AUG 14 2001

1999 Project Abstract
For The Period Ending June 20, 2001

FINAL REPORT

TITLE: Economic Analysis of Agriculture for Multiple Benefits

PROJECT MANAGER: Mara Krinke
ORGANIZATION: Land Stewardship Project
ADDRESS: 3203 Cedar Avenue South, Minneapolis, MN 55407
WEB SITE ADDRESS: www.landstewardshipproject.org
FUND: Minnesota Future Resources Fund????
LEGAL CITATION: ML 1999, Chap. 231, Sec. 16, Subd. 007 (n)

APPROPRIATION AMOUNT: $200,000

A 15-member working group analyzed environmental and social benefits in two Minnesota watersheds that could result from changing agricultural land use practices. The 40,000 plus acre study areas were in the lower Chippewa River Basin, and the entire Wells Creek watershed. Staff characterized baseline agricultural land-use environmental performance and found that current farming systems contribute from almost zero to several tons or lbs/acre of various pollutants to the streams.

Watershed residents helped develop scenarios for possible land-uses: (A) continuation of current trends, (B) adoption of best management practices in row crops, (C) more economic diversity through longer crop rotations and wetland restoration and (D) adding more perennial cover to the working landscape. We used the ADAPT model to predict in-stream environmental benefits including impacts on fish in the streams for each scenario. We reviewed other potential wildlife impacts and calculated greenhouse gas emissions. Social scientists analyzed social and farm economic impacts. Economists estimated non-market economic values for environmental benefits by calculating avoided costs and by performing a contingent valuation survey of Minnesota citizens.

Results show that changes in Scenarios B, C and D in Wells Creek and C and D in the Chippewa could meet national goals for reducing in-stream nitrogen (40%) and state goals for phosphorous (40%). Analyzing institutional missions and resource flows of farmers made it clear that institutions need to support farmers marketing diversified crops. Scenarios C and D would have significant non-market economic values in avoided costs. On average, Minnesota households would be willing to pay an additional $201 per household or a total of $362 million dollars for significant improvements in environmental performance. Our project points to the urgent need to develop public policy, research, education and marketing strategies to promote greater diversification of food/fiber production in ways that yield clear environmental and social benefits.

Date of Report: July 1, 2001
Date of Next Status Report: None
Date of Work Program Approval: June 16, 1999
Project Completion Date: June 30, 2001

LCMR FINAL WORK PROGRAM REPORT

I. PROJECT TITLE

007n Economic Analysis of Agriculture for Multiple Benefits

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Total Biennial Project Budget:

$ LCMR:	$ 200,000	$ Match:	$ 0
- $ LCMR Amount Spent:	$ 198,154	- $ Match Amount Spent:	$ 0
= $ LCMR Balance:	$ 1,846	= $ Match Balance:	$ 0

A. Legal Citation: ML 1999, Chap. 231, Sec. 16, Subd. 007 (n)

Appropriation Language: (n) Economic Analysis of Agriculture for Multiple Benefits. $200,000 is from the future resources fund to the commissioner of agriculture for an agreement with the Land Stewardship Project to evaluate economic and environmental benefits from current and future agricultural production.

B. Status of Match Requirement: Not applicable

II and III. FINAL PROJECT SUMMARY

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IV. OUTLINE OF PROJECT RESULTS

Four project results are outlined.

Result 1: Characterize existing land management practices in each watershed and apply or develop social and physical models to ascertain baseline data.

LCMR Budget: $ 68,500 Match: $ 0
Balance: $ 200 Match Balance: $0

The Chippewa River Study (C) area is 44,445 acres immediately upstream from the confluence of the Chippewa and the Minnesota (see maps Chippewa River Study Area and C Baseline). Eighty-one percent of the acres are cultivated. The land is relatively flat and includes a significant amount of drainage. The current or baseline land use by cover, crop and tillage practices are shown in Table C-1 and on the Baseline Chippewa Map. Maps were prepared by Mankato State University.

The Wells Creek Watershed (WC) as a whole is a study area and includes 40,172 acres in Goodhue and Wabahsa counties of southeastern Minnesota (see maps Wells Creek Study Area and WC Baseline). Sixty-one percent of the acres are cultivated. There are many small tributaries, the land is hilly and significant acreage of tree and grassland cover is part of the current land use. The current or baseline land use by cover, crop and tillage practices are shown in Table WC-1 and on the Baseline Wells Creek Watershed Map.

ENVIRONMENTAL IMPACTS

Field-edge sediment, nitrogen, and phosphorus losses were estimated for each current farming system using the Agricultural Drainage and Pesticide Transport (ADAPT) model by agricultural economists at the University of Minnesota, with the advice of soil scientists. The ADAPT model incorporates farming practices, soil types, topography, and 50 years of weather data to estimate sediment and nutrient losses. The ADAPT model provides edge-of-field estimates for nutrient and soil losses from the different systems, based on soil type, application rates and management techniques, and daily weather data (C-2 and WC-2).

Based on the field-edge estimates and delivery ratios specified by University soil scientists, aggregated values for the watershed were calculated. These aggregated values show how much sediment, nitrogen, and phosphorus are predicted to reach the mouth of the watershed.

Loss of sediments and nutrients in surface runoff and through the drainage system (where appropriate) was obtained for a given system on all three soils for the soil association in which the system was simulated. The proportion of that loss which actually reached the mouth of the sub-watershed in which the system occurred depended on the delivery ratio associated with the location of that system. Soil types with drainage had a deliver ratio for surface water of 100% for sediment, nutrients and phosphorous. Un-drained soil types had surface water delivery ratios as noted below.

Un-drained soil types for sediment and phosphorous:	Wells Creek	Chippewa
Close to waterway:	20%	10%
Distant from waterway:	10%	5%

Un-drained soil types for nitrogen:	Wells Creek	Chippewa
Close to waterway:	1%	5%
Distant from waterway:	0%	1%

Data from the model from fields in Management Intensive Grazing and pasture were compared to data on soil and nutrient loss collected from field-scale monitoring in the nearby Sand Creek watershed and within the Chippewa River Basin on similar soils. Intensive meetings focused on comparing the results with reviewers' understanding of systems and measured results from other studies. This led to multiple iterations that were reviewed by other academics, farmers, and nonprofit representatives. A 50-year average for the number of acres estimated for each farming system is presented for each study area in Tables C-4 and WC-4.

SOCIAL IMPACTS
The number of farms decreased by 15% in Chippewa County and by 12% in Goodhue County between 1990 and 2000. The population is aging in Chippewa County, with 21% over the age of 65. A full discussion of changes in human and social capital will be included in a subsequent report that is being written and will be published with other funds (see result four below).

Social scientists also reviewed documents and/or interviewed people from 30 entities affecting the Wells Creek Watershed and 35 entities influencing the Chippewa Study Area. Scientists found that most institutions in both watersheds tend to replicate the currently dominant production and marketing systems. In both watersheds, the current institutional network structure around ecosystem health does not include input dealers, processors or marketers. Alternative organizations exist but are not sufficiently linked to all major educational, social and business institutions. Most alternative farmers turn toward institutions outside the local watershed to get information and sometimes inputs for the farms. A full discussion of this will be included in a subsequent report that is being written and will be published with other funds (see result four below).

A graduate student/project consultant interviewed a range of conventional and alternative farms to create resource flow diagrams and illustrate how farms relate to communities. Five farms in the Chippewa Study Area and four in the Wells Creek Watershed were interviewed. Both conventional and alternative farmers expressed a need for more institutional and market choices in their areas. We found in one case that a larger and smaller farm exchanged resources with each other. Farmers implied that innovation on the farm is more likely to occur if local institutions are willing to change along with the farmers. A copy of this report is provided as Attachment A.

ECONOMIC IMPACTS
A brief synopsis of research relating to the economic impacts of different farming systems on local communities is appended as Attachment B.

Result 2: Develop scenarios on future farming systems in each watershed.

LCMR Budget: $ 38,200
Balance: $ 100

Match: $ 0
Match Balance: $0

SCENARIOS
The scenarios for possible future land use provide the basis for the multiple benefits of agriculture analysis. The goal of the scenario development was to create three or four alternate future states, for analysis of the varying levels of environmental, economic, and social benefits that would result from alternative futures. The scenarios are citizen-driven, based on written materials created by watershed residents and through in-person focus groups and interviews.

Focus groups were assembled by project staff and consultants and were asked to provide general outlines of their desires and expectations for future agricultural land use in the watersheds. Watershed residents were asked about their preferences about how the neighboring landscape might look in the future. Residents were also asked to make predictions about what would happen to the environment and communities under the different scenarios. From these discussions, we developed four main scenarios, which vary slightly between the watersheds to account for local conditions.

Based on the focus groups and the work of the Core Working Group, four scenarios were further developed for the analysis. These scenarios are intended to illustrate the range of environmental, social and economic effects that result from changes in farming practices. They are not intended to be prescriptive for land use in the watersheds. Rather, they were designed to show the variety of effects that can result from specific changes in management. Table WC- 3 and C –3 contain detailed descriptions of the crop and land use practices adopted for each of the scenarios. The four scenarios are described below.

The ***extension of current trends scenario*** is characterized by fewer and larger farms with increasing acreage in row crops and no significant trend towards the application of best management practices. The trend toward leasing land continues, to neighbors or management companies. Without incentives to control external effects of farming, there will likely continue to be negative environmental outcomes such as erosion, nitrification, and habitat loss. Small, more diversified farms are the other surviving forms of agriculture.

The ***adoption of best management practices (BMPs) scenario*** includes the introduction of conservation tillage, 100 foot buffers around streams, and recommended nutrient application rates on all farmland. The assumptions for this scenario were taken from current recommendations from extension agents, county Soil and Water Conservation District staff, and a variety of conservation programs. The purpose of this scenario is to show what levels of benefits can be gained with currently recommended management practices in existing cropping systems.

An increased diversity on the agricultural landscape characterizes the ***expanded community and economic diversity scenario***. In modeling different versions of this scenario, we include increased crop diversity and shifted to a five-year rotation, shifted grazing systems to management intensive rotational grazing systems, and introduced wetland restoration in appropriate areas. Buffers around streams are used in a working landscape.

Where feasible, a continuous cover on working farms characterizes the ***managed year-round cover*** scenario. Management intensive rotational grazing, cover cropping and land managed for hunting preserves are common land uses in this scenario. Prairie and wetland restorations are included in the scenario. Expanded (300') buffers around streams are used in a working landscape.

PREDICTED ENVIRONMENTAL BENEFITS

Estimates for sediment and nutrients are presented for each the four scenarios by running the ADAPT model with different proportions of each type of land use or farming practice. Buffer strips, wetlands, and government set-aside programs are modeled as grassland with no animals. This methodology is likely to create conservative estimates of the erosion and nutrient reduction potential of the different scenarios that include these types of conservation practices because the literature suggests far more benefit can be realized from well managed wetlands or buffer strips than from grassland. Sensitivity analyses were conducted on each of the four scenarios to test variations in the assumptions regarding land use changes. The aggregated values four the scenarios are compared to the baseline estimates for each watershed.

Field Edge Sediment and Nutrient Losses

Comparing farming practices on different types of soil, the delivery of sediment and nutrients to water can vary widely. Exhibit 2-1 shows the different edge of field loss estimates from different systems in Wells Creek. Exhibit 2-2 presents similar data for the Chippewa River. The differences are due to different soil types and variations on practices for the same crops between watersheds. The erosion numbers for the different farming systems appear lower than the Wells Creek watershed in part because the model only predicts water-based erosion.

Exhibit 2.1: Edge of Field Losses – Comparison between Farming Systems
Wells Creek Watershed [1]

	Corn Soybean V	Corn Soybean S	Continuous Corn V & S	Hay V & S	Pasture [2]	Rotational Grazing (Dairy) [3]
Sediment (tons/acre via water)	12.51	6.65	8.62/6.80	0.93	0.00	0.00
Nitrogen (lbs/acre)	6.99	5.40	37.39/32.32	0.00	2.62	0.00
Phosphorus (lbs/acre)	0.38	0.14	0.11/0.08	0.13	0.38	0.03

[1] Weighted average for soil types in Wells Creek
[2] Average of five stocking rates
[3] Average of four stocking rates

Exhibit 2.2 Edge of Field Losses – Comparison between Farming Systems
Chippewa River Study Area

	Corn Soybean V	Corn Soybean S	Corn Beets V	Hay S	Pasture[1]	Rotational Grazing (Beef)[2]
Sediment (tons/acre via water)	0.274	0.051	0.397	0.000	0.000	0.000
Nitrogen (lbs/acre)	5.554	3.802	1.996	0.000	1.996	0.197
Phosphorus (lbs/acre)	0.029	0.004	0.018	0.003	0.172	0.030

[1] At the higher of two stocking rates
[2] At this highest stocking rate

Watershed Level Estimates and Scenario Results

Table WC-4 shows the total watershed loss estimates for different future land use scenarios in Wells Creek. Under current conditions, approximately 39,615 tons of sediment, 3001 pounds of nitrogen and 7,547 pounds of phosphorous are predicted to reach the mouth of Wells Creek each year. Changing farming practices, as demonstrated in Scenarios A through D, lead to changes in the sediment, nitrogen, and phosphorus added to Wells Creek each year. As shown in Exhibit 2-3, increasing diversity, managed grassland, and judicious use of buffer strips lead to dramatic (over 80 percent) decreases in sediment deposition in the river from water-based erosion. In Wells Creek, adoption of best management practices (scenario B) would help meet national goals for hypoxia (40% in-stream reduction of nitrogen).

Exhibit: 2.3 Watershed Losses – Comparison between Scenarios
Wells Creek Watershed

