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Potential for Cost-share Policies to Improve Groundwater Quality without Reducing Farm Profits[1]

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Thomas L. Dobbs and John H. Bischoff[2]

The Federal Agricultural Improvement and Reform Act (FAIR) of 1996 reinforced the Federal government's commitment to environmental aspects of farm policy that received major attention in 1985 legislation and reinforcement in 1990. All three pieces of legislation placed emphasis on incentive and cost-share policies to reduce adverse soil and water effects of farming practices. A major initiative under FAIR is the Environmental Quality Incentives Program (EQIP), for which $1.3 billion is authorized over 7 years to provide cost-share or incentive payment contracts with crop and livestock producers for environmental and conservation improvements (Young and Shields, 1996). In part, this program is a greatly expanded outgrowth of two other Federal programs that originated in

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the early 1990s--the Integrated Crop Management (ICM) program and the Water Quality Incentives Program (WQIP).

The U.S. Department of Agriculture (USDA) began offering the ICM cost-share program under its Agricultural Conservation Program (ACP) starting in the 1990 crop year. Participating farmers were eligible for cost-share payments for crop consultants and other costs associated with such practices as pest and nutrient management, cover crops, improved rotations, and green manure crops. Payments of up to $7/acre for small grains and row crops and $20/acre for orchards, vegetables, and specialty crops were allowed. Contracts up to 3 years in length were allowed, with payments not to exceed $3,500/year. The program was originally limited to a few counties in participating states and to a fixed number of farms in some of the counties. Later, states were allowed to make all counties and farms eligible. (Dobbs, 1993)

The WQIP was authorized as part of the 1990 farm bill, and subsequently was administered under the ACP program. Many of the WQIP practices that qualified for funding were the same as those that qualified under the ICM program, such as soil testing, cover crops, and integrated management of crop rotations. In addition, various practices specific to water management qualified for financial assistance, including well testing, filter strips, and irrigation water management. While the ICM program paid a 75% cost share, the WQIP paid a fixed per acre amount (Higgins, 1995); depending on the practice, that amount could be up to $35/acre, with total payments for an individual contract limited to $25/acre

(Dobbs, 1993). Like the ICM program, multi-year contracts paying up to $3,500/year were allowed. The WQIP was first funded for the 1992 crop year, at $6.8 million. It was then funded at $15 million/year in the following 3 years. (Higgins, 1995)

As the USDA enters into implementation of EQIP, its major new agricultural environmental initiative, it is important to take stock of experiences under the forerunner ICM and WQIP initiatives. Only a very limited number of studies have examined the effectiveness of the ICM and WQIP programs. Dicks et al. (1993) and Osborn, et al. (1994) analyzed some of the effects of the ICM program in its first year of operation, 1990. Their analyses relied heavily on records farmers must keep as part of the program, and no farm-level modeling was done. The American Farmland Trust conducted a general assessment of likely WQIP impacts (Kraft and Lant, 1994), and Higgins (1995) analyzed barriers to full implementation of the WQIP and proposed some changes to make the program more attractive and effective. Also, USDA economists used survey data to predict farmer adoption rates of different WQIP practices under various incentive payment levels (Feather and Cooper, 1995; Cooper and Keim, 1996). However, we are not aware of any previous analyses which have actually estimated both farm profitability and environmental effects of these two programs.

A recent article in the Journal of Soil and Water Conservation did contain estimates of farm net return, soil loss, and nitrogen runoff and leaching impacts of Best Management Practices (BMPs) in a Georgia watershed (Sun et al., 1996), but the source of farmer cost share funds for BMPs in this demonstration project watershed was not indicated. The Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model was used to simulate nitrogen contamination and soil erosion in the Georgia study. GLEAMS also was used in an Iowa analysis of potential economic and environmental effects of various water quality policies, including a generic "integrated crop management" policy similar to the ICM program (Contant et al., 1993).

Various modeling approaches to examine potential tradeoffs between farm profits and indicators of environmental quality associated with adoption of BMPs have been reported in several other recent articles. Hoag et al. (1994) developed a model called Pesticide Economic and Environmental Tradeoffs (PEET) to estimate tradeoffs between economic losses to farmers and groundwater contamination from herbicide applications on peanuts. This model followed a similar one developed by Hoag and Hornsby (1992) for analysis of herbicide applications to soybeans in North Carolina. Foltz et al. (1995) used the GLEAMS and EPIC (Erosion Productivity Impact Calculator) models to simulate environmental impacts in their examination of economic-environmental tradeoffs associated with different farming systems in Indiana. Versions of EPIC also were used in such tradeoff analyses to estimate nitrate leaching impacts associated with different practices on representative farms in Oklahoma (Teague et al., 1995), Nebraska (Supalla et al., 1995), and Texas (Chowdhury and Lacewell, 1996). The Nitrate Leaching and Economic Analysis Package (NLEAP), which we selected for the environmental portion of our analysis reported in the present article, also was used in a Missouri farm-level case study. In that study, Xu et al. (1995) examined tradeoffs among net farm income, nitrate leaching, and soil erosion for alternative farming systems in Missouri's Management System Evaluation Area (MSEA) Project. NLEAP has been incorporated in version 2.0 of the economic-environmental software package PLANETOR to handle the nitrate leaching component of that package.[3] Roberts and Swinton (1995) used this recently completed version of PLANETOR in examining gross margin (a profitability measure), nitrate leaching, and phosphorus runoff relationships for different crop systems on a representative Michigan farm. An earlier version of PLANETOR also was used for representative farm economic-environmental analysis in Michigan (Hewitt and Lohr, 1995), but the nitrogen portion of the analysis with that package was much weaker prior to incorporation of NLEAP.

