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USE OF SOIL AND WATER PROTECTION PRACTICES AMONG FARMERS IN THE NORTH CENTRAL REGION OF THE UNITED STATES

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ABSTRACT: Data were collected in the fall of 1998 and the winter of 1999 from 1,011 land owner-operators within three watersheds in the North Central Region of the United States to assess adoption of soil and water protection practices. Farm owner-operators were asked to indicate how frequently they used 18 different agricultural production practices. Many farmers within the three watersheds had adopted conservation protection practices. However, they also employed production practices that could negate many of the environmental benefits associated with conservation practices in use. Comparison of adoption behaviors used in the three watersheds revealed significant differences among the study groups. Respondents in the Iowa and Ohio watersheds reported greater use of conservation production systems than did farmers in Minnesota. However, there were no significant differences between Ohio and Iowa farmers in terms of use of conservation production practices. This was surprising, since farmers in the Ohio watershed had received massive amounts of public and private investments to motivate them to adopt and to continue using conservation production systems. These findings bring into serious question the use of traditional voluntary conservation programs such as those employed in the Ohio watershed. Study findings suggest that new policy approaches should be considered. It is argued that "whole farm planning" should be a significant component of new agricultural conservation policy
(KEY TERMS: watershed; adoption behavior; agricultural production systems; soil and water conservation, farm management.)

WATER POLLUTION FROM AGRICULTURAL SOURCES

Erosion of agricultural land remains a significant socio-environmental issue within the United States (U.S.) due to on-site and off-site damages associated with soil loss from cultivated crop land (Halcrow et al., 1982; Lovejoy and Napier, 1986; Swanson and Clearfield, 1994). Displaced soil contributes to water pollution and reduces future productivity of land resources that have significant environmental and socio-economic consequences for society.

Displaced soil from crop land frequently contains large quantities of fertilizers and pesticides that contaminate water resources. Agricultural chemicals must be removed from public water supplies to make water safe for human consumption, and the major portion of the cost of making water potable is nearly always assumed by nonfarm populations. The ultimate outcome is that agricultural polluters are not forced to assume responsibility for contaminants contributed by their farming operations.

Soil erosion from agricultural land also contributes to other water-related problems. The number of years that reservoirs can be used for water storage and flood control purposes are often reduced by deposited silt from agricultural sources. Water transportation systems are frequently disrupted by deposition of eroded topsoil, and waterways often must be periodically dredged to remove sediments. The remedial costs are primarily assumed by taxpayers who do not contribute to agricultural pollution.

Water pollution from agricultural sources also affects wildlife habitat with attendant implications for recreational use of private and public land and water resources. Water quality degraded by agricultural pollution can make boating and other water-based recreation activities less desirable.

Soil erosion from agricultural land also creates on-site damages. Soil loss from agricultural land can reduce soil fertility and change the composition of land resources to the point that infiltration of water is inhibited (Boardman et al., 1990; El-Swaify and Yakowitz, 1998; Lal and Stewart, 1995). Both of these outcomes nearly always result in a decline in farm

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output and reduced resale value of land resources. While the costs of on-site damages are primarily borne by the land owner, society is adversely affected by loss of food and fiber available for domestic and international trade.

On-site damages associated with soil erosion are frequently of much less concern for society than off-site damages, because land owner-operators are often motivated to control degradation of soil resources on their land. Land owners usually respond to on-farm damages caused by soil erosion, because failure to stop serious erosion can result in significant loss of income and reduction of property value. The desire of land owners to protect future productivity of crop land and the value of land resources is a strong motivator to adopt conservation production

While land owners will often invest limited economic resources to protect their crop land from on-site damages associated with erosion, off-site damages are frequently ignored. While the cumulative effects of multiple farm operations may significantly damage the environment, crop land operated by individual farmers may only suffer minor damage over time. Farmers will not invest in conservation production systems under such conditions because they do not suffer any significant on-site losses. Application of chemical fertilizers effectively counters minor adverse effects of erosion that make it possible for land owner-operators to maintain high levels of farm production. Powerful farm technologies can operate effectively even when land has been eroded by severe rainfall events and can remove evidence of erosion when land is tilled.

Most farmers are aware that it is extremely difficult to monitor agricultural pollution and that it is highly unlikely that individual farmers will be held accountable for their contributions to non-point pollution problems (Halcrow et al., 1982; Napier et al., 1994, 2000a; Swanson and Clear-field, 1994). If individual farmers cannot be identified as contributing specific quantities of contaminants, they cannot be required to pay for environmental damages caused by agricultural pollution.

While environmental problems associated with agricultural pollution have been recognized for at least six decades, efforts to reduce agricultural pollution to levels deemed acceptable by society have not been successful. Practically all attempts to address agricultural problems in the U.S. have relied heavily on voluntary approaches, because policy makers have argued that command and control mechanisms for addressing soil erosion are not feasible to implement at the farm level. Policy makers argue that use of incentives to motivate farmers to adopt and use conservation production systems is the best alternative.

The creation of new technologies will not resolve agricultural pollution problems because many technologies and techniques already exist to control soil erosion at the farm level (El-Swaify and Yakowitz, 1998; El-Swaify et *al.*, 1985; Lal and Stewart, 1995; Napier et *al.*, 1994); however, they are often not used. Barriers to adoption of conservation production systems at the farm level are sociological in nature (Lovejoy and Napier, 1986) rather than technological.

