Paired watershed studies for nutrient reductions in the Minnesota River Basin

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Summary

This project is a farmer-initiated, farmer-led effort to accelerate the voluntary adoption of best management practices (BMPs) for nutrient management in the Minnesota River Basin to improve water quality. Farmers have helped to assemble a team of University of Minnesota soil scientists, economists, and extension educators, local government water planners, state agricultural training and education personnel, local government water quality monitoring specialists, and local government policy makers to a conduct paired watershed water quality studies in Nicollet County, Minnesota. The objectives of this project are to: (1) accelerate the voluntary adoption of BMPs in the Minnesota River Basin to achieve measurable improvements in water quality using a paired watershed approach; (2) evaluate the effectiveness of farmer-selected BMPs to improve water quality, and; (3) develop and disseminate farmer led and sanctioned water quality initiatives in the Minnesota River Basin.

Introduction

This project focuses on reducing non-point source nutrient loads to the Minnesota River Basin. It involves a team, initiated and led by farmers, which arose out of the Minnesota River Agricultural Team (MNRAT). MNRAT was initially formed under the auspices of the Minnesota Department of Agriculture to provide producer feedback on a report initiated by the Minnesota Pollution Control Agency for cleaning up the Minnesota River Basin (MPCA 1994). Producers had serious reservations about portions of the report dealing with sources of pollution. For instance, the report used indirect measurements to conclude that 20% of the sediment arose from streambank erosion. In reality, subsequent direct measurements and surveys of streambank erosion showed that 40% of the sediment originates in streambank erosion. In a similar vein, the report concluded that land-applied manure accounted for 20% of the phosphorus load carried by the Minnesota River. Subsequent research showed that land applied manure accounts for 35% of the phosphorus load. Now that producers are satisfied that the sources of pollution are accurately known (Mulla et al. 2001), they wish to begin improving water quality through paired watershed studies to evaluate the costs and benefits of BMP implementation.

Farmer-initiated efforts to improve water quality are important in watersheds with significant non-point source pollution. In Minnesota, most of the water quality improvement projects are organized by local government or by NGOs. To date, they have not been very successful at addressing nutrient reductions from cultivated cropland, including nutrients from land applied manure and fertilizers. Most of the water quality improvement efforts to date have focused on reducing pollution from point sources, septics, urban stormwater, and feedlot runoff. Producers have been reluctant to adopt new management practices without research documenting the environmental improvements gained, as well as the direct and indirect costs from potential yield reductions. For real progress in reducing non-point source pollution, it is important for producers to be directly involved in determining what BMPs are most feasible for adoption, what these BMPs will cost to adopt, and how effective the BMPs are in reducing non-point source pollution. An example of a successful water quality study with significant farmer participation and involvement is the Walnut Creek, Iowa, paired watershed study (Hatfield et al. 1999, Jaynes et al. 1999). We are emulating the Walnut Creek study in Minnesota.

As a consequence of four meetings involving producers, state agency personnel, local government personnel, and University of Minnesota researchers, we have developed two goals and four objectives for this project.

The goals are to: (1) to accelerate the voluntary adoption of nutrient BMPs by producers in the Minnesota River Basin and achieve measurable improvements in water quality due to reductions in non-point source nitrate and phosphorus loads, and (2) develop and disseminate farmer-led and farmer-sanctioned water quality improvement initiatives in the Minnesota River Basin. Project objectives include: (1) work with producers and agency personnel to

develop a menu of nutrient BMP options that are feasible for adoption, maintain crop and animal productivity, and are effective at reducing nutrient losses from cultivated cropland to the Minnesota River Basin; (2) measure the extent of water quality improvements in two minor watersheds after implementation of nutrient BMPs relative to paired watersheds without BMP implementation; (3) estimate the costs and benefits of water quality improvements achieved in paired watershed studies, and assess the potential for differential economic impacts of specific nutrient BMPs based on selected producer characteristics; and (4) develop public education programming to increase the adoption of the demonstrated nutrient BMPs throughout the Minnesota River basin, thereby improving water quality and maintaining farm productivity.

Methods

Site description

Two sets of paired watersheds, Huelskamp Creek and Seven Mile Creek, have been selected for study in Nicollet County, Minnesota. Seven Mile Creek is in the St. Peter wellhead protection area, meaning that its non-point source pollution may degrade the quality of drinking water used by residents of the nearby town of St. Peter, Minnesota. All watersheds are in the Minnesota River Basin. The Seven Mile Creek watersheds (HCU 28062 and 28066) have been monitored by the Nicollet County Clean Water Partnership for water quality and flow for one and a half years. Huelskamp Creek is divided into two minor watershed pairs that contain 4,075 and 3,711 acres, respectively. Seven Mile Creek tends to be slightly flatter and more poorly drained than Huelskamp Creek. Seven Mile Creek also has a greater density of rural households and a smaller density of animal feedlots than Huelskamp Creek.

