deliberations is to understand people's general knowledge, awareness, and beliefs about water, discovering agreement as well as differing viewpoints. This information can provide a foundation for negotiating differences and building common ground that can motivate cooperative environmental planning to improve water quality [7].

The scientific community has documented that the U.S. Midwestern agricultural land practices are significant sources of non-point source (NPS) pollution in the Mississippi drainage basin [8]. However, without citizen acknowledgement of water quality problems and perceptions that there is some urgency to the environmental degradation, it will be difficult to mobilize responses and change practices. In this research we explored the extent to which farm, rural non-farm, and urban residents agree and differ on the importance of water quality, water pollution causality, responsibilities for solving water problems, and global views on the environment in general. The research focused on residents of four states (Iowa, Kansas, Missouri, and

Nebraska), where agriculture is a dominant industry. We propose that place of residence and environmental viewpoints are associated with how water quality issues are perceived.

Materials and Methods

Watershed and Place-Based Environmental Management

Kemmis, in *Community and the Politics of Place*, proposed that place has a way of "claiming" people, of holding diverse kinds of people together [9]. Emergence and development of community and place-based collaborative partnerships such as watershed associations in the U.S. since early 1990s give support to Kemmis' argument. In this kind of collaboration, participation is open to individuals of diverse background. The collaboration process emphasizes communal learning, trust building, public engagement and joint implementation [5,10]. Place-based environmental management efforts are directed at convening people with a stake in a shared problem. The intent is to concretely identify and solve the natural resource problem through cooperation and negotiation. The umbrella of common concern for a specific, local environmental issue offers people with diverse knowledge and ideologies an opportunity to compromise their differences in worldview and experience and agree to assess actual ecosystem conditions. The search for scientific facts fueled by public beliefs and perceptions becomes the foundation for environmental planning. The US Environmental Protection Agency (US EPA) and many other government agencies have endorsed and offered funding to new partnership arrangements in the hopes that they can do what government has been unable to fully accomplish [1].

Central to an effective place-based effort is the recognition that local citizens and different sectors within a society come to public discussions with their own knowledge and ideology about natural resources, their functions and value. The challenge for local leaders is to channel or constrain behaviors while keeping communication open [11]. The beliefs, attitudes and knowledge that different sectors of residents bring to public conversations about non-point source pollution and water quality is particularly relevant to developing solutions.

Understanding Water Quality Perceptions

General environmental attitudes are the basis of perceptions and attitudes towards specific environmental issues. On an individual level, personal norms and beliefs influence how people approach the natural environment, and on higher levels cultures, social norms, and political paradigms influence the way societies interact with nature [6]. Study of water quality perceptions, therefore, starts with understanding about people's general attitudes towards the environment.

Residents' experiences with their natural resource base influence their ways of framing the human-nature relationship. The New Ecological Paradigm (NEP) scale has been used over the last 30 years to document the general public's worldviews on how they feel about nature and the environment and the extent to which American beliefs are shifting [12-17]. Previous studies of the environmental worldview scale reveal that U.S. urban populations are more likely to have higher levels of environmental concern compared to rural and suburban counties outside the Standard Metropolitan Statistical Area (SMSA) [13,18].

A number of explanations for differences between rural and urban environmental world views have been posited. These include theories that urban environmental degradation is more visible; rural people, especially people who are engaged in natural resources extracting occupations, have utilitarian orientations and; small-town residents have a pro-growth orientation [19-20]. The residence effect is also found to be significant in water quality perceptions.

According to Tomazic and Katz [7], rural people generally rated the potential sources of pollution (including hazardous waste landfills, factories, solid waste landfills, mining, timber harvesting, crop farming and animal production) to be less of a threat to water quality than urban and small town residents. In particular, rural views of farming and timber harvesting as sources of pollution were significantly lower than the other two groups, whereas small town respondents showed a large concern with pollution from crop farming due to agrichemicals in municipal supplies.

Although differences in residents' views and concerns about water quality may result in different priorities when building partnerships between different sectors, such differences also lead to an opportunity of open discussion about water quality issues and may bring in valuable local knowledge to an integrated approach to solving water problems.

Local Knowledge about Water

Non-scientific, subjective knowledge has historically been dismissed by many scientists and natural resources managers as of little value [21]. Local knowledge was viewed as unacceptable, and incompatible with scientific knowledge or expertise. Chambers (1980) observed that "the most difficult thing for an educated expert to accept is that poor farmers may often understand their situations better than he does. Modern scientific knowledge and the indigenous technical knowledge of rural people are grotesquely unequal in leverage. It is difficult for some professions to accept that they have anything to learn from rural people, or to recognize that there is a parallel system of knowledge to their own which is complementary, that is usually valid and in some aspects superior" [22].

In recent years, however, mainstream scientists, especially social scientists, are starting to change their evaluation about the nature and status of Western science, in recognition that there are other ways of knowing the world in addition to the positivist ones [23]. More and more scholars have acknowledged the potential of local knowledge in their research on agricultural decision making [24], fisheries management [25-26], environmental justice [27], wetland rehabilitation [28], and so on. Local knowledge is increasingly credited as an important as well as reliable information source to supplement scientific knowledge.

A rising trend of environmental movement and place-based environmental management practices further gives weight to local knowledge and non-expert involvement in decision making. Water management and other environmental planning programs have been designed and developed to encourage involvement of local affected stakeholders and residents in the agenda-setting, decision-making, monitoring, and enforcement activities [11]. Participation of ordinary citizens and their subjective knowledge about the environment can often help in complex decisions about social and environmental problems [29].

Research Questions and Hypotheses

According to Cheng's proposition [5], people's perceptions and evaluations of the environment are expressions of place-based self-identity. In this research we explored the water quality perceptions among three groups: Midwestern farmers, rural non-farmers, and urban people, to discover the effect of residence on the evaluations and perceptions of water quality. Of course drinking water as an important source of life is viewed as important by all people, but as water takes different forms, functions, and uses, its importance is also viewed differently. Therefore, in this study, we first assessed the degree to which different groups value different types of water resources. Then we looked at different sources of pollution and how urban, rural non-farm, and farm people perceived those sources to be affecting their local water. Next, we examined the parties that people think should be responsible for protecting water, and their self-reported actions and behaviors regarding water and the environment in general. Finally, we used an ordinal logistic model to examine the effect of residence and general environmental attitudes on water quality perceptions. Based on the literature about environmental views, we hypothesized that a person with stronger pro-environment attitudes is more likely to have negative assessment of the quality of natural resources such as water. Also, due to the differences in orientations towards the environment [19-20], we hypothesized that urban and rural non-farm residents have lower perceptions about the quality of local water than farmers.

Methodology

Data on perceptions of water quality in the four U.S. states (Iowa, Kansas, Nebraska, and Missouri) were collected using a state stratified random sample mail survey conducted by University of Idaho from February to April 2006. The survey was part of a national USDA 406 Water Quality project asking about citizens' beliefs and attitudes about water [30]. Data were made available to the authors for state and regional analyses. In each state, residents were randomly selected from phonebooks. Each state was allocated 200 surveys for a base population of 500,000 people. Then, for every 250,000 people in addition to the base population, 25 more surveys were added [31]. An additional 10% was added to the final total number of sample calculated for each state to account for bad addresses. State population numbers were based on July 1, 2005 U.S. Census estimates (rounded to nearest 10,000) of the current population in each of the Heartland states. Surveys were mailed to 1,925 randomly selected residents using the Dillman four-stage mail survey methodology [32]. A total number of 1,059 surveys were completed, the overall response rate being 54% with a low of 48% (Missouri) and high of 64% (Nebraska). The 10 page survey booklet (approximately 8.5" × 5.5") consisted of 38 closed end questions and took about 15–20 minutes to complete.

Two types of analyses are reported in this paper. The first is analysis of variance (ANOVA) to discover significant differences among urban, rural non-farm, and farm respondents. Variables examined include perceptions of the importance and use of water resources; beliefs about water quality and perceptions of impaired water quality causality; beliefs about protecting local waters; and environmental views. For results with significant statistical differences, Bonferroni post-hoc tests were conducted to further examine pair comparisons of the three residential groups. In the second part of the analysis, we focus on the perceptions of surface and ground water quality and use two ordinal logistic models to test the hypothesized relationships between environmental attitudes, residence, and water quality perceptions. For the purpose of better clarity, the variables used for both analysis and explanation about their measurements are explained together with their findings in the next section.

In the original questionnaire, all the perception questions had an option of “Don’t Know/No Opinion” for respondents to choose. While these responses can offer important signals of respondents’ lack of awareness on the subject matter, the analysis of these non-substantive responses are removed from the analysis and not included in this study.

Results

Almost 70% of respondents self-reported living inside town or city limits (Table 1). These responses were classified as urban regardless of town size. About 23% lived in rural areas but are not farming and 7.6% reported living on a farm [33]. A little more than a quarter (26.3%) lived in towns with less than 3,500 people; 11.6% lived in towns with populations of 3,500 to less than 7,000; 15.4% lived in towns with populations of 7,000 to less than 25,000; and 21.7% lived in towns of 25,000 to less than 100,000. The remaining 25% lived in a community with population more than 100,000. The average age of the respondents was 56.54, with standard deviation 15.97 (median age being 55 years). Mean educational level was some college or vocational training. About seven percent of all respondents had less than high school education, 23% of them were high school graduates, 32% had some college or vocational training, another 23% were college graduates, and 15% had advanced degrees. 65% of the respondents were male, and 35%.

Analysis of Variance

Perception of water resources. Respondents were presented a list of ten water issues and asked to rate each using a scale of 1 to 4 (1 = not important, 2 = somewhat important, 3 = very important, and 4 = extremely important). These questions identified a variety of functions and uses of water resources. Variations among urban, rural non-farm, and farm respondents' views on importance were significantly different in three of the issues: clean rivers and lakes, water for recreation, and water for aquatic habitat (fish, ducks, *etc.*) (Table 2). All three groups attached importance (somewhere between 3 = very important and 4 = extremely important) to clean rivers and lakes, with the mean scores being 3.42 (urban), 3.44 (rural non-farm), and 3.23 (farm). Although mean differences appear to be small, the effect sizes associated with each pair comparison respectively show that the differences between farm and urban and farm and rural non-farm were statistically significant.

Water for aquatic habitat was valued significantly more by urban and rural non-farm residents than farm respondents. The mean for farmers is 2.89, while the mean scores for urban and rural non-farm residents are both 3.22. This represents a difference between beliefs that aquatic habitat was "somewhat" *versus* "very" important. Rated of lesser importance for all groups was water for recreation with the urban group having the highest mean score (2.78), closely followed by rural non-farm (2.72), and then the farm group (2.45). All mean scores fall between 2 (somewhat important) and 3 (very important) with farmers having significantly lower perceptions towards water for recreation than both non-farm groups.

Responses on seven other questions are not significantly different. The overall mean scores for those questions are listed as follows: clean drinking water (3.82), clean ground water (3.54), water for household private sector (3.54), water for municipal use (3.32), water for agriculture (3.20), water for power generation (3.00), and water for commerce/industry (2.99). Overall, this suggests the three groups were more likely to agree than disagree on the importance of different water functions. Potential areas of conflict and negotiation may be public investments in recreation and aquatic habitat remediation and even these differences were small.

Perception of water quality and knowledge of causality to water quality problems. Perceptions of the quality of ground and surface water offer insight into beliefs about to what extent water quality is perceived to be a concern or not. Respondents were asked to evaluate their local water quality. Responses were grouped into three categories, 1 = poor, 2 = fair, and 3 = very good/excellent. Overall, all three groups viewed ground water quality as fair, closer to poor rather than good. Urban respondents gave the lowest score (2.20) to their ground water quality with rural non-farm and farm both increasingly evaluating their water higher (2.38). As shown in Table 3a, beliefs about ground and surface water quality differed significantly between urban respondents and rural non-farm residents.

Differences in perceptions of surface water quality are significant between farmers and residents in cities. The farm group rated surface water quality as “fair” (2.12) while both the urban group (1.88) and the rural non-farm group (1.96) gave a lower rating. Mean differences among the groups are more pronounced with surface water than with ground water ratings, although both are well within the moderate effect range for Cohen’s d test of significant difference. This may signal that public water quality conversations around surface waters could be more contentious than ground water and lead to discussions about whether the situation is more or less “fair” *vs.* “poor” and needing urgent attention.

