Linking Public Attitudes with Perceptions of Factors Impacting Water Quality and Attending Learning Activities

D. E. Clay, C. Ren, C. Reese, R. Waskom, J. Bauder, N. Mesner, G. Paige, K. Reddy, M. Neibauer, and R. Mahler*

ABSTRACT Increasingly, people are being asked to make decisions about water use in the semi-arid regions of the United States. "Good decisions" depend on an understanding of the linkages between sustainability of the resource, management, and economic development. This article reports on findings from a water quality survey conducted in Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming. The survey goals were to: (1) identify linkages between perceptions and perceived factors degrading water quality; and (2) define how to implement educational programming that would ultimately lead to improved water quality. Findings from the survey suggest that many peoples' perceptions about water use, the importance of adopting improved techniques, and factors influencing water quality were not in harmony. For example, the use of improved grazing techniques was identified as very or extremely important by 65% of the respondents even though the consequences of poor livestock or manure management (high bacterial counts in water) were identified in 19% of the respondents as a suspected or known problem. These results were attributed to many people not having a clear understanding of the relationships between water quality and the adoption of natural resource management techniques. Improving peoples' ability to link perceptions and problems will require educational programs that integrate problems with solutions. Surprisingly, most respondents did not identify a willingness to attend structured learning activities (short course, watch video, obtain certification, or be trained), where detailed problems and solutions can be explored. To overcome this problem, educators should consider developing targeted and sequential educational programming which employs print or video media.

articles

Many small communities in the Great Plains and Rocky Mountains desire to increase economic development, alternative energy production, as well as recreational and tourism opportunities. To accomplish these goals, land and water management decisions must involve integration of solutions to complex economic and environmental questions.

Teaching people about natural resource management has been an important goal within the cooperative extension service for decades. Educational approaches have generally relied on: (1) demonstration sites to show linkages between management and profitability, and (2) use of the diffusion model to transfer ideas and techniques from innovative people to the general public (Ryan and Gross, 1943; Rogers and Showmaker, 1971; Stephenson, 2003). Despite considerable economic and human resource investment in educational programs, implementation by the general public of practices designed to improve water quality have generally been poor (King and Rollins,1995; Drost et al., 1996; Kansas Department of Agriculture, 1997; Shepard, 1999; Shennan et al., 2001; Bauder et al., 2003; Rahelizatovo and Gillespie, 2004; USDA-NASS, 2005).

Slow adoption rates of practices designed to improve water quality can be attributed to a number of factors including: (1) the proposed management practices not being consistent with cultural practices (Barnett, 1953); (2) proposed practices may not produce measurable increases in profitability (Rogers and Showmaker, 1971; Rahelizatovo and Gillespie, 2004); (3) proposed new technologies contains significant risk and requires a higher level of management (Wolf, 1998); (4) producers' perceptions that their action will not make a difference (Harrington et al., 1985); and (5) mixed messages being delivered to producers (Rehm et al., 1998; Bundy, 2000; Lory and Scharf, 2003). For example, several Midwestern states recently made a

Impact Statement

Understanding peoples perceptions about water quality is important for developing educational programs that will solve problems. A water quality survey was conducted in South Dakota, North Dakota, Montana, Wyoming, Colorado, and Utah. The survey showed that many people have conflicting ideas about water quality. Improving peoples' ability to link perceptions with problems will require educational programs that integrate problems with solutions.

D. Clay, C. Ren, and C. Reese, South Dakota State Univ., Brookings SD 57007; R. Waskom and M. Neibauer, Colorado State Univ., Fort Collins, CO 80523; J. Bauder, Montana State Univ., Bozeman, MT 59717; N. Mesner, Utah State Univ., Logan UT 84322; G. Paige and K. Reddy, Univ. of Wyoming, Laramie, WY 82071; and R. Malher, Univ. of Idaho, Moscow, ID 83844. South Dakota State Univ. Exp. Stn. no. 3568. Support for this research was provided by the USDA-CSREES-406 Water Quality Program grant no. 2004-51130-02248. Received 22 June 2006.
*Corresponding author (David.clay@sdstate.edu).

J. Nat. Resour. Life Sci. Educ. 36:36–44 (2007).
http://www.JNRLSE.org

677 S. Segoe Rd., Madison, WI 53711 USA

change in nitrogen fertilizer guidelines from the yield goal to alternative approaches that are state and site specific. The previous yield goal approach made conceptual sense (higher yields remove more nutrients) to many farmers and had been promoted for more than 40 years. Adoption of the new approach is complicated by different states having different guidelines, some states not adopting the new approach, and some scientists and crop consultants within the region not agreeing with proposed changes.

To serve the educational needs of the public about water quality, a better understanding of peoples concerns, priorities, and willingness to implement practices designed to improve water quality is needed. This article presents findings from a water quality survey aimed to: (1) identify linkages between perceptions and perceived factors degrading water quality; and (2) define how to implement educational programming that would ultimately lead to improved water quality.

