
# Opportunities for Agroforestry in the Temperate Zone Worldwide:

## Proceedings of the Third North American Agroforestry Conference

August 15-18, 1993

Department of Forestry, College of Agriculture
Iowa State University
Ames, Iowa

Richard C. Schultz and Joe P. Colletti, Editors

1994

# A Socio-Economic Assessment of the Bear Creek Watershed

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**ABSTRACT: A socio-economic assessment was made of water quality, nonpoint source (NPS) pollution, soil conservation practices, and willingness to pay (WTP) for improved water quality of surface and ground water of a small stream, Bear Creek, located in central Iowa. Data were collected in the spring of 1992 from a stratified random sampling of 160 landowners in the Bear Creek watershed. Farmer, absentee landowners, and nonfarmer groups were compared. A contingent valuation method (CVM) was used to estimate the WTP for improved water quality of Bear Creek.**

**The results indicate two major uses of Bear Creek; nature appreciation/wildlife and as a place to drain water from field tile lines. Soil erosion, fertilizer, and pesticide runoff from farmland were the primary sources of NPS pollution in Bear Creek. Over 85% of the farmers surveyed produced row crops on non-highly erodible lands. Farmers used many soil conservation practices on the HEL acres farmed. Based on a water quality ladder, the current surface water quality was rated about 6.0, indicating moderate quality unfit for humans, but fit for livestock and crop use. The acceptable (desired) surface water quality was > 8.0. The mean maximum WTP was about $4 per month to improve the surface water quality from the current level to the acceptable level. Respondents agreed that a vegetative buffer strip would function to improve water quality and indicated a need for shared responsibility associated with the voluntary establishment of buffer strips along the creek.**

**KEYWORDS: riparian buffer strip, willingness to pay, nonpoint source pollution, water quality, best management practices**

The highly efficient production agriculture of the Midwest and nationwide has produced many intended benefits, such as great quantities of high quality and relatively inexpensive food stuffs and industrial raw materials. Also, the success of modern production agriculture has caused some unintended environmental problems, namely NPS pollution.

Nationwide, NPS pollution of our water resources is a serious problem. Soil sediment eroded from cropland contributes about 1.4 billion Mg annually to our waterways. In total, over 2.7 billion Mg of soil enters water as NPS pollution each year [Welsch, 1991]. In Iowa, it is estimated that 240 million tons of rich Iowa topsoil enters the Missouri River each year [Kelley, 1990]. In Iowa, two Army Corps of Engineers reservoirs are reported to receive thousands of metric tons of soil sediment daily. For example, Saylorville Lake on the Des Moines River receives an estimated 4,000 Mg of sediment per day. Whereas, Lake Red Rock, farther downstream from Saylorville and with three additional uncontrolled drainages entering its conservation pool receives about 15,000 Mg per day [Kelley, 1990].

Pesticides and fertilizers also contribute NPS pollution to our nations waters. Atrazine and alachlor, two pesticides used in row crop production, have been found in Midwestern surface waters for some time [Kelley, 1990]. Phosphorus (P) and nitrogen (nitrate-nitrogen) are major fertilizers that can enter the surface and groundwater resources in great quantities. It was estimated that in 1989, nearly 1 million Mg of P entered our Nation's waterways. In 1980, an estimated 2.6 million Mg of nitrate-nitrogen became NPS pollution [Welsch, 1991]. Kelley [1990] reported that in 1991 many Iowa surface waters had nitrate-nitrogen levels exceeding 10 mg $l^{-1}$. Kelly also reported water flowing from tile lines entering various waterways having nitrate-nitrogen levels of 70 to 80 mg $l^{-1}$.

Removal of fertilizer/pesticide NPS pollutants is expensive and is borne by downstream users of surface and groundwater. The city of Des Moines, IA has invested over $4 million in new equipment to filter nitrates from the drinking water extracted from the Des Moines and Raccoon rivers. And it is considering another $13.5 million investment for an advanced filtration system to remove atrazine from the polluted river water [Hubert, 1992]. Welsch [1991] reported that it costs about $10 to $15 per month for a family of three for community water facility to remove excess nitrate from groundwater. It is expensive to clean-up the NPS pollution, and the cost is borne by downstream users.

The government and agricultural community has addressed NPS pollution by developing upland soil conservation practices (e.g., reduced tillage and no-till) and better fertilizer/pesticide management (e.g., more accurate and better timed applications). These agricultural best management practices (BMPs) have included grass-only vegetative filter strips.