Respondents were asked whether they knew or suspected eleven conditions which scientific data show can affect water quality were sources of problems where they lived. Possible responses were 1 = know it is not a problem, 2 = suspect it is not a problem, 3 = suspect it is a problem, 4 = know it is a problem. Urban, rural non-farm, and farm residents’ perceptions significantly differed on 7 conditions (Table 3b). In general, urban respondents were significantly more likely to suspect agriculture-related conditions were affecting local water quality compared to farm respondents. They reported suspecting fertilizer/nitrates (2.80), pesticides (2.80), and animal waste (2.55) to be a problem. Rural non-farm respondents were on the fence regarding whether they suspected a problem or not (2.66, 2.58, and 2.44 respectively). Farm residents were more likely to rate those conditions as not a problem (2.52, 2.20, and 2.09 respectively). The greatest differences in perceptions are associated with farm vs urban assessment of pesticides affecting water quality in their area (Cohen’s d = 0.81).

Industry-related factors like pharmaceuticals and petroleum were generally suspected to be less of a problem by all three groups (all means below 2.50) (Table 3). Although means are close, statistical results show that urban respondents were more likely to be concerned about these conditions than the other two groups.

The three groups’ views differed on several other specific factors in addition to the two broad categories of agriculture and industry-related conditions. For example, urban respondents showed more concern with heavy metals than farmers (Table 3).

In a separate set of questions, respondents were asked to identify up to three factors which they thought were most responsible for the existing pollution problems in rivers and lakes in their state or territory. The responses were recoded as 0 = no and 1 = yes. The mean score of each question reflects the percentage of respondents who chose "yes" to that factor (Table 3). All groups raised higher concern with agriculture factors than other factors, livestock/poultry operation in particular. However, the three groups did not agree on how "responsible" crop production was for water pollution in their states. Significant (but small effect, Cohen's d = 0.22) difference is found between urban and rural non-farm respondents regarding their perceptions of crop production as a responsible factor for water pollution. Rural non-farm respondents are significantly more likely than urban respondents to identify road/construction erosion and septic systems to be factors most responsible for existing pollution in their area. The percentages of these positive responses are far from being majority, though.

Beliefs about the water protection responsibility. Significant differences exist in respondents' perceptions of who should be most responsible for protecting local water quality (Table 4). Urban and rural non-farm respondents tended to believe that local government (including governments at county, city, and town levels) should take the most responsibility in protecting local water quality. However, among farm respondents, 42% of them chose individual citizens as the most responsible parties for local water quality protection. Only 8% of urban and 17% of rural non-farm respondents believed that individual citizens should be most responsible to protect local water quality. These responses represent the largest mean differences (with Cohen's d tests registering moderate and strong effects ranging from −0.30 to −1.13) among these groups of any of the other survey items.

Urban respondents tended to rate their local government (county, city, and town government) as protecting water quality very well. The majority of rural non-farm and farm groups also shared a positive view on this point, but not as strongly compared to the urban group. A majority of farmers (66%) considered individual citizens' efforts in protecting water quality as being done very well. This is a significantly different viewpoint compared to urban and rural non-farm respondents.

With a rating of 1 to 3, with 1 = too much emphasis, 2 = right amount of emphasis, and 3 = not enough emphasis, respondents were asked to rate the emphasis that local government is giving to the environment. Both urban and rural non-farm residents tended to believe that local government was not giving enough emphasis to the environment. Farmers, however, tended to consider that the emphasis was about the right amount. These differences can affect public discussions about whether additional public dollars should be invested into solving environmental concerns.

General environmental attitudes and and actions. The respondents were presented a visual line representing a continuum of environmental attitudes and asked how they saw themselves on environmental issues. The line represented a 1–10 scale with 1 = totally natural resource use and 10 = totally environmental protection, and respondents were asked to place a mark on the line to show their position. Marks on the line were evaluated and scored according to the closest increment on the scale. Table 5 summarizes how respondents rated themselves on the environmental view continuum. All three groups fall in the mid-range of the two extremes, suggesting moderate views by most respondents. However, there are statistically significant differences among them with the urban and rural non-farm residents selfreporting mean scores of 5.76 and 5.65, respectively, compared to the farm group's lower mean of 5.04.

Water monitoring is often an activity that local watershed groups undertake. Some states have active voluntary citizen water monitoring programs supported by state agency training and staffing. A number of farmer watershed groups engage in voluntary water monitoring in order to confirm or disprove state assessments that place their watershed on EPA impaired water (303d) lists and to identify places in their watershed which need targeting of conservation practices [35]. In the survey questionnaire, respondents were asked if they were participating or had ever participated in volunteer water quality monitoring. Participation in volunteer water quality monitoring activities in the farm was relatively high—13%. For rural non-farm and urban residents, the participation rates were generally lower—4% for rural non-farmers and 2% for urban respondents, respectively. Farmers are significantly more active in monitoring their local waters than the other two groups.

Water Quality Models

ANOVA comparisons among urban, rural non-farm, and farm mean responses evidence a generalized pattern of urban respondents most likely to give water quality problems and causes the highest ratings of concern, followed by rural non-farm and then farm. To test the association between environmental views and assessments of water quality, two ordinal logistic regression models are proposed (Table 6). The dependent variables studied are perceptions of surface and ground water quality, respectively (1 = poor, 2 = fair, 3 = good/excellent). The predictor variables of primary interest are environmental attitudes (1–10 scale) and residence (urban, rural non-farm, and rural farm). Four additional variables, gender, age, education and community size are included as control variables.

In an ordinal regression, the dependent variables are ordinal categorical, which means although the real distance between categories is unknown the categories follow a certain ordering which makes it different from a nominal variable in nature. In the case of surface and ground water quality perceptions, we are assuming that the three categories of responses from lowest (poor) through medium (fair) to highest (good) follow a strictly ascending order.

In both models, the event of interest is observing a certain perception score or less. A theoretical explanation about the models is given by the following equations:

$$\theta j = \text{prob (score} <= j)/\text{prob(score} > j)$$

$$\ln(\theta j) = \alpha j - \beta X \text{ (where } \beta \text{ and X are vectors)}$$

Although it is difficult to explain relationship between independent variables and the dependent values in a straightforward way, from the above equation, we can see that if β (location) takes a positive value, then as the value of X increases, the value of ln(θj) decreases, which means that the probability of higher scores are greater than lower ones. On the other hand, if β takes a negative value, the probability of lower scores is greater [36]. There is one α value (threshold) for each category of the dependent variable. They are much like intercepts in the ordinary least squares regression.

The relationships between our explanatory variables and water quality perception values are presented in Table 6. The coefficients associated with environmental attitudes in both models are negative, which suggests that if other variables are held constant, a respondent with higher value in environmental attitudes (more pro-environmental views) is more likely to give a lower rating for both surface and ground water quality. The coefficients are significantly different from zero in both models.

Residence is a factor variable which takes three values: city, rural non-farm, and rural farm. In order to avoid singularity in matrix calculation, the last category in all factor variables is automatically set to be zero. Therefore, in the case of residence, the farm group is set to be the reference. When everything else is equal, urban residents are more likely to give lower ratings to their surface water quality than rural farm residents (coefficient different from zero at the .05 significance level). Although rural non-farm residents tended to give lower ratings to their surface water quality than rural farm residents, the differences found between these two groups were not as significant (p-value 0.067). For ground water quality, urban residents tended to perceive ground water to be of lower quality than farmers, while rural non-farmers tended to share the same perceptions about ground water quality with rural farmers (coefficient not significantly different from zero).

When other variables are controlled, there is no significant difference in both surface and ground water quality perceptions between residents from communities of various sizes. Coefficients associated with age are positive, which suggests that older respondents were more likely to hold significantly positive perceptions about both ground and surface water quality than younger respondents. In addition, when everything else is equal, female respondents were more likely to give lower ratings to their ground water quality (at significance levels of 0.002) than male, but their perceptions about surface water quality were basically the same as their male counterparts. People with higher educational levels tended to rate their surface water quality higher, but there was no significant difference with ground water quality.

Several statistics can be used to measure the strength of association between the dependent variables and explanatory variables, although the interpretation of these statistics is not as straightforward as the R-squared in ordinary linear regression [37]. Cox and Snell pseudo

R^2 is 0.090 for the surface water quality model and 0.097 for the ground water quality model. Nagelkerke pseudo R^2 is 0.122 and 0.115 for the two models respectively. Both models have a large observed significance level for goodness-of-fit measures (0.514 and 0.391), which suggests a good model fit. For both models, the slopes are parallel for different categories of the dependent variables, which meet the underlying assumptions for ordinal regression models.

Discussion

Our data reveal that urban, rural non-farm, and farm populations in the Heartland Region have many common views regarding their waters. These different groups agreed on the importance of clean drinking water, clean ground water, water for households and private sectors, and water for agriculture and industry. This suggests they could build a common watershed agenda around these issues. The greatest differences between farm and non-farm respondents were found in perceptions of water quality conditions, causes of water impairment, and responsibility for solving water problems. Urban respondents were more likely to have negative views about their ground water quality conditions. Farmers and the non-farm rural respondents both gave a significantly higher rating to their ground water, although the means of all the three groups were within the range of “fair”. The differences shown with surface water quality is more significant. Farmers’ perception of their surface water was moderately higher than that of rural non-farm residents and significantly higher than that held by urban residents. These perceptions could lead to differences regarding whether any actions are needed and how urgent it is to respond to water issues. There was general agreement that agriculture-livestock, agriculture-crops and wastes from urban areas were top sources of water problems. In agreement with Tomazic and Katz’s findings in 2002, we also found that urban respondents were much more likely than farmers to see agriculture as the cause and conversely farmers were more likely to see wastes from urban areas as an important pollution source. The self-reported concern about local and state agricultural and industrial conditions could be useful in locating the causes of water quality problems. Nevertheless, agriculture related practices and conditions were rated higher to be a responsible factor affecting water quality by all the three groups. Residents of all places seem to share a bigger concern about agricultural conditions such as fertilizer/nitrates, pesticides, animal wastes, etc, and the difference is only about how serious and to what extent.

One important obstacle to building rural-urban watershed coalitions is the differences in expectations for who is responsible for solving water problems. This suggests that acceptable solutions to water issues and decisions about who will implement them may require more public dialogue and negotiation than other issues. Urban residents believed it is governments at all levels responsibility to protect the environment. This translates into social interventions such as laws, regulations, and requests for monitoring and enforcement agencies.

Farmers believed individuals should be most responsible for protecting the environment not government. Many farmers are likely to advocate voluntary actions rather than legislative ones [36]. The higher percentage of participation in water monitoring suggests significantly different experiences that farmers and non-farmers have with their local water. Previous research finds Midwestern farmers believe they are good stewards of their land and water resources [38] and reaffirms the perceived role of the individual farmer in environmental protection. This belief has found expression in farmer participation in government funded conservation programs and voluntary implementation of conservation practices on their own lands.

Our logistic regression models confirmed general environmental attitudes and place of residence to be significant factors predicting water quality perceptions. We found that both urban and rural

non-farmers tended to give lower ratings to their surface water quality when compared to farmers. On the other hand, more pro-environmental views are associated with worse water quality perceptions, which suggests that regardless of farm or non-farm status, people with stronger beliefs about the environment needing to be protected rather than used are more likely to perceive there is a problem with water quality conditions and that more efforts should be put to address the problem.

There are several limitations to this study. A ten point continuum was used to represent environmental views ranging from total natural resource use to total natural resource protection. This conceptually aligns with items in the NEP scale which focus on the belief that nature has its own right to exist rather than primarily for human use. The authors recognize that this single question is insufficient to fully represent environmental attitudes. The 12- or 15-item version of NEP Scale might provide a more comprehensive measurement for environmental worldviews [15,39]. However, space limitations in the water quality survey prevented the use of either the 12 or 15 item NEP scale.

Secondly, the response rate is moderate (overall 54% return rate). In the mailed survey, it was specified that the addressee or any adult in the household could respond to the survey questions. Our sample ended with more male respondents (65%) than female (35%). Our sample, compared with the general population in the four states, also included more rural farmers and non-farm residents [40]. Some of the population is possibly missing out by the sample and the views and opinions held by those who did not respond to the survey may not be accurately reflected in the sample. Future researchers might consider mixed-mode surveys using multiple survey methods to achieve higher response

rate [41], or stratified samples to collect views of target groups.