Materials and Methods

Survey

A direct mail survey was developed to assess: (1) public attitudes about water resource issues; (2) how respondents rate their awareness of water quality issues; and (3) where respondents obtain their water-resource related information. The survey was mailed to randomly selected residences in South Dakota, Montana, North Dakota, Wyoming, Colorado, and Utah in November 2004 (Table 1). The number of surveys sent to each state was based on the state's population. Results were tabulated in February and March of 2005. The overall return rate was 57%

In addition, the questions reported by Mahler et al. (2005) the survey asked participants to identify: (1) how they rate importance of clean rivers, groundwater, and drinking water; (2) how they rate importance of water for power generation, livestock, commerce, household landscapes, recreation, irrigation, aquatic habitats, and municipal use; (3) their perception of quality of groundwater and surface water in their area; and (4) the top three learning opportunities they would most likely utilize from a list (printed fact sheets, website, short courses, demonstrations, newspaper, TV, videos, certification courses, volunteer, water practice assessment, and local fair or festival). Individuals were also asked: (1) if they received water quality information from television, newspaper, extension service, universities, schools, environmental agencies, environmental groups, magazines, and/or other; (2) about their awareness on the linkages between water quality and agricultural water management, animal waste management, drinking water and human health, environmental restoration, nutrient and pesticide management, pollution prevention and assessment, water conservation, water policy and economics, and watershed management; (3) to identify their top three choices impacting water quality from a list consisting (forestry, crop production, livestock and poultry operations, erosion from roads, wastes from urban areas, mining, military bases, range, septic systems, fires, drought, and runoff from home landscapes); (4) who they believe is most responsible for protecting water quality from a list (federal government, state or territorial government, local county/city/town government, or individual citizens); and (5) if they or their community has adopted water-saving appliances, landscaping designed to minimize water use, how vehicles are washed, and if they disposed of household chemicals or yard wastes at an approved facility.

Categorical data for selected responses in this survey was analyzed in SAS using PROC FREQ. The percentages for each category and their statistical significance were based on the *p* value from Pearson Chi-squared test. When appropriate, the method of Goodman (1965) was used to determine the 95% confidence intervals for multinomial proportions. For one question that produced ordinal data (producers rate their commitment to environmental quality) the *p* value from "Row Mean Scores Differ" was used to evaluate differences. This analysis was deemed more powerful since the ordinal test has a power advantage over tests using Pearson Chi-squared.

Results and Discussion

Demographics and Survey Return Rates

Respondents were categorized by gender, size of community, education level, occupation, state, and age. The number of surveys distributed and returned, as well as the demographic characteristics of the respondents was summarized (Table 1). Of those who identified their gender, 64% were male and 30% were female. Of the surveys returned, 4% identified themselves as farmers or ranchers, 4% identified themselves in manufacturing, 6% identified themselves in teaching, 12% identified themselves in business, 31% identified themselves as professionals, 6% identified themselves in retail, 24% identified themselves as retired, and 13% identified themselves as other. More than 95% of the respondents completed high school. Almost three quarters (73%) of the survey participants obtained water from either city water or community wells. Only 13% of the participants obtained water from an individual well, river, or lake.

Most of the participants (55%) came from communities with a population greater than 25,000 and only 23% were from communities with populations between 3500 and 25,000 (Table 2). These statistics were consistent with the general demographics of the states participating in the survey. The smaller the community and rural residents were more likely to obtain water from individual wells. Associated with this decrease was an increase in those obtaining water from individual wells.

Linking Perceptions, Expectations, and Management

In the region, 67, 78, 75, and 79% of participants identified water for power, livestock, irrigation, and aquatic habitats as very or extremely important, respectively (Table 3). These results were interesting given that in water limited systems, providing water for one of the uses identified as important reduces water availability for other uses identified as important. For example, allocating water for irrigation can reduce water available for aquatic habitats. Linkage between water for irrigation and aquatic habitats

Table 1. Demographics of respondents to a the water quality survey conducted in USEPA Region 8 during the winter of 2004–2005.