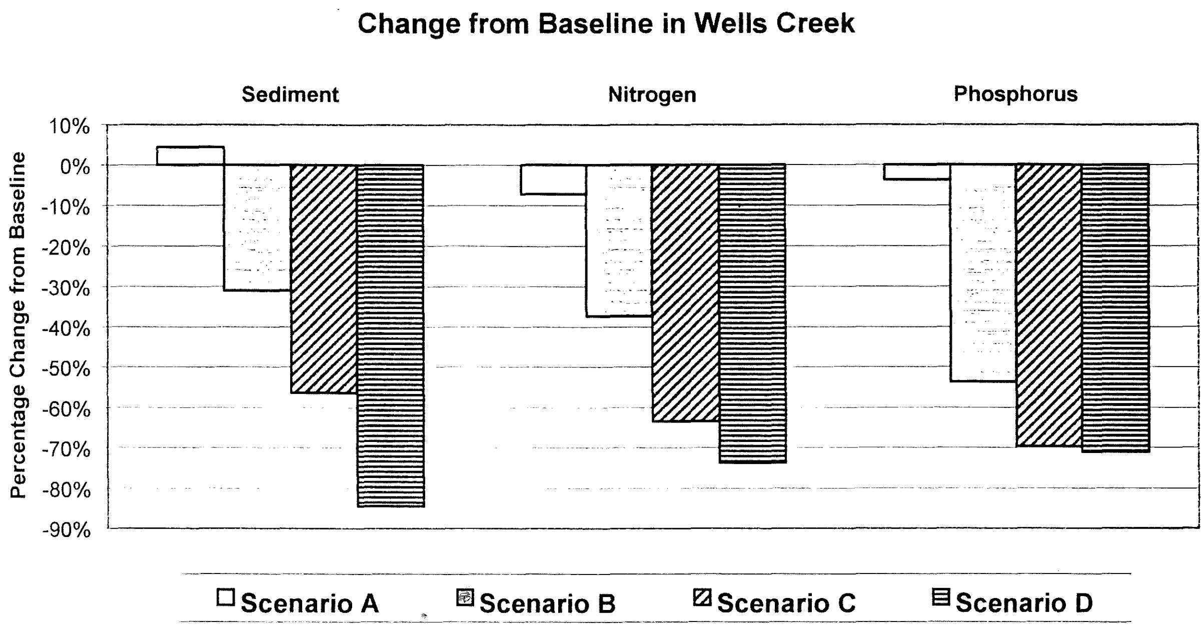
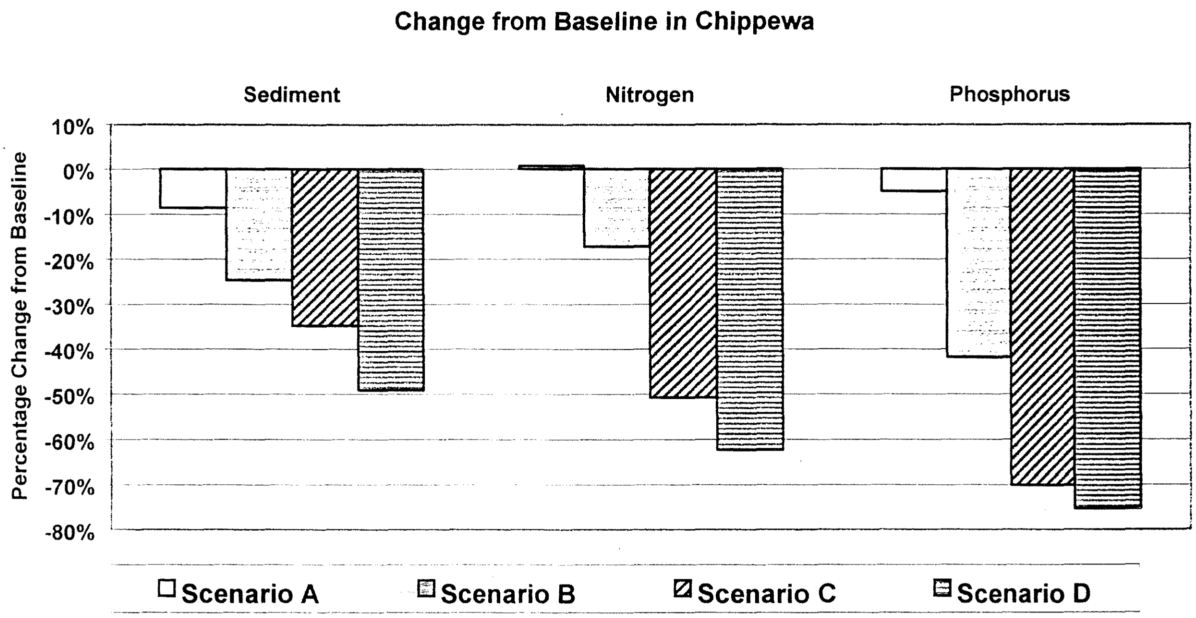


Table C-4 shows the total watershed loss estimates for different future land use scenarios in the Chippewa Study Area. Under current conditions, approximately 1,956 tons of sediment, 13,966 pounds of nitrogen and 5,108 pounds of phosphorous are predicted to reach the mouth of Chippewa River from this study area each year. Changing farming practices, as demonstrated in Scenarios A through D, leads to reductions in the sediment, nitrogen, and phosphorus added to the Chippewa River each year. As shown in Exhibit 2-4, increasing diversity, managed grassland, and judicious use of buffer strips lead to more than a 50 % decrease in sediment deposition in the river from water-based erosion. In the Chippewa, adoption of best management practices (scenario B) would not be adequate to meet national goals for hypoxia (30-40% in-stream reduction of nitrogen). Meeting such a goal for this study area would require the adoption of more diverse farming systems as shown in scenarios C and D. These scenarios would also provide considerable phosphorous reduction potential. Scenarios B, C and D would each meet goals for reduction of phosphorous in the Minnesota River.

Exhibit 2-4: Watershed Losses – Comparison between Scenarios
Chippewa River Watershed



Benefits to Fish

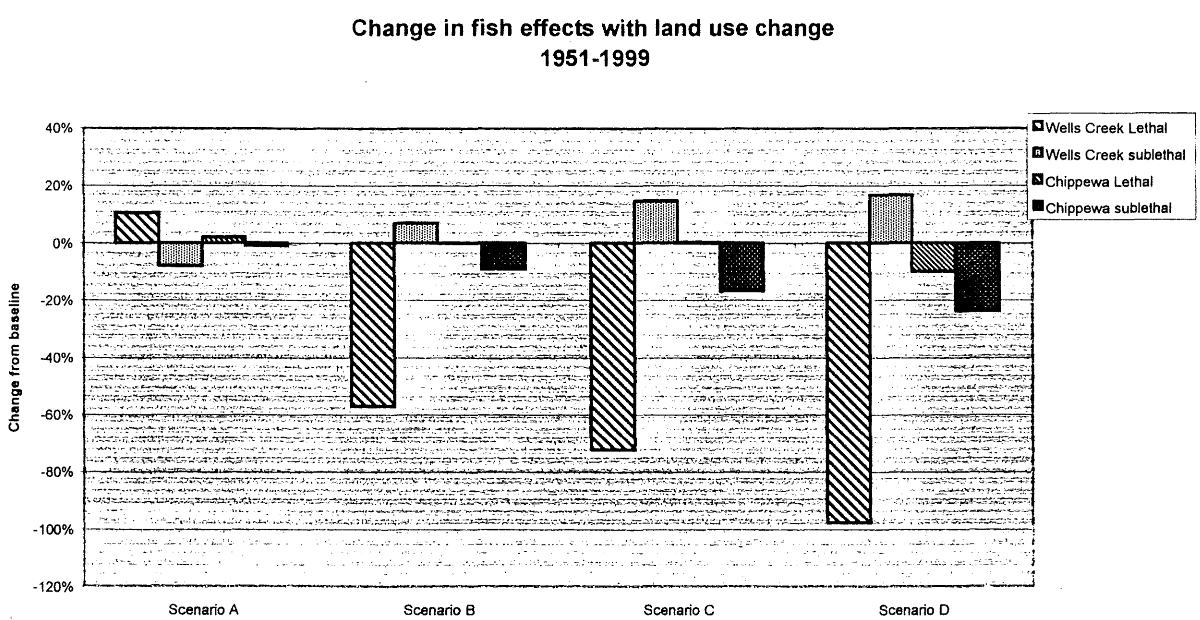
Scientists estimated benefits to fish populations from the scenarios. Daily suspended sediment concentrations were used to calculate the effects of these sediment levels on fish communities in each stream, by calculating the total number of days that sediment concentrations would be lethal or sublethal to fish in that stream. Although it is widely accepted that suspended sediment has negative impacts on fish, and the severity of the effects increase with increasing sediment concentrations and duration of exposure, few studies have attempted to make quantitative predictions of the effects of suspended sediment on fish communities. For our calculations, we referenced a meta-analysis of fish responses to suspended sediment in streams that quantitatively related the biological response of various fish communities to suspended sediment concentrations and duration of exposure. The fish communities in the analysis included juvenile and adult salmonids, which represented the Wells Creek coldwater stream community, and adult freshwater non-salmonids, representing the fish community tolerant of warm water, such as the Chippewa River. We applied previously published sublethal and lethal thresholds of sediment concentration based on total amounts of suspended sediment and duration of exposure for each fish community, and we used these thresholds to calculate the total number of days that sediment concentrations and duration of exposure met or exceeded the sublethal or lethal levels for fish in each watershed.

Sublethal effects are a reduction in feeding rates or feeding success, physiological stress such as coughing and increased respiration rate, moderate habitat degradation, and impaired homing. Lethal effects are described as reduced growth rate, delayed hatching, reduced fish density, increased predation, severe habitat degradation, and mortality.

We compared the total number of lethal and sublethal events between current conditions and each of the four land use scenarios for each watershed to determine changes in the effects of sediment concentrations on fish as land use and farming practices changed in the watersheds. We tested for differences between the mean annual days with lethal and sublethal sediment concentrations using analysis of variance (ANOVA), and compared individual means among treatments if a significant difference was detected ($p<0.05$).

The results of this analysis are shown in Exhibit 2-5 Water temperature and sediment are likely both limiting to trout abundance and reproduction in Wells Creek. Land use changes that provide more permanent cover in the watershed and increase vegetation in riparian areas, such as those hypothesized in scenarios C and D, may shift the fish community to one more characteristic of a cold water stream. As for the Chippewa River, lowering sediment concentrations should benefit the warmwater fish community and could shift fish populations to encompass a greater diversity and abundance of sensitive species. However, due to differences in fish community tolerances to suspended sediment, as well as topographical differences between the Wells Creek and Chippewa River watersheds, more drastic land use change may be needed in the Chippewa drainage to see a measurable change in the fish community. More information is provided in Attachment C.

Exhibit 2-5.



Benefits to Birds
The assessment of the potential changes in bird populations for this report is based on a literature review from bird research in the Midwest. The baseline information was gathered from local sources. Scenario B will provide additional habitat through the buffer strips. In general Scenarios C and D will provide more habitat for grassland birds and the size of the corridors between patches increases significantly with Scenario D. Scenario D would be the most beneficial for grassland bird species. Attachment D provides fuller detail.

Greenhouse Gas Changes
Agriculture in Minnesota contributes 5.28 million metric tons of carbon equivalent to the atmosphere, between 14 and 19 percent of the state's total emissions. The breakdown of emissions between gases follows.

Exhibit 2-6: Greenhouse Gas Emissions, Minnesota Agriculture (1997)

Gas	Million metric tons (MMT)	Global Warming Potential	MMT Carbon equivalent	Percent of Total Agricultural Emissions
Nitrous Oxide (N2O)	0.038	310	3.2	60.6 %
Methane (CH4)	0.25	21	1.4	26.5 %
Carbon Dioxide (CO2)	2.5	1	0.68	12.9 %
Total			**5.28**	**100 %**

Source: McIntosh, Gordon. "Minnesota Agriculture and the Reduction of Greenhouse Gases," 2000. See Attachment E.

N2O, or nitrous oxide, is Minnesota agriculture's largest contributor to greenhouse gases, based on carbon equivalency. N2O is introduced into the atmosphere from the overuse of nitrogen fertilizers. In 1997, 0.58 million metric tons of N-based fertilizers were used on Minnesota farms and resulted in the release of 0.038 million metric tons of N20 (3.2 MMT carbon equivalent), 61 percent of agriculture's contribution. Reducing the quantities of nitrogen applied to fields will decrease the release of this potent greenhouse gas.

Methane (CH4) is the second largest contributor to greenhouse gases from Minnesota agriculture. Methane is emitted as a byproduct of ruminant digestion and the decomposition of manure. Livestock farms in Minnesota produce an estimated 25.4x10^7 Kg of methane per year, equivalent to 1.4 million metric tons of carbon and 27 percent of the total greenhouse gas emissions in Minnesota from agriculture. Milk cows and hogs produce the majority (33 and 26 percent, respectively) of methane emissions from Minnesota.

Carbon Dioxide is produced by the combustion of fossil fuels. Farmers in Minnesota cause the release of 2.5 million metric tons of carbon via the use of fossil fuels each year, 13 percent of the total released from agricultural sources in Minnesota in 1997. Carbon released from the soil from transition of land between uses (e.g., from wetland to cropland) is negligible as most lands have been converted and soil carbon is generally at equilibrium levels.

Modeled Greenhouse Gas Emissions in the Watersheds

Calculations of the greenhouse gas emissions, in carbon equivalents, for the current and potential farming practices in the watersheds are presented in Table WC-5/ C-5. Reductions as high as 63% from the baseline are predicted in the Chippewa Study Area if Scenario D2 were to be adopted and the number of animals in the watershed were held constant. In Wells Creek Watershed reductions would be smaller because dairy animals generate more methane than beef animals. If the number of dairy animals were increased by 15% in the Wells Creek Watershed, overall greenhouse gas emissions would increase by almost 56 %.

Result 3: Calculate economic benefits.

LCMR Budget: $ 77,200	Match: $ 0
Balance: $ 600	Match Balance: $0

Economic benefits resulting from the different scenarios were estimated in several ways as described below. All of these and the returns to farmers from the different scenarios will be detailed in the published report.

AVOIDED COSTS FROM REDUCING SEDIMENT IN THE STREAMS

Estimates of the cost/ton of sediment in streams were utilized with predicted in-stream sediment levels from ADAPT. In wells creek the baseline costs of $213,131/year were estimated to decrease by as much as 84% if Scenario D were adopted. In the Chippewa Study area, the baseline of $10,525 could be reduced by as much as 50% in Scenario D.

AVOIDED FLOOD DAMAGES

Many of the options posed in the scenarios have potential to reduce runoff and flooding (see tables WC –2 and C -2 for changes in runoff by system). Scenario D, with a large increase in perennial cover, could have a significant impact.

Staff at IATP gathered information on avoided costs, which will be included in the final report and published separately this fall. Increased wetland area, proposed in scenarios C & D for both watersheds could reduce flooding for average storm events. In Wells Creek, which covers a total of 40,172 acres, this involves increasing wetland acreage from 52 to 587, an increase of 535 acres. This would be an increase of about 1.3% of the total acreage in wetlands, for a total of 1.5%. In Chippewa, which covers a total of 44,445 acres, this involves increasing wetland acreage from 381 to 1614, an increase of 1233 acres. This would be an increase of about 2.8% of the total acreage in wetlands, to a total of 3.6%. Using published estimates of benefit, such wetland restoration could result in reductions in peak flow and flood flow volumes of approximately 4.8% and 1.8%, respectively, for Wells Creek, and 10.4% and 3.9%, respectively, for the Chippewa River study area.

According to Goodhue County Assistant County Engineer Ken Bjornstad, flood related costs in Wells Creek have included bridge replacement and maintenance, shoulder washout repair, and ditch clean out. County accountant Sheila Bystrom provided numbers for a storm in June of 1998. Along three county roads within the watershed, the county spent $173 to inspect and identify damage, $5,381 to clear debris, and $167 for shoulder repair. Mr. Bjornstad pointed out that any numbers the county could provide would be a drop in the bucket compared to the real expense.

In Chippewa County (which contains the majority of the Chippewa Watershed), Country Ditch Inspector Ken Nash echoed this sentiment, adding that many damage costs are hidden because the damages are not addressed. He said this often occurs because farmers are reticent to allow repairs to be made on their property, as previous repairs may not have prevented the problem from reoccurring. While Nash couldn't provide a breakdown of costs, he estimated that Chippewa County as a whole spent $54,000 in clean-up and repair after a 1997 flood event, of which probably $15,000 was attributable to work in the Chippewa watershed.

Steve Kubista of Chippewa County Emergency Management pointed out another cost of flooding. Several years ago, after a 7"-12" July rain, the county had to replace a number of culverts. He mentioned that spring flood waters often back up over roads if the culverts are still frozen, and that this sometimes requires gravel to be hauled in, at additional costs.

ESTIMATING THE ECONOMIC VALUE OF ENVIRONMENTAL BENEFITS THROUGH CONTINGENT VALUTION

Many of the economic benefits of improved environmental quality are not reflected in market-based transactions. Therefore, no market mechanism exists for people to reveal their willingness to pay for these kinds of improvements in environmental quality. In this case, estimating the total economic value of improvements in environmental goods and services requires a method that utilizes non-price (non-market) data. A stated-preference estimation technique known as contingent valuation is employed.

Contingent valuation employs a survey that describes the prospective policy and its effects. The survey also indicates to the respondent how much adoption of the policy would cost their household in terms of higher taxes and higher prices for goods and services. Citizens' willingness to pay for the benefits of the policy are elicited from their responses on how they would vote in a referendum on this policy, given its effects and financial consequences. A statistical valuation function enables estimation of mean household willingness to pay.

Economists at Bemidji State University sent a mail survey to a randomly selected sample of Minnesota households. Screening of an initial sample of 1,000 to exclude businesses, deceased, non-residents, and those without a valid mailing address yielded 834 potential respondents.

Three hundred ninety four booklets were completed and returned, yielding an effective response rate of 47.2 percent. Also personal interviews were conducted with the help of several consultants in the two watersheds that were studied intensively in the other components of this project. Sixty-four personal interviews were conducted in the Wells Creek Watershed and sixty-one were completed in the Chippewa River Watershed for a total of 125 additional responses from Minnesota citizens.