Another limitation is the narrow variations in means among farm and non-farm respondents on many of the items. Mean differences were often between degree of importance rather than important versus unimportant. The distributions on most items were normal with the full range of responses. It is not clear if small mean differences are true difference or an artifact of large sample size, cultural homogeneity within the Heartland region and/or the way questions were worded. Future research will examine the same questions from similar surveys in other regions of the U.S. to discover if these responses are cultural or regional in nature.

Conclusion

The causes of water and other environmental resources problems are often complex and their solutions may require involvement of citizens from different residential sectors. In addition, in place-based environmental planning process, it is sometimes challenging to find a way to reconcile different or even competing concerns in a single planning decision. However, despite the differences, as our study findings show there are common concerns and agreements which can be utilized in future water management decisions. There is growing recognition that environmental destruction is everyone’s concern [42], and our research confirms that all parties believe that water quality issues are important. Agreements and disagreements about the environment among farmers, rural non-farmers, and urban residents is one of degree. Urban residents and farmers may disagree whether the environment should be totally protected or its value is in its use and applications to agriculture. However, in the Heartland, there seems to be sufficient shared concern about local water bodies that a common agenda for protecting local waters is possible.

To engage citizens of all places and get them to change practices, watershed groups should develop a deliberative process, which not only enables wide participation but also respects diversity and difference. These groups must understand the decision processes of their participants and find leverage points that gain their attention. Educators and regulators must start where people are in their belief systems in the development of concrete interventions to prevent abuse and protect nature. Social viewpoints on the environment are based on population "experience, embedded in values, and related to actual behavior" [13 (p. 389)]. Farmers' daily interactions and experiences with soil, water, plants, and animals are quite different than those of rural non-farmers, rural small town residents, and urban dwellers living in more population dense places. And because of the all-agreed agricultural factors in affecting water quality, engagement of farmers' efforts in the Midwest watershed approach is especially important.

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Tables

Table 1. Sample Descriptions.

Variable (Sample size)	Description	Mean/Percentage	S.D.
Residence (N = 997)	Inside city limits;	69.8%	
	Outside city limits but not on a farm;	22.6%	
	Outside city limits and on a farm	7.6%	
Community Size (N = 981)	1 = less than 3,500 people;	26.3%	
	2 = 3,500 to 7,000 people;	11.6%	
	3 = 7,000 to 25,000 people;	15.4%	
	4 = 25,000 to 100,000 people;	21.7%	
	5 = more than 100,000 people	25%	
Age (N = 983)	Age of respondents	56.54 (median = 55)	15.94
Gender (N = 997)	0 = female, 1 = male	0.65	0.48
Education (N = 982)	1 = less than high school; 2 = high school graduate; 3 = some college or vocational training; 4 = college graduate; 5 = advanced degree	3.16	1.14

Table 2. Comparisons of differences among urban, rural non-farm and farm perceptions of water resources [a].

	Group	N	Mean (Standard Deviation)	F-statistic	Bonferroni post hoc test [b] (Cohen's d [c])
How important are clean rivers and lakes? [a]	Urban	662	3.42 (0.58)	3.595	Farm (0.33)
	Rural non-farmFarm	216	3.44 (0.60)		Farm (0.36)
		73	3.23 (0.60)		
How important is water for recreation? [a]	Urban	581	2.78 (0.78)	4.831	Farm (0.42)
	Rural non-farm Farm	184	2.72 (0.85)		
		62	2.45 (0.86)		
How important is water for aquatic habitat (fish, ducks, etc.) [a]	Urban	619	3.22 (0.70)	7.304	Farm (0.46)
	Rural non-farm Farm	205	3.22 (0.68)		Farm (0.46)
		72	2.89 (0.83)		

[a] 1 = not important; 2 = somewhat important; 3 = very important; 4 = extremely important

[b] The categories shown below are the ones that show significant differences (at 0.05 level) from the group being considered. The same meaning also applies for the pairwise comparisons in the following tables.

[c] Cohen's d shows effect size for the difference between two means. Basicially the value is calculated by dividing the difference between the two means with the standard deviation (or pooled standard deviation). Usually a Cohen's d of 0.20 means small effect, 0.50 is moderate effect, and 0.80 is large effect. Practically, a Cohen's d falling in between 0.25 and 0.50 is considered significant [34]. The signs associated with the value just indicates whether the difference is positive or negative.

Table 3. Comparisons of beliefs about water quality and perceptions of causality among urban, rural non-farm and farm.

		N	Mean (S.D.)	F-statistic	Bonferroni post hoc test (Cohen's d)
What is the quality of ground water (sources of well water) in your area? [a]	Urban	431	2.20 (0.60)	6.627	Rural non-farm (−0.30)
	Rural non-farm	174	2.38 (0.64)		
	Farm	72	2.38 (0.57)		
What is the quality of surface water (rivers, streams, lakes) where you live? [a]	Urban	555	1.88 (0.47)	8.844	Farm (−0.51)
	Rural non-farm	182	1.96 (0.46)		
	Farm	65	2.12 (0.48)		
Do you know of/suspect that fertilizer/nitrates affect water quality in your area? [a]	Urban	420	2.89 (0.74)	8.098	Rural non-farm (0.30); Farm (0.49)
	Rural non-farm	140	2.66 (0.89)		
	Farm	52	2.52 (0.87)		
Do you know of/suspect pesticides affect water quality in your area? [b]	Urban	384	2.80 (0.73)	13.698	Rural non-farm (0.28); Farm(0.81)
	Rural non-farm	124	2.58 (0.90)		Farm (0.43)
	Farm	44	2.20 (0.82)		
Do you know of/suspect animal waste affects water quality in your area? [b]	Urban	359	2.55 (0.74)	8.238	Farm (0.62)
	Rural non-farm	126	2.44 (0.94)		Farm (0.40)
	Farm	55	2.09 (0.73)		
Do you know/suspect that pharmaceuticals (antibiotics, personal care products) affect water quality in your area? [b]	Urban	281	2.23 (0.71)	6.532	Rural non-farm (0.33); Farm (0.46)
	Rural non-farm	116	1.99 (0.79)		
	Farm	41	1.90 (0.77)		
Do you know/suspect petroleum products from leaking tanks, oil spills affect water quality in your area? [b]	Urban	364	2.28 (0.78)	6.072	Rural non-farm (0.30)
	Rural non-farm	129	2.04 (0.84)		
	Farm	48	2.00 (0.88)		
Do you know of/suspect heavy metals (lead, arsenic) affect water quality in your area? [b]	Urban	303	2.45 (0.79)	5.065	Farm (0.49)
	Rural non-farm	111	2.26 (0.77)		
	Farm	33	2.06 (0.86)		

Table 3. Comparisons of beliefs about water quality and perceptions of causality among urban, rural non-farm and farm (Continued).

Is agriculture/crop production one of the most responsible factors for existing pollution problem in rivers and lakes in your state? [c]	Urban	694	0.45 (0.50)	4.293	Rural non-farm (0.22)
	Rural non-farm	225	0.34 (0.48)		
	Farm	76	0.38 (0.49)		
Is agriculture-livestock and/or poultry operation one of the most responsible factors for existing pollution problem in rivers and lakes in your state? [c]	Urban	694	0.51 (0.50)	2.994	No significant differences
	Rural non-farm	225	0.43 (0.50)		
	Farm	76	0.41 (0.50)		
Is erosion from roads/construction one of most responsible factors for the existing pollution problem in rivers and lakes in your state? [c]	Urban	694	0.18 (0.38)	4.798	Rural non-farm (−0.18)
	Rural non-farm	225	0.25 (0.44)		
	Farm	76	0.29 (0.46)		
Is septic systems one of most responsible factors for existing pollution problems in rivers and lakes in your state? [c]	Urban	694	0.12 (0.33)	3.681	Rural non-farm (−0.20)
	Rural non-farm	225	0.19 (0.39)		
	Farm	76	0.18 (0.39)		

[a] 1 = poor; 2 = poor, but improving; 3 = fair; 4 = good, but deteriorating; 5 = good and improving; 6 = very good/excellent

[b] 1 = know not a problem; 2 = suspect not a problem; 3 = suspect a problem; 4 = know a problem

[c] 1 = yes; 0 = no

Table 4. Comparisons of beliefs about the protection of local waters among urban, rural non-farm and farm.

		N	Mean (S.D.)	F-statistic	Bonferroni post hoc test (Cohen's d)
Local government should be most responsible for protecting water quality in your community [a]	Urban	635	0.44 (0.50)	6.123	Farm (0.43)
	Rural non-farm	211	0.38 (0.49)		
	Farm	69	0.23 (0.42)		
Individual citizens should be most responsible for protection water quality in your community[a]	Urban	635	0.08 (0.27)	36.706	Rural non-farm (−0.30); Farm (−1.13)
	Rural non-farm	211	0.17 (0.37)		
	Farm	69	0.42 (0.50)		Farm (−0.62)
How well are county, city, town governments fulfilling their responsibility for protecting water quality in your community?[b]	Urban	367	0.69 (0.46)	5.585	Rural non-farm (0.34)
	Rural non-farm	115	0.53 (0.50)		
	Farm	35	0.57 (0.50)		
How well are individual citizens fulfilling their responsibility for protecting water quality in your community[b]	Urban	246	0.34 (0.48)	7.830	Farm (−0.67)
	Rural non-farm	91	0.36 (0.48)		Farm (−0.63)
	Farm	41	0.66 (0.48)		
Does the environment receive the right amount of emphasis from local government and selected officials in your state?[c]	Urban	501	2.57 (0.54)	11.282	Farm (0.68)
	Rural non-farm	164	2.52 (0.65)		Farm (0.50)
	Farm	58	2.19 (0.69)		

[a] 1 = yes; 0 = no

[b] 1 = very well; 0 = very poorly

[c] 1 = too much emphasis; 2 = right amount emphasis; 3 = not enough emphasis

Table 5. Comparison of differences in environmental views and actions among urban, rural non-farm and farm.

		N	Mean (S.D.)	F-statistic	Bonferroni post hoc test (Cohen's d)
Environmental View. On scale 1–10, how do you see yourself on environmental issues [a]	Urban	617	5.76 (1.50)	7.573	Farm (0.49)
	Rural non-farm	211	5.65 (1.44)		Farm (0.43)
	Farm	70	5.04 (1.34)		
Are you now participating/have you participated in volunteer water quality monitoring? [b]	Urban	696	0.02 (0.15)	11.595	Farm (−0.62)
	Rural non-farm	225	0.04 (0.20)		Farm (−0.37)
	Farm	76	0.13 (0.34)		

[a] 1 = totally natural resource use; 10 = totally environmental protection

[b] 1 = yes; 0 = no

Table 6. Surface and Ground Water Quality Perceptions: Ordinal Logistical Regression.

		Surface Water Quality			Ground Water Quality		
	Variables	Estimate	Std. Error	Sig.	Estimate	Std. Error	Sig.
Location	Environmental Attitudes (EA)	−0.292	0.062	0.000	−0.210	0.057	0.000
	Residence (ref: rural farm)						
	City	−1.262	0.358	0.000	−0.805	0.288	0.005
	Rural Non-Farm	−0.685	0.373	0.067	0.036	0.299	0.905
	Community Size	−0.053	0.065	0.414	0.048	0.060	0.425
	Age	0.031	0.007	0.000	0.024	0.006	0.000
	Gender (ref: male)						
	Female	−0.310	0.202	0.125	−0.614	0.195	0.002
	Education	0.201	0.087	0.021	0.115	0.080	0.151
Threshold	Perception = poor	−2.456	0.609	0.000	−2.504	0.546	0.000
	Perception = medium	2.244	0.607	0.000	0.713	0.532	0.180
Overall Model	Strength of Association						
	Cox and Snell pseudo R^2		0.090			0.097	
	Nagelkerke pseudo R^2		0.122			0.115	
	Pearson Goodness of Fit		0.514			0.391	
	Parallel Line Test		0.695			0.231	

Chapter Three A Multilevel Approach to Water Quality Perceptions

A paper submitted to Society and Natural Resources

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Abstract

Individuals' perceptions of their water quality can be substantially different from the reality, or different from each other's. Fundamental differences in water quality perceptions can result in different priorities or even polarized positions that paralyze community decision making regarding water issues. Although previous studies on water quality perceptions have found that differences in perceptions are associated with respondents' demographic characteristics, certain gaps still exist in identifying reliable and consistent variables to explain water quality perceptions, the formation of which is a multistage process. This research focuses on identifying both individual characteristics and contextual factors that help explain variations in perceptions about water quality. The findings offer guidance in establishing future effective policy, developing educational programs, and strengthening community engagement in solving water quality problems.