The U.S. Department of Agriculture policy instruments used to implement national soil and water conservation programs have traditionally emphasized information, partial economic subsidies and technical assistance to address agricultural pollution problems (Napier, 1990a; Swanson and Clear-field, 1994). The rationale for the use of such an approach is based on the argument that land owners-operators will respond more favorably to incentives than they will to disincentives (Napier, 1990b).

The traditional information-subsidy-technical assistance (ISTA) approach employed by conservation agencies in the US to motivate land owner-operators to adopt conservation production systems at the farm level consists of personal contact with land owner-operators by local and state conservation agents to inform farmers of the environmental damages associated with soil loss from agricultural land. Once the land owner has been made aware of environmental consequences associated with erosion, they are provided with information about possible solutions and encouraged to adopt production systems that will reduce soil loss to environmentally benign levels. Land owners are sometimes provided technical assistance and offered partial economic subsidies to off-set economic losses associated with adoption.

The ISTA approach has been used to motivate land owner-operators to adopt conservation production systems, since the Dust Bowl era of the 1930s. During the 1930s, the ISTA approach was shown to be effective in motivating land owner-operators to adopt and to use conservation production systems, because the very existence of the farm enterprise as a production unit was being threatened. It was in the best interests of farmers to adopt conservation production systems, because failure to do so would ultimately result in the destruction of the productive capacities of agricultural land resources and impoverish land owners. During the 1930s, farmers were not concerned about off-site damages, they were concerned about survival of their farm businesses. The livelihood of land owners was being blown away by the dust storms, and farmers were aware of the situation and of the consequences of not taking action to prevent erosion.

One of the most significant outcomes of the early successes of the traditional ISTA approach was its entrenchment as the primary means for facilitating the adoption of conservation production systems at the farm level. Little consideration was given to the possibility that changing conditions could reduce the effectiveness of the ISTA over time (Napier, 1990b; Napier, 2000). It was not until the late 1970s and early 1980s that concern was raised about the appropriateness of the ISTA approach (Napier and Forster, 1982; Swanson et *al.,* 1986).

Extensive research was initiated to identify factors affecting adoption of conservation production systems at the farm level. Findings from these studies demonstrated that many of the factors commonly argued to affect adoption of soil and water conservation practices at the farm level were relatively inconsequential in explaining adoption behaviors of farmers. One of the major findings produced by this body of research demonstrated that access to information was not a good predictor of adoption of conservation production systems (Duff et *al.,* 1991; Halcrow et al., 1982; Korsching and Nowak, 1980; Lovejoy and Napier, 1986; Napier et *al.,* 1983, 1994; Swanson and Clear-field, 1994). Similarly, access to technical assistance and small economic subsidies were shown not to be strongly correlated with conservation adoption behaviors (Batte and Bacon, 1995; Putman and Alt, 1987; Mueller et *al.,* 1985; Napier et *al.,* 1983, 1994). Variables assessing educational experiences were also shown to be of little consequence in the adoption decision-making process (Napier et *al.,* 1983, 1994; Swanson and Clear-field, 1994). A factor shown to be a strong motivator of land owner behaviors relative to adopting conservation production systems was large economic subsidies in the form of set-aside programs, such as the Conservation Reserve Program (CRP) included in the Conservation Title of 1985 (Napier, 1990a).

While an extensive research literature was focused on the adoption of soil and water conservation practices during the 1980s and 1990s, public policies have been very slow to respond. The ISTA approach continues to be extensively used, and criticisms of the approach are rejected by arguments that the ISTA approach has not been adequately evaluated in terms of behavioral outcomes. Assessments of behavioral change among farmers have relied heavily on cross-sectional correlation research designs. Napier and Johnson (1998a, 1998b) deviated from the research tradition by conducting longitudinal research using a study-restudy design of land owner-operators in a single watershed in Ohio. The findings from the long-term monitoring of the watershed revealed little change in the use of agricultural production systems used over time even though ISTA programs had been extensively employed throughout the study watershed.

A research methodology that has not been used to examine adoption of conservation production systems at the farm level is comparison of multiple watershed groups that have been exposed to different levels of ISTA initiatives. If ISTA components are important in the adoption decision making process, then farmers in watersheds with more extensive exposure to these types of intervention strategies should exhibit higher levels of conservation adoption behaviors. The purpose of this paper is to examine adoption of soil conservation production systems among land owner operators in three watersheds in the North Central Region of the U.S. The goal of the study was to determine if the ISTA approach has been effective in motivating land owner-operators to adopt conservation production systems. Research findings are discussed in the context of future soil conservation policies and conservation programs.

THEORETICAL MODELING

The ISTA approach used by public conservation agencies and private groups to encourage land owner-operators to adopt soil conservation production systems at the farm level is based on many of the assumptions and theoretical arguments advanced in the classical diffusion paradigm used to predict adoption of innovations (Rogers, 1995). The ISTA approach is subject to the same criticisms as the diffusion model.