Writing a few years ago, Lee and Lovejoy (1991, p. 64) indicated that "Robust agronomic, economic, and environmental databases needed to assess the economic trade-offs and environmental effects of reduced pesticides and/or fertilization rates do not exist." To a considerable extent, that is still true. Nevertheless, the studies just cited and the one reported in the present article indicate definite progress is being made in accumulation of data and analyses regarding economic-environmental

[3]The PLANETOR model has been under development for several years at the University of Minnesota's Center for Farm Financial Management.

tradeoffs. Much of the accumulating evidence is from case studies, because, as Ervin (1995, p. 22) points out, the application of "technologies to improve profit and environmental conditions depends upon site-specific farm/ranch and natural resource conditions." However, as results of these emerging case studies begin to become available in the literature, farming practice and agro-climatic patterns are likely to emerge, in spite of many site-specific differences.

The purpose of the study reported in this article was to determine whether the economic incentives offered by the ICM program and the WQIP are sufficient to induce Western Corn Belt/Northern Great Plains farmers in areas sensitive to groundwater contamination by nitrates to adopt farming systems and practices that could reduce contamination risks. The study was conducted by examining potential tradeoffs and/or complementarities between farm profits and reduced nitrate leaching in a watershed situated in eastern South Dakota. The general hypothesis was that complementarities may exist--or at least that tradeoffs may only be neglible--for at least some practices and systems.

The study area is described in the following section of this article, and then the methods of economic and environmental analysis are explained. Results of the analysis are presented next, and conclusions about cost-share incentive programs like ICM and WQIP are drawn at the end.

Study area

The study reported herein was focused on one of the USDA's 16 water quality demonstration projects across the country. This one, the Big Sioux Aquifer (BSA) Water Quality Demonstration Project, is located in eastern South Dakota. Here, a shallow aquifer is located under intensively farmed, fertile soils, making it vulnerable to contamination from fertilizers, pesticides, and animal wastes. A major component of the BSA project is aimed at reducing non-point source nitrate pollution of the aquifer. At the time our study began, 45 out of 400 farms in the BSA area had enrolled in the ICM program or the WQIP, or both. The most popular practices under these programs were nutrient management, pest management, conservation cropping sequence, and crop residue use. There was very little change in either crop type or crop rotation.

Four case study farms in the BSA area were used for analyses. They represented different farm sizes, soils, cropping systems, topography, and management in the study area. The case farms were a mix of three dryland operations and one irrigated operation. **Farm #1** was a dryland operation that used reduced tillage on a corn-soybean operation, with some alfalfa; it had 266 of its 1,283 acres enrolled in the ICM program, with enrolled acres consisting of Brandt, Marysland, and Fordville soils. **Farm #2** also was a dryland operation, and it used some aspects of reduced tillage on 299 ICM acres (out of the farm total of 1,858) on which corn, soybeans, and oats were grown; ICM acres had Lamo and Clamo soil types. The third dryland farm, **Farm #3**, had corn, soybeans, oats, alfalfa, and clover on 108 acres (made up of Brandt and La Prairie soils) enrolled in the WQIP; this small farm, of only 168 total acres, was operated by an individual who had full-time off-farm employment. This operator had long emphasized conservation practices. **Farm #4** was the irrigated operation; our study focused on 73 WQIP acres (out of a farm total of 838) which consisted of continuous corn on Marysland and Fordville soils under a center-pivot sprinkler irrigation system.

Methods of analysis

Data from the four case farms, as well as from various other sources for practices and systems that could be adopted on those farms, were used to estimate tradeoffs and complementarities between farm profitability and nitrate leaching. Crop enterprise and rotation budgets were developed for each of the farms, using a budget generator package called CARE (Cost and Return Estimator). Profitability results (from CARE) for individual crops, fields, and soils were aggregated to a rotation and farming system level with special spreadsheets that took Federal farm program acreage set-aside requirements into account. Farming system profits were estimated for the ICM/WQIP acres on each farm for both "before" and "after" participation in ICM or WQIP. ICM and WQIP payments were \$7/ac for enrolled acres on Farm #1, \$4.93/ac for Farm #2, \$7/ac for Farm #3, and \$14.30/ac for Farm #4. These payments were not added into the budgets, since the payments were used to directly pay for costs incurred to make management adjustments. Neither were costs such as crop consulting and soil testing services included in the budgets. Thus, those payments were treated as direct "pass-throughs".

Baseline economic analyses were completed using data collected from each case farmer. When the data were collected, the farmers were asked to make a distinction between practices that were typically used before enrollment in the ICM or WQIP program and practices that would typically be used after enrollment in these programs. Since the farms had only recently entered these special programs when interviews were initially conducted in winter 1993-1994, and since 1993 was extremely wet and cool, a good deal of farmer and researcher judgement was used in making yield and other estimates necessary for the "after" participation in ICM and WQIP economic analyses.

