Water **2011**, *3*, 217-234; doi:10.3390/w3010217

OPEN ACCESS

water

ISSN 2073-4441

www.mdpi.com/journal/water

Article

U.S. Midwestern Residents Perceptions of Water Quality

Zhihua Hu * and Lois Wright Morton

Department of Sociology, Iowa State University, Ames, IA 50010, USA; E-Mail: lwmorton@iastate.edu

* Author to whom correspondence should be addressed; E-Mail: zhihuahu@iastate.edu;
Tel.: +1-515-294-5154; Fax: +1-515-294-2303.

Received: 29 December 2010; in revised form: 6 February 2011 / Accepted: 16 February 2011 / Published: 21 February 2011

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

1. 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.

2. Materials and Methods

2.1. 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.

2.2. 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.

2.3. 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].

2.4. 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.

2.5. 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.

3. 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%.

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;	3.16	1.14
	3 = some college or vocational training;		
	4 = college graduate;		
	5 = advanced degree		

3.1. Analysis of Variance

3.1.1. 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.

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 Rural non-farmFarm	662 216 73	3.42 (0.58) 3.44 (0.60) 3.23 (0.60)	3.595	Farm (0.33) Farm (0.36)
How important is water for recreation? [a]	Urban Rural non-farm Farm	581 184 62	2.78 (0.78) 2.72 (0.85) 2.45 (0.86)	4.831	Farm (0.42)
How important is water for aquatic habitat (fish, ducks, etc.) [a]	Urban Rural non-farm Farm	619 205 72	3.22 (0.70) 3.22 (0.68) 2.89 (0.83)	7.304	Farm (0.46) Farm (0.46)

[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.

3.1.2. 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).

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)		
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)		

Table 3. *Cont.*

		N	Mean (S.D.)	F-statistic	Bonferroni post hoc test (Cohen's d)
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 Rural non-farm Farm	694 225 76	0.51 (0.50) 0.43 (0.50) 0.41 (0.50)	2.994	No significant differences
Is erosion from roads/construction one of most responsible factors for the existing pollution problem in rivers and lakes in your state? [c]	Urban Rural non-farm Farm	694 225 76	0.18 (0.38) 0.25 (0.44) 0.29 (0.46)	4.798	Rural non-farm (−0.18)
Is septic systems one of most responsible factors for existing pollution problems in rivers and lakes in your state? [c]	Urban Rural non-farm Farm	694 225 76	0.12 (0.33) 0.19 (0.39) 0.18 (0.39)	3.681	Rural non-farm (−0.20)

[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

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.

3.1.3. 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.

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);
	Rural non-farm	211	0.17 (0.37)		Farm (−1.13)
	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

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.

3.1.4. 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 self-reporting mean scores of 5.76 and 5.65, respectively, compared to the farm group's lower mean of 5.04.

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

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.

3.2. 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:

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

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

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.

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	

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.

4. 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.

5. Conclusions

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]. 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.

Acknowledgements

The survey was conducted as part of a National USDA 406 Water Quality grant under a #2004-51130-02245 Coordination of Water Quality Programs in the Pacific Northwest.