The information component of the ISTA was included in the approach, because it was believed by diffusionists that many land owner-operators are not aware that agriculture is a contributor to environmental degradation and that specific production systems contribute disproportionately to pollution problems. Proponents of the diffusion model argue that land owner-operators do not adopt conservation production systems because they are unaware of the socio-economic consequences of soil erosion. It is also argued that farmers are not aware of alternative production systems that will resolve the environmental problems. Proponents of the ISTA approach argue that the provision of information and access to educational opportunities will remove the knowledge barrier to adoption. The subsidy component of the ISTA was included in the approach, because it was believed that many land owners do not have sufficient economic resources to adopt conservation production systems. Partial subsidies were perceived to be necessary to off-set a portion of the costs of implementing conservation programs at the farm level. Partial subsidies are also justified on the basis that farmers require economic subsidies to compensate for lost income associated with adoption of conservation production systems. The technical assistance component of the ISTA approach was included because it was believed that land owner-operators lack necessary skills to effectively implement soil conservation programs at the farm level. Provision of technical assistance makes it possible for land owners with inadequate skill levels to adopt conservation production systems. Thus, the ISTA approach advances the position that removal of knowledge and economic barriers will facilitate adoption of conservation production systems at the farm level. Given the arguments advanced by proponents of the ISTA model, the primary research expectation for testing was that land owner-operators within watersheds receiving more ISTA programs will report more extensive adoption of soil and water conservation production practices at the farm level.

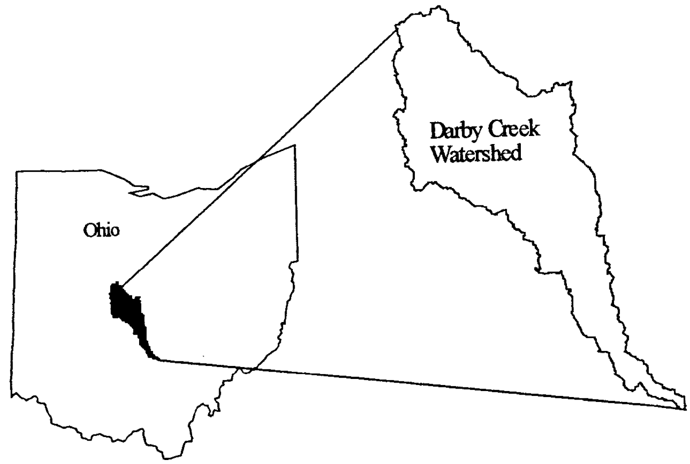

Figure 1. Darby Creek Watershed in Ohio.

STUDY METHODOLOGY

Data to assess the merits of the research expectations were collected from farmers in three watersheds in the North Central Region of the U.S. The methodologies used to conduct the study are as follows.

Study Watersheds

Watersheds for study were selected from Iowa, Ohio, and Minnesota to represent different agricultural specialties, different types of topography, and different types of ISTA programs implemented within the watersheds. Those chosen were the Darby Creek watershed in Ohio, the Maquoketa River watershed in Iowa, and the Lower Minnesota watershed in Minnesota

The Darby Creek watershed in Ohio is approximately 355,000 acres in size and is located in the central part of the state (see Figure 1 for location). Water quality has been defined by state and federal agencies as being good to excellent and the watershed has been designated as a scenic river. Soil erosion is very low within the watershed due to the flat topography

Most of the agricultural land within the watershed is now owned by people who no longer farm the land. A large proportion of the farm land is being operated by a small number of tenant farmers. Agriculturalists within the Ohio watershed specialize in the production of feed grains. Farm operators within the watershed employ technology-intensive agricultural practices, except for Amish farmers who constitute a significant minority in the upper region of the watershed (Napier and Sommers, 1996).

Since 1991, a host of ISTA programs devoted to conservation issues have been implemented within the Darby Creek watershed (Napier and Johnson, 1998a, 1998b). In addition to the federal and state conservation programs offered by the Natural Resources Conservation Service/USDA (NRCS) and the Ohio Department of Natural Resources to all land owners in Ohio, farmers within the Darby Creek watershed have been the focus of additional funding from the NRCS, ODNR, the US. Environmental Protection Agency, the Ohio State University Cooperative Extension Service, the U.S. Geological Survey, and the Agricultural Research Service/U.S. Department of Agriculture. In addition to these resources, private groups, such as the Nature Conservancy and the Kellogg Foundation, have made large contributions to the ISTA efforts within the watershed. During the early 1990s, over 1 million dollars per year were being used for the implementation of ISTA-like programs within the watershed, this does not include human resources donated to watershed projects by public and private conservation groups.

The Maquoketa watershed is located in northeastern Iowa and is approximately 1.2 million acres in size (see Figure 2 for location). Grain and animals compose the major agricultural products produced. Farm land within the watershed varies from gently rolling to steep slopes. Water quality within the watershed at times is problematic due to erosion of crop land.

Technology-intensive production systems are used throughout the watershed. ISTA programs focused on soil and water conservation issues have been confined to federal and state programs offered to all Iowa land owner-operators. While there are several local conservation initiatives within the watershed, such efforts have not been implemented extensively. to date.

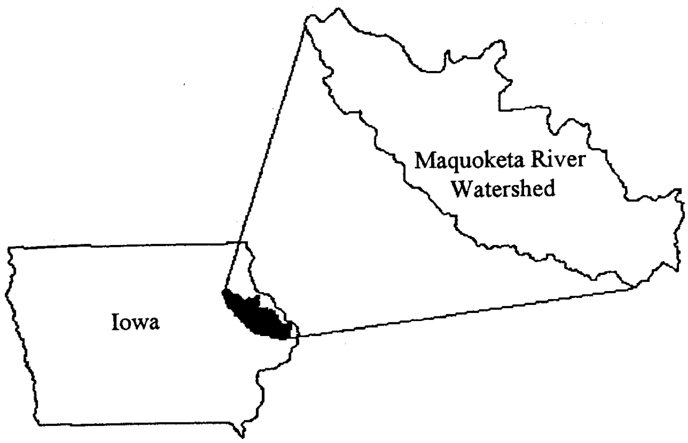

Figure 2. The Maquoketa River Watershed in Iowa.