Baseline economic analyses were conducted with the Federal farm program as it existed in 1993. Market prices were "typical" prices for the early 1990s in eastern South Dakota.

We also carried out profitability analyses for possible additional **practice** changes. These were potential changes that some farmers were not actually using at the time, but that could be added to the "after" scenario. One was banding fertilizer at planting and another was splitting nitrogen fertilizer applications. Other changes involved **system** changes--switching to more diverse crop rotations than existed in the "before" and "after" scenarios for each individual case farmer.

Nitrate leaching was the groundwater quality impact estimated for each case farm. The NLEAP model was used to make nitrate leaching estimates. Estimates of nitrate leaching were made for each of the practices and systems for which farm profits were estimated; this was done under three different rainfall scenarios--"typical", "wet", and "dry". Yields were adjusted for each weather scenario, so that nitrate leaching and profit estimates for each farm and scenario were made under a consistent set of model assumptions.

Results

Typical conditions: Results of the analyses under "typical" rainfall conditions are discussed first. The profitability results are shown in Table 1. Per acre results are composites for all farming systems on the affected fields of each farm; they were determined by dividing the total systems results by the number of acres. Table 1 's first row of data consists of "baseline" net returns to land and management per acre for each case farm; these represent net returns in a "typical" year "before" participating in the ICM or WQIP. In the second row are estimates of what net returns are likely to be in a typical year "after" participating in the ICM or WQIP and making associated farm management adjustments. The third and fourth rows of data in Table 1 constitute profitability estimates for possible additional **practice** changes. The final rows show estimates for four additional hypothetical scenarios; these involve **system** changes. All involve changes to more diverse crop rotations than existed in the "before" and "after" scenarios. The first two include oats (as a nurse crop for alfalfa), alfalfa (harvested for two years after seeding),

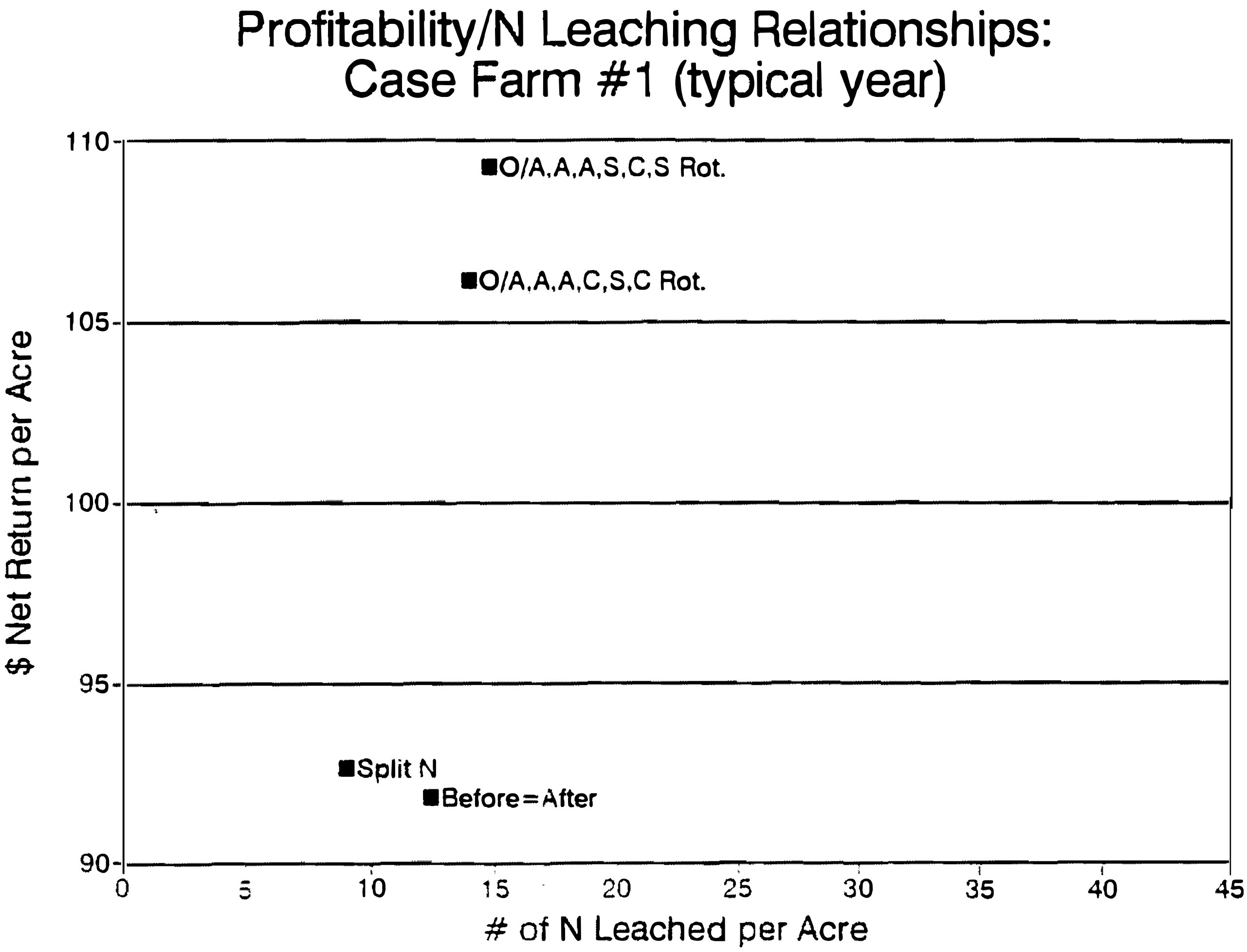
Table 1. Profitability Estimates for Selected Management Scenarios on Four Case Farms