This study evaluated the benefits that respondents derived from two different levels of multiple benefits. This study devoted most of its attention to a "baseline" policy scenario yielding a 50% reduction in most environmental impacts from agriculture. This was the level described in the interviews and half of the mail surveys, with the other half of the mail surveys describing a 10% level of reductions in environmental impacts.

For the baseline policy scenario, the mail survey resulted in an estimated annual household willingness to pay of $201. The personal interview results show a much higher willingness to pay of $394, possibly indicating "yea-saying" behavior from the personal nature of the interview procedure. It is consistent with the literature that personal interviews lead to higher estimates than responses to mail surveys.

Using the more conservative mail-survey estimate, a state-wide willingness to pay can be computed by multiplying the per-household figure ($201) by the number of households (1.8 million in 1999) to yield an annual state willingness to pay of $362 million. Given a state population of 4.75 million (1999 estimate) this translates into a figure of approximately $76.21 per person annually or $0.21 per person per day. Further information can be found in Attachment F.

Result 4: Analyze and Interpret Data and Produce report.

LCMR Budget: $ 16,200	Match: $ 0
Balance: $ 946	Match Balance : $0

Seven separate reports have been prepared for the project thus far. One report, on Multifunctional Agriculture is focused on policy and because it was not paid for with any LCMR funds, is not included here. At least two more will be added to that total in the next two months. Several of these will be prepared for submission in scientific journals.

A final project report from Phase I being prepared and will be published through Land Stewardship Project with other funds. The 60-page report will include colored maps and will be available in September 2001. Note that enough maps were copied with LCMR funds to give to project participants. With other funds, LSP also will publish a report on the policy ramifications of this data.

LSP has received funding for a Phase II to develop policy mechanisms to pay farmers for producing non-market public goods on the basis of the results they achieve on the land.

V. DISSEMINATION

The Core Working Group has and will continue to utilize additional (non-LCMR) funding to make presentations at professional and public meetings and with policymakers at various levels. We have and will communicate our progress electronically through a web site developed by the Land Stewardship Project. The published reports and all other reports will be available on LSP's web site early this fall.

Project staff and participants have presented preliminary data from the project to at least six national or state meetings using funds from other sources. We have also prepared several power point presentations on the project. That will continue during this upcoming year. Local newspapers, radio stations, and cable television stations will also be encouraged to do feature stories on the project.

VI. CONTEXT:

A. SIGNIFICANCE: The Governors Sustainable Development Initiative, Agriculture Team, stated in 1994 that: "Our legacy to future generations will be threefold: a healthy farming economy, vigorous rural communities and a healthy natural environment." The Initiative recognized that information on the benefits that are possible to achieve from the threefold legacy needs to be provided to the citizens of Minnesota.

Scientists and economists have been developing production functions to describe the costs and benefits of various land management alternatives on the parameters we describe in this proposal. Agencies have inventoried several watersheds in Minnesota. State and local agencies have kept track of dollars required to mitigate environmental problems resulting from land management and the value of agricultural production of different kinds. However, these existing data have not been brought together in a systematic way to be able to evaluate economic, environmental and social impacts of different future scenarios for agricultural production.

This project utilized new data and models being developed through research projects. For example, two projects looking at reduction of phosphorous loading in the LeSueur area. The Minnesota Institute for Sustainable Agriculture Sustainable Farming Systems project is gathering data on water quality impacts of different farming systems. Economist Paul Faeth analyzed pollution trading schemes to reduce phosphorous and other environmental impacts in sub-basins of the Minnesota River. Most existing projects are evaluating existing row crop systems or large-scale concentrated livestock production and specific best management practices to ameliorate natural resource problems. This project will measure the impacts of integrated agriculture *systems* whose purpose includes production of environmental and social benefits.

The project will build a dialogue in Minnesota around the idea of private incentives for "multiple production" to bring farmers and potential buyers together. Discussions with one major local corporation have already begun.

The information and models will be made available to state, local and federal agencies, private groups, companies and the agricultural community in Minnesota. This project will develop valuable decision-making tool for evaluating existing and future policies that could help channel entrepreneurial energy, private investment and public dollars in the directions the Sustainable Development Initiative had envisioned.

B. TIME: July 1, 1999 - June 30, 2001.

C. BUDGET CONTEXT

There is no match requirement, however we will be seeking additional funds to conduct policy analysis and dissemination of project results during and after the LCMR funding ends.

Note: Result three includes a contingent valuation survey to determine non-market values of certain benefits. To the extent that policy analysis is required to develop this survey, LSP will raise funds from other sources to assure that such analysis can be conducted in a timely fashion.

1. BUDGET:

Personnel:

Land Stewardship Project		$ 53,000	
Mara Krinke:	55%		
Mark Schultz	5%		
Richard Ness	3%		
Support:	10%		
University of Minnesota		$56,000	
Post doctoral scientist 80 % for 1.5 yrs			
Research Specialist/Research Assistant 50% for 1 year			
Bemidji State University		$16,000	
Graduate Student	for 1.5 yrs		
Institute for Agriculture and Trade Policy		$ 7,500	
Staff	14%		
Sub-total personnel:			$ 132,500
Equipment (Computer at UM for post doc)			$ 2,200
Acquisition			$ 0
Development			$ 0
Other:			
Occupancy (rent and utilities prorated to this project)			$ 1,700
Printing			$ 1,000
Communications			$ 2,750
(telephone, postage, copying prorated to this project)			
Contracts			
Professional Technical			$ 5,000
(to ME3 for contract with Dr. McIntosh and others)			
BSU and other contracts for contingent valuation survey costs			$ 15,000
Other assistance as needed			$ 0
Travel to MN by out-of-state consultants (as needed)			$ 0
Contracts for GIS input and modeling			$ 30,000
CWG and advisory council costs			$ 3,900
Project Staff travel			$ 3,400
Office Supplies			$ 2,550
TOTAL			**$200,000**

2. BUDGET DETAIL: See Attachment A.

3. BUDGET HISTORY: 1994-1998:

1. LCMR Budget History: $97,000 to develop on-farm monitoring tools
2. NON-LCMR Budget History: $50,000 from EPA through June 1998 and $50,000 from the National Science Foundation through May 1999. Joyce Foundation planning grant to LSP to be completed by February 1999: $29,300
3. Total: $ 226,400

VII. COOPERATION

A. The Core Working Group includes:

Mr. George Boody, Land Stewardship Project
Mr. Dan French, Farmer
Mr. Larry Gates, Minnesota Department of Natural Resources
Dr. Mary Hanks, Minnesota Department of Agriculture
Ms. Julie Henry, Department of Fisheries and Wildlife, University of Minnesota
Dr. Frances Homans, Department of Applied Economics, University of Minnesota
Dr. Paul Homme, Retired farmer
Dr. Cornelia Flora, University of Iowa
Dr. Jan Flora, University of Iowa
Ms. Mara Krinke, Project Coordinator at LSP
Dr. Steve Light, Institute for Agriculture and Trade Policy
Mr. Mark Schultz, Land Stewardship Project
Sister Kathleen Storms, Good Counsel
Dr. Bruce Vondracek, Department of Fisheries and Wildlife, University of Minnesota
Dr. Pat Welle, Bemidji State University
Mr. John Westra, Department of Applied Economics, University of Minnesota
Dr. Wynne Wright, West Central Research and Outreach Center, Morris

B. A Group of Technical Advisors is being assembled to include academic researchers and agency staff:

Mr. Jim Anderson, Minnesota Pollution Control Agency
Dr. Julie Bunn, Macalester College
Dr. Paul Faeth, World Resources Institute
Dr. John Ikerd, University of Missouri
Mr. Paul Johnson, Iowa farmer and DNR
Mr. Ken Meter, Crossroads Resource Center
Dr. David Mulla, University of Minnesota Dept of Soil, Water and Climate
Mr. Richard Ness, Land Stewardship Project
Dr. Kent Olson, University of Minnesota Dept of Applied Economics
Dr. Bill Vorley, International Institute for Environment and Development

C. Local watershed residents were involved.

D. A consultant pool was established.

VIII. LOCATIONS

We selected two watersheds for our analysis. We are working in the Wells Creek watershed, located in Goodhue county in southeastern Minnesota and in the lower southwestern portion of the Chippewa River watershed in Chippewa and Swift counties in western Minnesota. The Wells Creek watershed empties directly into the Mississippi River and the Chippewa River watershed is part of the Minnesota River Basin.

IX. REPORTING REQUIREMENTS

Periodic work program progress reports will be submitted no later than January 15, 2000; September 15, 2000; and March 23, 2001. A final work program report and associated products will be submitted by August 10, 2001.

ATTACHMENT A - Budget detail

LCMR Project Biennial Budget

Budget Item	Result 1 Characterized land management in each watershed	Result 2 Developed future farm system scenarios	Result 3 Calculated benefits	Result 4 Analyzed data and produced report	Total
Personnel costs					
Postdoctoral scientist and research assistant	20400	10000	25600	0	56000
Graduate Student (BSU)	5000	1000	8000	2000	16000
LSP staff	20000	13000	14500	5500	53000
IATP staff	1000	1500	4000	1000	7500
Occupancy costs	400	500	500	300	1700
Printing and advertising				1000	1000
Communications, telephone, etc	1000	1000	450	300	2750
Contracts					
Professional/technical	5000	0	0	0	5000
DNR for GIS work	10000	7500	7500	5000	30000
BSU & others for contingent valuation survey costs			15000		15000
Other contracts	0		0	0	0
Local auto mileage	1300	1000	300	200	2800
Other travel expenses in MN	450	100	50		600
Travel outside MN	0	0	0		0
Office Supplies	1200	600	500	250	2550
CWG/advisory council costs	2000	1450	450	0	3900
Tools and equipment	0	0	0	0	0
Office equipment & computers	700	500	500	500	2200
Other direct operating costs	0	0	0	0	0
Land Acquisition	0	0	0	0	0
Land Rights acquisition	0	0	0	0	0
Buildings or land improvement	0	0	0	0	0
Legal fees	0	0	0	0	0
COLUMN TOTAL	**68530**	**38150**	**77170**	**16150**	**200000**

ATTACHMENT B
Work Project Timeline

Jul 99 Sep 99 Dec 99 Mar 00 Jul 00 Sep 00 Dec 00 Mar 01 Jun 01

Result 1: Characterize existing land management practices in each watershed and apply or develop social and physical models to ascertain baseline data.

Recruited committees __________X
Confirmed methodologies __________X
Conducted peer review __________X
Selected farm samples ______________X
Characterized Mgmt in Watershed A ____________________X
Characterized Mgmt in Watershed B __________________________X
Modeled parameters in Watershed A _____________________X
Modeled parameters in Watershed B _________________________X

Result 2: Develop scenarios on future farming systems in each watershed.

Developed management scenarios in Watershed A _______________X
Developed management scenarios in Watershed B _________________X

ATTACHMENT B Page 2
Work Project Timeline

Jul 99 Sep 99 Dec 99 Mar 00 Jul 00 Sep 00 Dec 00 Mar 01 Jun 01

Result 3: Calculate economic benefits.

Modeled parameters for scenarios in Watershed A ______________X
Modeled parameters for scenarios in Watershed B __________________X
Drafted valuation surveys __________________X
Conducted valuation surveys ________________X
Calculated economic values in Watershed A ____________________X
Calculated economic values in Watershed B ________________________X

Result 4: Analyze and Interpret Data and Produce report.

Conducted data analysis ____________________X
Presented preliminary analysis for review _____________X
Completed analysis ________________X
Prepared first draft of report ___________X
Presented draft for review ____________X
Completed report: ____________X

TABLE WC-1

Wells Creek Land Use		Acres of Land by Land Use Category and Scenario				
		Baseline	Scenario A	Scenario B	Scenario C	Scenario D
Cultivated Land	Cultivated Land In Program	1,047	1,047	2,413	2,375	5,618
	Grain-Alfalfa Hay Conservation Tillage	3,241	2,584	4,994	12,974	8,563
	Grain-Alfalfa Hay Conventional Tillage	2,061	1,643	-	-	-
	Corn-Corn Conservation Tillage	2,745	-	3,330	3,255	2,148
	Corn-Corn Conventional Tillage	790	-	-	-	-
	Corn-Soybean Conservation Tillage	6,812	8,956	13,796	5,394	3,560
	Corn-Soybean Conventional Tillage	7,836	10,302	-	-	-
Grassland	Grassland In Program	163	163	163	163	163
	Pasture - dairy	2,981	2,981	2,981	2,510	2,510
	Intensive Grazing - dairy	157	157	157	627	3,909
	Pasture - beef	711	711	711	632	632
	Intensive Grazing - beef	79	79	79	158	984
Wetlands	Wetlands In Program	5	5	5	541	541
	Wetlands Non-Program	47	47	47	47	47
	Total	28,676	28,676	28,676	28,676	28,675

TABLE 1C-1

Chippewa Land Use		Acres of Land by Land Use Category and Scenario				
		Baseline	Scenario A	Scenario B	Scenario C	Scenario D
Cultivated Land	Cultivated Land In Program	2,794	2,794	3,673	3,633	10,828
	Grain-Alfalfa Hay Conservation Tillage	566	457	1,301	18,309	12,256
	Grain-Alfalfa Hay Conventional Tillage	770	205	-	-	-
	Corn-Soybean Conservation Tillage	9,377	15,392	27,373	11,379	7,613
	Corn-Soybean Conventional Tillage	18,741	13,112	-	-	-
	Corn-Sugar Beets Conventional Tillage	3,689	3,977	3,591	1,383	926
Grassland	Grassland In Program	487	487	487	487	487
	Pasture - dairy	576	576	576	485	485
	Intensive Grazing - dairy	30	30	30	121	719
	Pasture - beef	2,269	2,269	2,269	2,017	2,017
	Intensive Grazing - beef	252	252	252	504	2,989
Wetlands	Wetlands In Program	86	86	86	1,319	1,319
	Wetlands Non-Program	295	295	295	295	295
	Total	39,935	39,935	39,935	39,935	39,935

Table WC-2

Average Annual Edge of Field Estimates for Wells Creek (Area-weighted)

	Farming System	Tillage	Fertilizer	Rainfall inches	Runoff m3/sec	Sediment tons/acre	Nitrate lbs/acre	Phos lbs/acre
GRAZ1	Grazing 1			29.44	0.98	-	-	0.01
GRAZ2	Grazing 2			29.44	0.98	-	-	0.01
GRAZ3	Grazing 3			29.44	0.97	-	-	0.03
GRAZ4	Grazing 4			29.44	0.96	-	-	0.06
P2	Pasture 2			29.44	2.93	-	0.29	0.04
P1	Pasture 1			29.44	2.93	-	0.41	0.06
P5	Pasture 5			29.44	2.95	-	2.20	0.20
P4	Pasture 4			29.44	2.95	-	3.66	0.34
P3	Pasture 3			29.44	2.96	-	6.54	1.25
Hay S	Small Grain/Alfalfa Hay	Conservation		29.44	1.72	0.92	0.47	1.60
Hay V	Small Grain/Alfalfa Hay	Conventional		29.44	1.70	0.94	0.06	1.66
Hay 3S	Small Grain/Alfalfa Hay	Conservation	Reduced Rate	29.44	1.72	0.92	-	0.10
Hay 3V	Small Grain/Alfalfa Hay	Conventional	Reduced Rate	29.44	1.70	0.94	-	0.11
C-B S	Corn-Soybean	Conservation		29.44	2.23	6.65	5.28	0.14
C-B V	Corn-Soybean	Conventional		29.44	2.26	12.51	6.25	0.36
C-B S2	Corn-Soybean	Conservation	Manured	29.44	2.23	6.65	5.94	0.15
C-B V2	Corn-Soybean	Conventional	Manured	29.44	2.26	12.51	7.24	0.49
C-B S3	Corn-Soybean	Conservation	Reduced Rate	29.44	2.23	6.65	4.22	0.14
C-B S4	Corn-Soybean	Conservation	Reduced Rate/Manured	29.44	2.23	6.65	4.01	0.15
C-B S5	Corn-Soybean/Cover Crop	Conservation	Reduced Rate	29.44	2.54	2.97	1.55	0.08
C-B S6	Corn-Soybean/Cover Crop	Conservation	Reduced Rate/Manured	29.44	2.54	2.97	2.30	0.08
C-C S	Corn-Corn	Conservation		29.44	2.81	9.79	37.34	0.12
C-C V	Corn-Corn	Conventional		29.44	2.70	10.00	40.21	0.14
C-C S2	Corn-Corn	Conservation	Manured	29.44	2.86	9.86	18.94	0.12
C-C V	Corn-Corn	Conventional	Manured	29.44	2.71	10.30	20.52	0.14