Only recently has the role and importance of streamside forest [tree and shrub] vegetation in reducing and transforming NPS pollution from agriculture been clearly documented and quantified [see Welsch, 1991; Lowrance, 1992, Lowrance, et al., 1985]. Naturally occurring riparian ecosystems consisting of grass, tree, and shrub components can effectively remove sediment moving from croplands, and filter and transform nitrate nitrogen, phosphorus, and atrazine before these pollutants entering the surface or groundwater [Welsch, 1991; Lowrance, 1992; Lowrance, et al., 1985]. Moreover, natural or constructed vegetative buffer strips provide terrestrial and aquatic habitat and enhanced aesthetics [Welsch, 1991].

## Public Goods, Improved Water Quality, and Contingent Valuation Method

NPS pollution poses a difficult resource allocation and valuation problem. It is unclear who should pay for the clean-up of polluted water resources because of the dispersed nature of NPS pollution. Farmers do not plan to cause NPS pollution and may not be able to determine that the NPS pollution entering a stream on their property actually came from their agricultural practices. Yet NPS pollution does occur, and improvements in polluted water are valued by society and individuals. The unintended downstream effects of NPS pollution are externalities.

Water resources are mostly public or mixed goods. An improvement of NPS polluted water also represents a public good. The benefit from an improvement in water quality is the sum of the value associated with the improvement by all people effected directly or indirectly. This value is called willingness to pay (WTP). WTP measures people's verbal value of a specific improvement in water quality [Freeman, 1979]. To make efficient resource allocation decisions, it is important to have an accurate accounting of the benefits and costs. Thus, decisions regarding amelioration of NPS pollution need to consider the effects and the values that individuals and society place on these impacts.

Economists have used the contingent valuation method (CVM) to elicit verbal responses to questions where people give their willingness to pay for a specific non-market good or service (e.g., improved surface water quality) rather than do without the good [Kealy et al., 1990; Mitchell and Carson, 1989; Cummings et al., 1986; Bishop et al., 1983]. The nature of the good, in this case improved surface or groundwater quality, can make it difficult for consumers to understand the good being valued. With care, however, CVM questions can generate reliable and valid estimates of WTP [Kealy, 1990; Mitchell and Carson, 1989].

## Objectives

This study is designed to assess current and desired water quality of Bear Creek, uses of Bear Creek by the people living within the watershed, perceived sources of the pollutants entering Bear Creek, identify soil and water conservation practices being applied to farmland, potential of volunteer efforts at the "grass roots" level to improve the water quality of Bear Creek, and WTP for improved surface and ground water quality of Bear Creek. The results will help to define best management practices (BMPs) for the riparian zone along Bear Creek and agricultural and associated lands in the Bear Creek watershed that are economically viable, environmentally sound, politically expedient, and socially acceptable.

This study is part of an interdisciplinary, two-watershed research effort by the Leopold Center for Sustainable Agriculture, Agroecology Issue Team. The study setting involves the entire Bear Creek watershed, a 7,160 ha watershed in central Iowa. Bear Creek is about 35 km in length with another 28 km of tributaries draining into Bear Creek. The dominant land use is agriculture; corn, soybeans, and pasture/forage production. This socio-economic assessment will add important information to another part of the study effort, that of an ecologic/hydrologic analysis of critical needs areas of Bear Creek where the greatest risk from current NPS pollution exists. Data are being integrated within a geographic information system (GIS) framework to determine critical needs areas along Bear Creek and to illustrate the application of alternative best upland and riparian management practices.

## Methods

The method involved several steps. First, literature was reviewed regarding determination of water quality and willingness to pay. Next, an interdisciplinary team of natural resource and forest economists, ecologists, and sociologists identified the objectives of the socio-economic assessment, determined to use a survey approach, and developed a preliminary set of questions. The Dillman Total Survey Design method was used [Dillman, 1978]. To guide the survey development and design, GIS was used to delineate the watershed boundary so that landowners within the study area could be determined.

A stratified random sampling process was used to obtain a stratified sample of 1) farmers who resided and operated farms within the Bear Creek watershed, 2) landowners who owned farmland within the Bear Creek watershed, but who lived elsewhere, and 3) citizens (non-farmers) living in the town of Roland, IA, the only town located within the watershed. The "universe" for the assessment was established using County Auditor data and telephone listings (1991) for the town of Roland. The "universe" consisted of 292 farmers, 42 absentee landowners, and 546 citizens of Roland.

A focus group of farm leaders from within the watershed was used to review the survey and make refinements. To facilitate response, a town meeting was held in Roland, IA late February, 1992, to provide information concerning the purpose of the study. The survey was mailed in April of 1992 to 345 selected individuals divided into the three groups; farmers in the Bear Creek watershed (153), absentee landowners in the watershed (42) and citizens of Roland (150), through which Bear Creek flows. Three follow-up procedures were used to generate additional responses.