References and Notes

1. U.S. Environmental Protection Agency (EPA). *National Water Quality Inventory 2000 Report*; United States Environmental Protection Agency, Office of Water, Washington, DC, USA, 2002. Available online: http://www.epa.gov/305b/ (accessed on 1 December 2010).
2. Sabatier, P.A.; Weible, C.; Ficker, J. Eras of water management in the United States: Implications for collaborative watershed approaches. In *Swimming Upstream*; Sabatier, P.A., Focht, W., Lubell, M., Trachtenberg, Z., Vedlitz, A., Matlock, M., Eds.; MIT Press: Cambridge, MA, USA, 2005.
3. Morton, L.W.; Padgitt, S. Selecting socio-economic metrics for watershed management. *Environ. Monit. Assess.* **2004**, *99*, 1-16.
4. Dietz, T.; Stern, P.; Guagnano, G.A. Social structural and social psychological bases of environmental concern. *Environ. Behav.* **1998**, *30*, 450-472.
5. Cheng, A.S.; Kruger, L.E.; Daniels, S.E. 'Place' as an integrating concept in natural resource politics: propositions for a social science research agenda. *Soc. Natur. Resour.* **2003**, *16*, 87-104.
6. Lundmark, C. The New Ecological Paradigm revisited: Anchoring the NEP Scale in environmental ethics. *Environ. Educ. Res.* **2007**, *13*, 329-347.
7. Tomazic, T.J.; Katz, B.M. And not a drop to drink! Perceived threats to clean drinking water. In *The Social Risks of Agriculture: Americans Speak Out on Food, Farming, and the Environment*; Wimberley, R.C., Harris, C.K., Molnar, J.J., Tomazic, T.J., Eds.; Praeger Publishers: Westport, CT, USA, 2002.
8. Alexander, R.B.; Smith, R.A.; Schwarz, G.E.; Boyer, E.W.; Nolan, J.V.; Brakebill, J.W. Differences in phosphorus and nitrogen delivery to the gulf of Mexico from the Mississippi River Basin. *Environ. Sci. Technol.* **2008**, *42*, 822-830.
9. Kemmis, D. *Community and the Politics of Place*; University of Oklahoma Press: Norman, OK, USA, 1990.
10. Kruger, L.E.; Williams, D.R. Place and place-based planning. In *Proceedings of the National Workshop on Recreation Research and Management*; Kruger, L.E., Mazza, R., Lawrence, K., Eds.; 2007. Available online: http://www.fs.fed.us/pnw/pubs/pnw_gtr698.pdf (accessed on 1 December 2010).
11. Weber, E.P. A new vanguard for the environment: Grass-roots ecosystem management as a new environmental movement. *Soc. Natur. Resour.* **2000**, *13*, 237-259.
12. Albrecht, D.; Bultena, G.; Hoiberg, E.; Nowak, P. The new environmental paradigm scale. *J. Environ. Educ.* **1982**, *13*, 39-43.

13. Arcury, T.A.; Christianson, E.H. Environmental worldview in response to environmental problems: Kentucky 1984 and 1988 compared. *Environ. Behav.* **1990**, *22*, 387-407.
14. Dunlap, R.E.; van Liere, K.D.; Mertig, A.G.; Jones, R.E. Measuring endorsement of the New Ecological Paradigm: A revised NEP Scale. *J. Soc. Issues* **2000**, *56*, 425-442.
15. Dunlap, R.E.; van Liere, K.D. The 'New Environmental Paradigm'. *J. Environ. Educ.* **1978**, *9*, 10-19.
16. Dunlap, R.E.; van Liere, K.D. Commitment to the Dominant Social Paradigm and concern for environmental quality. *Soc. Sci. Quart.* **1984**, *65*, 1013-1028.
17. Dunlap, R.E. The New Environmental Paradigm Scale: From marginality to worldwide use. *J. Environ. Educ.* **2008**, 40, 3-18.
18. Scott, D.; Willits, F.K. Environmental attitudes and behavior: A Pennsylvania survey. *Environ. Behav.* **1994**, *26*, 239-260.
19. Freudenburg, W.R. Rural-urban differences in environmental concern: A closer look. *Sociol. Inq.* **1991**, *61*, 167-98.
20. Lowe, G.D.; Pinhey, T.K. Rural-urban differences in support for environmental protection. *Rural Sociol.* **1982**, *47*, 114-128.
21. *Traditional Ecological Knowledge: A Collection of Essays*; Johannes, R.E., Ed.; World Conservation Union (IUCN): Gland, Switzerland, 1989; p. 77.
22. Chambers, R. The small farmer is a professional. *Ceres* **1980**, *13*, 19-23.
23. Turnbull, D. Reframing science and other local knowledge traditions. *Futures* **1997**, *29*, 551-562.
24. Gladwin, C.H. Indigenous knowledge systems, the cognitive revolution, and agricultural decision making. *Agric. Human Values* **1989**, *6*, 32-41.
25. Mackinson, S.; Nottestad, L. Point of view: Combining local and scientific knowledge. *Rev. Fish Biol. Fisheries* **1998**, *8*, 481-490.
26. Mackinson, S. Integrating local and scientific knowledge: An example in fisheries science. *Environ. Manage.* **2001**, *27*, 533-545.
27. Corburn, J. *Street Science: Community Knowledge and Environmental Health Justice*; MIT Press: Cambridge, MA, USA, 2005.
28. Robertson, H.A.; McGee, T.K. Applying local knowledge: The contribution of oral history to wetland rehabilitation at Kanyapella Basin, Australia. *J. Environ. Manage.* **2003**, *69*, 275-287.
29. Fischer, F. *Citizens, Experts, and the Environment: The Politics of Local Knowledge*; Duke University Press: Durham, NC, USA, 2000; pp. 219-263.
30. The survey was conducted as part of a National U.S. Department of Agriculture 406 Water Quality grant under a #2004-51130-02245 Coordination of Water Quality Programs in the Pacific Northwest.
31. For example, Iowa has a population of 3,000,000, so it received a base of 200 surveys for the first 500,000 residents. Then, 25 additional surveys were allocated to Iowa for each additional 250,000 residents above the 500,000 base. So, the number of surveys allocated to Iowa is calculated as follows: Total population—base: 3,000,000–500,000 = 2,500,000. 2,500,000/250,000 = 10; 10 × 25 = 250, which means Iowa should be allocated 250 additional surveys besides the base number. In summary, the total number of surveys for Iowa is 200 (base) + 250 (additional) = 450.