1.13	*Weighted-average slope for region 468*
2.33	*Weighted-average slope for region 229*
5.71	*Weighted-average slope for region 218*
8.28	*Weighted-average slope for region 231*

GRAZ1	Grazing 1	*MIG with 8 dairy cows per acre for 12 hours (8 times per season)*
GRAZ2	Grazing 2	*MIG with 14 dairy cows per acre for 12 hours (8 times per season)*
GRAZ3	Grazing 3	*MIG with 22 dairy cows per acre for 12 hours (8 times per season)*
GRAZ4	Grazing 4	*MIG with 30 dairy cows per acre for 12 hours (8 times per season)*
P 2	Pasture 2	*Pasture with 31 dairy cows & 31 heifers on 150 acres for 10 days (19 times per season)*
P 1	Pasture 1	*Pasture with 23 dairy cows & 22 heifers on 90 acres for 10 days (19 times per season)*
P 5	Pasture 5	*Pasture with 130 dairy cows & 115 heifers on 150 acres for 10 days (19 times per season)*
P 4	Pasture 4	*Pasture with 30 dairy cows & 60 heifers on 60 acres for 10 days (19 times per season)*
P 3	Pasture 3	*Pasture with 70 beef cattle & 40 heifers on 40 acres for 10 days (19 times per season)*

Pasture/grazing season was April 20 to October 20 for all livestock systems
Dairy cows average 1,350 lbs each and dairy heifers averag 400 lbs each
Beef cattle average 800 lbs each and beef heifers/steer average 650 lbs each

Hay S	*Small grain - alfalfa hay rotation (3 years alfalfa) with conservation tillage*
Hay V	*Small grain - alfalfa hay rotation (3 years alfalfa) with conventional tillage*
C-B S	*Corn - soybean rotation (2 years) with conservation tillage*
C-B V	*Corn - soybean rotation (2 years) with conventional tillage*
C-C S	*Corn - corn rotation (2 years) with conservation tillage*
C-C V	*Corn - corn rotation (2 years) with conventional tillage*
C-B Hay S	*Corn - soybean - small grain - alfalfa hay rotation (5 years) with conservation tillage*
C-B Hay V	*Corn - soybean - small grain - alfalfa hay rotation (5 years) with conventional tillage*
C-C Hay S	*Corn - corn - small grain - alfalfa hay rotation (5 years) with conservation tillage*
C-C Hay V	*Corn - corn - small grain - alfalfa hay rotation (5 years) with conventional tillage*

0.13	*Proportion of Wells Creek for region 468*
0.07	*Proportion of Wells Creek for region 229*
0.19	*Proportion of Wells Creek for region 218*
0.61	*Proportion of Wells Creek for region 231*
1.00	*Total Wells Creek*

Table C-2

Annual Edge of Field Estimates for Chippewa (Area-weighted)

	Farming System	Tillage	Fertilizer	Rainfall inches	Runoff m3/sec	Sediment tons/acre	Nitrate lbs/acre	Phosphorus lbs/acre
CRP GRASS	CRP Grass			25.285	0.386	-	-	-
CRP TREES	CRP Trees			25.285	0.409	-	-	-
GRAZ1	*MIG with 15 beef heifers/steers per acre for 24 hours (8 times per season)*			25.285	0.889	-	-	0.008
GRAZ2	*MIG with 31 beef heifers/steers per acre for 24 hours (8 times per season)*			25.285	0.882	-	-	0.007
GRAZ3	*MIG with 46 beef heifers/steers per acre for 24 hours (8 times per season)*			25.285	0.870	-	-	0.014
GRAZ4	*MIG with 61 beef heifers/steers per acre for 24 hours (8 times per season)*			25.285	0.876	-	0.197	0.030
P1	*Pasture with 2 beef heifers/steers on 3 acres for 10 days (19 times per season)*			25.285	2.203	-	-	0.015
P2	*Pasture with 70 beef cattle & 40 heifers on 40 acres for 10 days (19 times per season)*			25.285	2.209	-	1.996	0.172
Hay S	Small Grain/Alfalfa Hay	Conservation		25.285	1.506	-	0.441	0.251
Hay V	Small Grain/Alfalfa Hay	Conventional		25.285	1.525	-	0.829	0.265
Hay 3S	Small Grain/Alfalfa Hay	Conservation	Reduced Rate	25.285	1.506	-	-	0.003
Hay 3V	Small Grain/Alfalfa Hay	Conventional	Reduced Rate	25.285	1.525	-	-	0.001
B-C S	Corn-Soybean	Conservation		25.285	1.825	0.051	3.372	0.009
B-C V	Corn-Soybean	Conventional		25.285	1.835	0.274	4.152	0.030
B-C S2	Corn-Soybean	Conservation	Manured	25.285	1.825	0.051	3.016	0.019
B-C V2	Corn-Soybean	Conventional	Manured	25.285	1.835	0.274	4.056	0.033
B-C S3	Corn-Soybean	Conservation	Reduced Rate	25.285	1.826	0.051	1.851	0.002
B-C S4	Corn-Soybean	Conservation	Reduced Rate/Manured	25.285	1.826	0.051	1.884	0.007
B-C S5	Corn-Soybean/Cover Crop	Conservation	Reduced Rate	25.285	1.972	0.028	1.615	0.002
B-C S6	Corn-Soybean/Cover Crop	Conservation	Reduced Rate/Manured	25.285	1.973	0.028	1.870	0.003
C-SB V	Corn-Sugar Beet	Conventional		25.285	2.116	0.397	1.996	0.018

1.44 — *Weighted-average slope for region 102*
1.44 — *Weighted-average slope for region 099*
1.74 — *Weighted-average slope for region 100*
2.16 — *Weighted-average slope for region 096*
3.14 — *Weighted-average slope for region 101*

GRAZ1 — *MIG with 15 beef heifers/steers per acre for 24 hours (8 times per season)*
GRAZ2 — *MIG with 31 beef heifers/steers per acre for 24 hours (8 times per season)*
GRAZ3 — *MIG with 46 beef heifers/steers per acre for 24 hours (8 times per season)*
GRAZ4 — *MIG with 61 beef heifers/steers per acre for 24 hours (8 times per season)*
P1 — *Pasture with 2 beef heifers/steers on 3 acres for 10 days (19 times per season)*
P2 — *Pasture with 70 beef cattle & 40 heifers on 40 acres for 10 days (19 times per season)*

Pasture/grazing season was April 20 to October 20 for all livestock systems
Dairy cows average 1,350 lbs each and dairy heifers averag 400 lbs each
Beef cattle average 800 lbs each and beef heifers/steer average 650 lbs each

Hay S — *Small grain - alfalfa hay rotation (3 years alfalfa) with conservation tillage*
Hay V — *Small grain - alfalfa hay rotation (3 years alfalfa) with conventional tillage*
C-B S — *Corn - soybean rotation (2 years) with conservation tillage*
C-B V — *Corn - soybean rotation (2 years) with conventional tillage*
C-SB V — *Corn - sugar beet rotation (2 years) with conventional tillage*
C-B Hay S — *Corn - soybean - small grain - alfalfa hay rotation (5 years) with conservation tillage*
C-B Hay V — *Corn - soybean - small grain - alfalfa hay rotation (5 years) with conventional tillage*

0.229 — ***Proportion of Chippewa Subwatershed for region 102***
0.074 — ***Proportion of Chippewa Subwatershed for region 099***
0.249 — ***Proportion of Chippewa Subwatershed for region 100***
0.118 — ***Proportion of Chippewa Subwatershed for region 096***
0.330 — ***Proportion of Chippewa Subwatershed for region 101***
1.000 — ***Total***

TABLE W-1 **Scenario Descriptions**

***WELLS CREEK* Scenarios**	**Crop mix**	**Conservation tillage**	**Nutrient application**	**Slope / Buffers**	**Proportion Grazing**
Baseline	15% CC 62% BC 23% hay	78% of CC 47% of BC 61% of hay	Actual rates, but higher than recommended	-	5% dairy MIG, 10% beef MIG
Scenario A – Trends	82% BC 18% hay	Trend = baseline levels	Baseline levels	-	Baseline levels
Scenario A1	16% CC 66% BC 18% hay	Same as A	Same as A	-	Baseline levels
Scenario A2	82% BC 18% hay	Same as A	More manure than baseline	-	Baseline levels
Scenario A3	Same as A	Same as A	More manure than baseline	Row crops on cropland >12% slope	Baseline levels
Scenario A4	82% CC 18% hay	Same as A	More manure than baseline	-	Baseline levels
Scenario B – BMP	Baseline levels	100% - all crops	UM Extension Service rates	Baseline levels, 100' buffers on all cropland	Baseline levels
Scenario B1	Baseline levels	100% - all crops	Baseline levels	Baseline levels	Baseline levels
Scenario B2	Baseline levels	100% - all crops	Baseline levels	33' buffers	Baseline levels
Scenario C – Diversity	15% CC 25% BC 60% hay	100% - all crops	UM Extension Service rates	535 acres new wetland, 100' buffers	20% dairy MIG, 20% beef MIG
Scenario C1	Same as C; CC and BC have cover crops	100% - all crops	UM Extension Service rates	Same as C	Same as C
Scenario D – Cover	Same as C; CC and BC have cover crops	100% - all crops	UM Extension Service rates	535 acres new wetland, 300' buffers; cropland >6% retired (61% baseline levels)	Same as C, 20%+ cropland to grazing

TABLE C-3

Chippewa River **Scenarios**	**Crop mix**	**Conservation tillage**	**Nutrient application**	**Slope / Buffers**	**Proportion Grazing**
Baseline	11% CSB 85% BC 4% hay	0% of CSB 33% of BC 42% of hay	Actual rates, but higher than recommended	-	5% dairy MIG, 10% beef MIG
Scenario A – Trends	12% CSB 86% BC 2% hay	0% of CSB 54% of BC 69% of hay	Baseline levels	-	Baseline levels
Scenario A1	Same as A	Same as A	Same as A	-	Baseline levels
Scenario A2	Same as A	Same as A	More manure than baseline	-	Baseline levels
Scenario A3	Same as A	Same as A	More manure than baseline	Row crops on land >12% slope	Baseline levels
Scenario A4	12% CSB 86% CC 2% hay	Same as A	More manure than baseline	-	Baseline levels
Scenario B – BMP	Baseline levels	100% - all crops except CSB	UM Extension Service rates	Baseline levels, 100' buffers on all cropland	Baseline levels
Scenario B1	Baseline levels	100% - all crops except CSB	Baseline levels	Baseline levels	Baseline levels
Scenario B2	Baseline levels	100% - all crops except CSB	Baseline levels	33' buffers	Baseline levels
Scenario C – Diversity	4% CSB 37% BC 59% hay	100% - all crops except CSB	UM Extension Service rates	1,233 acres new wetland, 100' buffers	20% dairy MIG, 20% beef MIG
Scenario C1	Same as C; BC has cover crops	100% - all crops except CSB	UM Extension Service rates	Same as C	Same as C
Scenario D – Cover	Same as C; BC has cover crops	100% - all crops except CSB	UM Extension Service rates	1,233 acres new wetland, 300' buffers; cropland greater than 3% and 20% of baseline values retired (63% baseline levels)	Same as C, 20%+ cropland to grazing

TABLE WC 4

Wells Creek Scenario Comparison

Scenario	Rainfall inches	Sediment tons	Nitrogen lbs	Phosphorus lbs	Sediment tons/acre	Nitrogen lbs/acre	Phosphorus lbs/acre
Baseline	29.4	39,615	3,001	7,547	0.99	0.08	0.19
Scenario A	29.4	41,349	2,783	7,262	1.04	0.07	0.18
Scenario B	29.4	27,321	1,878	3,495	0.68	0.05	0.09
Scenario C	29.4	17,292	1,098	2,281	0.43	0.03	0.06
Scenario D	29.4	6,148	788	2,180	0.15	0.02	0.05
Scenario A1	29.4	41,671	3,128	6,970	1.04	0.08	0.17
Scenario A2	29.4	39,623	2,985	7,680	0.99	0.07	0.19
Scenario A3	29.4	43,467	3,238	6,571	1.09	0.08	0.16
Scenario A4	29.4	43,048	4,400	5,825	1.08	0.11	0.15
Scenario B1	29.4	29,442	2,925	7,231	0.74	0.07	0.18
Scenario B2	29.4	29,860	1,965	3,686	0.75	0.05	0.09
Scenario C1	29.4	10,565	950	2,020	0.26	0.02	0.05

TABLE C-4

Chippewa Scenario Comparison

Scenario	Rainfall inches	Sediment tons	Nitrogen lbs	Phosphorus lbs	Sediment tons/acre	Nitrogen lbs/acre	Phosphorus lbs/acre
Baseline	25.4	1,956	13,966	5,108	0.05	0.32	0.12
Scenario A	25.4	1,788	14,068	4,852	0.04	0.33	0.11
Scenario B	25.4	1,473	11,555	2,974	0.03	0.27	0.07
Scenario C	25.4	1,275	6,882	1,524	0.03	0.16	0.04
Scenario D	25.4	995	5,267	1,261	0.02	0.12	0.03
Scenario A1	25.4	1,788	14,068	4,852	0.04	0.33	0.11
Scenario A2	25.4	1,956	13,988	5,174	0.05	0.33	0.12
Scenario A3	25.4	1,956	13,988	5,174	0.05	0.33	0.12
Scenario A4	25.4	1,956	13,988	5,174	0.05	0.33	0.12
Scenario B1	25.4	1,340	13,988	4,981	0.03	0.33	0.12
Scenario B2	25.4	1,382	11,680	3,022	0.03	0.27	0.07
Scenario C1	25.4	1,130	6,323	1,479	0.03	0.15	0.03

TABLE WC + C 5

Greenhouse Gas Production

GWP reduction (metric tons of carbon equivalent)

Scenario

Area and type of activity	Baseline	Scen A	Scen B	Scen C	Scen D1*	Scen D2~
Wells Creek						
Crops	1439	1347	794	473	275	275
Animals	3564	3564	3564	3564	7538	3564
Total	5003	4911	4358	4037	7813	3839
% reduction from baseline decrease (increase)	0%	2%	13%	19%	-56%	23%
Reduction by mt of carbon decrease (increase)	0	-92	-645	-966	2810	-1164

* Scenario D1 includes a 15% increase in the number of dairy and a 10% increase beef animals in the watershed, all added in Managed Grazing systems.
~Scenario D2 includes the same number of animals as scenarios A-C, but 15% of dairy animals and 10% of beef animals are transferred into Managed Grazing systems.

Area and type of activity	Baseline	Scen A	Scen B	Scen C	Scen D1*	Scen D2~
Chippewa						
Crops	1479	1486	1360	700	249	249
Animal Production	586	586	586	567	1077	566
Total	2065	2072	1946	1267	1326	815
% reduction from baseline decrease (increase)	0%	0%	6%	39%	36%	61%
Reduction by mt of carbon decrease (increase)	0	7	-119	-798	-739	-1250

* Scenario D1 includes a 15% increase in the number of dairy and a 10% increase beef animals in the watershed, all added in Managed Grazing systems.
~Scenario D2 includes the same number of animals as scenarios A-C, but 15% of dairy animals and 10% of beef animals are transferred into Managed Grazing systems.