## Results

### Response

One hundred seventy-four surveys were received, but only 160 were completed. The overall response rate was 46%. Response by stratum was 29%, 31%, and 68% for the farmers, absentee landowners, and citizens, respectively. The low sample response from the farmers was attributed to a delay in mailing the survey, which may have resulted in time conflicts with farm activities. The low response rate for absentee landowners was anticipated given that about one-half of these individuals lived out-of-state and had limited knowledgeable of Bear Creek. The results represent estimates from the sample and have not been expanded to the population level.

### Location and Use

One-half of the respondents live within 1.2 km of Bear Creek, and 90% live within 5.6 km. The primary uses of Bear Creek are nature appreciation/viewing wildlife (40%), and as a place to drain "excess water from tile lines" (23%). About 4% used Bear Creek as a source of water for livestock and as a human drinking source. Recreational use was nearly absent. About 14% did not use Bear Creek or did not answer the question. There were no group differences between farmers, absentee landowners, and citizens of Roland in terms of use of Bear Creek (a = 0.05).

### Current Farming Practices

In 1991, farmers planted an average of 68 ha of corn, 58 ha of soybeans, 8.5 ha of oats, 5.3 ha of hay, and 2 ha of grass waterways. They also had on average 8 ha of pasture. The average total acreage per farm was 125 ha with the median at 73 ha. For corn, 50% of the respondents planted ≤40 ha and, for soybeans, 50% had ≤38 ha planted. Farm sizes ranged from 5 to 817 ha.

Most (88%) farmers surveyed did not grow corn or soybeans in 1991 on highly erodible land (HEL). Of the 12% that did, 80% used soil conservation practices of contour farming and terraces to control erosion. The tillage practices included moldboard plowing, chisel plowing, disking, no-till planting and ridge-till. On average 202 kg $ha^{-1}$ of anhydrous ammonia was applied to corn in 1991. NPK fertilizer use averaged 198 kg $ha^{-1}$ and urea fertilizer averaged 161 kg $ha^{-1}$. About 25% of the farmer respondents indicated that they applied manure to fields with the average rate of use at 22 Mg $ha^{-1}$. Among all farmers eighteen different herbicides were used in 1991 on the corn and soybean acres. There were ten hog, eleven cattle, three sheep, and one horse operations. Eighteen of the livestock operations had manure/waste management systems. Four of eighteen had pit/liquid manure systems, and the balance spread manure on fields.

### Potential Sources of Water Pollution

The respondents were asked to rate various potential sources of water pollution in Bear Creek and Iowa in general using a 10 point scale where 1 meant an unimportant source and 10 a very important source. The results are presented in Table 1. Overall, the respondents rated the most important sources of water pollution in Bear Creek as being from runoff from fertilizers and pesticides applied to farmland (6.89) and soil erosion (6.26).

There was a difference among farmers, absentee landowners, and citizens of Roland [(eferred to as a group difference) in the rating of two sources of pollution, 1) run-off from fertilizers, manure, and pesticides and 2) soil sediments (erosion) from farmland (a= 0.05). Farmers responded with a significantly lower level of importance for these potential sources compared with the absentee landowners and citizens of Roland. In fact, farmers indicated that the top four most important sources of water pollution in Bear Creek were 1) run-off from fertilizers, manure, and pesticides, 2) municipal sewage from cities and towns, 3) soil erosion from farmland, and 4) illegal dumping of wastes in water. Absentee landowners and citizens in Roland rated municipal sewage less important as a source of water pollution in Bear Creek, but gave higher ratings to soil erosion, and runoff from fertilizers and pesticides applied to farmland.

For Iowa, the top four potential sources (mean rating values) of water pollution were: 1) run-off from fertilizers, manure, and pesticides, 2) soil erosion from farmland, 3) illegal dumping of wastes in water, and 4) municipal sewage from cities and towns. Group differences exist for all sources except municipal sewage (a= 0.05). Again, farmers gave lower ratings to these potential sources. Farmers also indicated significantly lower mean ratings for animal confinement/feedlot operations and agricultural support activities.