Management scenario	Net returns to land and management ($/ac.)			
	Case Farm #1	Case Farm #2	Case Farm #3	Case Farm #4
Baseline ("before" ICM or WQIP)	$92	$39	$95	$63
"After" ICM or WQIP	$92	$69	$101	$81
Banding fertilizer at planting	Not Applicable	$71	$102	Not Applicable
Splitting nitrogen applications	$93	$73	$102	$88
Diverse rotation with 1 yr oats, 2 yrs alfalfa, 2 yrs soybeans, & 1 yr corn (between soybean years)	$109	$96	$109	Not Applicable
Diverse rotation with 1 yr oats, 2 yrs alfalfa, 2 yrs corn, & 1 yr soybeans (between corn yrs)	$106	$83	$111	Not Applicable
Diverse rotation with 2 yrs Alfalfa, 2 yrs soybeans, & 2 yrs corn	Not Applicable	Not Applicable	Not Applicable	$54
Corn/soybean rotation	Not Applicable	Not Applicable	Not Applicable	$75

soybeans, and corn in 6-year rotations. In one alternative, soybeans are grown 2 years out of 6 and corn is only grown 1 year; in the other, soybeans are grown 1 year and corn is grown 2 years. The last two alternatives are system changes for Case Farm #4. These hypothetical scenarios also involve changes to more diverse rotations, but the scenarios are different from those of the other farms because the irrigated farm's baseline involves a continuous corn system. In one alternative, a 6-year rotation, alfalfa (clear-seeded) is harvested 2 years, and soybeans and corn are each grown for 2 years. The other alternative for Case Farm #4 is a corn/soybean rotation. (Corn/soybean rotations were part of the baseline for some of the other case farms.)

Tradeoffs and complementarities between profitability and nitrate leaching for each case farm are depicted in Figures 1 through 4. In the "typical" year on Case Farm #1 (Figure 1), estimated "before" and "after" net returns and nitrate leaching were the same, because the crop consulting services received under the ICM program for that farm apparently did not lead directly to any farming practice or system changes. Profitability was less than 1 percent higher for splitting the nitrogen application ($92.51/ac) than for the baseline scenario ($91.80/ac). The alternative <u>systems</u> had significantly greater economic returns ($109.26/ac for one alternative and $106.15/ac for the other alternative) than the baseline system and the alternative practice. Environmental results for splitting nitrogen application showed a 25 percent decrease in the amount of nitrogen leached, dropping

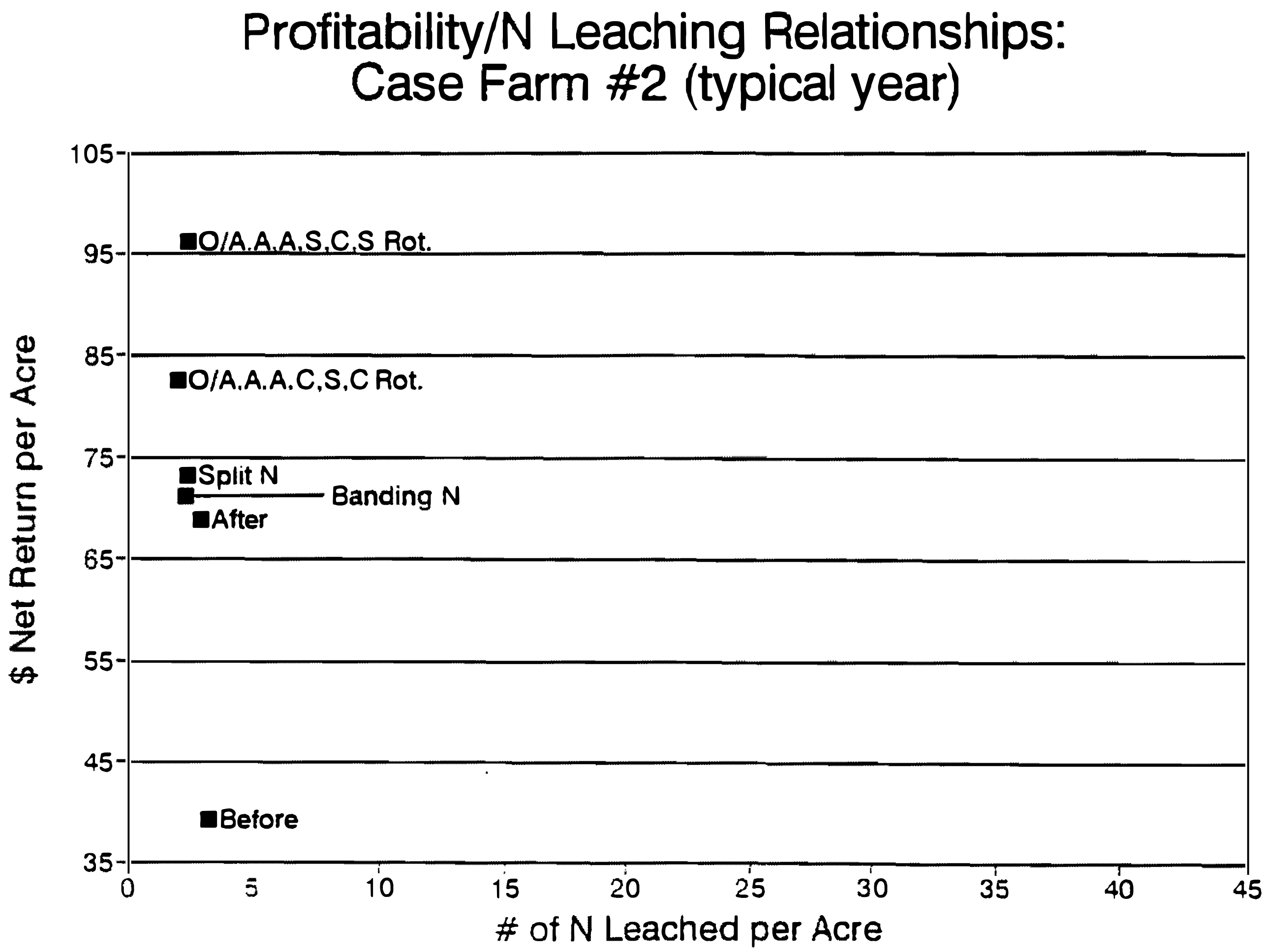
Figure 1.