Key words: Water quality perception, environmental attitudes, place of residence, social context

Introduction

Water plays a vital role in the functioning of the Earth's ecosystems, and water pollution can have serious negative effects on all living creatures. Although the quality of water may be objectively quantified with scientific indicators, individuals' perceptions of their water quality can be substantially different from the reality, or different from each other's (Pickens, 2005). Fundamental differences in water quality perceptions can result in different priorities or even polarized positions that paralyze community decision making regarding water issues. In this article the authors identify both individual characteristics and contextual factors that help explain variations in perceptions about water quality. Our findings offer guidance in establishing future effective policy, developing educational programs, and strengthening community engagement in solving water quality problems.

Previous studies on water quality perceptions have found that differences in perceptions are associated with respondents' demographic characteristics such as age, gender, education, and place of residence (Tomazic and Katz, 2002; Williamson et al, 2006; Redfern and Wells, 2007), but no particular study delved into the relationship between general environmental attitudes and water quality perceptions. Furthermore, past studies are mostly based on regional samples. Certain gaps still exist in identifying reliable and consistent variables to explain variation in water quality perceptions for a larger, more general population. The authors proposed environmental attitudes and community size as two variables substantially influencing individuals' perceptions of their water quality. In addition, we argue that since every individual is nested in a geographical location, the individuals' perceptions are subject to the influence from the social and environmental circumstances they live in. We use water survey random samples from thirty-six states of the US, and apply a multilevel modeling method to test contextual effects from states.

Theoretical Framework

Human perception is highly selective and may be limited by the person's existing beliefs, attitudes, motivation, and personality (Pickens, 2005). In this section, we examine a combination of theories which provide insight into the process of developing water quality perceptions. Theories of environmental attitudes, the effect of place of residence, and multistage formation of perceptions are integrated to propose hypotheses.

From a psychological point of view, perception is closely related to attitudes, which are typically defined by three components including feelings, thoughts, and actions (Pickens, 2005). Attitudes could be the evaluation of an object or a person, emotional reactions to the object/person, or internal cognition or beliefs about the object/person. How we see a certain situation and how we choose to behave toward the situation are both defined by our own attitudes (Pickens, 2005).

Another important aspect of this study -- perception, is usually defined as "the process by which organisms interpret and organize sensation to produce a meaningful experience of the world." (Lindsay and Norman, 1977). In other words, when a person is confronted with some situation or stimuli, he or she tends to interpret the situation into something meaningful to him or her based on existing attitudes or previous experience. A person's awareness or acceptance of the situation is highly selective and may be limited by the person's existing beliefs, attitudes, motivation, and personality (Assael, 1995). Because of this selective process, when a group of people are confronted with the same situation, what one person perceives may be substantially different from reality, or from what another person perceives (Pickens, 2005).

The psychological theories about cognition provide important insights to the studies of water quality perceptions. Water quality perceptions can be viewed as a reflection on the physical water conditions, the final product of processing multiple sources of information about water, a result from some general attitudes, or a combination of all above. In this study, we posit that water quality perception is influenced by an individual's general environmental attitudes and a group of social and structural factors.

Water Quality Perceptions and Environmental Attitudes

Environmental attitudes are a collection of evaluative judgments about the use, function, and value of the general environment or certain aspects of the environment. These attitudes range from the view that nature is a resource with specific human-centered uses and functions to the view that nature is at risk and needs human protection from uses and abuses (Buttel and Humphrey, 2002). Environmental attitudes guide individual citizens' and society's interactions with nature. On an individual level, personal norms and beliefs influence how people approach the natural environment while at higher levels cultures, social norms, and political paradigms influence the way societies interact with nature (Lundmark, 2007).

Industrial societies have viewed their natural resource base including water as an asset to utilize for social and economic growth and technological innovation. The emergence of global environmental problems has increased awareness about the interconnectedness of human society and the physical natural environment (Stern, Young, and Druckman, 1992).

Many sectors of post-industrial society have subsequently realized that the unregulated exploitation of the natural resource base endangers not only nature but human society that depends upon it. At the end of the 1970's, with an increasing number of people coming to the recognition that human activities were having huge impacts on the ecosystems, A reevaluation of the US worldview resulted in a rising that a more sustainable form of development may be needed. (Milbrath, 1984; Dunlap and Van Liere, 1978).

Like the case of general environmental attitudes, the US government and its citizens' understanding about the water quality conditions and their approaches to addressing water problems have also gone through many changes ever since the 1970's. Water polluted by industries convinced many in society that it was time to restrict exploitation of natural resources, control environmental degradation and start protecting the environment (Mitchell, 1991). With environmental legislation and economic sanctions, the government has played a major role in addressing point pollution. However, one problem with water legislations and regulations is that they focus on controlling pollutants after release has been done rather than prevent it from happening. Therefore, this form of regulatory approaches do not work as effectively on controlling non-point source pollution, where the sources of pollution are diffuse rather than stationary (US EPA, 2009). A more effective approach to the water quality issues, therefore, lies in the concerted efforts from the whole society.

Stakeholders in a watershed engaged in decision-making regarding their water often have completely different perceptions of the problem and the prospective solutions because of their different backgrounds, beliefs, environmental attitudes, and experiences with water. Understanding these differences can provide a foundation for developing solutions with greater social acceptability of the need to act and find solutions. In this research we propose to use environmental attitudes as a predictor for water quality perceptions.

Water Quality Perceptions and Place of Residence

The previous section focused on perceptions as individual cognitive mechanism and its relations to environmental attitudes. All the cognitive processes, however, happen in a social setting. In other words, individuals each form their perceptions in a social environment, and hence, their perceptions are not something unconnected to the social systems. Previous studies have identified several important social aspects as having key effects on perceptive and behavioral change, which include social system (Rogers, 1995), social control (Flora, 2004), community attachment (Vorkinn and Riese, 2001; Brehm et al., 2006), civic connections among individuals and communities (Morton and Weng, 2009), and the strength of network ties among individuals (Scherer and Cho, 2003). One important common aspect among these studies is place of residence. A number of studies have focused on the differences between rural and urban residents in their respective environmental views. Various reasons have been identified and hypothesized. These include theories that urban environmental degradation is more visible, rural people have utilitarian orientations, small-town residents have a pro-growth orientation (Freudenburg 1991; Lowe and Pinhey 1982), and that there is a difference in socialization and expectations for solutions to environmental problems (Lowe and Pinhey, 1982).

Furthermore, rural or urban residency also leads to differences in interpersonal relationships and social networks, which is argued to play an important role in risk perceptions (Sherer and Cho, 2003). For example, it is easy to see that the friends of a person in a small, rural community will likely be friends with each other, because there are fewer other potential friends. This generates overlapping neighborhoods and high network closure (i.e. high interconnection), which generate high trust between friends, facilitates cooperation and strengthen mutual perceptions. Despite the similar perceptions, however, its direction can not necessarily be inferred from the enhanced network relations (Scherere and Cho, 2003).

Water Quality Perceptions and General Social/Environmental Context

Beyond interpersonal connections and networks, the general social and environmental context also exerts influence on an individual's perception process. The traditional research approach to studying environmentally related attitudes and behavior has focused on the later stages of the following multistage process. As observed by Kilbourne (Kilbourne el al., 2002), a general model for the formation of environmental attitudes and motivation of behaviors should include the following stages, which are (1) institutional structures, (2) value systems, (3) general environmental beliefs, (4) specific beliefs and attitudes, (5) behavioral commitments, and (6) behavior. Most research to date has focused on the lower levels, more specific stages, particularly (4) and (5), but the earlier stages tend to be omitted. Based on the arguments of Kilbourne and other scholars (Kilbourne el al., 2002; Stern et al., 1995), we propose that the higher stages must be included to adequately model perception differences, and with this research we examine state level social and environmental context and their associations with the formation of individual water quality perceptions.

Research Hypotheses and Multilevel Models

The previous section reviewed the literature on environmental attitudes, place of residence, and multistage process of perception formation, which constitute the theoretical framework for our model to explain the variation in water quality perceptions. In this section, we will specify our research hypotheses and the multilevel models to test those hypotheses respectively.

Multilevel Modeling of Water Quality Perceptions

A multilevel modeling approach reflects the theoretical basis and research hypotheses. That is the assumption that although each individual respondent responds to the water surveys independently, respondents from similar geographical locations share some common social and environmental settings which lead them to similar perceptions. Therefore, the places where they live and their geographical nesting have some random effect on their perceptions, which can be best modeled using multilevel modeling. Multilevel linear modeling (MLM), also known as hierarchical level modeling (HLM), allows variance in the outcome variables to be analyzed at multiple hierarchical levels (Snijders and Bosker, 1999; Tabachnick and Fidell, 2006). An advantage of multilevel modeling is that it allows researchers to introduce higher/contextual level variables to explain lower/individual level propositions without committing ecological error about the data structure (Snijders and Bosker, 1999). In our study, there are two levels of variables we are interested in – individual level, and state level.

Hypotheses

We first hypothesize that variation in perception of water quality comes from two parts – the variation among individuals and the variation among states, meaning that people living in the same state tend to have similar perceptions about their water quality and are more homogeneous in terms of water quality perceptions. People residing in different states, on the other hand, have more heterogeneous perceptions about their local water quality.

The second hypothesis is that on the individual level, perceptions about water quality, as perceptions of all other objects, are product of the cognitive mechanism. Specifically, water quality perceptions are hypothesized to be influenced by individuals' general attitudes towards the environment and their place of residence. It is hypothesized that with socio-demographic characteristics such as age, gender, education, and length of residence in the state being equal, the greater a person's pro-environmental attitudes, the worse the person will perceive the water quality to be. In addition, it is hypothesized that as the community size increases, residents will perceive their water quality to be worse than those living in smaller communities.

At the state level, we hypothesize that the state random effect on their residents' water quality perceptions can be explained by the states' overall geographical, social, and environmental characteristics. Specifically, we hypothesize that the state average water quality perceptions are influenced by the states' population density, average annual rainfall, number of impaired water bodies, and investment on natural resources. The four variables very roughly represent the climate, water conditions, and the general environmental and social conditions of each state. The hypothesis is: the less populous a state is, the better its average water quality perception; the fewer number of impaired water bodies, more annual rainfall, and more investment on natural resources a state has, the better its general water quality perception will be.

Methodology

Study Design and Data Description

Data used for the research were collected through a national survey about water issues conducted by University of Idaho. Because of the wide coverage, the survey is still an on-going process, and in this article, we used completed survey data from thirty-six states of the US, which covered eight of the Environmental Protection Agency (EPA) regions[1]. Data collection was conducted through mailed questionnaires. First of all, sample sizes of each state were calculated based on the state population and targeted sampling error of four to six percent, with anticipation that the return rate exceed fifty percent (Mahler et al., 2010). In each individual state, samples were randomly selected from phone books, and then questionnaires were sent to sampled names and addresses. Any adult in the household could fill out the survey questionnaire. Because states in different regions had different priorities and foci about specific water issues the final questionnaires varied by region in content questions and wording. The length was generally about 50 questions, and some had core questions in common asking about respondents' perceptions of water quality, water use importance, responsible factors for water pollution, sources of information about water, general environmental attitudes, and demographic information are consistent across all regions and states. It is these core questions that are analyzed in this research. Standard mail survey methods as recommended by Dillman (2000) were followed in all the regions and states, and the final result is a total number of 9,332 completed surveys. Response rates ranged from 37% to 70%, with median return rates reaching the targeted 50%.

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[1] The U.S. EPA groups the fifty states into 10 regions based on geography and regional conditions. See attached map (Figure 1) for a visual illustration of the division of EPA regions.