		States					
Demographics	**All states**	**Colorado**	**Montana**	**North Dakota**	**South Dakota**	**Utah**	**Wyoming**
Returned surveys	1087	309	130	145	129	235	139
Mailed surveys	1925	600	250	225	250	400	200
Level of education	----------% respondents----------						
<High school	4	3	5	6	6	2	5
High school graduate	18	13	16	17	28	18	23
Some secondary school	32	27	40	30	30	31	38
College graduate	32	34	29	37	27	35	23
Advanced college degree	15	24	10	10	9	14	12
Occupation							
Farming	1	1	1	1	1	1	1
Ranching	3	2	6	6	3	8	3
Manufacturing	4	3	4	3	3	6	3
Teaching	6	7	3	6	9	18	7
Business	12	12	9	12	14	33	5
Professional	31	35	23	28	26	65	29
Retail	5	7	3	5	2	20	6
Retired	24	22	35	21	27	9	30
Other	13	12	14	16	14	0	16
Gender							
Male	68	66	70	70	68	68	68
Female	32	34	31	30	32	32	32
Age							
<50	45	45	41	46	41	56	37
>50	55	55	59	54	59	44	63
Length of residence							
All life	44	26	52	64	34	51	29
>10 < whole life	44	57	37	28	34	39	57
5–9 years	6	10	5	4	2	6	8
<5 years	6	7	7	4	4	4	6
Source of water							
City water	70	74	56	66	60	79	75
Individual well	12	13	28	10	13	2	15
Community well	8	8	9	9	11	5	5
River or lake	1	0	2	1	3	1	0
Bottled or reverse osmosis	9	5	6	13	13	11	6
Don't know	1	1	0	1	0	1	0

was identified by the Montana River Action (2006), when they reported more than 4000 miles of streams and rivers were routinely dewatered in Montana and the primary cause of dewatering was irrigation. In North and South Dakota similar cases can be made between providing water for power generation on the Missouri River, providing water for recreational uses (fishing), providing water to maintain aquatic habitats, and providing water for downstream barge traffic.

Slight differences of opinion on the importance of preserving riparian areas were observed between occupations. Fewer farmers and ranchers (47%) than professionals identified the preservation of riparian areas as very or extremely important (63%, data not shown). These differ-

Table 2. Community sizes of respondents completing the USEPA Region 8 water quality survey conducted during the winter of 2004–2005.

	Community size				
Water source	>100,000	25,000–100,000	7000–25,000	3500–7000	<3500
No. respondents	285	317	149	91	157
% response	26.2	29.2	13.7	8.4	14.4
	----------% responses----------				
City water	77	73	66	57	37
Individual well	2	9	12	20	26
Community well	3	4	9	7	17
River or lake	1	1	0	1	4
Bottled or reverse osmosis	8	9	8	7	10
Don't know or incorrectly filled out	8	4	5	9	7
No. of responses	285	317	149	91	157

ences may be related to: (1) farmers and ranchers desire to manage their land as they wish (Klapproth and Johnson, 2001); (2) producers' interest in using natural resources to produce income (Alexander, 1994); and (3) some respondents' lack of interest in bearing the costs of long-term projects with ambiguous goals (Nowak, 1987).

In a different example, water for landscaping (34%) and recreation (49%) were not identified as important as providing water for livestock (78%) and commerce (61%). The lower importance of providing water for landscaping is not consistent with actual practices in many areas of the region. For example, the Utah Division of Water Resources (2001) reported statewide per capita daily water use was 321 gallons, of which 66% was for residual use (cooking, drinking water, sanitation,

Table 3. The percentage of respondents that identified different water quality issues as very or extremely important. The survey was conducted during the winter of 2004–2005 in USEPA Region 8. The 95% confidence intervals are shown in parentheses.

		States					
Topic	All states	Colorado	Montana	North Dakota	South Dakota	Utah	Wyoming
	----------% very or extremely important----------						
Clean rivers	92 (2.0)	95 (2.9)	95 (4.7)	88 (6.6)	87 (7.1)	91 (4.5)	93 (5.2)
Groundwater	93 (1.9)	95 (3.0)	96 (4.0)	89 (6.2)	90 (6.3)	92 (4.2)	92 (5.5)
Drinking water	97 (1.3)	97 (2.4)	99 (1.8)	97 (3.3)	94 (5.1)	96 (3.0)	99 (2.4)
Water for:							
Power	67 (3.6)	61 (7.0)	72 (9.9)	72 (9.3)	69 (10.2)	69 (7.6)	70 (9.7)
Livestock	78 (3.2)	75 (6.2)	80 (8.9)	83 (7.8)	79 (9.0)	73 (7.3)	86 (7.3)
Commerce	61 (3.7)	61 (6.9)	60 (10.8)	63 (10.0)	58 (10.9)	61 (8.0)	65 (10.1)
Landscaping	34 (3.6)	30 (6.5)	32 (10.2)	39 (10.1)	31 (10.2)	38 (7.9)	36 (10.2)
Recreation	49 (3.8)	45 (7.1)	58 (10.9)	59 (10.2)	45 (10.9)	46 (8.1)	50 (10.6)
Irrigation	75 (3.3)	80 (5.7)	81 (8.6)	61 (10.1)	60 (10.8)	77 (6.8)	83 (8.0)
Water aquatic habitats	79 (3.1)	82(5.5)	91(6.3)	72(9.3)	72(9.9)	77 (6.9)	79(8.6)
Municipal use	68 (3.5)	62 (6.9)	75 (9.5)	83 (7.8)	69 (10.2)	60 (8.0)	73 (9.4)
Better agricultural prac.	78 (3.1)	83 (5.4)	76 (9.3)	77 (8.8)	76 (9.4)	73 (7.2)	83(8.0)
Preserve riparian areas	61 (3.7)	68 (6.7)	74 (9.6)	57 (10.3)	53 (11)	53 (8.1)	60 (10.4)
Watershed management	70 (3.5)	76 (6.0)	73 (9.7)	60 (10.2)	63 (10.6)	66 (7.7)	72 (9.5)
Restoring disturbed land	60 (3.7)	66 (6.8)	77 (9.2)	51 (10.4)	57 (10.9)	48 (8.1)	67 (10.0)
Urban stormwater runoff	56 (3.8)	61 (6.9)	61 (10.7)	57 (10.3)	52 (11.0)	49 (8.1)	50 (10.6)
Preserve ag and open areas	71 (3.4)	80 (5.7)	77 (9.2)	70 (9.5)	64 (10.5)	63 (7.9)	71 (9.6)
Improved grazing	65 (3.6)	68 (6.6)	67 (10.4)	66 (9.9)	59 (10.8)	57 (8.1)	73 (9.4)
Management rec. activities	58 (3.7)	59(7.0)	62 (10.7)	56 (10.3)	56 (10.9)	55 (8.1)	63 (10.3)