### Surface Water Quality in Bear Creek

Water quality was determined by application of the "Water Quality Ladder." This model, seen in Table 2, was used to identify the current and desired quality of the surface and ground water associated with Bear Creek. The ladder ranges from 0 to 10, (10 = best quality fit for human consumption, 0 means water unfit for human, wildlife, livestock, and crops). The respondents rated current surface water quality at about 6.0. There was a group difference (a = 0.05) in the rating of the current surface water quality. The group means were:

**Table 1. Mean values and standard deviations (in parenthesis) for potential sources of water pollution for Iowa in general and Bear Creek in particular. The people were responding to the question:**

Now we would like your opinion concerning the importance of various sources of water pollution in the USA, Iowa, and Bear Creek. Using a scale between 1 and 10, please rate each potential source of water pollution. A value of "1" means that the item is an unimportant source of water pollution in your opinion and a value of "10" means that it is a very important source of water pollution. Do this for the Iowa, and Bear Creek.

| Potential Sources of Water Pollution | Mean Rating for | |
|---|---|---|
| | Iowa | Bear Creek |
| Municipal Sewage from cities and towns | 5.87 (3.09) | 4.64 (3.40) |
| Drainage from mines (Coal, Iron, etc.) | 3.60 (3.60) | 2.25 (2.62) |
| Run-off from roads | 3.85 (2.25) | 2.95 (2.65) |
| Run-off from storm drains | 4.65 (2.65) | 4.45 (2.98) |
| Run-off and leaching from Land fills | 5.30* (2.91) | 3.82 (3.00) |
| Run-off from agricultural chemicals applied to farmlands | 6.68* (2.98) | 6.89* (3.14) |
| Run-off of soil sediments from farmland | 6.17* (2.80) | 6.26* (3.26) |
| Run-off from developments (Parking lots, building sites, etc.) | 4.78 (2.56) | 3.14 (2.37) |
| Illegal Dumping of wastes in water | 6.05 (3.11) | 4.93 (3.50) |
| Leaking underground storage tanks (gasoline tanks, etc.) | 5.41* (2.89) | 3.80 (3.24) |
| Animal confinement / Feedlot operations | 4.89* (2.56) | 4.77 (3.02) |
| Agricultural support activities (Grain elevators, Fertilizer depots etc.) | 4.65* (2.66) | 4.30 (3.08) |
| Aquifer penetrations (Sinkholes, Surface mines etc.) | 4.31 (2.91) | 3.48 (3.03) |

* means for Iowa and Bear Creek are statistically different at the 0.05 level.

**Table 2. The Water Quality Ladder used to assess the surface and groundwater quality for Bear Creek over the period April, 1991 through October, 1991.**

| | |
|---|---|
| **BEST POSSIBLE WATER QUALITY** | |
| 10 ---> | Best Quality water (Drinking water for humans) |
| 9 | |
| 8 | |
| 7 | |
| 6 | |
| 5 | |
| 4 | |
| 3 | |
| 2 | |
| 1 | |
| 0 ---> | Unfit for any use (Human, Wildlife, Livestock, & Crops) |
| **WORST POSSIBLE WATER QUALITY** | |

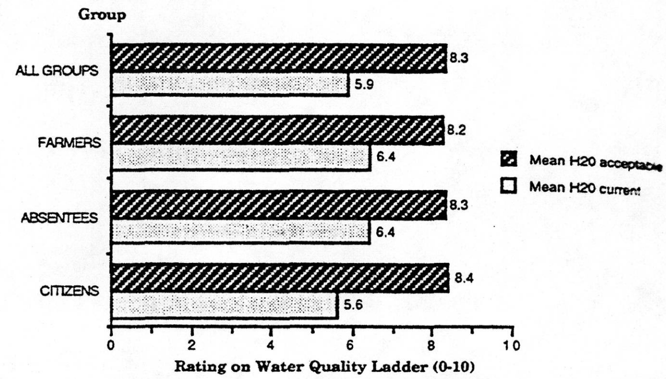


**Figure 1. Group and all respondent ratings of the current and acceptable surface water quality level using the Water Quality Ladder (scale 0 - 10).**

citizens of Roland = 5.6; farmers = 6.4; and absentee landowners = 6.4. Figure 1 presents group comparisons. Farmers and absentee landowner respondents felt that the surface water quality of Bear Creek was of higher quality relative to citizen respondents.

Because everyone has different opinions on water quality, it was important to assess what the respondents felt were suitable uses for the Bear Creek surface water given their rating of the current water quality. Only eighteen percent of the respondents indicated that the current (mean value = ~6) water quality was fit for human consumption, 50% indicated that it was fit for swimming/recreational activities, 87% indicated that it was suited for wildlife and fishing, 90% indicated that it was suited for livestock use and 95% indicated that it was suited for crop use. The only group difference was with swimming/recreational use in which 77% of the farmers and absentee landowners indicated that the current surface water quality was suited for this use whereas only 41% of the Citizens of Roland felt that this was a suitable use (a = 0.01).

To correctly value WTP for improved water quality, the respondents must first establish their desired water quality for both the surface and the groundwater. The acceptable level of surface water quality was determined using the water quality ladder. Over 60% of the respondents indicated they would accept a water quality level of 8.0 or greater in Bear Creek. The acceptable (desired) surface water quality mean value was 8.3 (see Figure 1) with no group differences (a > 0.05).