TABLES C-6 and WC-6

Estimated Economic Damage From Soil Erosion

Chippewa Estimated Economic Damage					
	Baseline	**Scenario A**	**Scenario B**	**Scenario C**	**Scenario D**
Total @ $5.38 per ton soil eroded	10,525	9,617	7,925	6,858	5,355

Wells Creek Estimated Economic Damage					
	Baseline	**Scenario A**	**Scenario B**	**Scenario C**	**Scenario D**
Total @ $5.38 per ton soil eroded	213,131	222,456	146,989	93,033	33,076

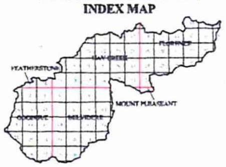
Chippewa maps follow Wells Creek maps

WELLS CREEK WATERSHED
HYDROGRAPHIC AND CULTURAL FEATURES

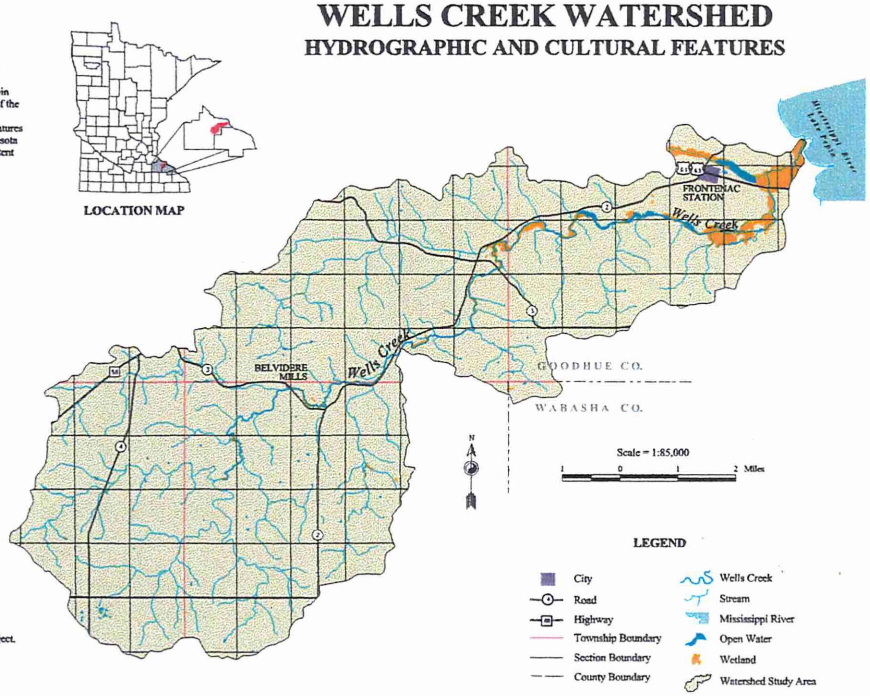
EXPLANATION

The Wells Creek Watershed study area is located in Goodhue and Wabasha counties of south eastern Minnesota. The 40,172 acre study area is comprised of the three minor watersheds 38002, 38003 and 38006 and is part of the Mississippi River - Lake Pepin Major Watershed. Wells Creek is the outlet stream of the watershed, which drains directly into the Lake Pepin region of the Mississippi River. The hydrographic features display the NWI wetland data and the State of Minnesota stream and lake data. The stream data show intermittent and perennial streams.

TOWNSHIP AND SECTION INDEX MAP



LOCATION MAP



CREDITS

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Sources of data for the project were the Board of Water and Soil Resources, Minnesota Department of Natural Resources, Minnesota Department of Transportation, Minnesota Pollution Control Agency, and Minnesota River Basin Data Center.

This map was prepared for the Land Stewardship Project.
Cis Berg, Water Resources Center
Minnesota State University, Mankato
ARCINFO 7.1.2 and ArcView 3.1 Software
June, 2001

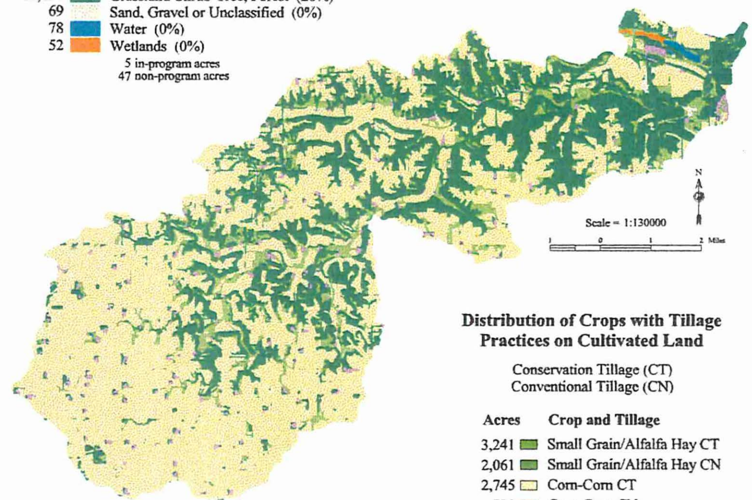
WELLS CREEK WATERSHED
BASELINE: CURRENT LAND USE AND COVER

LAND USE AND COVER

Acres	Description
24,533	Cultivated Land (61%)
	1,047 in-program acres
	23,486 non-program acres
920	Development (2%)
4,090	Grassland (10%)
	163 in-program acres
	3,927 non-program acres
10,430	Grassland-Shrub-Tree, Forest (26%)
69	Sand, Gravel or Unclassified (0%)
78	Water (0%)
52	Wetlands (0%)
	5 in-program acres
	47 non-program acres

EXPLANATION

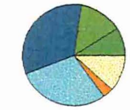
The land use map displays the current land use and cover in the watershed based on 1990 data. The Land Use and Cover table reports the acres and percent of each classification including conservation program information. Cultivated land, grassland and wetland acres enrolled in a conservation program are designated as in-program. The remaining acres are designated as non-program. Total watershed area is 40,172 acres.



Distribution of Crops with Tillage Practices on Cultivated Land

Conservation Tillage (CT)
Conventional Tillage (CN)

Acres	Crop and Tillage
3,241	Small Grain/Alfalfa Hay CT
2,061	Small Grain/Alfalfa Hay CN
2,745	Corn-Corn CT
790	Corn-Corn CN
6,812	Corn-Soybean CT
7,836	Corn-Soybean CN



Prepared for: The Land Stewardship Project, Multiple Benefits of Agriculture
Prepared by: Cis Berg, Water Resources Center
Minnesota State University, Mankato
Date: June, 2001
Software: ARC/INFO 7.1.2 and ArcView 3.1
Data Sources: Land Use and Cover data are from the International Coalition Land Use/ Land Cover (1990). Conservation program data were developed from the GAP Stewardship and BWSR Easement Parcel GIS data. Scenario data were developed by the Multiple Benefits of Agriculture Project Team.

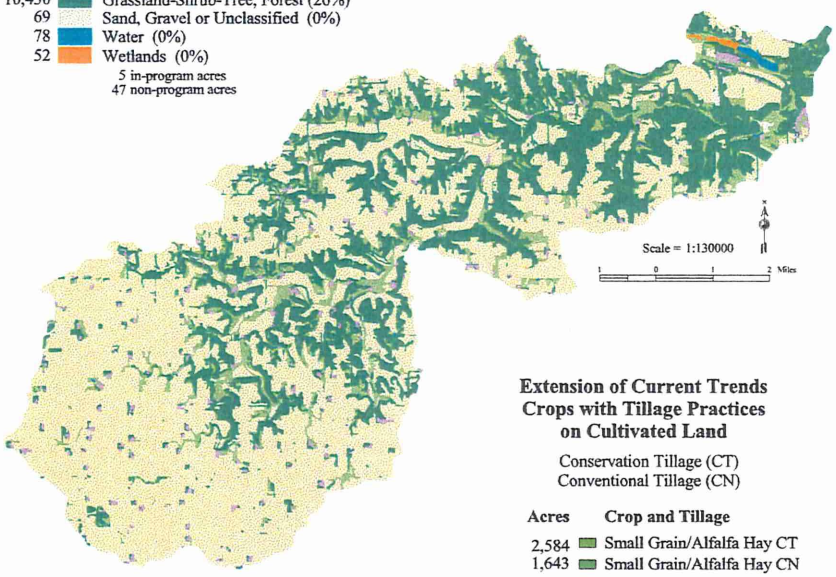
WELLS CREEK WATERSHED
SCENARIO A: EXTENSION OF CURRENT TRENDS

LAND USE AND COVER

Acres	Description
24,533	Cultivated Land (61%) 1,047 in-program acres 23,486 non-program acres
920	Development (2%)
4,090	Grassland (10%) 163 in-program acres 3,927 non-program acres
10,430	Grassland-Shrub-Tree, Forest (26%)
69	Sand, Gravel or Unclassified (0%)
78	Water (0%)
52	Wetlands (0%) 5 in-program acres 47 non-program acres

EXPLANATION

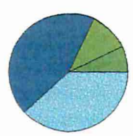
The land use map displays the current land use and cover in the watershed based on 1990 data. The Land Use and Cover table reports the acres and percent of each classification including conservation program information. Cultivated land, grassland and wetland acres enrolled in a conservation program are designated as in-program. The remaining acres are designated as non-program. Total watershed area is 40,172 acres.



Extension of Current Trends Crops with Tillage Practices on Cultivated Land

Conservation Tillage (CT)
Conventional Tillage (CN)

Acres	Crop and Tillage
2,584	Small Grain/Alfalfa Hay CT
1,643	Small Grain/Alfalfa Hay CN
8,956	Corn-Soybean CT
10,302	Corn-Soybean CN



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WELLS CREEK WATERSHED
SCENARIO B: BEST MANAGEMENT PRACTICES

LAND USE AND COVER

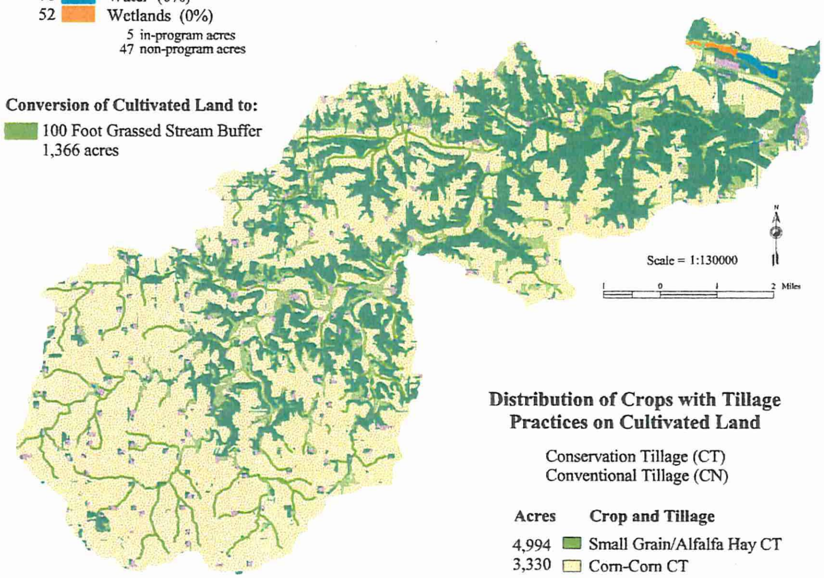
Acres	Description
24,533	Cultivated Land (61%) 2,413 in-program acres 22,120 non-program acres
920	Development (2%)
4,090	Grassland (10%) 163 in-program acres 3,927 non-program acres
10,430	Grassland-Shrub-Tree, Forest (26%)
69	Sand, Gravel, or Unclassified (0%)
78	Water (0%)
52	Wetlands (0%) 5 in-program acres 47 non-program acres

Conversion of Cultivated Land to:

100 Foot Grassed Stream Buffer
1,366 acres

EXPLANATION

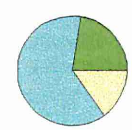
The land use map displays the current land use and cover in the watershed based on 1990 data modified by Scenario B parameters. The Land Use and Cover table reports the acres and percent of each classification including conservation program information. Cultivated land, grassland and wetland acres enrolled in a conservation program are designated as in-program. The remaining acres are designated as non-program. The cultivated land in-program acres are increased by implementing a 100 foot grassed stream buffer on cultivated land. Total watershed area is 40,172 acres



Distribution of Crops with Tillage Practices on Cultivated Land

Conservation Tillage (CT)
Conventional Tillage (CN)

Acres	Crop and Tillage
4,994	Small Grain/Alfalfa Hay CT
3,330	Corn-Corn CT
13,796	Corn-Soybean CT



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WELLS CREEK WATERSHED
SCENARIO C: COMMUNITY AND ECONOMIC DIVERSITY

LAND USE AND COVER

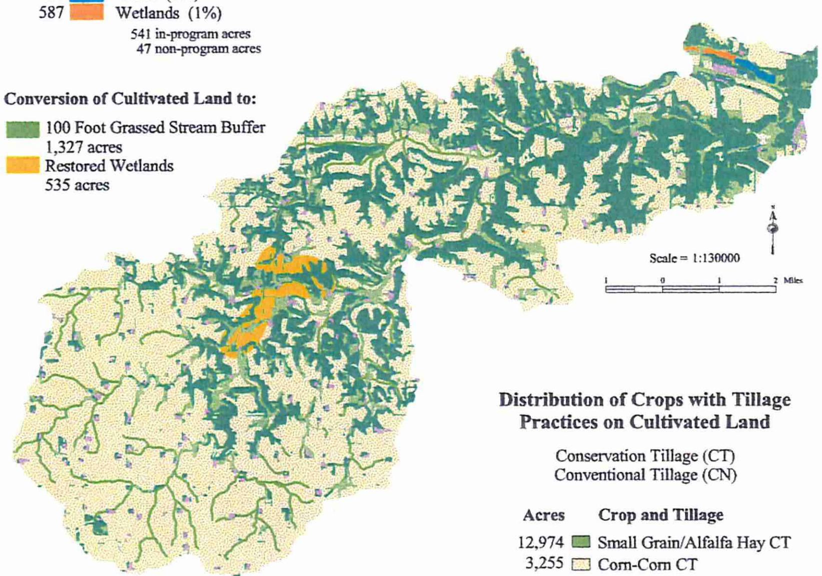
Acres	Description
23,998	Cultivated Land (60%) 2,375 in-program acres 22,120 non-program acres
920	Development (2%)
4,090	Grassland (10%) 163 in-program acres 3,927 non-program acres
10,430	Grassland-Shrub-Tree, Forest (26%)
69	Sand, Gravel or Unclassified (0%)
78	Water (0%)
587	Wetlands (1%) 541 in-program acres 47 non-program acres

EXPLANATION

The land use map displays modified land use and cover in the watershed using Scenario C parameters. The Land Use and Cover table reports the acres and percent of each classification including conservation program information. Cultivated land, grassland and wetland acres enrolled in a conservation program are designated as in-program. The remaining acres are designated as non-program. The cultivated land in-program acres are increased by implementing a 100 foot grassed stream buffer on cultivated land. Cultivated lands are decreased overall through the restoration of 535 acres to wetlands.