Table 4. Respondents awareness of factors influencing water quality and domestic water purchases in USEPA Region 8. The survey was conducted during the winter of 2004–2005. The 95% confidence intervals are in parentheses.

		States					
Topic	All states	Colorado	Montana	North Dakota	South Dakota	Utah	Wyoming
	----------% yes responses----------						
Purchase 5 gal. water	7 (1.6)	7 (2.8)	12 (5.6)	15 (5.9)	3 (3.1)	6 (3.1)	25 (7.5)
Use bottled water	36 (2.9)	39 (5.4)	34 (8.2)	30 (7.4)	33 (8.2)	41 (6.3)	31 (7.6)
Satisfied with water	69 (2.8)	68 (5.2)	76 (7.4)	64 (7.8)	74 (7.6)	66 (6.1)	72 (7.4)
Good to ex. groundwater, improving	25 (3.6)	20 (6.1)	33 (11.1)	23 (9.4)	22 (10.1)	26 (7.8)	28 (10.3)
Good to ex. surface water, improving	16 (3.0)	15 (5.5)	22 (9.8)	17 (8.4)	12 (7.8)	12 (5.8)	19 (9.0)
Awareness of the following factors:	----------% aware----------						
Agricultural water man.	65 (2.9)	61 (5.5)	69 (8.1)	73 (7.4)	70 (8.2)	55 (6.5)	71 (7.8)
Animal waste man.	51 (3.0)	46 (5.6)	57 (8.6)	59 (8.2)	61 (8.6)	39 (6.4)	56 (8.6)
Human health	88 (2.1)	88 (3.7)	86 (6.0)	92 (4.6)	83 (6.7)	85 (4.6)	92 (4.5)
Environmental restoration	69 (2.9)	70 (5.2)	75 (7.6)	70 (7.8)	68 (8.3)	61 (6.4)	74 (7.6)
Nutrient and pest man.	58 (3.1)	55 (5.6)	63 (8.4)	67 (7.8)	66 (8.4)	50 (6.63)	57 (8.6)
Pollution and prevention	67 (3.0)	67 (5.3)	69 (8.1)	67 (7.9)	67 (8.3)	61 (6.4)	60 (7.8)
Water conservation	86 (2.3)	90 (3.3)	81 (6.9)	79 (6.7)	76 (7.5)	88 (4.2)	90 (5.1)
Water policy	66 (3.0)	74 (5.0)	59 (8.6)	58 (8.2)	59 (8.8)	63 (6.3)	71 (7.9)
Watershed management	58 (3.0)	59 (5.6)	61 (8.5)	58 (8.2)	57 (8.8)	54 (6.5)	64 (8.2)

and landscaping). High water use was partially attributed to lawn maintenance in desert environments. They noted that residential outdoor water conservation (reduce use on landscapes) could reduce residential water use 67%.

The importance of water for recreation (49%) was rated less important than water use for irrigation or aquatic habitats (79%). Slight differences across the states were observed. Among the states, 59% of the surveys from North Dakota identified water for recreation as very or extremely important while only 45% of the South Dakota survey identified water for recreation as very or extremely important. Farmers and ranchers generally rated water for recreation of less importance (21%) than professionals (54%, data not shown).

Individuals in the region that responded to the survey were generally aware of the importance of water conservation (86%) and the impact of water on human health (88%, Table 4). They were less aware of management practices designed to protect or improve water quality. For example, 65% of the respondents identified use of improved grazing practices as very or extremely important (Table 3), whereas 51% were aware of the importance of animal waste management and 58% were aware of the importance of nutrient and pest management with respect to water quality (Table 4). Similar percentages of farmers/ranchers (66%) and professionals (64%) identified the importance of adopting improved grazing techniques (data not shown).