The Lower Minnesota River watershed in Minnesota is located south and west of Minneapolis and is approximately 1.45 million acres in size (see Figure 3 for location). The land is flat to gently rolling on the plateau surrounding the flood plain and immediately adjacent to the river. The land rises very rapidly from the flood plain to a plateau which creates a very erosive environment. The Lower Minnesota River has been monitored by the Minnesota Pollution Control Board since 1970 and water quality has frequently exceeded state and federal standards for bacteria, phosphorus, turbidity, and dissolved oxygen (Mallawatantri and Mulla, 1996).

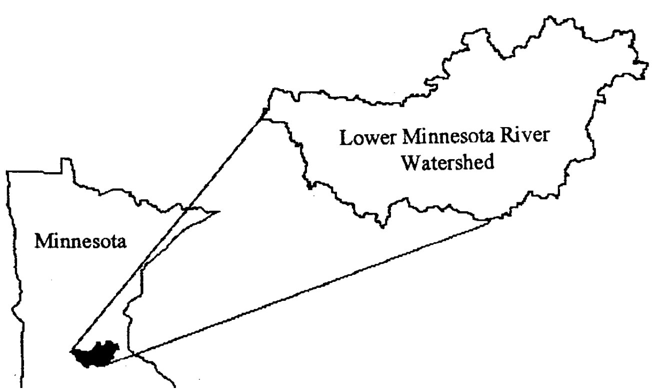

Figure 3. The Lower Minnesota River Watershed in Minnesota.

ISTA programs are primarily confined to federal and state conservation initiatives such as those provided by NRCS. Several quasi-formal conservation organizations have recently emerged within the watershed to coordinate conservation efforts of public and private conservation groups,; however, ISTA programs have not been extensively implemented within the watershed.

Farm products accounting for the largest portion of farm income within the Minnesota watershed are feed grains and dairy products. Production agriculture within the watershed is technology-intensive.

Examination of the ISTA programs that have been implemented within the three study watersheds reveals that land owner-operators within the Darby Creek (Ohio) watershed have been exposed to more extensive ISTA programs than farmers in the two other watersheds. If the theoretical arguments used to justify ISTA approach have merit, then empirical assessments of adoption of conservation production systems within the study watersheds should reveal significantly greater use of conservation production practices among the Ohio farmers than farmers in either of the other two watersheds.

Data Collection

Data were collected from 1,011 primary farm operators within the three study watersheds in the fall of 1998 and early winter of 1999. Trained data collectors contacted land owner-operators at farmsteads selected using a systematic random sampling approach. The sampling procedure used consisted of selecting every other occupied farmstead within designated subsampling areas along rural highways. This procedure was abandoned in the Ohio watershed because it became apparent after two weeks of intense search that it would be nearly impossible to locate 105 farmers (goal of the sampling) using the approach initially employed. To locate a sufficient number of primary farm operators within the Ohio watershed, every occupied farmstead was approached to locate enough farmers to adequately represent the watershed.

Primary farm operators were asked to complete a structured questionnaire that required about 45 minutes to complete. The sample was widely distributed over all three watersheds and all areas within the watersheds were canvassed. Approximately 80 percent of the farmers contacted by field staff-persons completed questionnaires. Given the systematic sampling procedure employed, large sample size, wide distribution of respondents over each of the watersheds, and the high response rate, it is argued that the samples are representative of the study populations in each watershed.

Measurement of Study Variables

The dependent variable used to examine the merits of the research expectations was developed from responses to the 18 agricultural production practices evaluated in the study. Primary farm operators were asked to indicate how frequently **each** of the 18 farm practices was presently being used on their farms (see Table 2 for the production practices assessed).

The possible responses to each of the agricultural production practices were as follows: never use, use once every five years, use once every four years, use once every three years, use every other year, and use every year. The scores attributed to the responses ranged from 0 for **never use** to 5 **use every year** for all of the production practices assessed except fall tillage, fall application of fertilizer, deep plowing, and winter application of manure whose scores were reversed. The use of this scoring scheme resulted in higher values representing more frequent use of conservation production practices.

A composite index was calculated from the responses to the 18 production practices in use at the time of the study. A panel of knowledgeable agricultural professionals was used to classify production practices assessed as having benign or negative impacts on the environment. These responses were used to nominally define each production practice as being environmentally benign or abusive. Values used to differentially score responses to reflect severity of environmental impacts were determined using the same methodology.

Fall tillage, deep plowing, and winter application of manure were designated as being the worst types of farm production practices assessed in terms of contributing to environmental degradation. Conversely, no-till and chisel plowing with one-third ground cover with crop residue at planting time were designated as being the most environmentally benign of the practices assessed. Original scores assigned to responses to these five agricultural practices were multiplied by two to give greater emphasis to adoption of these practices (see Table 2). The computed values for all of the 18 production practices were summed to form a composite index termed **conservation production index** (CPI). The range of possible scores was theoretically 0 to 115; however, farmers tend to specialize in production practices that would preclude farmers from adopting both no-till and chisel plowing with one-third ground cover at planting time. Interpretation of mean index scores must be made in the context of this constraint on the range of possible scores. The index score for each respondent was used as the dependent variable for analysis of variance statistical modeling.