Conversion of Cultivated Land to:

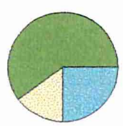
100 Foot Grassed Stream Buffer
1,327 acres
Restored Wetlands
535 acres



Distribution of Crops with Tillage Practices on Cultivated Land

Conservation Tillage (CT)
Conventional Tillage (CN)

Acres	Crop and Tillage
12,974	Small Grain/Alfalfa Hay CT
3,255	Corn-Corn CT
5,394	Corn-Soybean CT



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Minnesota State University, Mankato
Date: June, 2001
Software: ARC/INFO 7.1.2 and ArcView 3.1
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WELLS CREEK WATERSHED
SCENARIO D: YEAR ROUND COVER

LAND USE AND COVER

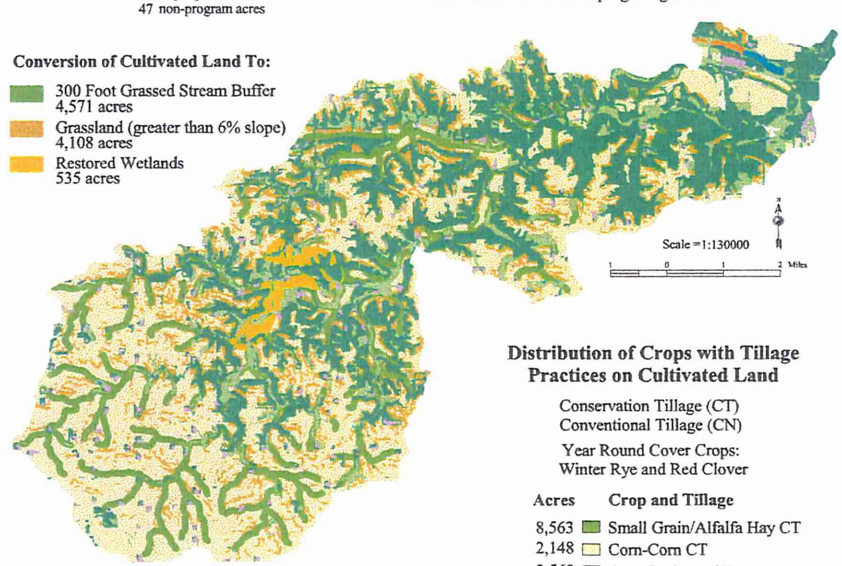
Acres	Description
19,890	Cultivated Land (50%) 5,618 in-program acres 14,272 non-program acres
920	Development (2%)
8,198	Grassland (20%) 163 in-program acres 8,035 non-program acres
10,430	Grassland-Shrub-Tree, Forest (26%)
69	Sand, Gravel or Unclassified (0%)
78	Water (0%)
587	Wetlands (1%) 541 in-program acres 47 non-program acres

EXPLANATION

The land use map displays modified land use and cover in the watershed using Scenario D parameters. The Land Use and Cover table reports the acres and percent of each classification including conservation program information. Cultivated land, grassland and wetland acres enrolled in a conservation program are designated as in-program. The remaining acres are designated as non-program. The cultivated land in-program acres are increased by implementing a 300 foot grassed stream buffer on cultivated land. Cultivated lands are decreased overall through the restoration of 535 acres to wetlands and the conversion of 4,108 high slope acres of non-program cultivated land into non-program grassland.

Conversion of Cultivated Land To:

300 Foot Grassed Stream Buffer
4,571 acres
Grassland (greater than 6% slope)
4,108 acres
Restored Wetlands
535 acres

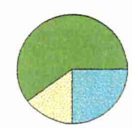


Distribution of Crops with Tillage Practices on Cultivated Land

Conservation Tillage (CT)
Conventional Tillage (CN)

Year Round Cover Crops:
Winter Rye and Red Clover

Acres	Crop and Tillage
8,563	Small Grain/Alfalfa Hay CT
2,148	Corn-Corn CT
3,560	Corn-Soybean CT



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Minnesota State University, Mankato
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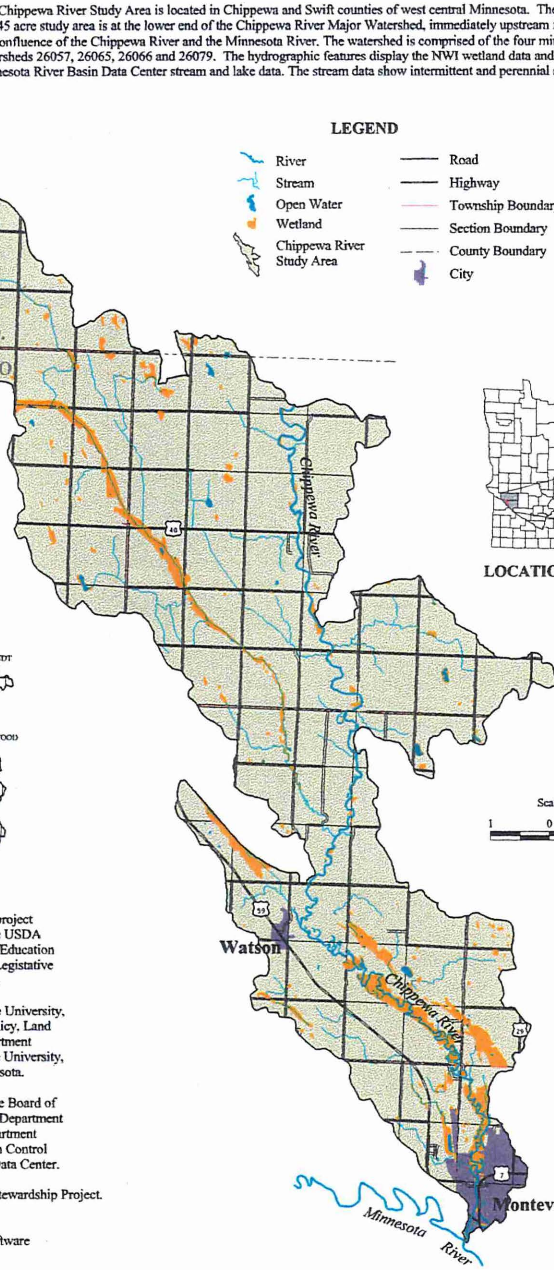
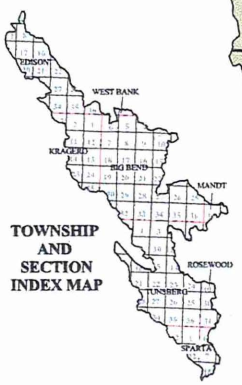
CHIPPEWA RIVER STUDY AREA
HYDROGRAPHIC AND CULTURAL FEATURES

EXPLANATION

The Chippewa River Study Area is located in Chippewa and Swift counties of west central Minnesota. The 44,445 acre study area is at the lower end of the Chippewa River Major Watershed, immediately upstream from the confluence of the Chippewa River and the Minnesota River. The watershed is comprised of the four minor watersheds 26057, 26065, 26066 and 26079. The hydrographic features display the NWI wetland data and the Minnesota River Basin Data Center stream and lake data. The stream data show intermittent and perennial streams.





TOWNSHIP AND SECTION INDEX MAP

LOCATION MAP

CREDITS

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Cis Berg, Water Resources Center
Minnesota State University, Mankato
ARCINFO 7.1.2 and ArcView 3.1 Software
June, 2001

CHIPPEWA RIVER STUDY AREA
BASELINE: CURRENT LAND USE AND COVER

LAND USE AND COVER

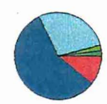
Acres	Description
35,938	Cultivated Land (81%) — 2,794 in-program acres; 33,144 non-program acres
1,573	Development (3%)
3,615	Grassland (8%) — 487 in-program acres; 3,128 non-program acres
2,667	Grassland-Shrub-Tree, Forest (6%)
5	Sand, Gravel or Unclassified (0%)
266	Water (1%)
381	Wetlands (1%) — 86 in-program acres; 295 non-program acres

EXPLANATION

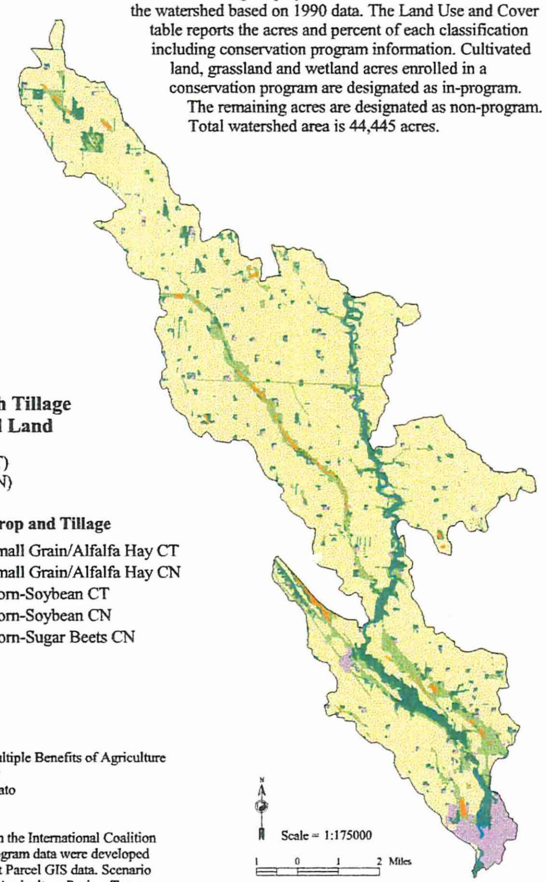
The land use map displays the current land use and cover in the watershed based on 1990 data. The Land Use and Cover table reports the acres and percent of each classification including conservation program information. Cultivated land, grassland and wetland acres enrolled in a conservation program are designated as in-program. The remaining acres are designated as non-program. Total watershed area is 44,445 acres.

Distribution of Crops with Tillage Practices on Cultivated Land

Conservation Tillage (CT)
Conventional Tillage (CN)



Acres	Crop and Tillage
566	Small Grain/Alfalfa Hay CT
770	Small Grain/Alfalfa Hay CN
9,377	Corn-Soybean CT
18,741	Corn-Soybean CN
3,689	Corn-Sugar Beets CN



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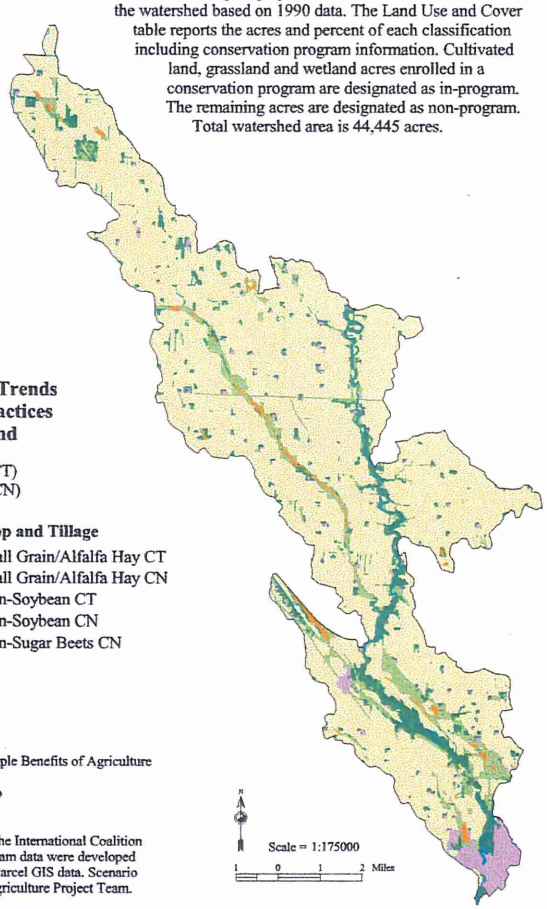
CHIPPEWA RIVER STUDY AREA
SCENARIO A: EXTENSION OF CURRENT TRENDS

LAND USE AND COVER

Acres	Description
35,938	Cultivated Land (81%) 2,794 in-program acres 33,144 non-program acres
1,573	Development (3%)
3,615	Grassland (8%) 487 in-program acres 3,128 non-program acres
2,667	Grassland-Shrub-Tree, Forest (6%)
5	Sand, Gravel or Unclassified (0%)
266	Water (1%)
381	Wetlands (1%) 86 in-program acres 295 non-program acres

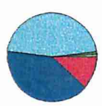
EXPLANATION

The land use map displays the current land use and cover in the watershed based on 1990 data. The Land Use and Cover table reports the acres and percent of each classification including conservation program information. Cultivated land, grassland and wetland acres enrolled in a conservation program are designated as in-program. The remaining acres are designated as non-program. Total watershed area is 44,445 acres.



Extension of Current Trends Crops with Tillage Practices on Cultivated Land

Conservation Tillage (CT)
Conventional Tillage (CN)



Acres	Crop and Tillage
457	Small Grain/Alfalfa Hay CT
205	Small Grain/Alfalfa Hay CN
15,392	Corn-Soybean CT
13,112	Corn-Soybean CN
3,977	Corn-Sugar Beets CN

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Prepared by: Cis Berg, Water Resources Center
Minnesota State University, Mankato
Date: June, 2001
Software: ARC/INFO 7.1.2 and ArcView 3.1
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N
Scale = 1:175000
1 0 1 2 Miles

CHIPPEWA RIVER STUDY AREA
SCENARIO B: BEST MANAGEMENT PRACTICES

LAND USE AND COVER

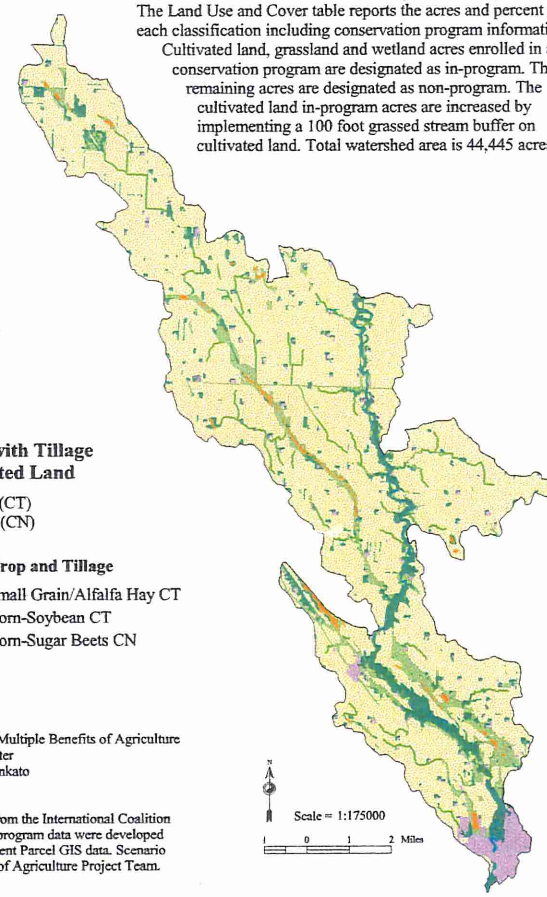
Acres	Description
35,938	Cultivated Land (81%) 3,673 in-program acres 32,265 non-program acres
1,573	Development (3%)
3,615	Grassland (8%) 487 in-program acres 3,128 non-program acres
2,667	Grassland-Shrub-Tree, Forest (6%)
5	Sand, Gravel or Unclassified (0%)
266	Water (1%)
381	Wetlands (1%) 86 in-program acres 295 non-program acres

Conversion of Cultivated Land to:

100 Foot Grassed Stream Buffer
879 acres

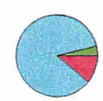
EXPLANATION

The land use map displays the current land use and cover in the watershed based on 1990 data modified by Scenario B parameters. The Land Use and Cover table reports the acres and percent of each classification including conservation program information. Cultivated land, grassland and wetland acres enrolled in a conservation program are designated as in-program. The remaining acres are designated as non-program. The cultivated land in-program acres are increased by implementing a 100 foot grassed stream buffer on cultivated land. Total watershed area is 44,445 acres.