Benefits of implementing agricultural best management practices (BMP) were recognized but linkage to water quality was not apparent to many respondents. For example, across the states the utilization of better agricultural practices (78%) and using improved grazing (65%) was identified as very or extremely important, yet only 19% of the respondents identified high bacterial counts as a suspected or known problem (Table 5). In reality high bacterial counts and pharmaceutical detections in surface water have been linked to livestock and poultry operations in the region (Yang and Carlson, 2003). Occupation had a limited impact on the identification of bacteria as a known and suspected problem: 14% farmers/ranchers and 16% professionals identified bacteria in water was a suspected or known problem (data not shown). The relatively low number of survey participants who identified high bacterial counts and pharmaceuticals as a suspected or known problem were surprising, given that these are serious or potentially serious problems in the region. For example, only 25% of South Dakota's respondents identified high bacterial counts as a suspected or known problem. This low percentage is despite numerous newspaper articles that routinely discuss water quality in the Big Sioux River. This river provides 65% of the drinking water to South Dakota's largest and most rapidly growing city, Sioux Falls. Water from the river has been reported to contain human pharmaceuticals, veterinary compounds, herbicides, fecal coliform populations as high as 15,000 bacteria/100 mL, and suspected endrocrine disruptors (Schaap, 2002; Sando et al., 2005). Swimming in portions of this river is not recommended.

Various percentages of the responders states viewed nitrate (28–33%), pesticides (19–37%), heavy metals (16–34%), minerals (28–33%), and products from mining (14–30%) as a suspected or known factors impacting water quality (Table 5). South Dakota had the highest percentage

Table 5. Perceived importance of factors influencing water quality in USEPA Region 8 during the winter of 2004–2005. The 95% confidence intervals are shown in parentheses.

		States					
Topic	All states	Colorado	Montana	North Dakota	South Dakota	Utah	Wyoming
	----------% suspect or perceived as a known problem----------						
High bacterial counts	19 (3.0)	20 (5.7)	17 (8.3)	17 (8.0)	25 (10.1)	17 (6.3)	16 (8)
Nitrates	31 (3.6)	34 (6.8)	38 (10.7)	39(10.2)	42 (11.1)	19 (6.4)	21 (8.8)
Heavy metals	23 (3.2)	26 (6.3)	34 (10.4)	19 (8.2)	16 (8.3)	23 (7.0)	19 (8.4)
Minerals	31 (3.6)	33 (6.8)	30 (10.2)	28 (9.5)	33 (10.7)	32 (7.7)	30 (9.8)
Pesticides	27 (3.4)	29 (6.7)	26 (9.7)	32 (9.9)	37 (11)	19 (6.6)	20 (8.6)
Products from mining	22 (3.2)	25 (6.3)	30 (10.2)	16 (7.6)	14 (8.0)	19 (6.5)	24 (9.2)
Salinity	13 (2.6)	12 (4.7)	14 (7.7)	22 (8.8)	9 (6.5)	8.5 (4.7)	14 (7.4)
Pharmaceuticals	10 (2.3)	17 (5.3)	10 (6.7)	10 (6.3)	7 (5.6)	7 (4.3)	4 (4.0)

while Utah had the lowest percentage of respondents rating nitrate as a suspected or known problem. The high rating in South Dakota may be attributed to public awareness related to the closure of several municipal water supplies due to high nitrate concentrations. Interestingly, the relatively low rating of nitrates and pesticides as a known or suspected water quality problem did not correspond with the high awareness on the importance of nutrient and pest management (58%) and large number of people who identified use of better agricultural practices as very or extremely important (78%).

Waste products and residuals from mining were identified in 22% of the survey responses as a suspected or known problem, while 60% of the people identified restoring disturbed land as very or extremely important. Slightly different responses regarding mining were observed in the different states. In Montana, 30% of the participants identified mining products as being a suspected or known problem (Table 5) and 77% of the survey participants (Table 3) identified restoring disturbed land as very or extremely important. In South Dakota, different results were observed, with 14% of the respondents identifying mining products as an important or known problem (Table 5) and 57% identifying restoring disturbed land as very or extremely important (Table 3). Occupation had a minimal impact on these responses. For example, farmers/ranchers (20% suspected or known problem) and professionals (19% suspected or known problem) had similar responses about mining problems (data not shown). These findings suggest that the high ranking for restoring disturbed land was related to the importance of preserving agricultural and open areas, rather than reducing the impacts of disturbed mined areas on the environment.

The respondents' occupation influenced the responses about the stated importance of environmental issues (Table 6). Farmers and ranchers generally rated themselves less concerned (4.6 on a scale of 1 to 10 with 10 equal to total environmental protection) about the environment, when compared with teachers (score of 6.2). Respondents from communities with a population <3500 rated importance of environmental issues lower (score of 5.2) than respondents from communities with populations >100,000 (score of 6.0) (data not shown). Hagan (1996) had similar results, and reported that the typical Buffer Incentive Program participant in Maryland was: (1) more educated (two-thirds had at least a college degree), younger, and had less farm management experience than landowners not in the program; (2) obtained less income from the farm than non-participating farmers; and (3) was less likely to be a full time farmer (one-third managed 20 acres or less).