In terms of what this acceptable water was useful for, 45% indicated that it was suited for human drinking purposes, 89% indicated that it was suited for swimming/recreational activities, 98% said that it was suitable for wildlife and fishing, 99% said that it was suitable for livestock, and 100% said that it was suitable for crops. Thus, for 55% of the respondents, this improved surface water quality is still not suited for human consumption.

## WTP for Surface Water Quality Improvement

Both a closed-ended and an open-ended CVM format were to determine WTP [Kealy et al., 1990, Mitchell and Carson, 1989]. Nearly seven of ten (68.9 %) respondents were not willing to pay a minimum of $4 per month for as long as they live within the Bear Creek watershed to improve the surface water quality from the current level to their acceptable water quality level. People unwilling to pay $4 per month could be indicating that they are willing to pay more than $4 per month or less than that amount. Thus, the respondents were asked to indicate the maximum amount per month that they would be willing to pay to improve the current water quality level to their acceptable level. Fifty-two percent were willing to pay between $0 and $3 per month, and 48% were willing to pay $4 or more per month to achieve this improved surface water quality level. The mean maximum WTP value for all respondents was $4.08 per month (mean annual WTP = $ 49.01 and S.D. = $62.70 $yr^{-1}$). Although there were no group differences for WTP (a > 0.05), the maximum WTP for improved water quality from the current level to the acceptable level for the farmer respondents was $4.32 per month (mean WTP = $51.89 $yr^{-1}$ and S.D. = $85.70 $yr^{-1}$). For the Absentee landowners maximum WTP was $3.76 per month (mean WTP $45.17 $yr^{-1}$ and S.D. = $42.97 $yr^{-1}$) and for the citizens of Roland it was $4.02 per month (mean WTP = $48.23 $yr^{-1}$ and S.D. = $52.23 $yr^{-1}$).

About 37% of those willing to pay nothing to achieve this improvement in surface water quality did so because they do not use Bear Creek and never expect to use the stream. Only 3.5% of those who were willing to pay nothing did so because they felt that it was inappropriate to place a dollar value on water quality in Bear Creek, and another 12% were uncomfortable with placing a dollar value on water quality improvement in Bear Creek.

Analysis of the maximum WTP value by farmers to improve the surface water quality to the higher quality acceptable level as a function farm-related variables was done. The thought was to investigate the predictive power of farming variables regarding the maximum WTP values for farmers. The farming-related variables were evaluated using SAS general linear models procedure. The results shown in Table 3 indicate no apparent relationship between maximum WTP and various farming-related variables. Similar analysis was made of socio-economic variables. Age of farmer and family size were modestly related (a = 0.05). The older a farmer

Table 3. **Correlation of maximum willingness to pay values for improving surface water quality with farm related and socio-economic variables.**

| | correlation | Pr>\|r\| |
|---|---|---|
| Farm related variables | | |
| total acres operated | 0.11 | 0.49 |
| primary type of livestock | 0.08 | 0.59 |
| acres of corn chisel plowed | -0.09 | 0.56 |
| acres of corn field cultivated | -0.02 | 0.88 |
| acres of corn crop cultivated | -0.15 | 0.34 |
| acres of soy beans disked | 0.07 | 0.67 |
| Socio-economic variables | | |
| age of respondent | -0.43 | 0.01 |
| family size | 0.32 | 0.05 |
| gross family income | -0.05 | 0.73 |
| distance of household from Bear Creek | -0.04 | 0.81 |

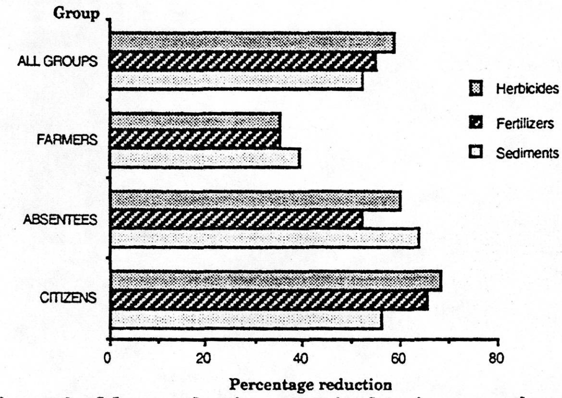


**Figure 2. Mean reductions required to improve the surface water quality from the current level to the acceptable level by type of pollutant for all individuals and by group.**

the lower the maximum WTP. The larger the family size the greater the maximum WTP. A t-test of maximum WTP means for farmers who had seen or heard about an established vegetative buffer strip in the watershed (the Risdal riparian buffer strip project) and those who had not revealed no differences (a > 0.05).