Profitability/N Leaching Relationships:
Case Farm #1 (typical year)
$ Net Return per Acre
# of N Leached per Acre
O/A,A,A,S,C,S Rot.
O/A,A,A,C,S,C Rot.
Split N
Before=After
110
105
100
95
90
0
5
10
15
20
25
30
35
40
45

from 12 lbs/ac for the baseline system to 9 lbs/ac. However, the alternative systems showed an unexpected 17-25 percent increase (to 15 lbs/ac for one alternative and to 14 lbs/ac for the other) in the amount of nitrogen leached. This may be attributed to the high amount of nitrogen leached for the oats/alfalfa component of the alternative rotations. Even though there is alfalfa in the baseline system, it is on fewer acres, so the contribution to the whole-farm nitrogen leaching figures is not as great as in the alternative systems.

Results for the "typical" year on Case Farm #2 (Figure 2) indicate that profitability increased by 76 percent from the baseline "before" scenario ($39.28/acre) to the baseline "after" scenario ($68.99/acre). Profitability was slightly (3-6 percent) higher for banding fertilizer ($71.12) and splitting nitrogen applications ($73.29) than for the baseline "after" scenario. The alternative systems had significantly greater economic returns ($96.28/acre for the O/A,A,A,S,C,S rotation and $82.63/acre for the O/A,A,A,C,S,C rotation) than the baseline systems and the alternative practices. As expected, environmental results for the baseline "after" scenario showed a slight decrease in the amount of nitrate leached (down to 2.9 lbs/acre, compared to the baseline "before" 3.3 lbs/acre). Even further decreases in the amount of nitrate leached were observed for banding fertilizer (down to 2.3 lbs/acre) and splitting nitrogen applications (down to 2.4 lbs/acre). The amount of nitrate leaching for the O/A,A,A,S,C,S rotation (2.4 lbs/acre) was similar to that for the alternative

Figure 2.



Profitability/N Leaching Relationships:
Case Farm #2 (typical year)
105
95
85
75
65
55
45
35
$ Net Return per Acre
O/A.A.A.S.C.S Rot.
O/A.A.A.C.S.C Rot.
Split N
Banding N
After
Before
0
5
10
15
20
25
30
35
40
45
# of N Leached per Acre

practices, and was slightly lower for the O/A,A,A,C,S,C rotation (2 lbs/acre). It should be emphasized that the nitrate leaching calculated by the model was only to the nearest pound, but the 6-year annual average is given in tenths of pounds to help the reader see trends.