Collectively results from the survey indicate that water is considered important to most people in the region. However, responses regarding perceptions about water quality and the actual factors perceived to degrade water in many cases were inconsistent. To ensure that "good decisions" are made, educational programs must teach people how resource use, management practices, and water quality problems are linked.

Source of Information and Educational Activity

Across the region, the majority of participants identified that they were more likely to obtain information from TV (64%) and newspapers (75%) than from the cooperative extension service (32%). A larger percentage of respondents identified they were more likely to obtain information from environmental groups (40%) than from the extension service (32%) or schools (17%). Occupation also affected respondents' responses. Farmers and ranchers were less likely to obtain water quality information from TV (47% obtained information) and newspapers (53% obtained information) than teachers (>80%), and more likely to obtain information from cooperative extension (69%) than any other occupation group (Table 6).

Structured and unstructured learning opportunities were also evaluated by the survey (Table 7). Structured programs included taking short courses, watching a video, obtaining certification, and training. Unstructured education opportunities included visiting a website, reading a newspaper, and watching TV. In structured programs, experts help students (learners) understand cause and effect

Table 6. Occupation influence on the environmental continuum score (scored 1 to 10 with score of 10 for total environment protection) and the percentage of respondents that received water quality information from different sources in USEPA region 8. The survey was conducted during the winter of 2004–2005. The 95% confidence values are in the parentheses.

Occupation and environmental contimum	All backgrounds	Background						
		Crop and ranch	Manufac.	Teaching	Business	Profes.	Retail	Retired
	----------score out of 10----------							
Environmental continuum	5.6 (0.2)	4.6 (0.54)	5.6 (0.52)	6.2 (0.43)	5.5 (0.31)	5.8 (0.19)	5.9 (0.46)	5.5 (0.22)
Information source	----------% respondents obtaining information----------							
TV	64 (3.8)	47 (17.3)	60 (16.2)	84 (10.2)	66 (9.4)	61 (6.2)	77 (13.2)	69 (6.8)
Newspaper	75 (3.4)	53 (17.3)	76 (14.4)	82 (10.6)	75 (8.6)	75 (5.3)	80 (12.4)	76 (6.0)
Extension service	32 (3.8)	69 (15.4)	25 (15.0)	48 (15.7)	30 (9.8)	25 (5.8)	33 (16.0)	44 (7.8)
University	27 (3.1)	45 (17.0)	37 (17.3)	40 (15.2)	27 (10.0)	29 (6.0)	18 (13.2)	19 (6.7)
School	17 (3.1)	13 (15.9)	29 (15.1)	34 (8.5)	17 (5.0)	16 (15.3)	29 (5.1)	9 (17.0)
Gov. agency	48 (4.1)	52 (17.0)	41 (17.9)	57 (14.9)	48 (10.8)	46 (6.5)	56 (16.7)	46 (8.1)
Environ. group	40 (4.0)	40 (17.5)	39 (17.1)	47 (15.5)	37 (10.6)	41 (6.4)	49 (16.2)	34 (7.9)
Magazines	44 (4.0)	53 (17.8)	43 (17.2)	54 (15.3)	46 (10.6)	41 (6.4)	37 (16.0)	44 (7.9)

relationships in complex problems, while in non-structured programs learning often follows a non-linear approach and important details can be overlooked. Each of these formats constitutes meaningful learning activities. The top three preferred learning opportunities selected by respondents were the unstructured approaches (Table 7). Structured approaches [take a short course (6%), obtain certification (6%), and get trained (6%)] were the least preferred. These results suggest many people may not be obtaining the necessary information required to assess complex environmental problems. Teaching individuals the depth and detail needed to evaluate landuse and environmental questions linked to water quality is important because many of these problems can only be addressed locally. One way to overcome this shortcoming may be to develop targeted sequential factual and topical articles for distribution through print or video media.

Type of learning opportunities respondents preferred was influenced by occupation (Table 7). Farmers and ranchers were less willing or likely to visit a website than participants in teaching, business, or professional occupations. These results could be attributed to the lack of internet access, slow internet speeds in rural areas, lack of training, or discomfort with the use of electronic techniques. However, survey results also suggested that farmers and ranchers were more willing than other professions to request

Table 7. Relationship between occupation and the three most preferred learning opportunity of participants located in USEPA region 8. The 95% confidence values are shown in parentheses.