## Reductions Required in NPS Pollutants

When asked what level of reductions in sediments, fertilizers, and herbicides entering Bear Creek must occur for the current surface water quality level to improve to their acceptable (better) water quality level, there were significantly different answers among the three groups (see Figure 2) (a = 0.05). The farmer respondents mean values were 39%, 35% and 35% for reductions in sediments, fertilizers, and herbicides, respectively. In comparison, the absentee landowners mean values were 64%, 52%, and 60%, respectively for sediments, fertilizers, and herbicides. The citizens of Roland had mean reduction values of 56% for sediments, 64% for fertilizers and 68% for herbicides. The "non-farmer" respondents seem to feel that significantly greater reductions in these sources of NPS pollution must occur for the improvement in surface water quality to be achieved. The overall mean reductions were 52% for sediments, 55% for fertilizers, and 59% for herbicides.

## Groundwater Quality of the Bear Creek Watershed

In 1991, 50% of the respondents indicated that they owned a groundwater well, and forty-three percent had municipal water. Less than 1% used bottled water, and 6% had a combination of their own groundwater well and municipal water. Using the water quality ladder, the mean groundwater quality level was 7.26 for all respondents. There was a significant difference among the groups (a = 0.05). Farmer respondents had a mean value of 8.0, absentee landowners had a mean value of 7.17, and citizens of Roland had a mean value of 6.94. Interestingly, respondents indicated that the current (1991) groundwater quality was good, but not pure.

It seems more difficult for people to value an improvement in groundwater compared with surface water. About 68% of the respondents indicated that they were not willing to pay $10 per month for the improvement in groundwater quality to the drinkable level (with a Water Quality Ladder rating of 10.0). Out of the 160 respondents, only twenty-one gave any WTP value. Of these individuals, their mean WTP value was $6.67 per month. There were no group differences. Of those who responded to the question as to why they answered $0.00 to WTP for groundwater improvement, 33% said that they did so because they do not use the Bear Creek aquifer as the source of their water. Twenty-one percent were uncomfortable with placing a dollar value on the groundwater improvement associated with Bear Creek. About 3% did not think it was appropriate to place a dollar value on this improvement.

## Soil Conservation & Riparian Zone Practices

Respondents were asked to agree or disagree with a set of statements relating to accepted soil conservation practices and other stream zone practices. The frequencies are given in Table 4. Over 70% of the respondents "somewhat agree to strongly agree" that a vegetative buffer strip would reduce sediment and pesticides from entering a stream. Fifty-two percent of the respondents "somewhat agree to strongly agree" that vegetative buffer strips will absorb nitrate pollution in the root zone. Over 85% of the respondents "somewhat agree to strongly agree" that vegetative buffer strips will reduce stream bank damage. Sixty-nine percent of the respondents indicated that they "somewhat disagree to strongly disagree" with the statement that "planting crops up to the edge of a stream is acceptable." This suggests a strong sense of social responsibility on the part of the respondents to avoid planting crops to the edge of a stream. Eighty-one percent of the respondents "somewhat agree to strongly agree" that conservation tillage on land up slope (from a stream) will reduce erosion and sedimentation (in the stream). Eighty-eight percent of the respondents "somewhat agree to strongly agree" that contour planting will reduce erosion and sedimentation. Nearly 85% of the respondents "somewhat agree to strongly agree" that terracing practices will reduce erosion and sedimentation.

The greatest degree of uncertainty and neutrality existed with the statement "Using combinations of conservation tillage, contour planting, and terracing will be more effective in improving water quality than planting buffer strips." Still,

Table 4. **Individual response to the supposed advantages or functions of a vegetative buffer strip and other conservation measures in protecting the water resources of Bear Creek.**

| | SD* | SWD | N | SWA | SA | UN |
|---|---|---|---|---|---|---|
| A vegetative buffer strip will reduce sediment entering a stream (n=144) | 1 | 1 | 11 | 38 | 88 | 5 |
| A vegetative buffer strip will reduce pesticide run-off into a stream (n=141) | 9 | 12 | 13 | 39 | 62 | 6 |
| A vegetative buffer strip will absorb nitrate pollution in the root zone (n=142) | 7 | 12 | 19 | 42 | 46 | 16 |
| A vegetative buffer strip will reduce stream bank damage (n=144) | 5 | 6 | 12 | 50 | 70 | 1 |
| Planting crops up to the edge of Bear Creek is acceptable (n=142) | 75 | 23 | 16 | 16 | 9 | 3 |
| Conservation tillage on land up slope will reduce erosion & sedimentation (n=145) | 2 | 5 | 16 | 44 | 74 | 4 |
| Contour planting will reduce erosion and sedimentation (n=145) | 0 | 2 | 10 | 45 | 83 | 5 |
| Terracing practices will reduce erosion and sedimentation (n=145) | 0 | 2 | 15 | 37 | 86 | 5 |
| Using combinations of conservation tillage, contour planting, and terracing will be more effective in improving water quality than planting buffer strips (n=145) | 6 | 18 | 38 | 30 | 38 | 15 |
| Using buffer strips in combination with one or more of the above measures will improve water quality the most (n=145) | 0 | 2 | 13 | 29 | 93 | 8 |