32. Dillman, D.A. *Mail and Internet Surveys: The Tailored Design Method*; Wiley: New York, NY, USA, 2000.
33. From the sample composition, we see that more respondents are urban residents. This means that for the analysis of variance the three groups in comparison have unequal sample size. However, for most of the variables in interest, the three groups have about equal variance, so the unequal sample sizes do not pose too much problem. See Agresti, A.; Finlay, B. *Statistical Methods for the Social Sciences*; Dellen Publishing Company: New York, NY, USA, 1986; pp. 405-406.
34. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*, 2nd ed.; Lawrence Erlbaum Associates: Hillsdale, NJ, USA, 1988.
35. Morton, L.W. The role of civic structure in achieving performance based watershed management. *Soc. Natur. Resour.* **2008**, *21*, 751-766.
36. Norušis, M.J. *PASW Statistics 18 Advanced Statistical Procedures*; Prentice Hall Press: Upper Saddle River, NJ, USA, 2010.
37. Hu, B.; Shao, J.; Palta, M. Pseudo-R^2 in logistic regression model. *Stat. Sinica* **2006**, *16*, 847-860.
38. Buttel, F.H.; Gillespie, G.W., Jr.; Larson, O.W., III.; Harris, C.K. The social bases of agrarian environmentalism: A comparative analysis of New York and Michigan farm operators. *Rural Sociol.* **1981**, *46*, 391-410.
39. Hawcroft, L.J.; Milfont, T.L. The use (and abuse) of the new environmental paradigm scale over the past 30 years: A meta-analysis. *J. Environ. Psychol.* **2010**, *30*, 143-158.
40. About 17% of the U.S. population live in non-metropolitan areas, and farmers comprise about 6% of the rural population. See more detailed information at the U.S. Environmental Protection Agency. Available online: http://www.epa.gov/agriculture/ag101/demographics.html (accessed on 1 December 2010).
41. Dillman, D.; Phelps, G.; Tortora, R.; Swift, K.; Kohrell, J.; Berck, J.; Messer, B.L. Response rate and measurement differences in mixed-mode surveys using mail, telephone, interactive voice response (IVR) and the Internet. *Soc. Sci. Res.* **2009**, *38*, 1-18.
42. Kline, B. *First along the River: A Brief History of US Environmental Movement*; Rowman & Littlefield Publishers: New York, NY, USA, 2007.