The criterion variable used to partition the respondents into study groups was the state in which each of the watersheds was located. All respondents within the Iowa watershed composed one study group, all of the farmers in the Ohio watershed composed a second study group, and all of the farmers within the Minnesota watershed composed the third study group.

Statistical Analysis

Descriptive statistics were used to examine general trends within the data set, while one-way analysis of variance was used to test the research expectations. Missing data were attributed a value of 0 for the 18 farm practices assessed in the calculation of the analysis of variance statistics reported in this paper. It was reasoned that some farmers would leave the response blank, if they did not use the practice being evaluated. Calculation of the conservation production index using a means substitution approach with multiplication by a factor of two resulted in a rather significant inflation of the scores for Minnesota respondents. It was the decision of the researcher to adopt the more conservative approach for salvaging observations.

STUDY FINDINGS

The descriptive findings for the characteristics of the study populations are presented in Table 1. The findings show that farmers within the Minnesota watershed were better educated, younger, worked more days off-farm, owned fewer acres of land than farmers within the other watersheds, and reported the lowest percentage of economic support and technical assistance received from government sources. Iowa farmers reported renting and cultivating the fewest acres each year. Iowa farmers also reported the smallest percentage of farm income derived from grain production and the highest percentage derived from the production of animal products. Farmers within the Ohio watershed reported the largest number of acres usually under cultivation, acres owned, and number of acres usually rented. They also reported the lowest percentage of farm labor provided by the primary farm operator. Ohio farmers reported the highest percentage of gross farm income below $59,999; however, they also reported the largest percentage of gross farm income over $360,000. Minnesota farmers reported the highest percentage of gross farm income between $60,000 and $239,999 (62.6 percent).

TABLE 1. Characteristics of Study Respondents: Ohio (n = 105), Iowa (n = 355), and Minnesota (n = 551).

	Ohio	Iowa	Minnesota
Age in Years			
Mean	48.6	49.1	46.2
S.D.	11.9	11.8	11.1
Education in Years			
Mean	12.7	12.8	13.0
SD.	2.1	2.4	1.6
Acres Usually Cultivated			
Mean	826.4	378.7	421.1
S.D.	896.1	470.4	493.9
Acres Owned			
Mean	283.3	265.6	233.7
S.D.	461.1	248.6	187.3
Acres Rented			
Mean	498.8	189.1	316.7
S.D.	610.1	265.2	623.2
Days Usually Worked Off-Farm			
Mean	50.8	55.6	95.2
S.D.	94.4	95.8	104.0
Percent of Total Farm Income			
Grain	68.6	45.0	62.1
Animals	16.0	39.9	26.3
Percent Labor by Primary Farm Operator			
Mean	68.1	76.4	78.9
S.D.	27.0	21.6	20.9
Percent Who Received Government Economic Support			
Yes	21.0	15.7	5.8
No	79.0	84.3	94.2
Percent Who Received Technical Assistance			
Yes	27.6	28.4	8.7
No	72.4	71.6	91.3
Gross Farm Income (percent)			
< 59,999	21.9	19.7	8.6
60,000-119,999	18.1	23.6	12.7
120,000-179,999	12.4	12.6	22.5
180,000-239,999	8.7	13.2	27.4
240,000-299,999	4.8	5.1	10.4
300,000-359,999	2.9	2.8	2.4
360,000 >	16.2	7.3	4.7
Missing	15.2	15.7	11.4

Descriptive findings for the various production practices assessed in the study are presented in Table 2. The findings show that fall tillage, soil testing, and crop rotation are practices that were being used extensively in all watersheds. Fall application of fertilizer was used frequently in the Ohio and Minnesota watersheds; however, the practice was used less frequently in the Iowa watershed. No-till farming was used extensively in Ohio but not in the other watersheds. Chisel plowing with one-third ground cover at planting time was used frequently in the Minnesota watershed and less so in the other two watersheds. Moldboard plowing was used extensively in Minnesota but not in the other watersheds. Winter application of manure was frequently practiced in the Iowa and Minnesota watersheds but not in the Ohio watershed. Banded application of fertilizer was seldom used in the Minnesota watershed, however, many farmers in the Ohio and Iowa watershed used this production practice. Side dressing of fertilizer during the growing season was not used very often in the Iowa and Minnesota watersheds; however, a significant minority of farmers in the Ohio watershed used this practice. Mechanical weed control was practiced extensively in the Iowa and Minnesota watersheds but not in the Ohio watershed. Use of ridge tillage, nitritication inhibitors, buffer strips, integrated pest management, and precision farming were not used very often in any of the watersheds assessed in the study.

The CPI was treated as the dependent variable in the study and the state of residence was used as the criterion variable to partition the respondents into groups for comparison purposes. The analysis of variance findings are presented in Tables 3 and 4. Table 3 presents analysis of variance statistics for all three groups.