Concepts and Measurements

The dependent variables used for this study were perceptions about surface and ground water quality. Because of some significant differences in the properties of these two types of water (visibility, accessibility, source of information), the two variables were modeled separately rather than being combined together. The two variables were measured in the questionnaire by asking respondents their opinions about the water conditions in their area. Responses were coded 1=poor, 2= fair, and 3=very good or excellent.

The independent variable of most interest was general environmental attitudes. The general environmental attitude represents where an individual stands in terms of human-nature interaction. A well-known measure for a comprehensive system of ecological beliefs and attitudes (New Ecological Paradigm Scale) was first introduced and subsequently revised by Dunlap and Van Liere (Dunlap and Van Liere, 1978; Dunlap et al., 2000). Due to survey questionnaire length limitations, general environmental attitude in this project was measured as a single item rather than a scale with multiple items as suggested by in the New Ecological Paradigm Scale (Dunlap et al., 2000). However, the underlying rationale is similar—to capture the extent to which a person has a pro-anthropocentric (people centered) versus pro-environmental worldview. In the survey, respondents were asked to indicate where they stood on environmental issues by placing a mark on a line with numbers 1 to 10, where 1 represents support for total natural resource use and 10 represents support for total environmental protection with the median point (5.5) representing an equal distant position between the two.

Community size was measured by asking respondents to choose from the options which best described their community size, although no strict definition was given to the term “community”. Community sizes were measured with five categories -- 1 being “less than 3,500”; 2 = “3,500 to 7,000 people”; 3 = “7,000 to 25,000”; 4 = “25,000 to 100,000”, and 5 “more than 100,000”. Other individual level control variables included in the study were age (continuous variable), gender (male and female), educational levels (a five-level variable ranging from “less than high school” to “advanced degree”), and residence length in the state (ranging from 1=less than five years to 4=all lifetime).

The state level variables introduced in the models were state population density, state average annual precipitation[2], number of impaired water bodies, and state government investment on natural resources[3]. Population density was calculated as state population divided by total state land area in square miles[4]. However, because of the extreme right-skewness of the variable, we took logarithm transformation on the variable to meet assumptions about linear regression. Number of impaired water bodies was obtained from the national US EPA 303(d) report[5]. Note that the 303(d) does not cover all the water bodies in the state, but is a sample of about one third of the each state’s total water bodies. In addition, the number does not reflect a percentage of impaired water bodies in the total number of water bodies in the state.

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[2] See state total precipitation by month in inches at http://www.cdc.noaa.gov/data/usclimate/pcp.state.19712000.climo.

[3] State investment on natural resources/parks in year 2005. Unit is in million dollars. More information can be found at the following site.
http://www.census.gov/govs/estimate05.html

[4] Information about state population and land area can be found at the U.S. Census Bureau. Data retrieved at the following web site as of May 11, 2010.
http://factfinder.census.gov/servlet/GCTTable?_bm=y&-ds_name=DEC_2000_SF1_U&-CONTEXT=gct&-mt_name=DEC_2000_SF1_U_GCTPH1_US9&-redoLog=false&-_caller=geoselect&-geo_id=&-format=US-25%7CUS-25S&-_lang=en

[5] The term, "303(d) list," is short for the list of impaired waters (stream segments, lakes) that the Clean Water Act requires all states to submit for EPA approval every two years (even-numbered years). More information about the 303(d) list can be found at EPA web site http://www.epa.gov/reg3wapd/tmdl/303d.htm.

Model Description and Analysis

In this study, like many attitudinal surveys, the responses of interest are ordinal categorical, which means that although the real distance between categories is unknown the categories follow a certain ordering which makes it different from a nominal variable in nature. In the case of surface and ground water quality perceptions, we used three categories of responses ranging from poor, fair, to good, and we assumed the three categories followed a strictly ascending order.

Ordinal regression models are used with the purpose to minimize efficiency loss and bias (Hedeker, 2008). At the individual level, the event of interest is observing a certain perception score or less. Let Y stand for the individual water quality perception response, then

$$\lambda = \text{Log } [\ P(Y<=c) \ / \ 1\text{-}P(Y<=c)\ ] = \gamma_c - x'\beta, \text{ where}$$

c = 1, ….C-1 for the C categories of the ordinal outcome;
x = vector of explanatory variables (plus the intercept);
γ_c = thresholds which reflect cumulative odds when x = 0.

Positive association between x and Y is reflected by $\beta > 0$, that is, if β takes a positive value, then as the value of X increases, the value of the log function decreases, which means that the probability of Y taking some higher scores are greater than lower ones (Norušis. 2010).

At the state level, the multilevel model assumes a random average water quality perception (random intercept) for each state. Thus, for our first hypothesis, the models were as follows.

<u>Individual level model – level 1</u> (j = 1,….n_i individuals within the state)

$$\lambda_{ijc} = \text{Log } [\ P(Y_{ij}<=c) \ / \ 1\text{-}P(Y_{ij}<=c)\ ] = \gamma_c - (b_{0i}), \text{ and}$$

State level model – level 2 (i = 1,…...36 states)

$b_{0i} = \beta_{00} + \upsilon_{0i}$ where $\upsilon_{0i} \sim \text{NID}(0, \sigma_{\upsilon}^{2})$

For our second hypothesis, the models were:

$\lambda ijc = \gamma c - [b0i + \beta 10$ (environmental attitudes) + $\beta 20$ (community size) + $\beta 30$ (age) + $\beta 40$ (education) + $\beta 50$ (gender) + $\beta 60$ (length of residence)]

$b_{0i} = \beta_{00} + \upsilon_{0i}$

And models to test the third hypothesis were:

$\lambda ijc = \gamma c - [b0i + \beta 10$ (environmental attitudes) + $\beta 20$ (community size) + $\beta 30$ (age) + $\beta 40$ (education) + $\beta 50$ (gender) + $\beta 60$ (length of residence)]

$b_{0i} = \beta_{00} + \beta_{01}$ (population density) + β_{02} (annual rainfall) + β_{03} (investment on natural resources) + β_{04} (number of impaired waters) + υ_{0i}

Findings

The grand mean for surface water quality perception was 2.01, which is "fair". When the means are examined state by state, states in the far northeast (see Table 1, Connecticut through Vermont), in the mountain region (Colorado through Wyoming), and those in the north Pacific (Alaska through Washington) tended to show higher means than others. One state, Delaware, had a mean far lower than any other state (1.77). The total mean for ground water quality perception was 2.21. Nevada and Delaware both have the lowest mean scores on ground water quality perceptions (1.94). There seems to be less variation in ground water quality perceptions across the states. See Table 1 for a detailed state and total means on the two dependent variables, and the four state-level independent variables.

The grand mean for environmental attitudes was 5.85, which suggests that on average, the respondents take a balanced view towards the relationship between human society and the environment. About 12.7% of all respondents lived in a community with population less than 3,500, 10% in a community with 3,500 to 7,000 people, and 17.7% in a community with 7,000 to 25,000 people. About 28% of all lived in a community with 25,000 to 100,000 people; and 32% in a big city with more than 100,000 people. Sixty-five percent of all respondents were male, and median education level was some college. About 47% of all residents lived in their current state all their lifetime, and another 41% lived in the state for above ten years. Only 12% of total residents lived in their states no more than ten years.

The between-state difference shown with surface water quality perceptions seems higher than with ground water quality perceptions. Therefore, we looked at the variance in surface water quality perceptions first. First of all, we ran a random intercept empty model, which assumes that each state has a random state average which may well reflect their residents' perceptions about the surface water quality. The variance of a random intercept was .372, and the intra-class correlation was .102 (see Table 2), which suggests that about 10% of the total variance in surface water quality perceptions comes from the differences in state means. This soundly confirms our multilevel approach, because a significant amount of variance is shown to come from the second level – the states where the respondents live.

Then individual level variables were introduced in the second model. This model says that we are fitting a regression model using the proposed variables for all states, and yet we are allowing the state intercepts to vary from each other. The estimates suggest a negative association between environmental attitudes and surface water quality perceptions. Community size was also found to be negatively associated with surface water quality perceptions. In addition, older in age and higher educational achievement are associated with better perceptions of surface water quality. When all other characteristics were equal, a male respondent tended to give a higher score to their surface water quality than a female respondent. Length of residence did not show as a significant explanatory variable for surface water quality perceptions.

Four state level variables were added in the third model. Only one of the four variables, logarithm of population density, shows an effect on explaining the differences in state level means. The estimated slopes associated with the other three state level variables are not significantly different from zero, which suggests that there is no significant association between state average surface water quality perceptions and the state average precipitation, investment on natural resources, or number of impaired water bodies. The negative association between population density and surface water quality perception says that as the population density in the state increases, its general surface water quality perception decreases. Compared with the previous model, addition of the state level variables did bring down the between state variance from 0.108 to 0.069. The decrease was about 36% of the previous between state variance. As shown in Table 3, the model with state level variables significantly improves model fit to the data.

The same models were tested on ground water quality perceptions. However, there was no significant difference between state variance on ground water quality perceptions. The variance of a random intercept was only .144, which accounts for 4.2% of the total variance in groundwater quality perception. This suggests that the main source of variance in ground water quality comes from individual differences rather than state differences, and all thirty-six states tended to have similar averages on ground water quality perceptions.

Therefore, only one-level, the individual level variables were modeled in an ordinal logistic regression to examine the relationship between ground water quality perceptions and individual characteristics. Table 4 shows that the pattern well resembles what we found with model 2 for surface water quality. Environmental attitudes and community size both have negative associations with ground water quality perceptions. Age, education, and being male are positively related with better ground water quality perception. Unlike with surface water quality perception, however, length of residence was found to be a significant predictor for ground water quality perception.

Discussion

The findings about surface water quality perception partially confirm our research hypotheses. First of all, a significant amount of variance (about 10%) in perception about surface water quality was accounted for by the states, although the majority of the variance was still due to differences in individual respondents. For ground water quality perception, however, the picture was somewhat different. Only a very small amount of variance (less than 5%) in groundwater quality perception was due to state differences. Therefore, unlike the scenario with surface water, an ordinal logistic regression suffices to test the proposed explanatory variables rather than a multilevel model. Two reasons might have led to this result: one is that the ground water quality does not vary much from state to state, and the respondents views reflect such similarity; another possibility is that the ground water quality does vary, but people in general know little about their ground water because of less visibility and fewer educational programs on the subject.

For both surface and ground water quality perceptions, environmental attitudes, community size, age, gender, and education were all found to be significant predictors to account for individual differences. The negative associations hypothesized with environmental attitudes and community size were confirmed. A person with more pro-environmental attitudes was more likely to give lower ratings on water quality. Also, a resident from a larger community was more likely to view the water as worse compared with a counterpart from a smaller community.

Length of residence was found to be a significant predictor for surface water quality perception but not for ground water quality perception. As a person lives longer in the state, he or she was likely to have better perception about their ground water quality. Again, this might be due to the fact that ground water is less visible and that it is a less discussed issue than that of surface water. As people live longer in the state and in their community, there is a better chance that they come across the opportunities to learn more about their ground water. Also, community attachment and sense of place might play a role as an intervening factor and the underlying relationship may require further research to uncover.

As the between-state difference shows significance, the question remains– "What are the possible factors that may explain such difference?". Based on the observations of formation of environmental attitudes and motivation of behaviors, we proposed a series of variables which we thought reflected the social and natural settings of the states. However, only one of the variables we proposed - state population density - seemed to be a significant explanatory variable for the random intercept effect. The other three state level variables we selected (average annual rainfall, investment on natural resources, and number of impaired water bodies) did not show a significant association with the random state intercepts. Future research needs to focus on exploring more about the possible state level explanatory factors for surface water quality perception.

Conclusion

While a considerable amount of variance in surface water quality perceptions come from between state differences, the variance in ground water quality is basically random and subject to the variations in individuals. General environmental attitudes and community size were found to be significant predictors for both surface and ground water quality. Although the nature of this study is primarily exploratory, the findings may have important implications for public policy making. First of all, given the significant associations found with environmental attitudes and individual demographic traits, a strategy of policy making and planning targeting at certain groups or people sharing certain similarities might work more effectively than a more general strategy. For example, programs of water quality protection could be first presented to environmental groups in large cities who would be strongest supporters. Engaging community activists and then spreading to the remaining part of the watershed could be an effective way in gaining local engagement and commitment in solving water quality issues.