*SD = Strongly Disagree, SWD = Somewhat Disagree, N = Neutral, SWA = Somewhat Agree, SA = Strongly Agree, UN= Uncertain

over 46% of the respondents "somewhat agree to strongly agree" with the statement. Eighty-four percent of the respondents "somewhat agree to strongly agree" with the statement that "Using buffer strips in combination with one or more of the above measures will improve water quality the most."

There were few group differences (a = 0.10) for statements listed in Table 4. Specifically, regarding the statement that a vegetative buffer strip will reduce sediment, 95% of the farmer respondents indicated that they "somewhat agree to strongly agree, " 100% of the absentee landowners "somewhat agree to strongly agree," and 87% of the citizens of Roland "somewhat agree to strongly agree." Another significant group difference occurred regarding the statement "planting crops up to the edge of a stream is acceptable." Eight percent of the farmer respondents "somewhat agree to strongly agree" whereas 20% of the citizens of Roland "somewhat agree to strongly agree," and 25% of the absentee landowners "somewhat agree to strongly agree." Clearly, the farmer respondents have a stronger sense of "social responsibility" in terms of not cropping to the edge of a stream. A group difference exists for the statement that terracing practices will reduce erosion and sedimentation. Only 80% of the farmers "somewhat agree to strongly agree" with the statement, whereas 85% of the citizens of Roland "somewhat agree to strongly agree," and 100% of the absentee landowners "somewhat agree to strongly agree."

There were no group mean differences for the statement "Using combinations of conservation tillage, contour planting, and terracing will be more effective in improving water quality than planting buffer strips." There was a statistical difference between group means for the statement "Using buffer strips in combination with one or more of the above measures will improve water quality the most."

## Willingness to Implement Vegetative Buffer Strips

Respondents were asked whether they would establish a vegetative buffer strip along Bear Creek assuming that they owned farmland along Bear Creek. Eighty-seven percent of the respondents indicated that they would do so. The reasons given for establishing a vegetative buffer strip included; improve water quality, preserve top soil and avoid polluting the stream, provide wildlife habitat, and because it was just a good idea.

The relationship between willingness to establish a vegetative buffer strip and various farm and socio-economic variables was evaluated. T-tests of the means for total farm acres, age of farmer, family size, and the location of the farmer's land relative to Bear Creek indicated no differences between those farmers willing to establish a vegetative buffer strip and those unwilling to do so. An analysis of the relationship between willingness to establish a vegetative buffer strip and whether or not farmers had seen a poster display or read an article published in the Story City Herald dealing with the Risdal Bear Creek buffer strip project showed no relationship ($\chi^2 = 0.93$)

The respondents were asked to indicate their acceptable cost sharing scheme to finance the establishment and maintenance costs associated with the voluntary establishment of vegetative buffer strips along Bear Creek. The cost-share responsibility was nearly equal indicating that the farmer and government entities should share the financial burdens of constructing and maintaining the riparian buffer strips. The mean cost share percentages were 32%, 25%, 26%, and 28% for farmers, county, state, and federal entities, respectively.

The farmers were asked to indicate their willingness to accept (WTA) $125 per acre each year for their voluntary establishment of a buffer strip along any Bear Creek waterway on their farmland. Nearly 73% indicated that they would be willing to accept this annual rent to give up the opportunity to crop close to the riparian zone. This result is consistent with economic theory relating to WTA versus WTP. The primary ways that respondents would ensure the voluntary establishment of a vegetative buffer strip along Bear Creek were: 1) cost sharing between government and farmer, 2) tax breaks to minimize costs of establishment, and 3) good communications and education with landowners. Most respondents did not know or did not respond to the question regarding ensuring voluntary establishment of a vegetative buffer strip along Bear Creek.

## Social Actions

There are several public participation programs that have been established in the U.S. to promote citizen action regarding water protection and associated water quality monitoring. There are successful lake monitoring programs in

Florida and Missouri. People living within the Bear Creek watershed can share the planning, management, and financing of actions to improve the surface and groundwater quality of Bear Creek. By establishing a "Creek Team Program" (CTP), people interested in the Bear Creek watershed would have a grass-roots means to improve or maintain the quality of the water in the creek.