Net returns were estimated to increase by $6/acre on Case Farm #3, where the WQIP involved elimination of inorganic fertilizer and changes in pesticides on corn on upper fields, but no change in nitrate leaching because leaching was assumed only to occur from this farm's lower fields directly over the aquifer[4] (Figure 3). Profitability was slightly higher for banding fertilizer ($101.54/acre) and splitting nitrogen applications ($102.06/acre) when compared to the baseline "after" scenario ($100.81/acre) on Case Farm #3 in the "typical" rainfall year. The alternative systems had significantly greater economic returns--at $109.49/acre for the O/A,A,A,S,C,S rotation and $111.37/acre for the O/A,A,A,C,S,C rotation--than the baseline systems and the alternative practices. Environmental results for splitting nitrogen applications showed a slight increase in the amount of nitrogen leached, rising 0.2 lbs to 4.0 lbs/acre from 3.8 lbs/acre for the baseline system. The amount of nitrogen leaching for banding fertilizer was at the same level as the baseline "after" system. As expected, the alternative systems showed a decrease (to

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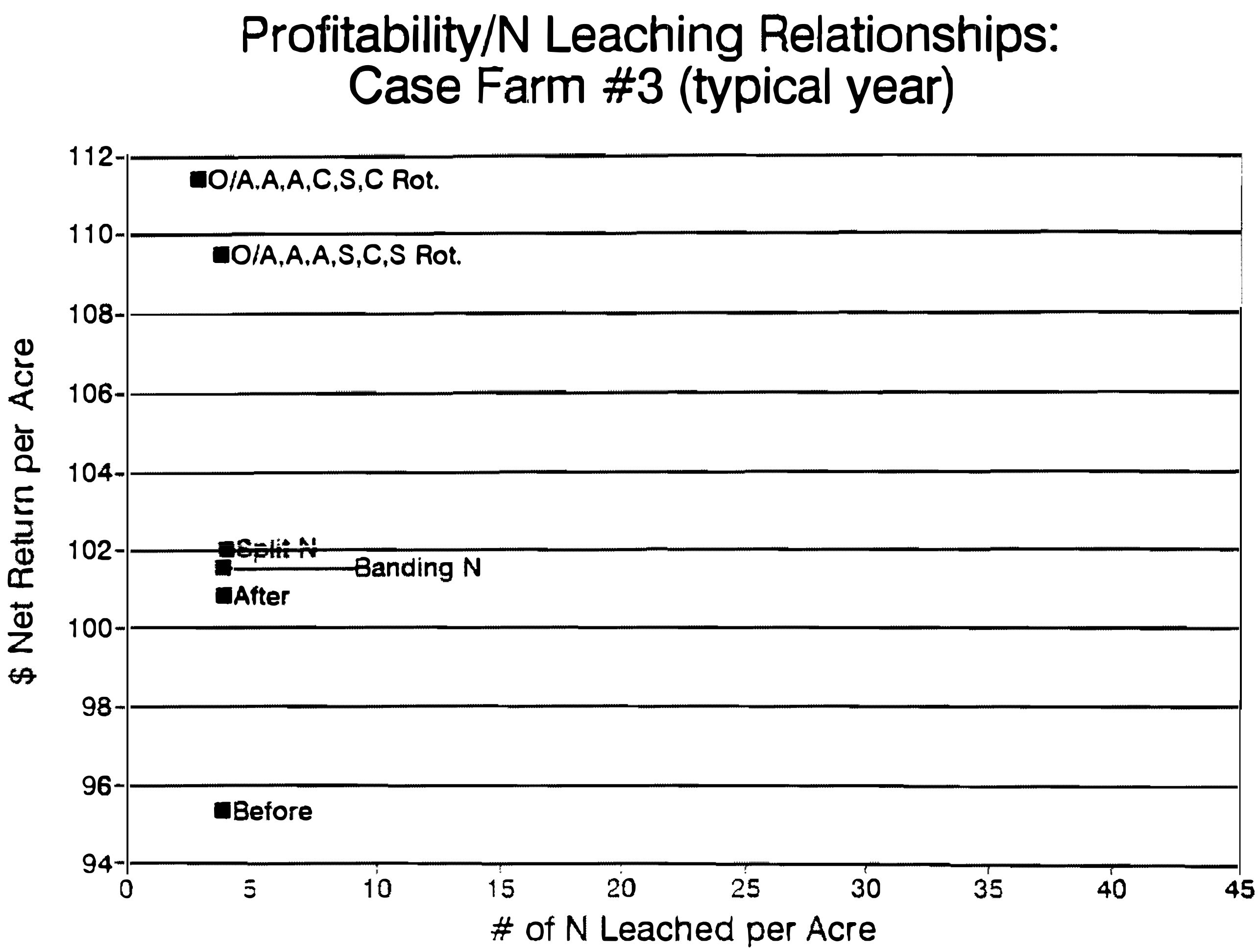
[4]Depth to the aquifer from the upper fields was great enough to make the no-leaching assumption realistic. We did not attempt to model any possible added leaching from the lower fields due to runoff from the upper fields.

Figure 3.