Findings presented in Table 3 revealed a significant difference among the three watersheds in terms of the conservation production index. The source of the significant difference in Table 3 are farmers in the Minnesota watershed who scored lower on the index. Minnesota farmers scored approximately 10 points lower on the conservation production index than did Ohio and Iowa farmers.

Findings presented in Table 3 also show that practically all respondents had adopted some conservation production practices, however, they also were simultaneously using production practices designated as contributing to degradation of the environment.

To examine the finding presented in Table 3 in greater depth, separate analysis of variance statistics were computed for comparisons of respondent index scores for each watershed with each of the other watersheds. These findings are presented in Table 4.

TABLE 2. Use of Agricultural Production Practices (percentages within parenthesis).

	Never Use	Once Every Five Years	Once Every Four Years	Once Every Three Years	Every Other Year	Use Every Year	MD	Score X̄	Score SD
Fall Tillage*									
Ohio	19 (18.1)	7 (6.7)	4 (3.8)	14 (13.3)	22 (21.0)	36 (34.3)	3 (2.9)	1.8	1.9
Iowa	80 (22.5)	22 (6.2)	17 (4.8)	41 (11.5)	52 (14.6)	115 (32.3)	28 (8.1)	2.1	1.9
Minnesota	49 (8.9)	5 (0.9)	0 (0.0)	5 (0.9)	30 (5.4)	454 (82.4)	(Y.5)	0.6	1.5
Fall Application of Fertilizer*									
Ohio	25 (23.8)	3 (2.9)	3 (2.9)	14 (13.3)	15 (14.3)	37 (35.2)	8 (7.6)	1.9	2.0
Iowa	174 (48.9)	12 (3.4)	13 (3.7)	35 (9.8)	37 (10.4)	48 (13.5)	36 (10.4)	3.3	1.9
Minnesota	202 (36.7)	49 (8.9)	19 (3.4)	53 (9.6)	74 (13.4)	133 (24.1)	21 (3.8)	2.7	2.1
Soil Testing**									
Ohio	9 (8.6)	8 (7.6)	4 (3.8)	34 (32.4)	24 (22.9)	21 (20.0)	5 (4.8)	3.2	1.5
Iowa	8 (2.2)	32 (9.0)	41 (11.5)	164 (46.1)	45 (12.6)	30 (8.4)	35 (10.1)	2.9	1.1
Minnesota	62 (11.3)	28 (5.1)	31 (5.6)	177 (32.1)	102 (18.5)	132 (24.0)	19 (3.4)	3.2	1.5
No-Till**									
Ohio	20 (19.0)	2 (1.9)	1 (1.0)	6 (5.7)	15 (14.3)	53 (50.5)	8 (7.6)	3.6	1.9
Iowa	201 (56.5)	16 (4.5)	3 (0.8)	23 (6.5)	24 (6.7)	42 (11.8)	46 (13.2)	1.3	1.8
Minnesota	451 (81.9)	30 (5.4)	11 (2.0)	12 (2.2)	4 (0.7)	14 (2.5)	29 (5.3)	0.3	1.0
Chisel Plowing With One-Third Ground Surface Covered With Residue at Planting**									
Ohio	26 (24.8)	7 (6.7)	4 (3.8)	13 (12.4)	20 (19.0)	30 (28.6)	5 (4.8)	2.8	2.0
Iowa	88 (24.7)	16 (4.5)	12 (3.4)	39 (11.0)	56 (15.7)	112 (31.5)	32 (9.3)	2.9	2.0
Minnesota	127 (23.0)	10 (1.8)	(1.3)	23 (4.2)	81 (14.7)	285 (51.7)	18 (3.3)	3.5	2.0
Ridge Tillage**									
Ohio	103 (98.1)	2 (1.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.2	0.1
Iowa	340 (95.8)	2 (0.6)	3 (0.8)	4 (1.1)	2 (0.6)	4 (1.1)	0 (0.0)	0.1	0.7
Minnesota	524 (95.1)	5 (0.9)	2 (0.4)	1 (0.2)	(k.2)	18 (3.3)	0 (0.0)	0.2	0.9

TABLE 2. Use of Agricultural Production Practices (percentages within parenthesis) (cont'd.).