Distribution of Crops with Tillage Practices on Cultivated Land

Conservation Tillage (CT)
Conventional Tillage (CN)



Acres	Crop and Tillage
1,301	Small Grain/Alfalfa Hay CT
27,373	Corn-Soybean CT
3,591	Corn-Sugar Beets CN

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Minnesota State University, Mankato
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Software: ARC/INFO 7.1.2 and ArcView 3.1
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N
Scale = 1:175000
1 0 1 2 Miles

CHIPPEWA RIVER STUDY AREA
SCENARIO C: COMMUNITY AND ECONOMIC DIVERSITY

LAND USE AND COVER

Acres		Description
34,705		Cultivated Land (78%) 3,633 in-program acres 31,072 non-program acres
1,573		Development (3%)
3,615		Grassland (8%) 487 in-program acres 3,128 non-program acres
2,667		Grassland-Shrub-Tree, Forest (6%)
5		Sand, Gravel or Unclassified (0%)
266		Water (1%)
1,614		Wetlands (4%) 1,319 in-program acres 295 non-program acres

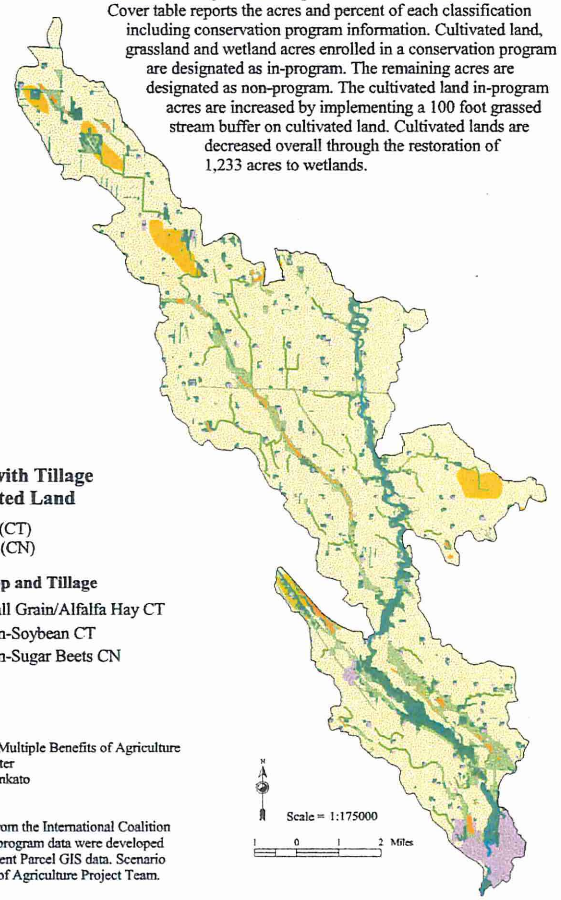
Conversion of Cultivated Land to:

100 Foot Grassed Stream Buffer
839 acres

Restored Wetlands
1233 acres

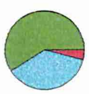
EXPLANATION

The land use map displays modified land use and cover in the watershed using Scenario C parameters. The Land Use and Cover table reports the acres and percent of each classification including conservation program information. Cultivated land, grassland and wetland acres enrolled in a conservation program are designated as in-program. The remaining acres are designated as non-program. The cultivated land in-program acres are increased by implementing a 100 foot grassed stream buffer on cultivated land. Cultivated lands are decreased overall through the restoration of 1,233 acres to wetlands.



Distribution of Crops with Tillage Practices on Cultivated Land

Conservation Tillage (CT)
Conventional Tillage (CN)



Acres	Crop and Tillage
18,309	Small Grain/Alfalfa Hay CT
11,379	Corn-Soybean CT
1,383	Corn-Sugar Beets CN

Prepared for: The Land Stewardship Project, Multiple Benefits of Agriculture
Prepared by: Cis Berg, Water Resources Center
Minnesota State University, Mankato
Date: June, 2001
Software: ARC/INFO 7.1.2 and ArcView 3.1
Data Sources: Land Use and Cover data are from the International Coalition Land Use/ Land Cover (1990). Conservation program data were developed from the GAP Stewardship and BWSR Easement Parcel GIS data. Scenario data were developed by the Multiple Benefits of Agriculture Project Team.

CHIPPEWA RIVER STUDY AREA
SCENARIO D: YEAR ROUND COVER

LAND USE AND COVER

Acres		Description
31,623		Cultivated Land (71%) 10,828 in-program acres 20,795 non-program acres
1,573		Development (3%)
6,698		Grassland (15%) 487 in-program acres 6,210 non-program acres
2,667		Grassland-Shrub-Tree, Forest (6%)
5		Sand, Gravel, or Unclassified (0%)
266		Water (1%)
1,614		Wetlands (4%) 1,319 in-program acres 295 non-program acres

Conversion of Cultivated Land to:

300 Foot Grassed Stream Buffer
3,063 acres

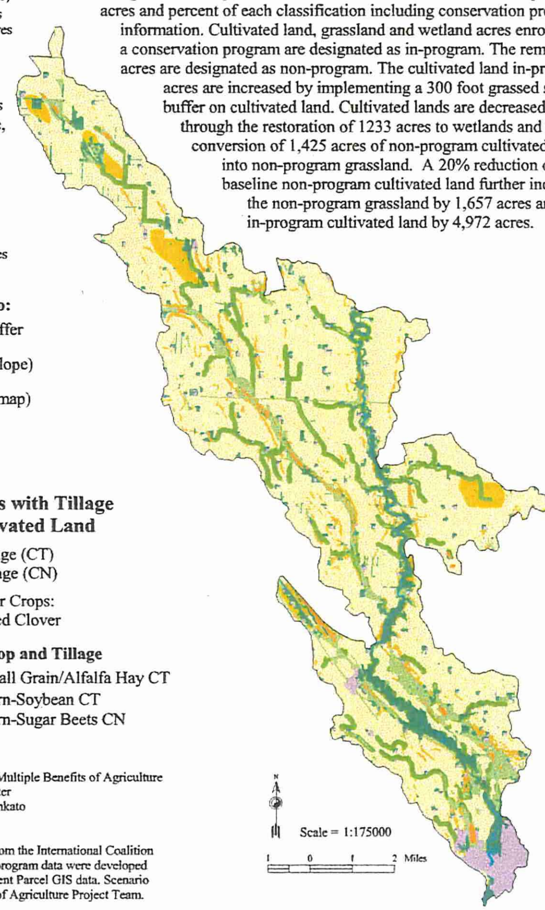
Grassland (greater than 3% slope)
1,425 acres

Grassland (not displayed on map)
additional 1,657 acres

Restored Wetlands
1,233 acres

EXPLANATION

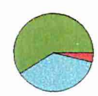
The land use map displays modified land use and cover in the watershed using Scenario D parameters. The Land Use and Cover table reports the acres and percent of each classification including conservation program information. Cultivated land, grassland and wetland acres enrolled in a conservation program are designated as in-program. The remaining acres are designated as non-program. The cultivated land in-program acres are increased by implementing a 300 foot grassed stream buffer on cultivated land. Cultivated lands are decreased overall through the restoration of 1233 acres to wetlands and the conversion of 1,425 acres of non-program cultivated land into non-program grassland. A 20% reduction of the baseline non-program cultivated land further increased the non-program grassland by 1,657 acres and the in-program cultivated land by 4,972 acres.



Distribution of Crops with Tillage Practices on Cultivated Land

Conservation Tillage (CT)
Conventional Tillage (CN)

Year Round Cover Crops:
Winter Rye and Red Clover



Acres	Crop and Tillage
12,256	Small Grain/Alfalfa Hay CT
7,613	Corn-Soybean CT
926	Corn-Sugar Beets CN

Prepared for: The Land Stewardship Project, Multiple Benefits of Agriculture
Prepared by: Cis Berg, Water Resources Center
Minnesota State University, Mankato
Date: June, 2001
Software: ARC/INFO 7.1.2 and ArcView 3.1
Data Sources: Land Use and Cover data are from the International Coalition Land Use/ Land Cover (1990). Conservation program data were developed from the GAP Stewardship and BWSR Easement Parcel GIS data. Scenario data were developed by the Multiple Benefits of Agriculture Project Team.

RESEARCH PROJECT ADDENDUM

A-35 Economic Analysis of Agriculture for Multiple Benefits
Project Manager: Mara Krinke

I. Abstract (repeat of II. Project Summary and Results)

Farming systems can produce multiple environmental and social benefits in addition to commodities. Farmers, citizens and policymakers need to understand the economic value of those benefits in order to make informed choices about alternative farming systems. This project will measure the environmental and social benefits from current and future agricultural production systems in two watersheds in Minnesota. A Core Working Group will be convened with members chosen to represent a range of specialties (i.e., agricultural resource economics, ecosystem function, resource economics, ecological economics, rural sociology) and perspectives (i.e., farmers, agency staff, academics, non profits). Local watershed advisory councils and a group of technical advisors will be assembled. The project will hire a post doctoral scientist at the University of Minnesota and a graduate student at Bemidji State University to assist the Core Working Group. The economic valuation will include crops and livestock production, other market-valued items and non-market valued items such as water quality, soil erosion, wildlife habitat, biodiversity, local purchases from farming operations, social capital formation, etc. The results of this project include characterizing existing land management practices in each watershed and environmental and social impacts for selected criteria in two watersheds. The project will develop scenarios for possible future farming systems in the watershed and the changes in equipment, training, infrastructure needed for those systems, if any. Economic values of the benefits available if each scenario were to be implemented in each watershed will be calculated. Non-market benefits will be valued as avoided mitigation costs or willingness to pay. A final report will be produced for the project.

II. Background and hypothesis

Background

Despite significant reductions in point source emissions and total cropland soil erosion since 1982, water quality in the U.S. continues to deteriorate. Siltation causes about $450 million per year in economic damage in the Great Lakes region, alone (Faeth, 1998). Moreover, the rate of soil erosion in the U.S. has leveled off since 1995 to about 2 billion tons per year, or an average of 5.2 tons of soil loss per acre of cropland per year (NRI, 1997). Farming can also produce other environmental problems such as soil compaction, decreased wildlife habitat and reduced economic activity in communities (USDA, 1977; CLRSWC, 1993; Chism, 1993).

We know that farming produces commodities, food and fiber for people. These functions have economic values defined through the marketplace. However, improved farming practices can also produce multiple environmental, social and economic benefits for society, including improved water quality, enhanced soil quality, wildlife habitat, biodiversity and social capital formation (CLRSWC, 1993; Jackson and Boody, 1997; Levins, 1996; USDA, 1997). Without attaching economic values to at least a few of these benefits, such as clean water, landscape enhancement or tourism potential, society at large will not readily come to understand the value of sustainable farming systems (Goulder and Kennedy, 1977; USDA, 1997). Developing citizen-based processes and synthesizing information and analytical tools applicable at the watershed level to economically assess and compare the production of multiple benefits from various forms of agriculture will be critical early steps in creating the groundwork for markets and public policies that promote enhanced environmental performance in agriculture.

Several European and Asian countries describe the ability of sustainable farming to produce multiple benefits for society as "multifunctional agriculture." Aldington (1988) states that, "there is a broad consensus on what these functions are, although there is a variety of taxonomies by which they are organized." An electronic conference was held this winter and a conference is being organized by the United Nations Food and Agriculture Organization (FAO) and the Netherlands in September 1999 to explore these issues.

Freeman (1993) notes that some non-market benefits can be valued in economic terms. In other words, we can estimate what people would be willing to pay in taxes or for consumption through the market, if one existed. In addition, there also are ethical, social and ecological aspects of these multifunctional benefits that may be quantified within their disciplines, but are difficult to quantify in an economic sense (Cangelosi, 1999). Examples of such benefits are the maintenance of rural community stability, the provision of habitat for a grassland bird species such as the Dickcissel or the ethics of animal welfare.

This project will integrate quantification of environmental and social impacts, and economic valuation to prevent non-point source pollution and to promote the production of multiple environmental and social benefits for society. We will utilize citizen (stakeholder) involvement with experts to define important parameters and evaluate options.

Methodologies and data that may be useful in our study:

The following literature review is grouped into categories of citizen participation in analysis and interpretation; quantifying environmental and community impacts, quantifying economic values of non-market benefits; and assessing other community benefits.

Citizen Participation

Researchers are developing ecological economic methodologies and models with which to create linkages between ecological and economic systems (Daily, 1997; Costanza, 1996; Bockstael, et.al., 1995; Fitz, et.al., 1996). The integrated ecological-economic modeling and assessment proposed by Costanza and Folke (1997) calls for a framework that is a creative and learning process involving stakeholder groups that can lead to well-rounded decisions. The Minnesota Department of Natural Resources (1998) conducted a study of citizen involvement in watershed and monitoring activities in Minnesota that lends definition to such a process. The assessment produced a number of findings consistent with participatory research. They found the need for greater substantive dialogue about resource issues and the need for reliable sources of credible science. They also found the "need for a greater integration of science into political decision making, particularly at the local level."

Quantifying environmental and community impacts

In 1989, Ribaudo estimated that the Conservation Reserve Program would produce $3.5 to $4 billion in water quality benefits if 45 million acres were enrolled. He cited benefits such as lower water treatment costs, lower sediment removal costs, less flood damage, less damage to equipment which uses water, increased recreational fishing. He defined a conceptual system of causal linkages between loss of soil and nutrients and economic impacts. His analysis was at a national scale.

However, most economic analyses of agriculture, if not focused exclusively on farm profitability, have tended to be cost-benefit analyses of potential regulations for reducing pollution or tradeoffs between water quality improvements or other environmental gains and on-farm profitability (Contant et al., 1993; Faeth (personal communication); Morgenstern and Landy, 1977; Painter et al., 1995). Such studies evaluate the impact of adapting existing row crop/confined feedlot agricultural systems through the use of specific best management practices designed to modify tillage, time nutrient applications, contain manure through improved storage structures, add buffer zones, etc. The impact of farm income is also often evaluated. These studies have not reported economic values for other ecosystem impacts such as pesticide leaching or for ecosystem services such as flood control, or production of wild plants and animals in the landscape.

Faeth (1995) analyzed the potential impacts on pollution prevention and farm income of nutrient trading and other policy options for the Minnesota River Valley. According to Faeth the World Resources Institute model, outlined in the Growing Green study (Faeth, 1995) and used in the nutrient trading research, could be adapted to work at the level of smaller watershed.[1] The model estimates impacts for about 13 environmental variables. It would need to be expanded to include animal production systems. Updated and localized data sets would need to be produced. This model does not include the impacts of drainage.

The ADAPT (Agricultural Drainage and Pesticide Transport) model developed in Ohio (Alexander 1988; Schalk, 1990) has been calibrated for areas in Minnesota and used to predict potential reduction of nitrates and other pollutant sources from adoption of different management practices (Davis, 1998). The ADAPT model combines drainage and pollutant losses. Since drainage is likely to be common in our study areas, this is advantageous. Further studies are under way that will include farm profitability predictions (Mulla, personal communication).

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[1] This model is an adaptation of the USDA ERS U.S. Math Programming Model (House, 1987), EPIC, regional damage estimates from Ribaudo (1989) and the addition of soil depreciation values from (Faeth, 1991).

Faculty and graduate students at the University of Minnesota are using the ADAPT model to research economic or environmental impacts of alternative management scenarios or policy options. For example, the impact of alternative policy tools on reduction of phosphorous loading in the LeSueur area is being researched by combining modeling to predict pollutant reductions from various best management practices and effects on farm profitability (Olson-personal communication).

Several additional studies are being conducted that may yield data useful for this project. The Minnesota Pollution Control Agency is embarking on a major cost-benefit analysis study relating to water quality and sewage treatment plants. The state is engaging in a Generic Environmental Impact Statement for large-scale feedlot-based livestock production. The Institute for Agriculture and Trade Policy (IATP) is adapting the Nutrient and Pesticide Yardsticks from Holland for quantifying changes in inputs and environmental parameters. It is also pursuing the development of private incentives for the production of benefits from agriculture. The results and methodologies from these and other studies will be reviewed in detail before a final determination on our methodologies is complete.

Quantifying non-market economic values

Researchers in the field of economics have developed methodologies to value non-market goods, such as travel costs and contingent valuation (Goulder and Kennedy, 1997). The methodology of contingent valuation has been reviewed and can play a useful role in defining non-market values (Cameron, 1997; Randall, 1997, Cangelosi, 1999). The Northeast Midwest Institute has studied the use of economic valuation techniques in the Great Lakes area. They will be releasing a Guidebook on approaches to conduct such valuations, including Contingent Valuation. Cangelosi (1999) suggests that "economic information is valuable, but should not be confused with 'answers' to environmental policy questions."

Another approach to valuing economic activity is to develop regional multipliers related to cost savings or the production of other net benefits. The IMPLAN simulation model produces regional multipliers based on the economic activity, time and size of area. The inputs and assumptions in the model could reduce its utility for working with integrated farming systems (MN IMPLAN Group, 1997; Sheets, 1998). We chose not to use the IMPLAN model because the scale of our research is too small (i.e., 40,000 acre watershed level instead of county or multi-county level) to have robust results with the model. Further, we would have had to conduct significant research to support changing the parameters (i.e., the multipliers) in the model to adequately represent the differences between industrial and non-industrial style agricultural systems.