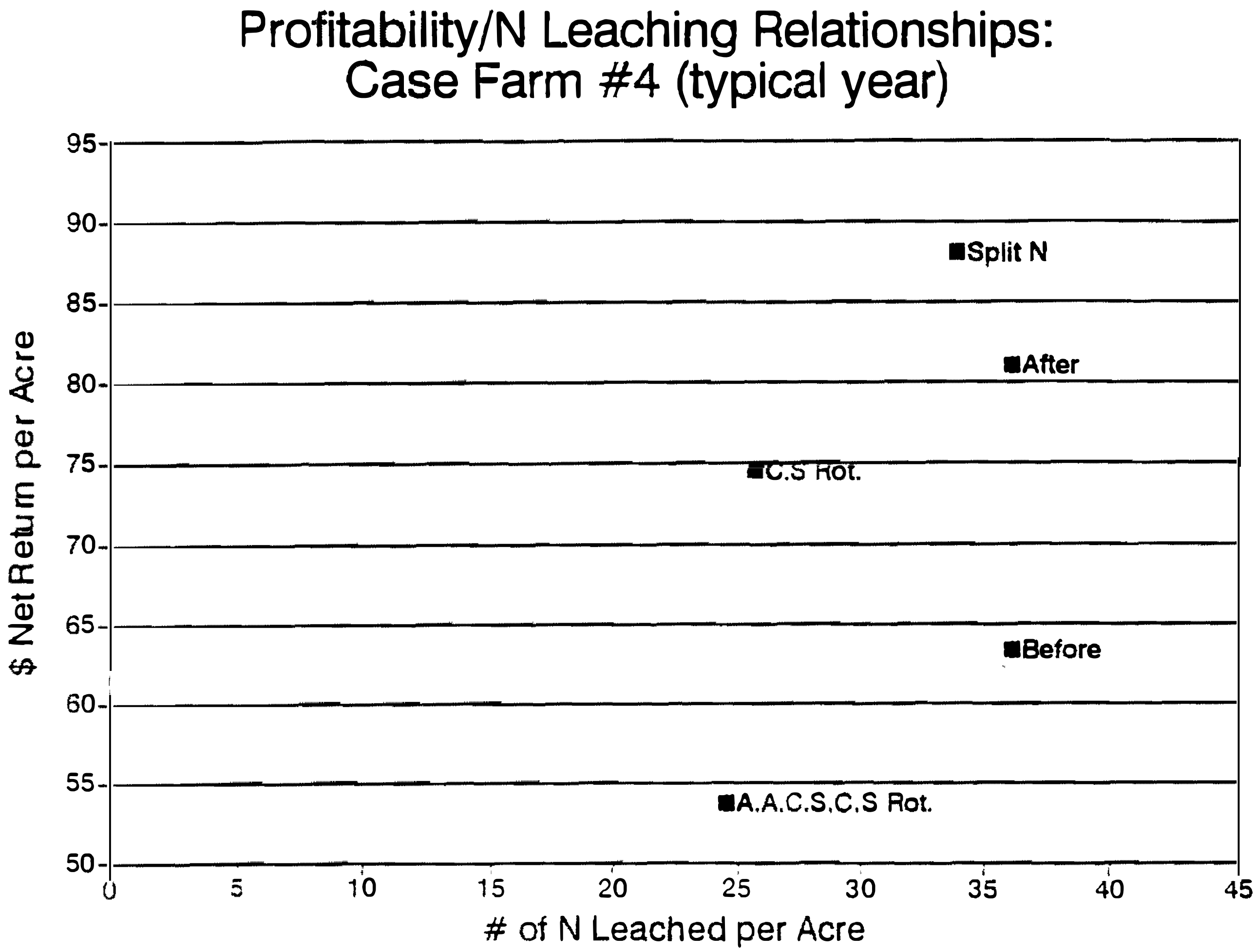

Profitability/N Leaching Relationships:
Case Farm #3 (typical year)
$ Net Return per Acre
112
110
108
106
104
102
100
98
96
94
0
5
10
15
20
25
30
35
40
45
# of N Leached per Acre
O/A,A,A,C,S,C Rot.
O/A,A,A,S,C,S Rot.
Split N
Banding N
After
Before

3.4 lbs/acre for the O/A,A,A,S,C,S rotation and to 2.8 lbs/acre for the O/A,A,A,C,S,C rotation) in the amount of nitrogen leached.

In the "typical" year for Case Farm #4 (Figure 4), estimated net returns increased by $18/acre (29 percent), where the WQIP involved eliminating dry preplant inorganic fertilizer; the nitrate leaching did not change much, however. Profitability was 9 percent greater for the alternative practice of splitting nitrogen applications ($88/acre) when compared to the baseline "after" scenario ($81/acre). The alternative systems had lower economic returns ($74.61/acre for the corn/soybean rotation and $53.82/acre for the A,A,C,S,C,S rotation) than the baseline "after" system and the splitting nitrogen practice. Environmental results for splitting nitrogen applications (33 lbs/acre) indicated an 8 percent decrease in the amount of nitrate leached when compared to the baseline "after" scenario (36 lbs/acre). The alternative systems showed a greater decrease in the amount of nitrate leached--to 26 lbs/acre for the corn/soybean rotation and to 25 lbs/acre for the A,A,C,S,C,S rotation--than did the alternative practice.

Wet and dry conditions: Due to space limitations, profitability/nitrate leaching modeling results under "wet" and "dry" climate conditions are discussed only briefly here. Detailed results are shown graphically in a set of South Dakota State University reports (Henning et al., 1995a, 1995b, 1995c, and 1995d). Results showed almost no leaching in dry years on Case Farms #2 and #3. There, changes in practices and systems serve mainly to increase profits--relative to what they would be in dry

Figure 4.