	Never Use	Once Every Five Years	Once Every Four Years	Once Every Three Years	Every Other Year	Use Every Year	MD	Score X̄	Score SD
Deep (Moldboard) Plowing*									
Ohio	49 (46.7)	12 (11.4)	1 (1.0)	3 (2.9)	8 (7.6)	23 (21.9)	9 (8.6)	3.2	2.1
Iowa	155 (43.5)	56 (15.7)	20 (5.6)	48 (13.5)	18 (5.1)	21 (5.9)	37 (10.7)	3.4	1.7
Minnesota	135 (24.5)	22 (4.0)	4 (0.7)	25 (4.5)	49 (8.9)	295 (53.5)	21 (3.8)	1.6	2.1
Winter Application of Manure*									
Ohio	56 (53.3)	4 (3.8)	3 (2.9)	2 (1.9)	1 (1.0)	32 (30.5)	7 (6.7)	3.2	2.2
Iowa	65 (18.3)	4 (1.1)	5 (1.4)	9 (2.5)	17 (4.8)	226 (63.5)	29 (8.4)	1.4	2.1
Minnesota	200 (36.3)	10 (1.8)	4 (0.7)	21 (3.8)	40 (7.3)	254 (46.1)	22 (4.0)	2.1	2.3
Banded (in furrow) Application of Fertilizer**									
Ohio	41 (39.0)	8 (7.6)	3 (2.9)	1 (1.0)	3 (2.9)	42 (40.0)	7 (6.7)	2.6	2.3
Iowa	134 (37.6)	9 (2.5)	6 (1.7)	15 (4.2)	12 (3.4)	143 (40.2)	36 (10.4)	2.6	2.2
Minnesota	405 (73.5)	47 (8.5)	4 (0.7)	5 (0.9)	20 (3.6)	70 (12.7)	0 (0.0)	0.9	1.8
Side-Dressing of Fertilizer During Growing Season**									
Ohio	36 (34.3)	4 (3.8)	3 (2.9)	8 (7.6)	7 (6.7)	41 (39.0)	6 (5.7)	2.7	2.2
Iowa	160 (44.9)	12 (3.4)	13 (3.7)	33 (9.3)	23 (6.5)	76 (21.3)	38 (11.0)	1.9	2.0
Minnesota	340 (61.7)	21 (3.8)	7 (1.3)	6 (1.1)	32 (5.8)	116 (21.1)	29 (5.3)	1.5	2.1
Banded Application of Herbicides**									
Ohio	71 (67.6)	1 (1.0)	1 (1.0)	4 (3.8)	1 (1.0)	17 (16.2)	10 (9.5)	1.1	1.9
Iowa	208 (58.4)	(Y.7)	2 (0.6)	18 (5.1)	21 (5.9)	58 (16.3)	42 (12.1)	1.4	1.9
Minnesota	290 (52.6)	15 (2.7)	37 (6.7)	7 (1.3)	38 (6.9)	164 (29.8)	0 (0.0)	2.0	2.3
Mechanical Weed Control**									
Ohio	47 (44.8)	5 (4.8)	14 (13.3)	8 (7.6)	3 (2.9)	28 (26.7)	0 (0.0)	2.0	2.1
Iowa	24 (6.7)	3 (0.8)	6 (1.7)	13 (3.7)	32 (9.0)	244 (68.5)	33 (9.6)	4.4	1.4
Minnesota	77 (14.0)	0 (0.0)	1 (0.2)	11 (2.0)	34 (6.2)	404 (73.3)	24 (4.4)	4.2	1.7

TABLE 2. Use of Agricultural Production Practices (percentages within parenthesis) (cont'd.).

	Never Use	Once Every Five Years	Once Every Four Years	Once Every Three Years	Every Other Year	Use Every Year	MD	Score X̄	Score SD
Use of Nitrification Inhibitor**									
Ohio	60 (57.1)	2 (1.9)	(32.9)	5 (4.8)	6 (5.7)	17 (16.2)	12 (11.4)	1.4	1.9
Iowa	224 (62.9)	7 (2.0)	5 (1.4)	29 (8.1)	10 (2.8)	26 (7.3)	54 (15.4)	0.9	1.5
Minnesota	353 (64.1)	10 (1.8)	11 (2.0)	29 (5.3)	42 (7.6)	63 (11.4)	43 (7.8)	1.2	1.8
Crop Rotation**									
Ohio	2 (1.9)	0 (0.0)	2 (1.9)	6 (5.7)	12 (11.4)	75 (71.4)	8 (7.6)	4.6	0.9
Iowa	10 (3.1)	5 (1.4)	14 (3.9)	81 (22.8)	90 (25.3)	155 (43.5)	0 (0.0)	4.0	1.2
Minnesota	57 (10.3)	4 (0.7)	4 (0.7)	17 (3.1)	66 (12.0)	403 (73.1)	0 (0.0)	4.3	1.6
Contour Planting**									
Ohio	85 (81.0)	0 (0.0)	1 (1.0)	0 (0.0)	2 (1.9)	7 (6.7)	10 (9.5))	0.5	1.4
Iowa	109 (30.6)	6 (1.7)	(30.8)	11 (3.1)	9 (2.5)	175 (49.2)	42 (12.1)	3.1	2.2
Minnesota	454 (82.4)	0 (0.0)	3 (0.5)	2 (0.4)	5 (0.9)	52 (9.4)	35 (6.4)	0.6	1.5
Buffer Strips**									
Ohio	65 (61.9)	3 (2.9)	2 (1.9)	0 (0.0)	1 (1.0)	21 (20.0)	13 (12.4)	1.3	2.0
Iowa	162 (45.5)	16 (4.5)	11 (3.1)	13 (3.7)	7 (2.0)	99 (27.8)	47 (13.5)	1.9	2.1
Minnesota	440 (79.9)	2 (0.4)	2 (0.4)	5 (0.9)	6 (1.1)	60 (10.9)	0 (0.0)	0.7	1.6
Integrated Pest Management**									
Ohio	73 (69.5)	14 (13.3)	4 (3.8)	2 (1.9)	0 (0.0)	12 (11.4)	0 (0.0)	0.8	1.6
Iowa	218 (61.2)	11 (3.1)	8 (2.2)	8 (2.2)	8 (2.2)	54 (15.2)	48 (13.8)	1.2	1.8
Minnesota	420 (76.2)	5 (0.9)	4 (0.7)	3 (0.5)	6 (1.1)	77 (14.0)	36 (6.5)	0.8	1.8
Precision Farming**									
Ohio	90 (85.7)	2 (1.9)	1 (1.0)	0 (0.0)	1 (1.0)	11 (10.5)	0 (0.0)	0.6	1.6
Iowa	297 (83.7)	5 (1.4)	4 (1.1)	7 (2.0)	5 (1.4)	37 (10.4)	0 (0.0)	0.7	1.6
Minnesota	422 (76.6)	37 (6.7)	3 (0.5)	2 (0.4)	5 (0.9)	82 (14.9)	0 (0.0)	0.9	1.8

**Weighted 5 through 0 with "never use" receiving a value of 5 and "use every year" receiving a value of 0.
**Weighted 0 through 5 with "never use" receiving a value of 0 and "use every year" receiving a value of 5.