Leaning opportunities available	All backgrounds	Background						
		Crop and ranch	Manufac	Teaching	Business	Profes.	Retail	Retired
	----------% selected as preferred technique----------							
Read fact sheet	57 (3.5)	53 (15.9)	64 (15.1)	55 (12.8)	60 (9.0)	59 (5.7)	43 (13.9)	54 (6.5)
Visit website	37 (3.3)	24 (13.5)	28 (14.1)	38 (12.5)	43 (9.0)	53 (5.8)	31 (12.9)	20 (5.2)
Take short course	6 (1.6)	11 (9.8)	8 (8.4)	9 (7.2)	6 (4.4)	7 (3.0)	6 (6.7)	3 (2.2)
Look at demonstration	20 (2.7)	24 (13.5)	18 (12.0)	16 (9.3)	13 (6.2)	21(4.7)	24 (12.0)	22 (5.4)
Read newspaper/watch TV	62 (3.4)	50 (15.9)	64 (15.1)	67 (12.1)	63 (8.8)	57 (5.8)	57 (13.9)	71(5.9)
Watch video	17 (2.5)	24 (13.5)	13 (10.5)	17 (9.7)	17 (6.8)	14 (4.1)	14 (9.8)	21(5.3)
Volunteer	10 (2.0)	8 (8.6)	10 (9.5)	19 (10.1)	10 (5.4)	12 (3.8)	12 (9.2)	7 (3.2)
Obtain certification	6 (1.6)	5 (7.1)	3 (5.0)	10 (7.8)	7 (4.7)	10 (3.5)	4 (5.5)	1(1.5)
Get trained	6 (1.5)	0 (nd)	3 (5.0)	2 (3.4)	7 (4.7)	7 (3.0)	8 (7.7)	4 (2.7)
Conduct assessment	9 (1.9)	26 (14.0)	5 (6.9)	10 (7.8)	10 (5.6)	6 (2.7)	16 (10.4)	8 (3.6)
Attend fair	9 (1.9)	11 (9.8)	8 (8.4)	12 (8.4)	5 (4.1)	9 (3.4)	12 (9.2)	10 (3.8)

an assessment for a home, farm, or workplace. Observed differences among occupational groups were attributed to differences in personal experiences and perceptions about the environment. For example, farmers and ranchers were much more aware of the importance of watershed management (81% aware vs. 57% for all other occupations combined) and nutrient and pest management (81% aware vs. 53% for all other occupations combined) in maintaining water quality. High awareness in the farm and ranch group is most likely an outcome of extension and USDA-NRCS educational activities that they have participated in over the past decade.

In summary, many respondents did not have a clear understanding of how resource management, soils, water, and landscapes interact to influence water quality. Evidence supporting this finding was shown by many respondents having conflicting responses to action and effect questions. These results suggested many respondents' ability to link the importance of using watershed management, improved grazing, preservation of riparian areas, and better agricultural practices (Table 3) to specific problems was limited. Improving linkages between perceptions and actual problems will require educational programs that integrate problems with solutions.

Survey results also indicate that many people do not understand the linkages between water quality and watershed management. We have three recommendations to overcome this shortcoming. First, educators should consider developing targeted sequential factual articles which provide in-depth analysis of specific problems. Cause-and-effect relationships should be discussed. Second, educators should consider utilizing outreach models that rely on developing personal relationships rather than those that solely rely on seminars and mass communication (Drost et al., 1996; Shepard, 1999; Blissett et al., 2005). Third, if the audience is farmers and ranchers, outreach models that rely on the internet may miss a large portion of the target audience. Effectiveness of internet-based outreach approaches should be assessed for specific audiences.

References

Alexander, S.V. 1994. Riparian restoration through integrated resource management. p. 232–239. *In* Riparian ecosystems in the humid U.S. Functions, values, and management. Proceedings of a conference, Atlanta, GA. 15–18 Mar. 1993. National Association of Conservation Districts, Washington, DC.

Barnett, H. 1953. Innovation: The basis of culture change. McGraw Hill, New York.

Bauder, T.A., R.M. Waskom, and W.M. Frasier. 2003. Producer adoption of nutrient best management practices in Colorado. *In* Proceedings of the Western Nutrient Management Conference, Salt Lake City UT, 5:102–105. Available at http://isnap.oregonstate.edu/WCC103/2003_proccedings/p102%20Bauder%20-%20BMPs.pdf (accessed 4 Jan. 2006; verified 2 Feb. 2007).

Blissett, H., S. Simmons, N. Jordan, and K. Nelson. 2005. Evaluation of learning group approaches for fostering integrated cropping systems management. J. Nat. Res. Life Sci. Educ. 33:134–140.

Bundy, L.G. 2000. Nitrogen recommendations and optimum nitrogen rates: How do they compare? p. 5–13. *In* Proc. North Central Ext-Industry Soil Fert. Con., St Louis, MO. Vol. 16. Potash and Phosphate Inst., Norcross, GA.

Drost, D., G. Long, D. Wilson, B. Miller, and W. Campbell. 1996. Barriers to adopting sustainable agricultural practices. J. Ext. 34 (6). Available at www.joe.org/ (accessed 3 Jan. 2006; verified 2 Feb. 2007).