Water quality monitoring

Both pairs of watersheds at Huelskamp Creek and Seven Mile Creek are being monitored at the mouth of each minor watershed (4 sites total) for flow, sediment, total and orthophosphate, and nitrate using an automated sampler and standard procedures and facilities at the University of Minnesota Research Analytical Laboratory. For each pollutant monitored, daily, monthly, and annual loads will be estimated based on concentration and flow data. Baseline monitoring will be conducted for one additional year (beyond the two years of baseline monitoring already collected in both watersheds in Seven Mile Creek).

After the year of baseline monitoring, watersheds within each paired area will be designated as either a treated or control watershed.Treated watersheds will be targeted for enhanced adoption of BMPs. Control watersheds will remain in traditional management practices. Producers in the treated Huelskamp Creek watershed will be presented with a suite of potential BMPs along with monetary incentives for their adoption. Producers in the treated Seven Mile Creek watershed will be presented with a suite of potential BMPs along with education about the potential water quality and production impacts of each BMP. Water quality monitoring efforts will continue for another two years after BMP implementation. Nutrient concentrations and loads from the baseline and non-baseline monitoring periods will be evaluated to determine the extent of water quality improvements associated with the adoption of BMPs using the incentive-based versus the education-based adoption strategies.

Survey of existing practices, input costs, and crop yields

On-farm surveys of existing management practices will be conducted in each of the four watersheds. This inventory will be repeated every year of the study. The inventory will include number and types of animals, rates of fertilizer and manure applied, area of cultivated land and area used for manure spreading, timing of application, planting and harvest dates, crop yields, tillage practices, tile drainage practices, and pest management practices. At the end of the project, producers who changed their management practices will be surveyed to find out their reasons for changing management. Producers will be paid to participate in the surveys.

Best Management Practices promoted and implemented

A wide array of BMPs is available for reducing nutrient pollution while maintaining crop and animal productivity. The types of BMPs presented to producers in the paired watershed studies will be developed based on further input from our advisory and implementation teams, as well as feedback with producers. For the treated watershed within the Huelskamp Creek watershed pair, we will implement incentive-based BMPs on approximately 70% of the

watershed acres. This will be achieved through incentive payments to farmers to compensate for any possible yield reductions resulting from the adoption of BMPs. Farmers will be provided a choice of several nitrogen and phosphorus BMPs from the list developed by our project team and producer participants. Farmers will collectively decide which BMPs for nitrogen and phosphorus are most acceptable for adoption. Each farmer receiving incentive payments will then implement two BMPs on their fields, one BMP for nitrogen and one for phosphorus. Technical assistance will be provided to each farmer making a change in management practices. In the control watershed, we will ask farmers to avoid making changes to their management practices.

In the treated watershed within the Seven Mile Creek watershed pair, we will use traditional education-based strategies to obtain increased adoption of BMPs. Education will focus on results from the tile drainage and fertilizer nitrogen rate studies being conducted in this watershed, which show significant reductions in tile drain nitrate concentrations and that optimum fertilizer N rates range from 77-118 lb/ac. Education strategies will involve a combination of techniques. Target audiences will include producers in the treated Seven Mile Creek watershed, and members of the local agricultural co-ops and certified crop advisors. The resulting rates of adoption of BMPs will be carefully documented, and compared to rates of adoption in the control watershed, where no enhanced educational programming will be offered. Technical assistance will be provided to each farmer making a change in management practices. In the control watershed, we will ask farmers to avoid making changes to their management practices.

Water quality modeling

The ADAPT model will be used to evaluate the long-term impacts of changes in farm nutrient management for the paired watersheds studied. This model operates at a daily time step, and accounts for hydrology (precipitation, soil frost, snowmelt, evapotranspiration, infiltration, runoff, drainage, seepage), nutrient cycling, erosion, and crop growth (Davis et al. 2000). Management parameters needed by the model include rate, timing, and method of fertilizer application, dates and types of tillage, depth and spacing of tile drains, and dates of planting and harvesting. We will obtain these from farmer surveys. Once the model has been calibrated and validated, it will be used with long-term climatic records (50 yrs) from existing nearby climatic stations (Mankato, Minnesota) to investigate the long-term water quality impacts of the control versus treated watersheds. Several scenarios will be investigated to provide information for an economic evaluation of BMPs. These include increased adoption of conservation tillage, increased adoption of phosphorus application rate reductions and improved methods of application, increased adoption of N credits and reasonable yield goals, and increased adoption of late fall N applications. In addition, we will simulate water quality trends after increased tile drainage in the watersheds. Outputs from the model will give the mean loads of sediment, nitrogen, and phosphorus, as well as cumulative probability distributions for water quality impacts of each practice.