TABLE 3. Analysis of Variance Findings for Conservation Production Index Scores for Ohio (n = 105), Iowa (n = 355), and Minnesota (n = 551) Respondents.

State	Mean	Std. Dev.	F-Test	Sig. Level
Ohio	50.0	13.1	80.7	0.0001
Iowa	48.9	13.1		
Minnesota	38.5	13.0		

TABLE 4. Analysis of Variance Findings for Conservation Production Index Scores Comparing Responses from Each Watershed With Those of all Other Watersheds.

States Being Compared	F-Test	Significance Level
Ohio Versus Iowa	0.5	Not Sig. at 0.05 level
Ohio Versus Minnesota	65.7	0.001
Iowa Versus Minnesota	132.9	0.001

Findings presented in Table 4 indicate that the source of significant differences among the study groups were the Minnesota respondents. Minnesota farmers reported significantly less use of conservation production practices than land owner-operators within the other two watersheds. There was no significant difference between Ohio and Iowa respondents.

CONCLUSIONS

Study findings bring into question arguments advanced to justify use of ISTA approaches. The argument that ISTA approaches will result in widespread adoption of conservation production practices at the farm level was not validated by the study findings. While respondents within the Ohio watershed had received extensive soil and water conservation programs using the ISTA approach, adoption as measured by the CPI was not significantly different from Iowa respondents who had not been exposed to comparable conservation programs. The findings also demonstrated that Minnesota farmers had adopted conservation production practices even though they had been exposed to few ISTA programs. Findings reported here support conclusions drawn by Napier *et al.* (2000a) that ISTA factors are not good predictors of adoption of conservation production systems.

POLICY IMPLICATIONS OF STUDY FINDINGS

The variability of the production systems reported within the three watersheds raises an important policy issue regarding the effectiveness of focused conservation initiatives. While public conservation efforts have traditionally emphasized specialized conservation solutions (i.e., adoption of conservation tillage or no-till) that vary over time, study findings suggest that such approaches may not be the most appropriate implementation approach in all geographic regions because some production systems will not be adopted for a variety of reasons.

Farmers in Minnesota and Iowa have not adopted no-till production systems; however, they have adopted other environmentally benign production practices. Ohio farmers have adopted no-till. The impact on the environment of adopting no-till in Ohio may be the same as adopting alternative conservation production systems in other states. Conservation policies and programs focused on advancing a specific technological solution may not be relevant to all farmers. Conservation policies and programs should be formulated for the specific needs of potential users and not for general farming populations.

While farmers in all of the study watersheds had adopted some conservation production practices, most land owner-operators were simultaneously using production practices that could off-set benefits achieved by the conservation practices presently in use. To prevent this type of a situation, conservation policies and programs should place more emphasize on **whole farm planning** so that land owner-operators will adopt complementary production practices. Adoption of a specific production practice should not be used as the only indicator of achieving environmental policy goals. Farmers could adopt no-till practices and remain significant agricultural polluters by applying manure during the winter and by over-applying inorganic fertilizers during the growing season. Compliance with environmental policy objectives should be assessed in the context of all production practices being used. All components of production systems should be examined and conservation programs implemented to ensure that environmentally degrading practices will be eliminated from the system.

Study findings and conclusions drawn from this and other studies (Lovejoy and Napier, 1986; Napier, et *al.,* 2000b, Napier and Johnson, 1998a) suggest that new public policy approaches will be required to address nonpoint pollution in the U.S. Future public conservation policy should emphasize whole farm planning and flexibility. Environmental goals should be established and individual land owner-operators should be permitted to select the means he/she deems most appropriate to accomplish the objectives to be achieved. The only constraint to land owner-decision making would be the requirement that all production practices should contribute to an integrated conservation production system. Such an approach would deemphasize or eliminate most conservation initiatives that place priority on specific conservation production practices in favor of whole farm conservation planning. It would eliminate information-education programs designed for general audiences in favor of information and technical assistance programs designed for targeted audiences. Such an approach would change the content of conservation information and technical assistance because the information needs of land owner-operators would be more complex and technical in nature. The new integrated approach would result in a redirection of financial support to land owner-operators who engage in whole farm planning.

Modifications of existing soil and water conservation programs and policies will be very difficult to achieve in the U.S. because the ISTA approach is so strongly entrenched. It is highly likely that nonpoint pollution goals will never be achieved until a new paradigm embracing whole farm planning is implemented because the ISTA approach has been shown to be inadequate to resolve environmental problems created by modern agricultural systems. The ISTA approach was formulated and implemented effectively at a different time in U.S. History. Unfortunately, we have failed to recognize that the ISTA approach is no longer relevant and that new approaches are required.

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