Water bodies often run through multiple states and states of geographic adjacency need to work together on their water issues. It is important to acknowledge that water quality perceptions in those adjacent states are not necessarily similar, and social dynamics might not work exactly the same way in each state. The policy makers, water project managers, and watershed facilitators in each state will be able to seize cooperation opportunities and negotiate differences as they learn about the common grounds and dissimilarities among stakeholders. The study of water quality perceptions may also help educators to identify the gaps between physical water conditions and people's awareness and knowledge about their water quality.

There are certain limitations to this study. We used state as the higher level unit to account for correlated individual water quality perceptions, because state is the only geographic identification we had with the dataset. However, lower-level, smaller-sized communities like neighborhoods, cities, or counties may work better as higher level units because people of these communities may share more common traits, and most important, they are more likely to share the same watersheds. For future studies, researchers could make use of geographic information to identify smaller level communities such as county, census tract, blocks, etc., and match geographic information with the physical conditions of water bodies in the area to conduct more extensive research on perceptions, knowledge, and awareness about water quality.

Tables and Figures

Table 1. Summary Statistics by State

State	Perception of surface water	Perception of ground water	Population density (people per square mile)	Mean annual precipitation (in inch)	Investment on natural resources (in million dollar)	Number of impaired waters
Connecticut	2.05	2.30	702.90	50.39	347	408
Maine	2.19	2.30	41.30	42.28	221	157
Massachusetts	2.02	2.26	809.80	47.88	568	837
New Hampshire	2.11	2.31	137.80	43.42	149	5211
Rhode Island	2.05	2.15	1003.20	47.98	106	141
Vermont	2.17	2.44	65.80	42.82	122	131
New York	1.96	2.11	401.90	41.90	2593	491
New Jersey	1.95	2.06	1134.40	47.15	2573	835
Delaware	1.77	1.94	401.10	45.68	186	101
Maryland	1.90	2.15	541.90	44.64	1129	501
Pennsylvania	2.02	2.23	274.00	43.02	1312	6957
Virginia	1.95	2.23	178.80	44.39	1099	2534
West Virginia	1.91	2.12	75.10	45.30	324	1271
Iowa	1.91	2.31	52.40	34.05	599	225
Kansas	1.89	2.02	32.90	28.92	480	1333
Missouri	1.91	2.29	81.20	42.23	761	228

Table 1. Summary Statistics by State (Continued)

State	Perception of surface water	Perception of ground water	Population density (people per square mile)	Mean annual precipitation (in inch)	Investment on natural resources (in million dollar)	Number of impaired waters
Nebraska	1.96	2.30	22.30	23.63	442	177
Colorado	2.08	2.24	41.50	15.97	1342	200
Montana	2.24	2.32	6.20	15.37	305	677
North Dakota	2.11	2.15	9.30	17.82	290	247
South Dakota	2.03	2.07	9.90	20.14	229	168
Utah	2.09	2.35	27.20	12.26	560	118
Wyoming	2.17	2.23	5.10	12.97	300	106
Arizona	1.96	2.17	45.20	13.61	1459	68
California	1.94	2.13	217.20	22.20	9637	691
Hawaii	1.93	2.38	188.60	70.00	344	311
Nevada	1.86	1.94	18.20	9.54	882	129
Alaska	2.45	2.54	1.10	21.81	306	32
Idaho	2.18	2.30	15.60	18.96	335	1056
Oregon	2.11	2.20	35.60	27.55	879	1397
Washington	2.10	2.27	88.60	38.78	1604	2419
Arkansas	2.17	2.28	51.30	50.78	421	189
Louisiana	1.85	2.23	102.60	60.09	1095	250
Oklahoma	1.98	2.12	50.30	36.55	481	743
Texas	1.98	2.22	79.60	28.87	2935	651
Tennessee	1.97	2.19	138.00	54.22	659	900
Total	**2.01**	**2.21**	**203.78**	**34.45**	**1925**	**994**

Table 2. Multilevel Ordinal Logistic Regression Models for Surface Water Quality Perceptions (N=6604)

	Model 1	Model 2	Model 3
Thresholds: Good (3)	-2.026***	-2.100***	-1.647***
	(0.11)		
Fair (2)	2.257***	2.337***	2.789***
	(0.11)		
Individual Level Variables			
Environmental attitudes		-.210***	-.210***
		(.0190)	(.0190)
Community size		-.106***	-.0104***
		(.0236)	(.0236)
Age		.0134***	.0134***
		(.00196)	(.00196)
Education		.0933***	.0872***
		(.0286)	(.0286)
Gender (Male)		.236***	.228***
		(.0648)	(.0648)
Length of residence		.0326	.0322
		(.0383)	(.0383)
State Level Variables			
Log Population density			-.254***
			(.0910)
Annual rainfall			.0046
			(.00902)
Investment in NR			-.00002
			(.000061)
Log Number of impaired waters			.0787
			(.0804)
Intercept variance	.372	.398	.245
Intra-class correlation	.102	.108	.069
-2logL	8883.64	8653.22	8655.54

Table 3. Model Comparison for Surface Water Quality Perceptions

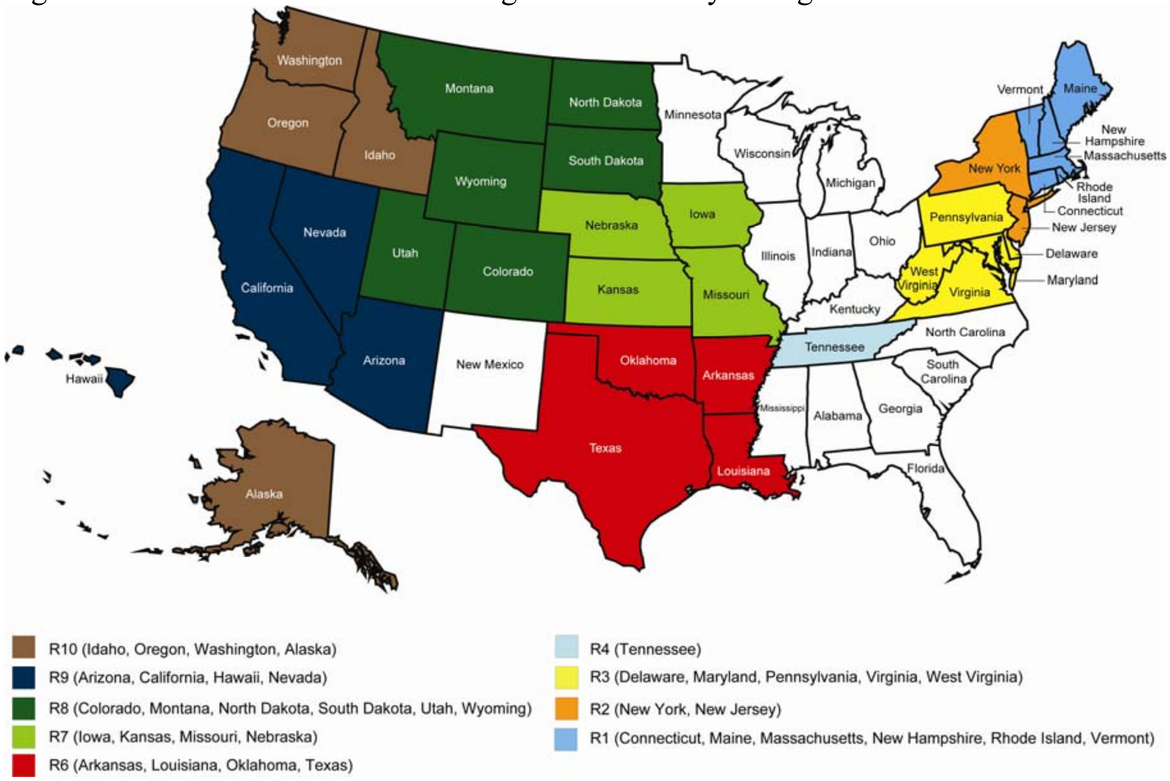
Model	AIC	BIC	-2LL	Df	Chi-square Test
Model 1	9012	9016	9006	3	
Model 2	8795	8809	8777	9	***
Model 3	8790	8810	8764	13	**

Table 4. Ground Water Quality Perceptions

	Estimates
Thresholds Good (3)	-2.183***
	(.236)
Fair (2)	1.188***
	(.233)
Environmental attitudes	-.153***
	(.018)
Community size	-.135***
	(.021)
Age	.013***
	(.002)
Education	.151***
	(.027)
Female (vs. male)	-.304***
	(.065)
Length of residence	.152***
	(.037)

Note: in all the tables above, *** means significant at .001 level; ** significant at .05 level; and * stands for significant at .1 level.

Figure 1. Illustration of EPA Water Regions and Surveyed Regions/States.



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Chapter Four Don't Know Responses in Water Quality Surveys

A paper submitted to *Agriculture and Human Values*

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Abstract

It is important to understand the public's awareness and knowledge about their water quality and learn about individuals' attitudes and concerns about local water in order to create effective watershed based deliberations among citizens of all sectors. When using water surveys to gather public opinions about water, researchers and scholars usually have to make a decision about how to deal with non-substantive responses, i.e. the responses of "don't know" or "no opinion". These non-substantive responses in water surveys were usually treated as missing because they were thought to convey no clear opinions of the respondents. However, patterns about don't know responses, once found, may help researchers to better understand the public's awareness and knowledge about water quality, and guide future design and development of targeted programs for community engagement in solving water problems. This research asked if there is a systematic pattern of don't know responses in water quality surveys, and what social factors may be useful in understanding knowledge/awareness or the lack of it about water quality.

Keywords: don't know responses, water quality survey, complex systems, water supply systems

Introduction

The watershed approach which coordinates both public and private sector efforts to address ground and surface water problems provides an effective framework to address water resource challenges (U.S. Environmental Protection Agency, 1996). A first step in creating effective watershed based deliberations is to discover agreement as well as differing viewpoints among all stakeholders. Because water is visible and has so many functions in almost every aspect of people's life, it is one component of the environment on which most people have some opinions or attitudes. Surveys about water quality and other water issues provides a feasible and convenient way for scholars and community leaders to learn about individuals' attitudes and concerns about local water. Non-substantive responses, responses of "don't know" and "no opinion" in these surveys convey no clear opinion of the respondents and were usually treated as missing. These don't know responses, however, may still be very useful in terms of revealing valuable insights about citizens' awareness, knowledge, or the lack of so regarding their water and thus have profound implications for building effective watershed partnerships.

Citizens' perceptions about their water quality offer important guidance for developing appropriate and effective environmental intervention strategies. The "don't know" responses can provide valuable information regarding knowledge and awareness about their water quality. Patterns about don't know responses, once found, may help researchers to better understand the public's awareness and knowledge about water quality, and guide future design and development of targeted programs for community engagement in solving water problems. In this sense, analysis of DK responses provides an important piece of information to researchers and community leaders with interest in moving from attitude and knowledge assessment to citizen action and engagement on an issue of public concern. The authors analyzed data from a national survey about water issues and in particular explored two questions related to DK. First, we asked if there is a systematic pattern of don't know responses in water quality surveys. Secondly, we searched for social factors that may be useful in understanding knowledge/awareness or the lack of it about water quality. One social factor we looked at in particular, is the water supply system and its complexity.

Non-substantive Responses in Survey Research

Two core dimensions of a public opinion survey are the respondent's knowledge or awareness of the issue and their interest in the problem or concern about it (Rossi et al., 1983). A challenging issue facing social researchers is the presence of "don't know" (DK) responses in survey data and how to handle these non-opinion responses. No general guidelines exist for handling such responses. A typical practice, what is called the standard question form, is not to include a "don't know" option as part of a question (Schuman and Presser, 1981; Rossi et al., 1983). Researchers holding this position often argue that inclusion of no-opinion options in the surveys may not necessarily enhance data quality and instead may preclude measurement of meaningful opinions (Krosnick et al., 2002). The assumption is that DK is the lazy answer that respondents will choose when given the option (Rossi et al., 1983). As a result, DK responses are typically treated as a form of missing data in the analysis.