Economic evaluation

The modeling results will provide valuable information regarding the effectiveness of alternative management practices to reduce agricultural pollution, but farmers will not adopt these practices unless they are economically viable. Understanding both the water quality and economic implications of alternative practices is an important ingredient for making good investments and sound policy to reduce agricultural water pollution.The problem facing decision-makers in the Minnesota River Basin is a lack of information on the effectiveness of alternative management practices to reduce agricultural water pollution and the associated costs and benefits of these practices for different types of agricultural producers.To understand the economic implications of alternative practices, economic data from the annual on-farm surveys will be analyzed for potential changes in profits associated with adoption of alternative BMPs. Data from the surveys will include production practices, input levels and costs, and yields. Because risk and uncertainty influence production practices as well as profitability, these factors will be incorporated quantitatively into the analysis to the extent possible.

The results of this analysis will be used with the modeling results to determine abatement costs for various levels of reduction in phosphorus and nitrogen loads to surface waters. We have used this approach in the Sand Creek watershed of the Minnesota River Basin successfully (Johannsen et al. 2001). Abatement costs are the difference between profits before and after implementation of BMPs (Yiridoe and Weersink 1998). Abatement costs will be evaluated across selected producer characteristics (size of operation, soil types, density of tile drainage, etc.) to determine the most effective practices to achieve specific pollution load reduction targets. This assessment will

examine the ability of a BMP to achieve specific load reductions, and its associated costs and benefits. Because producer characteristics will likely influence benefits (extent of load reduction) and costs (profitability effects), the distributional implications of alternative BMPs are an important policy input.

Results to date

During winter of 2002, two farmer representatives in the watersheds and one agronomist from a local fertilizer dealer were asked to attend meetings of the research team and provide feedback on the study approach. These local representatives helped develop and test a farm practice survey, and encouraged other farmers in the watersheds to participate in the survey. Subsequently, a graduate student conducted an in-person surveyed each farmer with more than 40 acres of cultivated land in the watersheds (86% of watershed). This survey included detailed questions about their farm management practices, including land ownership, labor and machinery costs, tillage and drainage practices, planting and harvesting operations, crop yields and yield goals, fertilizer and manure management, and crop protection products. Survey data were entered into an Access database, and the results summarized. This survey will be conducted again in the remaining two years of the project. In spring of 2002, all accessible fields were surveyed for crop residue cover. The main findings from the farmer and field surveys were:

- Half of farmers still used moldboard plowing on corn residue
- Only 22% of cultivated land had more than 30% residue cover after planting
- Of the fields that had phosphorus soil tests, 75% were in the "very high" category
- Manure is applied to 20% of cropland with 30% surface-applied
- Total rates of N from both fertilizer and manure ranged from 50-383 lb N/ac
- Total rates of P_2O_5 from both fertilizer and manure ranged from 20-405 lb P_20_5/ac

During summer of 2002, meetings were held with farmers to discuss results of water quality monitoring and farm practice surveys. Based on these meetings, farmers in the western watershed (treated) decided that they wanted to begin making changes in their farm management practices to improve water quality. Farmers indicated a preference for the following changes in management:

- Tillage practices that left more crop residue
- Soil and manure nutrient testing and crediting
- Buffer strips along ditches
- Replacement of surface tile intakes with buried rock inlets

During fall of 2002, contracts to implement these changes were signed with farmers managing over 80% of the cultivated land in the treated watershed. Simultaneously, contracts were signed with nearly all the farmers in the control watershed to make no changes in their farm management practices. Water quality monitoring will continue for the next two years to determine how changes in farm management in the treated watershed influence water quality. Farm surveys will be administered again for the next two years to track changes, if any, in the treated and control watersheds.

The water quality data and farm survey data will be used for economic and water quality modeling to determine the costs and benefits of various management practices as a function of farm size and soil type, as well as the advantages of targeted adoption of BMPs, and the level of BMP adoption needed to attain various levels of improvement in water quality. Results from the project will be used to develop educational materials for farmers, fertilizer co-ops, agency personnel, researchers and Extension educators, policy makers, and the general public.

The project has an advisory team consisting of ten members:

Will Anthony, farmer, Nicollet County, Chair of Minnesota River Agricultural Team
Dave Preisler, President, Minnesota Pork Producers Association
Gerald Heil, Paul Burns, Mary Hanks, Minnesota Department of Agriculture
Two farmers from paired watershed study
David Mulla, Mary Renwick, and Jim Anderson, University of Minnesota

The research, implementation, and education team includes individuals from the University of Minnesota and state and local government:

David Mulla, Mary Renwick, Jim Anderson, and Prasanna Gowda, University of Minnesota
Gary Hachfeld, Educator, University of Minnesota Extension Service
Kevin Kuehner, Water Quality Monitoring Specialist, Nicollet County Clean Water Partnership
Tina Rosenstein, Nicollet County Environmental Services
Pam Rivers, Water Planner, Nicollet County
Derek Fisher, Board of Water and Soil Resources
Mark Dittrich and Wayne Monsen, Minnesota Department of Agriculture

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