The respondents were asked to indicate all activities that they might possibly be involved with as part of a CTP for Bear Creek. Figure 3 gives the frequencies for all respondents. Planting stream-side trees, shrubs, and grasses, and cleaning-up debris such as bottles, plastics were the two most frequent responses. On average, respondents were willing to volunteer 3 days per year for CTP activities.

### About the Respondents

The mean age of the respondents was 57 years. Twenty-two of the 160 respondents were female. The average family size was 3 people. The respondents lived at the same location for an average of 22 years. The respondents had a wide variety of jobs including, but not limited to, secretary, engineer, school teacher, business person, retired, farmer, housewife, and contractor. In 1991, the mean total household gross income was in the range of $30,000-$39,999. About 24% of the respondents had total household gross income above $50,000 in 1991.

## Discussion

There is a dichotomy of utilitarian use (draining field tiles) and environmental/conservation use (nature appreciation/wildlife viewing) of Bear Creek. Respondents recognize that sediments, fertilizer, and pesticides are major sources of NPS pollution. The farmers place more importance on municipal sewage from the town of Roland, IA than town folks do.

The citizens of Roland perceive that the current surface water quality is poorer than the farmers or absentee landowners do. All groups wanted surface water of higher quality. Farmers indicated that smaller reductions in sediments, fertilizers, and herbicides were required to achieve this higher desired surface water quality level. Citizens of Roland and absentee landowners indicated greater reductions were needed to improve the current surface water quality to the acceptable level.

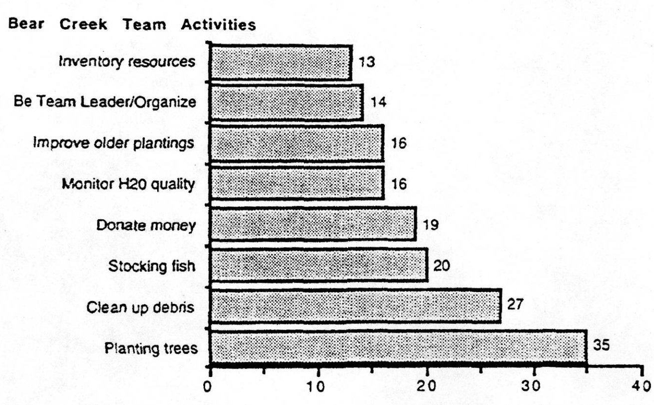


**Figure 3. Frequency distribution of Bear Creek Team Program activities in which respondents were willing to participate to improve or maintain the quality of water in the creek.**

In general, the mean maximum WTP was over $4 per month to improve surface quality. Placing a value on a similar improvement in groundwater proved to be difficult for the respondents. Perhaps people felt that they did not use groundwater that came from a Bear Creek aquifer or perhaps they were uncomfortable with placing a value on an improvement in the groundwater.

Respondents indicated agreement with the functions of a vegetative riparian grass-tree-shrub buffer strip. They indicated a "politically correct" attitude that planting (row) crops to the stream edge was unacceptable. Moreover, they were in agreement that buffer strips used in combination with traditional agricultural BMPs (reduced tillage, better nutrient/pesticide management) would improve water quality the most.

Farmers indicated a willingness to accept (WTA) $309 $ha^{-1}$ $yr^{-1}$ to voluntarily establish a vegetative buffer strip on their land along Bear Creek. It seems that respondents are willing to participate in specific way in a grass-roots effort to protect and improve Bear Creek. On average, the respondents were willing to donate three days each year for Bear Creek activities.

In a recent Ames Tribune newspaper article (June 12, 1993), a rural drinking water project was discussed. This project, which is nearing completion, involves the communities and landowners in and around the Bear Creek watershed. This project will bring clean drinking water to about 5,000 people in Central Iowa through 3,200 km of plastic water pipe for a capital cost of $6.4 million. There will be over $1200 per capita of capital investment in this rural water project. The average monthly water bill is expected to be around $50. On a per capita basis, each customer is expressing a price that they are willing to pay to have pure drinking water delivered to their rural household. The desire by citizens to have clean drinking water is clear as is their willingness to pay to obtain the high quality water.

NPS pollution has many impacts on individuals and society. Based on this survey, it is evident that the respondents have a clear idea as to the source of the NPS pollution. Also, it is evident that the farmers are using several soil conservation and nutrient management actions to reduce off-site impacts. The respondents have expressed an understanding and acceptance of the role and functioning of vegetative buffer strips along the riparian zone. In the main, the respondents are willing to pay for improved surface water quality and less inclined to pay for improvement in groundwater quality.

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