Profitability/N Leaching Relationships:
Case Farm #4 (typical year)
$ Net Return per Acre
95
90
85
80
75
70
65
60
55
50
Split N
After
C.S Rot.
Before
A.A.C.S.C.S Rot.
0
5
10
15
20
25
30
35
40
45
# of N Leached per Acre

years without the changes, not relative to what they would be in typical rainfall years. There would be some leaching in dry years on Case Farm #1, though less than in typical rainfall years. In contrast to the typical year results for this case farm, the more diverse rotation systems showed slightly reduced leaching--compared to the "Before=After" baseline--in the dry year. Some leaching also takes place in dry years on the irrigated farm (Case Farm #4). The profitability/leaching relationships for the different practices and systems are the same on this farm in dry years as in typical years, except that nitrate leaching appears highest, rather than lowest, for the diverse rotation that includes alfalfa. However, the estimated leaching differences between all practices and systems on the irrigated farm were very small in dry years.

The case farm modeling for wet years showed relationships similar to those for typical rainfall years in many situations. Nitrate leaching, of course, tends to be higher in wet years than in typical years; the major exception was Case Farm #1, where we found little difference in nitrate leaching between those two types of weather conditions. Overall profitability tends to be higher in wet years than in typical years on Case Farms #1, #3 and #4; on Case Farm #2, which has some low-lying fields where crops can suffer from late-planting and drowning in exceptionally wet years, estimated profits were lower in wet years.

Some interesting differences in profitability/nitrate leaching relationships in wet years, compared to typical years, were observed in the analyses for some case farms. For example, on Case

Farm #2, where the rotation system with oats, alfalfa, 2 years of corn, and 1 year of soybeans showed the least nitrate leaching of all systems in both typical and wet years, that system was found to be the second most profitable in typical years but the least profitable in wet years. Moving from the baseline "after" system to that system on Case Farm #2, in order to reduce nitrate leaching, would increase farm profitability in typical rainfall years, but decrease profitability in wet years. A similar phenomenon was observed in the model results for Case Farm #3, where switching from a corn/soybean rotation system on the low-lying field to rotation systems that also include oats and alfalfa decreases nitrate leaching in both typical and wet years (though only very slightly in typical years). In typical rainfall years, such a switch increases farm profitability (a complementary situation for profitability and environmental quality goals), but in wet years it decreases profitability (a tradeoff situation) due to reduced alfalfa yields associated with some drowning out.

Summary and implications

Results indicate that changes in at least some farming practices and systems could yield both increased farm profits and improved groundwater quality. In three of four case farm studies in the Big Sioux Aquifer area of eastern South Dakota, changes in farmers' practices associated with ICM or WQIP participation lead to increased profits (ranging from $6 to $30/acre) and very little change in nitrate leaching to groundwater in typical rainfall years. For all four case farms, there appears to be at least one additional practice or system change that could lead to increased profits and decreased nitrate leaching to groundwater. Some practice or system changes involve tradeoffs between farm profits and groundwater quality, however. Also, complementarities and tradeoffs between farm profits and groundwater quality sometimes differ with weather conditions, adding another element of risk to farmers' decision making.

What are the implications of these findings for cost-share environmental policies aimed at non-point source groundwater pollution? Recall from the methods of analysis discussion that the ICM and WQIP cost-share payments were handled as "pass-throughs" in our budgets, representing payments passed on for services like crop consulting. We did not change the payment level for different practices and systems. In reality, some of the rotation changes would have qualified for higher payment levels if the farmer were not already at his or her $3,500/year payment limitation. The alternative rotations appear to be profitable on the dryland case farms in typical rainfall years even without additional cost-share. The irrigated case farm (#4) presumably would have qualified for an average additional $5/acre if it had gone to the alfalfa/corn/soybean rotation that averages one third of the acreage in alfalfa, since a $15/acre payment was allowed under the WQIP for legumes in rotation. However, that additional $5/acre would not have been nearly enough to make that rotation as profitable as either the continuous corn or the corn/soybean rotation. The irrigated farm was already close to the $3,500/year payment limit, so it would not have been eligible for an additional average payment of $5/acre on all of its acreage under the WQIP contract anyway.

Additional policy analyses not presented in this article, due to limits of space, demonstrated that reforms similar to those eventually embodied in the 1996 farm bill (FAIR) would probably make a corn/soybean rotation system more profitable than the existing continuous corn system on the irrigated farm. However, such "free market" reforms do not necessarily cause more diverse rotations, which also include oats and alfalfa as part of the system, to be as profitable as corn/soybean systems. (Dobbs, 1995) Thus, while the new FAIR legislation may facilitate movement to somewhat more diverse rotations in some instances, cost-share policies are still needed if some kinds of practice and system changes are to be brought about voluntarily.

On dryland farms of the Northern Plains/Western Cornbelt like ones in eastern South Dakota, nitrate leaching reductions resulting from practices and systems induced by cost-share policies often may be modest in typical rainfall years. However, the environmental gains are likely to be more substantial in wet years. Thus, cost share programs like ICM, WQIP, and the new EQIP constitute a form of environmental risk protection. The analyses reported in this paper demonstrate that careful attention needs to be given to the likely profitability/environmental quality tradeoffs and complementarities in each target area if the government cost-share is to be "adequate", yet not more expensive than necessary to provide the desired level of risk protection.

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