DK responses, however, differ from refusal to answer the question in nature, and should therefore be analyzed separately (Shoemaker et al., 2002). First of all, omitting a DK response option risks frustrating the respondent when she or he truly doesn't have knowledge or an interest in the item in question (Rossi et al., 1983). Without a DK option, respondents are forced to state an opinion about something they have no experience with, never thought of before and may not likely consider again (Rossi et al., 1983). Furthermore, DK responses can be indicators of lack of knowledge, low saliency of the issue (it is not important), and/or indifference. The implications of a DK response suggest disengagement from the issue or lack of confident knowledge which can be a deterrent to a readiness to act on a public problem such as water quality. Past studies have identified consistent correlates with DK responses, and respondents with certain characteristics are found to be more likely to give DK responses than others in attitudinal and opinion surveys. In particular, researchers have found that females, nonwhites, low-educated, low-income, and non-involved respondents with feelings of low political efficacy give a predictably high number of DK responses (Francis and Busch, 1975; Faulkenberry and Mason, 1978; Pickery and Loosveldt, 1998; Singer et al., 2000; Krosnick et al. 2002; Stocke, 2006).

Water Supply Systems and Water Quality

Water supply systems could be complicated in some communities and how the systems work may be far beyond many people's knowledge. Anthony Giddens, in his discussion about modernity, talks about expert systems and their implications for everyday life in the modern society. Expert systems are "systems of technical accomplishment or professional expertise that organize large areas of the material and social environments that we live in today" (Giddens, 1991, p.27). There are always experts who know about all the details and who will ensure the whole system goes all right. To a large extent, a water supply system is an expert system. As the system get more complex, ordinary people usually do not know how their water is treated before it reaches their home for drinking. In stead, ordinary people are more likely to have only some “surrounding” knowledge such as how to turn on their tap to get water. Therefore, because “experts” are taking care of their water, they usually do not need to worry about the quality of their water source. In large communities where residents usually depend on city water supply systems, people may have little idea about where their drinking water comes from, or what is added to their water to make it safe and clean to drink. They simply trust the expert systems of water supply and turn on their tap expecting their water to be of good quality and safe to drink. In contrast, in smaller communities and outlying rural places where residents get water from private wells or nearby surface water bodies, the system is much less complicated, and the users have more direct experience with their water. These users are also more likely to be experts on their water supply themselves and are therefore more likely to be knowledgeable about the water quality in general in their area.

Hypotheses

Based on the above argument about expert systems, we developed our first hypothesis regarding the “don’t know” response to water quality questions. We hypothesized that respondents who get their drinking water from public water supply systems (city or rural district) are less likely to bemotivated to learn or be aware of the water quality conditions in their area. The users of individual water supplies or community wells, on the other hand, are hypothesized to be more concerned with local water quality, and therefore, less likely to give DK responses to water quality questions.

H1: public water supply users more likely to give DK responses to water quality questions compared with individual water supply/community well users.

Secondly, we expected the size of the community where a person lives to have effect on water quality awareness/knowledge or the lack of such awareness/knowledge. As a community increases in size, it is more likely that the water supply system becomes more complex, and the citizens also are less likely to be involved in local water issues. Therefore, the second hypothesis states that:

H2: The larger the community size, the more likely a respondent gives a “don’t know” response to questions about their water quality.

Other variables controlled for in the study included age, gender, and education. We used these variables to test whether the previously found patterns about female, less-educated respondents and their association with don’t know responses also hold true in water quality surveys.

All the hypotheses were based on the assumption that DK responses were given purely because of lack of knowledge or awareness on the subject matter. In other words, from the nature of our data (collected via mailed survey), we assumed there were no confounding effects from interviewers’ characteristics, sensitivity issues, or general attitudes toward the survey, etc.

Methodology

Data were collected from a multi-state water issue survey completed in 36 of the 50 US states (2002 through 2009). The survey was conducted by University of Idaho under a USDA Integrated Water Quality project, and the data were made available to the authors for analysis. Households were randomly sampled from phone books in each state, and calculation of targeted sample size was based on the total population of the state. Mailed surveys were sent to sampled names and addresses, with any adult in the household, whether or not addressee, invited to complete the survey questionnaire. Question content and wording in the surveys varied from state to state, with the total survey length about 50 questions. Several core questions were the same across all states and asked about respondents' perceptions of water quality, water use importance, factors responsible for water pollution, sources of information about water, general environmental attitudes, and demographic information. Standard mail survey methods as recommended by Dillman (2000) were followed in each of the surveys with a total of 9,332 returned surveys and response rates ranging from 37% (Massachusetts) to 70% (Wyoming).

Survey questions examined in this study included drinking water supply types (individual system, community well, or city/rural public water supply system) which represents the complexity of water supply systems, community size, three demographic items and overall ground and surface water quality perception. Respondents were asked where they got their drinking water, whether it was from individual system (well or surface water) or community well system (well serving 15 or more residences but not a city system), or public (city or rural) water system[6]. Community size was measured with five increments: population less than 3500; 3500 to 6999; 7000 to 24,999; 25000 to 100,000; and more than 100,000. Demographic variables were age, gender, and education. Age was divided into six increments of adult years (18-29; 30-39; 40-49; 50-59; 60-69; 70 and above). Gender

[6] The water supply source question also has an option of "purchase drinking water", but this category is omitted in this study and covered in a separate research.

responses were male or female. Educational attainment responses were five increments including less than high school, high school graduate, some college, college graduate, and advanced degrees. Two perceptions of water quality questions asked about ground and surface water conditions: "In your opinion, what is the quality of surface (ground) water in your area?" Possible responses ranged from "poor" to "fair" to "excellent" plus "don't know/no opinion". For the purpose of analysis, responses of "don't know/no opinion" were recoded as 1 and all other substantive responses were recoded as 0. After recoding, the means reflected percentage of DK responses. The final sample with no item missing data resulted in a total number of 6,401 cases.

First, analysis of variance (ANOVA) was used to examine the percentage of DK responses about surface and ground water quality among groups with different water supply types, residence community size, and demographic characteristics. Then post hoc Tukey tests were used to evaluate pairwise differences. This particular statistical test was chosen because of its relative advantage in statistical power and its appropriateness in pairwise comparison (Kutner et al., 2005). Then in a second step, all the predictor variables were fit into a logistic regression model for prediction of the occurrence of DK about ground water quality and surface water quality responses.

Findings

Water Supply Systems as Expert Systems

For both ground and surface water quality questions, the percentage of "don't know" responses given by respondents who used individual water supply (well or surface water) or community well are significantly less than those given by users of public water supply systems. Especially for the ground water quality question, 30% of respondents who used public water supply systems reported “don’t knows”, while less than 6% of the users of individual/community water supply systems said “don’t know”. The difference between the two percentages is highly significant. This confirms our hypothesis about water supply systems – as the water supply systems get more complex, users of these systems are more likely to say they don’t know about their water quality.

Community Size

Findings about community size also support our hypothesis that people residing in larger communities are significantly associated with greater likelihood of responding DK to ground or surface water quality questions (Tables 2a, 2b). For both water quality questions, the percentage of DK responses rose as the respondents’ community size increased. In communities with a population of less than 3,500, fewer than 15% of the respondents said they did not know about their ground water quality. But in large communities of 100,000 people or more, about 33% of the respondents gave DK responses to the same question. With surface water quality, the differences in the percentages of DK responses are less strong as with ground water quality, but the general pattern is consistent as shown with ground water quality.

Demographics

Respondents were divided into six increments according to their age (Tables 3a, 3b). The percentage of DKs about surface water quality is higher in the youngest age group (18-29, about 10%), and the percentages in three age groups from 30 to 59 are about the same (around 8%). The age group of 60-69 has a slightly higher percentage of DKs (about 10%), while the age group of 70 and above has the highest percentage of DK responses (over 20%).

DK responses to the ground water quality question tend to share the same general pattern (Table 3b). However, with ground water quality, the DK percentage within each age category is much higher than that with surface water quality. DK responses show the highest percentage in the youngest and the oldest age groups, and are about the same across all other age groups from 30 to 69.

About 17% female respondents said they don't know about their local surface water quality, while only about 8.2% among the male respondents reported DKs. With ground water quality, the difference between the two groups of respondents is even more considerable. Almost 35% of female respondents said "don't know", while 21% of the male respondents said so (See Tables 4a, 4b).

Previous studies have reported a correlation between education and DK, with lower education correlating with higher DK responses. Our data, however, do not reveal a similar pattern (Tables 5a, 5b). From our findings, there are no significant differences across any educational achievement groups in terms of their DK responses to the ground water question. For surface water quality DK responses, the pattern is fairly curious – respondents who were high school graduates gave more DK responses than respondents of any other educational levels. No other significant differences were found with regards to educational levels.

Results of Logistic Regression

The expert system and user knowledge hypotheses about water quality DK responses were further tested using a logistic regression model where water supply type and community size were used as predictors of DK responses, and demographic variables such as age, gender, and education were controlled for (Tables 6a, 6b). Although these models do not explain a large amount of the variance in DK responses (Pseudo R^2 less than .10 of the total variation in both cases), the statistical significance of tested variables confirmed our hypotheses for both surface and ground water quality DKs. Public water supply system and larger community size were associated with an increased likelihood of DK responses to the ground water quality question when respondents' age, gender, and educational achievement were held constant. The logistic model for surface water showed similar results.

As Table 6a shows, the odds ratio of respondents using individual/community water supply systems versus public water supply system users was .163 for DK responses to ground water quality, which means the odds that an individual/community water supply user says "don't know" to the ground water quality question are 83.7% less than a user of public water supply systems when all other conditions are held equal. Community size also showed up as a significant predictor for DK responses. Compared with a resident whose community size is one category below (for example, a resident of community size over 100 thousand people compared to another person whose community size is between 25 to 100 thousand people), the odds for a person from the larger community to report DK about local ground water quality was about 16% higher, as long as the two persons have the same water supply type, age, education, and gender. For a person who is older in age for one year, the odds that the person says DK to the ground water quality question are 0.8% more than a person who was one year younger, with other things being equal. Also, for a person whose education is one category higher (for example high school graduates compared with less than high school), the odds that the person responds with DK to ground water quality question were reduced by 5% when compared with a person with lower education. A female respondent, when other things are all equal with a male respondent, was found to be more likely to say DK to the ground water quality question, with her odds almost twice that of the counterpart male respondent.

The logistic regression model for “don’t knows” about surface water follows the same pattern (Table 6b), except that education was no longer a significant predictor. When all other variables were held equal, there was no significant difference between respondents with different educational achievement in terms of their odds of saying “don’t know” about their local surface water quality. In addition, the difference in odds between individual/community water supply users and public water supply system users were not as pronounced as that with ground water quality DK responses. Compared with a city water supply user, an individual/community water supply user’s odds associated with surface water quality DK responses were reduced by 22.6%. Findings about community size, age, and gender were very similar to those for ground water quality DK responses.

Discussion

Water supply system type was found to be a highly significant predictor for DK responses to water quality questions. Public water supply users were much more likely to give DK responses to the water quality questions than users of individual or community water supply systems. This confirms our hypothesis about the system complexity. Public water supply users might be more likely to trust water experts for their safe drinking water, and therefore, less knowledgeable or concerned with the water quality in their area. On the contrary, users of individual or small community water systems might be experts with their own water supply, and they might be more concerned or knowledgeable about their local water quality because it is closely related to their drinking water safety. The size of the community where one lives was positively associated with “don’t know” responses to the water quality questions. As the community size increases, there is increased chance that respondents say they do not know the quality of either the ground or surface water in their community. It may be due to the reason that in a smaller community the residents have more opportunities to participate in community water activities including conservation and protection activities or decision-making processes regarding their water. For two persons using the same type of water supply, the person in a smaller community might have a better chance of following local water news and he or she may also have more experience with local lakes, streams, and rivers which are sources of their water supply.

Our findings about water quality questions also confirmed that females are more likely to give DK responses. Older respondents are also found to be associated with higher rates of DK responses. The association between education and DK responses to water quality questions is not consistent with ground and surface water. Education shows as a significant predictor for DK responses to the ground water quality question, but not for the surface water quality question. This might be due to the nature of these two water sources. Surface water is more visible and its quality can be easily judged by lay people from its appearance, whereas the quality of ground water can only be learned through other sources such as media, tech reports, water-related activities, etc., which are more likely to be related to a person’s education.