Goodman, L.A. 1965. On simultaneous confidence intervals for multinomial proportions. Technometrics 7:247–254.

Hagan, P.T. 1996. Evaluating determinants of participation in voluntary riparian buffer programs: A case study of Maryland's Buffer Incentive Program. M.S. thesis. Marine, Estuarine, and Environmental Sciences Program, Univ. of Maryland, Machias.

Harrington, W., A.J. Krupnick, and H.M. Peskin. 1985. Policies for nonpoint source water pollution control. J. Soil Water Conserv. 40:27–32.

Kansas Department of Agriculture. 1997. Governor's Water Quality Initiative. Kansas Cropping Practice Survey 1996, Topeka, KS.

King, R.N., and T.J. Rollins. 1995. Factors influencing the adoption of nitrogen testing program. J. Ext. 33:4.

Klapproth, J.C., and J.E. Johnson. 2001. Understanding the science behind riparian forest buffers: Factors influencing adoption. Virginia Coop. Ext. 420-154. Available at www.ext.vt.edu/pubs/forestry/420-154/420-154.html (verified 2 Feb. 2007).

Lory, J.A., and P.C. Scharf. 2003. Yield goal versus delta yield for predicting fertilizer nitrogen need in corn. Agron. J. 95:994–999.

Mahler, R.L., R. Simmons, and F. Sorensen. 2005. Drinking water issues in the pacific northwest. J. Ext. 45:6R1B6. Available at www.joe.org/ (accessed 3 Jan. 2006; verified 2 Feb. 2007).

Montana River Action. 2006. Keeping water in streams. Available at www.montanariveraction.org/ (accessed 6 Jan. 2006; verified 2 Feb. 2007).

Nowak, P.J. 1987. The adoption of conservation technologies: Economic and diffusion explanations. Rural Soc. 42:208–220.

Rahelizatovo, N.C., and J.M. Gillespie. 2004. Factors influencing the implementation of best management practices in the dairy industry. J. Soil Water Conserv. 59:166–175.

Rehm, G., M. Schmitt, and R. Elliason. 1998. Fertilizing wheat in Minnesota. Univ. of Minnesota Extension. FO-03772-GO. Available at www.extension.umn.edu/distribution/cropsystems/DC3772.html (accessed 6 Jan. 2006; verified 2 Feb. 2007).

Rogers, E., and F. Showmaker. 1971. Communication of innovations: A cross-cultural approach. 2nd ed. Free Press, New York.

Ryan, B., and N.C. Gross. 1943. The diffusion of hybrid seed corn in two Iowa communities. Rural Soc. 8:15–24.

Sando, S.K., E.T. Furlong, J.L. Gray, M.T. Meyer, and R.C. Bartholomay. 2005. Occurrence of organic waste water compounds in the wastewater effluent and the Big Sioux River in the upper Big Sioux River basin. South Dakota, 2003–2004. USGS South Dakota Water Science Center Publ. 2005-5249. Available at http://pubs.usgs.gov/sir/2005/5249/ (accessed 24 Feb. 2006; verified 2 Feb. 2007).

Schaap, B.D. 2002. Reconnainssance-level assessment of water quality near Flandreau South Dakota. USGS Open-file report 02-474. Available at http://pubs.usgs.gov/of/2002/ofr02474/ofr02474_files/ofr02474.pdf (accessed 30 Mar. 2006; verified 2 Feb. 2007).

Shennan, C., C.L. Cecchettini, G.B. Goldman, and F.G. Zalom. 2001. Profiles of California farmers by degree of IPM use as indicated by self-description in a phone survey. Agric. Ecosyst. Environ. 84:267–275.

Shepard, R. 1999. Making our nonpoint source pollution ducation programs effective. J. Ext. 37(5) Available at www.joe.org/ (accessed 3 Jan. 2006; verified 2 Feb. 2007).

Stephenson, G. 2003. The somewhat flawed theoretical foundation of the extension service. J. Ext. 41(4). Available at www.joe.org/ (accessed 3 Jan. 2006; verified 2 Feb. 2007).

USDA-NASS. 2005. Agricultural chemical use survey. Field crop survey. 2004.

Utah Division of Water Resources. 2001. Utah water resource planning for the future. Utah Board of Water Resouces. Available at www.water.utah.gov/waterplan/uwrpff/Title.htm (accessed 6 Jan. 2006; verified 2 Feb. 2007).

Wolf, S.A. 1998. Privatization of crop production information service markets. p. 151–182. *In* S.A. Wolf (ed.) Privatization of information and agricultural industrialization. CRC Press LLC, Boca Raton, FL.

Yang, S.W., and K. Carlson. 2003. Evolution of antibiotic occurrence in a river through pristine, urban and agricultural landscapes. Water Res. 37:4645–4656.