Conclusion and Policy Implications

In everyday life we probably interact with hundreds of “expert systems”: bank systems, computer systems, automobile systems, etc. We give full, almost blind trust to these expert systems, but the trust comes inherently together with risk – that the system may not function, or they function well but not to our benefit. While there does not seem to be any easy solution to counter the risk, the least we can do is to be actively involved in issues that are important to us. Water quality problems, like all other environmental issues, are social problems which at root require not only applications of science and technology but also human and social engagement. Participation of and contributions from ordinary citizens is not possible unless citizens are aware of and informed about the water issues. A high percent of DK responses on water quality issues signal public unawareness and lack of knowledge, and the revealed patterns about DK responses provide valuable information that could help guide education outreach and effective promotion of public awareness and knowledge.

Proper awareness and knowledge about water quality among involved citizens is essential for successful participatory watershed programs. Awareness of water quality also is a first step in addressing local water contamination and degradation issues. If citizens are to be mobilized to act on water concerns, they must first be motivated to increase their awareness and encouraged to learn about their water resources. These DK response patterns in water quality questions offer a map of lack of awareness/knowledge regarding water quality issues, which can provide guidance for future water programs and information campaigns to target their audiences in order to increase awareness. For example, traditional environmental education tends to focus on schools and classroom education, which might help explain why people of higher education tend to have lower percentages of "don't know" responses regarding ground water quality. In order to reach a wider range of audience environmental education programs need to be more diversified and customer-tailored. Awareness of local water quality could be increased by providing people of all ages more opportunities to personally experience their water resource base, and through volunteer clean up river days and recreational services. Efforts should be made to reach older residents, those with lower education, and females, and especially the more relaxed public water users who live in large communities. Special programs should be tailored to attract these audience's interests.

Tables

Table 1a. DK surface water by water supply type (ANOVA) [1]

	N	DK Mean[2]	Std. Dev.	Std. Error
A. individual/community	1294	.079 [B]	.269	.007
B. public system	5107	.117 [A]	.321	.004
Total	6401	.109	.311	.004

Table 4b. DK ground water by water supply type (ANOVA)

	N	DK Mean[2]	Std. Dev.	Std. Error
A. individual/community	1294	.059[B]	.235	.007
B. public system	5107	.307[A]	.461	.007
Total	6401	.256	.437	.005

[1]The letters behind DK means indicate from which group the mean is significantly different in a post hoc pairwise comparison using Tukey method.
[2]Percent of all respondents in this category responding DK
The above notes apply to tables 1 through 5.

Table 2a. DK surface water by community size (ANOVA)

	N	DK Mean	Std. Dev.	Std. Error
A. <3.5K	821	$.083^{E}$	.276	.010
B. 3.5 to 7K	625	.096	.294	.012
C. 7 to 25K	1146	$.095^{E}$	.293	.009
D. 25 to 100K	1794	.107	.309	.007
E. >100K	2015	$.133^{AC}$	.340	.008
Total	6401	.109	.312	.004

Table 1b. DK ground water by community size (ANOVA)

	N	DK Mean	Std. Dev.	Std. Error
A. <3.5K	821	$.146^{CDE}$	.353	.012
B. 3.5 to 7K	625	$.189^{DE}$	.392	.016
C. 7 to 25K	1146	$.223^{ADE}$	.416	.012
D. 25 to 100K	1794	$.270^{ABCE}$	.444	.010
E. >100K	2015	$.331^{ABCD}$	.471	.010
Total	6401	.258	.437	.005

Table 3a. DK surface water by age groups (ANOVA)

	N	DK Mean	Std. Dev.	Std. Error
A. 18-29	273	.099[F]	.299	.018
B. 30-39	724	.087[F]	.282	.010
C. 40-49	1155	.078[F]	.268	.007
D. 50-59	1541	.084[F]	.278	.007
E. 60-69	1236	.104[F]	.306	.009
F. 70 and above	1472	.202[ABCDE]	.380	.010
Total	6401	.129	.311	.004

Table 3b. DK ground water by age groups (ANOVA)

	N	DK Mean	Std. Dev.	Std. Error
A. 18-29	273	.293	.456	.028
B. 30-39	724	.253[F]	.435	.016
C. 40-49	1155	.226[F]	.418	.012
D. 50-59	1541	.221[F]	.415	.011
E. 60-69	1236	.261[F]	.439	.012
F. 70 and above	1472	.311[BCDE]	.463	.012
Total	6401	.257	.437	.005

Table 4a. DK surface water by gender (ANOVA)

	N	DK Mean	Std. Dev.	Std. Error
A. Female	1987	.170[B]	.375	.008
B. Male	4414	.082[A]	.274	.004
Total	6401	.109	.312	.004

Table 4b. DK ground water by gender (ANOVA)

	N	DK Mean	Std. Dev.	Std. Error
A. Female	1987	.348[B]	.476	.010
B. Male	4414	.216[A]	.411	.006
Total	6401	.257	.437	.005

Table 5a. DK surface water by education (ANOVA)

	N	DK Mean	Std. Dev.	Std. Error
A. < high school	769	$.087^{B}$	.282	.010
B. high school	1087	$.146^{ACDE}$	.354	.010
C. some college	1678	$.110^{B}$	.313	.008
D. college graduate	1649	$.107^{B}$	.3.10	.008
E. advanced	1218	$.090^{B}$	.286	.008
Total	6401	.109	.312	.004

Table 5b. DK ground water by education (ANOVA)

	N	DK Mean	Std. Dev.	Std. Error
A. < high school	769	.228	.420	.015
B. high school	1087	.278	.448	.014
C. some college	1678	.257	.437	.011
D. college graduate	1649	.258	.438	.011
E. advanced	1218	.254	.435	.012
Total	6401	.257	.437	.005

Table 6a. Logistic regression model: don't know about ground water quality (reference group = know)

	B	Std. Err	Sig.	Exp(B)
Individual/community supply	-1.816	.126	.000	.163
Comm. size	.149	.025	.000	1.161
Age	.008	.002	.000	1.008
Educ	-.051	.025	.037	.950
Female	.692	.062	.000	1.998
Cox and Snell Pseudo R^2	.088			

Table 6b. Logistic regression model: don't know about surface water quality (reference group = know)

	B	Std. Err	Sig.	Exp(B)
Individual/community supply	-.257	.121	.033	.774
Comm. size	.130	.034	.000	1.139
Age	.022	.003	.000	1.022
Educ	-.039	.033	.239	.961
Female	.857	.082	.000	2.355
Cox and Snell Pseudo R^2	.032			

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Chapter Five Conclusion and Public Policy Implications

Public perceptions of water quality are important because they will ultimately affect the extent to which the public take action to support public policies and projects designed to improve the quality of water. The objective of this dissertation was to provide a framework for examining the various factors and their associations with perceptions of individuals about their local water quality. First of all, in chapter two, the research focused on perceptions about water issues in four Midwest states (Iowa, Kansas, Missouri, and Nebraska) and proposed to use place of residence and environmental attitudes as explanatory variables for water quality perceptions. Then in chapter three, the study of water quality perceptions was extended to include more states and regions in order to examine state variations and to identify significant state level environmental and social factors that are associated with water quality perceptions. Lastly, “don’t know” (DK) responses to water quality questions were examined to understand patterns of unawareness or lack of knowledge regarding water quality.

Understanding how environmental attitudes, place of residence, and the general state contexts influence the public perceptions about their water quality will enable policymakers to better understand the differences and common ground regarding water quality issues in order to build concerted support for solutions to water quality problems. For example, as found in this research, environmental attitudes and place of residence have significant associations with individuals' perceptions about water quality. Thus, because of the citizens’ differences in backgrounds and environmental views, simply informing citizens about solutions to water quality problems may not recruit enough support necessary to implement a policy. Only an open discussion for all sectors to voice their views and concerns may lead negotiations and deliberations to cooperative planning to improve water quality.

The associations between water quality perceptions and the explanatory variables and their respective implications for policy and public decision making are summarized as follows. First of all, the hypotheses about negative relationships between environmental attitudes and water quality perceptions were confirmed by both the Heartland survey data discussed in chapter two and the multi-level analysis in chapter three with data from thirty-six states. As a respondent shows higher values for the environmental attitudes and more pro-environmental worldviews, it was more likely that the respondent gave a lower rating for both surface and ground water quality in the local area. On the other hand, a person with more pro-use attitudes towards the environment and natural resources was more likely to perceive their water quality as of higher quality. People with stronger pro-use attitudes may have very different experiences and interactions with water and the environment in general than others. To engage these people to change their practices with water and join water quality protection efforts, watershed groups must understand their decision processes and find leverage points that gain their attention. Educators and regulators must start where people are in their belief systems in order to develop concrete interventions to prevent abuse and protect nature.

Another important point raised in this dissertation is about the influence of place of residence. The place of residence, which provides both social and environmental settings to the respondents, has long been used in explaining environmental perceptions. Several specific aspects of place of residence were discussed in this dissertation. First of all, the significant rural-urban, farm-nonfarm differences in water quality perceptions were discussed in chapter two. The study showed that urban and rural farm residents have different perceptions about their water quality, and they tend to differ on their views about major pollutants, each party's responsibility in protecting water quality, and water monitoring actions. However, the research finds that farmers join rural non-farmers and urban people in believing that water quality issues are important. Agreements and disagreements about the environment among farmers, rural non-farmers, and urban residents was one of degree. Urban residents and farmers may disagree whether the environment should be totally protected or its value is in its use and applications to agriculture. However, in the Heartland, there seems to be sufficient shared concern about local water bodies that a common agenda for protecting local waters is possible.

A second place of residence aspect studied was the state effect. Perceptions of surface water quality are found to be subject to random state effects. A considerable amount of variance in surface water quality perceptions was found to be due to the differences in states, although the individual variances were still the predominant component of the total variance in surface water quality perceptions. Several social and environmental factors including population density, average annual rainfall, number of impaired water bodies, and investment on natural resources at the state level were proposed to explain the between-state variance, but only population density showed a significant association with the random state intercept on surface water quality perceptions. Furthermore, community size was used as a proxy for network strength based on the assumption that as communities get larger in size, their individuals' social network ties are weakened. Community size in general showed a negative association with both surface and ground water quality perceptions. As communities get larger, residents' views about their water quality gets worse. For future research, some qualitative study may be a good way to increase the understanding of community attachment, network strength, and water quality perceptions.

Residents of different social environments have different perceptions about their water, and it is therefore essential for the program facilitators to provide a friendly platform for negotiation and cooperation in order to achieve an agenda that accommodates all parties' concerns. Water bodies sometimes run through multiple states and states of geographic adjacency tend to work together on their water issues. It is important to acknowledge that water quality perceptions in those adjacent states may not necessarily be similar, and social dynamics might not work in exactly the same way in each state. Therefore, in each state policy makers, water project managers, and watershed facilitators need to see the common ground and dissimilarities among stakeholders so that they can better identify cooperation possibility and opportunities. In areas where records of physical water quality indicators are available, the findings about water quality perceptions may also help educators to spot the gaps between physical water conditions and people's awareness and knowledge about their water quality.

In the study of non-substantive responses in water quality surveys, community size is used to proxy for complexity of water supply systems, and it again showed up as a significant factor with larger community size positively associated with non-substantive responses to water quality questions. As the water supply system gets more complicated, respondents were more likely to respond with "don't know" in the water quality surveys. The study about "don't know responses" delineated populations that were more likely to ay they have no opinion about their water quality. Participation of and contributions from ordinary citizens are not possible unless they are aware of and informed about the water issues. A high percent of DK responses on water quality issues signal public unawareness and lack of knowledge, and the revealed patterns about DK responses provide valuable information that could help guide education outreach and effective promotion of public awareness and knowledge. Educational programs should reach out to groups with one or multiple of the following traits: older citizens, the female population, those with lower educational level, and/or live in large size communities. An integrated strategy needs these citizens' awareness and input.

These studies have certain limitations. The water surveys had different questions and wording throughout different regions and states, which made the list of common questions to very short. A larger pool of common questions about water quality, pollution sources, knowledge about water, and behavioral change to protect water quality, etc. would have made more contributions to the understanding about water quality perceptions in the US Also, for future study, researchers should consider matching the respondents' geographic information with the physical water quality indicators in the local watershed in order to better map the consistency/discrepancy of perceived water quality and watershed impairment conditions. Finally, to better measure environmental attitudes, the standard items as proposed in the NEP are recommended provided that the future water surveys can accommodate the more complex measurement.