Assessing other community impacts

Flora (1995) studied four communities in Minnesota and other states to track the changes in social capital. By using interviews, newspaper articles and direct observation, she and her colleagues looked at such things as amount of cooperation between community residents to work on civic projects, numbers of new businesses opening, improving the appearance of the town and so on.

Chism (1993) examined the impacts of different types and sizes of crop and livestock systems on levels of purchases of goods in local communities. His analysis relied on connections to Southwest Minnesota Farm Business Management Association out of which a sample of farmers was selected. Expense ledgers were reviewed and selected expenditures were analyzed for local spending.

Existing data In Minnesota

State, federal and local agencies have inventoried several watersheds in Minnesota (in both the Minnesota River and the Mississippi River drainage areas (MPCA, 1994). Some areas have detailed information on erosion potentials of various lands, drainage characteristics, crop productivity potential, precipitation, proximity to water courses etc. The University of Minnesota soils websites contain much useful information in the Minnesota and Mississippi Basin in southeastern Minnesota). The Minnesota River Assessment Program and the Metropolitan Council gathered extensive data in certain parts of the Minnesota River Basin. The Minnesota Institute for Sustainable Agriculture is conducting research on the relationship between improved soil quality and water quality on farming systems in the Minnesota River Basin.

State and local agencies have also kept track of the costs required to mitigate environmental problems resulting from land management and the value of agricultural production of different kinds. However, existing data have not been brought together in a systematic way to be able to evaluate the economic benefits of potential impacts of different production systems on non-point source pollution potential and other community factors (Larry Gates, personal conversation).

Summary

In addition to examining the impacts of future commodity based farming systems on ecosystems and communities, this project will evaluate the impacts of integrated agriculture systems whose purpose also includes the production of selected environmental and social benefits. There are a variety of methods and models that are relevant to this project.

Hypotheses

For the purposes of this LCMR project, we have developed two central hypotheses that we will test during the research:

1. There are discernable and different net benefits produced by different types of farming systems.

2. There are discernable and different net ecological and social benefits produced by different kinds of farming systems. Some of these benefits can be quantified and others can not be captured by quantitative indicators/measures.

III. Description of the methodology to be employed to carry out the proposed research.

A scoping session was held in early January 1999 with the Core Working Group and three people not currently on the team (Dr. Steve Light, Minnesota Department of Natural Resources planning; Dr. John Ikerd, University of Missouri; and Dr. Peter Ciborowski, Minnesota Pollution Control Agency.) Three others were invited to attend but last minute scheduling problems prevented their attendance (Dr. Julie Bunn, Macalester College; Dr. Paul Faeth, World Resources Institute; and Mr. Paul Johnson, director of Iowa Department of Natural Resources, farmer and former Natural Resources Conservation Service chief.) Conversations have been held with several Technical Advisors and others prior to the preparation of this design. We also are discussing with Dr. Cornelia Flora the possibility of her joining our Working Group in July 1999. This group developed the overall design and identified methodologies for each result.

The overall approach is first defined as a basis for completing the results. Methods are then identified for each result.

A. Overall design

<u>1) Interdisciplinary and multi-perspective decision-making and technical advice:</u>

- Project design, implementation, and interpretation of results will be overseen by an interdisciplinary *Core Working Group* (see section VII) of economists, farmers, natural resource and agricultural agency staff and nonprofit staff.

- We have enlisted technical advisors from research faculty and agency staff in Minnesota and elsewhere to serve on an ad hoc basis to advise the Core Working Group on overall study design, watershed selection, sampling design, baseline data collection, impact models, development of farming system scenarios, economic benefits estimation and data interpretation. They also will be asked to provide peer review for our methodological choices before we begin the characterization of land management. Thus far, nine people with differing expertise have been recruited to serve on a *Technical Advisory Group* for the project (see Section VII). This group will likely be expanded to include someone from the Northeast-Midwest Institute and others as needed.

- In each of the two watersheds, a *Local Watershed Advisory Council* will be formed to help identify existing farming systems, review baseline data, develop future scenarios and comment on economic calculations. It will include stakeholders from the watersheds.

<u>2) Watershed level of analysis:</u>

- The Core Working Group has narrowed the list of potential watersheds to four (each of 50,000 acres or less). Two watersheds were chosen by fall 1999 in consultation with a post doctoral scientist. These watersheds will be large enough to contain a town, but smaller than the Minnesota River Basin subwatersheds. This will allow us to model the production of benefits in a more specific ecological/social setting in two watersheds. One will be in the Minnesota River Basin and one may be in southeastern Minnesota with drainage to the Mississippi River. The final selection process will focus on availability of relevant data for models and the willingness to local groups to participate using criteria in the Appendix, Part One.

3) Local watershed citizen involvement and policy development process:

♦ The following process will be developed to use in a watershed setting (DNR, 1998).
- Choose Watershed Working Groups (Late summer 1999).
- Bring representatives into Core Working Group (early fall 1999).
- Use existing visions and long-term goals or develop if necessary (fall 1999).
- Confirm methodologies with citizens (fall 1999).
- Analyze selected key variables that are part of a cause-and-effect sequence[2] (winter 2000).
- Develop scenarios using "what if" options (spring 2000).
- Examine relationships among differing goals (spring 2000).
- Synthesize possibilities for change in watersheds (summer 2000).
- Develop scenarios about preferred futures for the watersheds (summer 2000).
- Identify sustainability criteria (summer 2000).
- Evaluate long-term policy options to influence choices in the watershed (fall 2000).

B. Methods for each result

These general design elements will be used to achieve results.

Result 1: Characterize existing land management practices in each watershed and apply or develop social and physical models to ascertain baseline data.

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[2] Through this process we will identify for each benefit the linkages between its positive (or reduced negative) impact and offsite enhancements (or level of damage). For example, soil erosion involves physical, biological and economic links. The loss of soil and nutrients leaves the field and enters streams. Once there, it has both physical and biological effects on water quality. The use of resources for recreation, tourism, etc is affected. That leads to economic impacts that may be costs, surpluses due to avoided costs, etc.

- Project staff will gather information from agencies and from surveys with representative farmers in the watersheds on existing production systems and land-use, and baseline environmental data. State, federal and local agencies have already inventoried several watersheds in Minnesota (in both the Minnesota River and the Mississippi River drainage areas (MPCA, 1994; MISA, unpublished). This information also will be reviewed by each watershed advisory council (fall 1999).

- Project staff will simulate the environmental impacts for each scenario using the World Resources Institute Growing Green model (Faeth, 1995) in conjunction with ADAPT model (Davis, 1998) to calculate changes in environmental benefits-see prioritized benefits list: Environment A1-A4 in Appendix, Part Two (spring 2000). We will use information and models provided by the DNR and USGS (Hawkins, private conversation) to estimate habitat and recreation/tourism impacts--see Prioritized Benefits List: Landscape B.1 in Appendix , Part Two.

- All data will be stored in a GIS system through the Minnesota Department of Natural Resources to aid analytical and visual comparisons between different farming systems within a watershed (Davis, 1998) (focused during first year).

- In partnership with Minnesotans for an Energy Efficient Economy, LSP will contract with Professor Gordon McIntosh to research options for evaluating carbon sequestration.

Result 2: Develop scenarios on future farming systems in each watershed.

- Using information from agencies, consultants, technical advisors and the Minnesota Institute for Sustainable Agriculture Sustainable Farming Systems project, the Core Working Group and the watershed advisory groups will develop scenarios for farming systems that will produce differing levels of multiple benefits. These groups will also be asked to review the preliminary scenarios developed by staff (winter 2000) .

  Possible scenarios include:
  - Commodity production of major crop(s) and concentrated animal production.
  - A Management Intensive Grazing system with a significant portion of grass in the operation, for which data on benefits exist.
  - The Wisconsin Integrated Cropping Systems Trial rotation that includes an organic or long-term crop rotation scheme.
  -A CRP regime where land is taken out of production.
  - A combined scenario that includes appropriately placed wetlands restoration, conversion to grazing, longer crop rotations and specific acreage for other practices.
  - Locally developed scenario(s) different than those already mentioned.

Result 3: Calculate economic benefits.

For the purpose of this study, we will estimate the economic value of certain non-market benefits. We will also include a qualitative component to consider additional social or ecological benefits, without attempting to attach a specific economic value to them. We will further discuss our economic valuation methods with staff from the Northeast Midwest Institute and utilize their Guidebook when it becomes available to help us finalize our methods.

- Where possible, we will calculate the economic benefits by using avoided costs for mitigation of ditch cleaning, lake reclamation, soil fertilization, flood control, etc. with available data from federal, state and local agencies--see Community Resilience: C.1 in Appendix, Part Two-- (summer and fall 2000).

- A statistically valid contingent valuation survey will be developed and utilized to determine the public's willingness to pay for changes in farming systems that produce high net environmental or social benefits (Goulder and Kennedy, 1997; Harrison and Lesley, 1996; Randall, 1997). Note that this will require a specific policy proposal to provide a basis for assessing impacts through the survey (fall 2000).

- Pending adequate funding, the IMPLAN community input/output model will be tested to see if watershed level economic impacts of the differing environmental/social benefits from each scenario in each watershed can be adequately quantified--see Prioritized Benefits List: Community Resilience C2 in Appendix, Part Two-- (MN IMPLAN Working Group, 1997). We have decided not to use IMPLAN for our analysis and to rely instead on the methodology employed by Drs. Cornelia and Jan Flora. IMPLAN results would not be sufficiently robust at a watershed level.

Assessing other community-level benefits:

- Selected additional community impacts will likely be analyzed through methodologies developed by Flora (1995) on social capital formation--see Prioritized Benefits List: Community Resilience C3 in Appendix, Part Two-- (fall 2000).

Result 4: Analyze and Interpret Data and Produce report.

- The Watershed Advisory Councils and Technical Advisors will be provided with the raw data and preliminary interpretations made by the Core Working Group. After reviews and discussion, a set of conclusions will be drafted (spring 2001).

- A final report will be produced and distributed to interested people.

IV. Description of results and products produced from the proposed research.

Results of this project will include having:

- Characterized existing land management practices in each watershed and existing environmental and social impacts for selected criteria such as water quality, soil erosion, wildlife habitat, biodiversity, local purchases from farming operations, social capital formation, etc.

- Developed scenarios for possible future farming systems in the watershed and the changes in equipment, training, infrastructure needed to change to those systems, if any.

- Calculated the economic value of the benefits available if each scenario were to be implemented in each watershed.

Products of the research will include:

- Local watershed groups engaged in the future of their watersheds and who have more information to determine how best to move in desirable future directions.

- More complete economic information for policy makers about the potential economic impacts from making choices about production systems in these watersheds.

- Information for the general public about the economic value of the multiple societal benefits that can be produced from agriculture.

- A final report providing details on the background, methodology, results and conclusions of the study.

V. Timetable for completing the proposed research

Phase I (scoping) completed prior to receipt of LCMR funding (with funding provided by the Joyce Foundation).
- Identified technical advisory panel members (October-November 1998)
- Held Scoping session (January 1999)
- Selected candidate watersheds (January 1999)
- Expanded Core Working Group (January 1999)
- Developed detailed study design (March 1999)
- Craft job description for post doctoral scientist (May 1999)
- Begin advertising for post doctoral position (June 1999)

Phase II: Beginning with LCMR funding July 1, 1999.
- Choose two watersheds (August 1999)
- Recruit watershed advisory committees (August 1999).
- Finalize methods (July 1999)
- Hold peer review with technical advisors (August 1999).

- Develop farm or field sample (September 1999)
- Characterize existing land management practices in each watershed and apply or develop social and physical models to ascertain baseline data (winter 2000)
- Develop scenarios on future farming systems in each watershed (winter 2000)
- Calculate benefits (beginning winter 2000 through fall 2000)
-Interpret data (winter 2000)
- Prepared project report (winter 2001)

Funds from Sustainable Agriculture Research and Education Program and private foundations will be used to conduct policy analysis and dissemination activities. Through these funds we intend to keep staff, including the postdoctoral scientist and graduate students employed with the project for a longer period of time than funds from LCMR allow.

VI. Budget:

A. See Attachment A.

B. LCMR funds will have leveraged the following resources:
- In kind contributions from faculty and agency staff are estimated to be at least $60,000.
- In kind contributions of time from technical advisors and others associated with the project who do not receive any payment (not yet estimated).
- The Joyce Foundation contributed $29,300 during the fall of 1998.
- Additional funds are being sought from other sources to complete the policy analysis and dissemination aspects of the original LCMR preproposal.

VII. Identification and brief background of principle investigators and cooperators

A. Listing of Core Working Group and Technical Advisors

MAJOR PARTICIPANTS

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B. Short biographies of Collaborators

NON-PROFIT PERSONNEL

Each has been involved in proposal development. Non-profit staff will continue as Core Working Group members and in the execution of the project through presentations (depending on availability) and other dissemination activities. They have responsibilities for project direction, coördination, organizing, data collection and interpretation, and dissemination.

1. The Land Stewardship Project:

George Boody, Executive Director. George was hired in September, 1990, as the General Manager of LSP and became the executive director in 1993. He coordinates the Monitoring Project in addition to administrative duties. George previously worked for the Minnesota Project and during the past fifteen years he has worked with farmers and professionals on sustainable agriculture, community development and energy conservation. George's background includes a master's degree in agriculture and nutrition from the University of Minnesota.

Richard Ness, Coordinator of Monitoring Project He also works with the Beginning Farmer Program. Richard has farmed, taught courses of Management Intensive Grazing and has a MS. in animal science from the Iowa State University.

Mark Schultz, Director, Policy Program From 1987 through 1989, Mark was the director of LSP's Farmland Investor Accountability Program, which successfully changed the conservation and farmland management policies and practices of major farmland owning insurance companies. He currently heads up LSP's policy efforts with priority on federal farm policy and livestock issues. Mark will direct activities described in this proposal. He graduated magna cum laude, Princeton University, 1980; B.A. in History.

Mara Krinke, Project Coordinator Mara Krinke was hired in November 1999 to coordinate the project, assist with modeling and facilitate ongoing outreach. Brad DeVries, located in Washington DC, was included on the project between July 1999 and October 2000 to help with outreach and maintaining regular contact with people on the National Policy Group.

LSP support staff contributing to the project. In addition, other LSP staff may be paid for work time allocated to this project including, accounting and/or administrative/clerical staff.

2. Others on the Core Working Group:

Dr. Steve Light is director of the Environment and Agriculture program at the Institute for Agriculture and Trade Policy.

ACADEMIC RESEARCHERS

Each has been involved in proposal development. These researchers will continue as Core Working Group members and in the execution of the project through presentations (depending on availability) and other dissemination activities. They will supervise key project staff in data collection, analysis and interpretation.

Dr. Frances Homans is an associate professor in the Department of Applied Economics, University of Minnesota, St Paul. She has received numerous awards for teaching and research. Her interests include resource development and environmental economics. She received her Ph.D. in 1993 in Agricultural Economics from the University of California, Davis. She will be supervising the post-doctoral scientist.

Dr. Patrick Welle is a professor of economics and environmental studies at Bemidji State University. His consultant work includes research for state, regional and local units of government on matters of cost benefits analysis, environmental policy, natural resource management, tourism and economic development. He has used economic surveys in much of that work. His consultant work with Minnesota Pollution Control Agency has included the use of Contingent Valuation. He will supervise a graduate student and the economic survey work.

Dr. Wynne Wright is a rural sociologist with a joint appointment at the University of Minnesota at Morris and the West Central Research and Outreach Center. Dr. Wright brings expertise in analyzing networks and social capital to the project.

Dr. Bruce Vondracek is in the University of Minnesota's Department of Fisheries and Wildlife. An ecologist, Dr. Vondracek brings his expertise to the project and will be supervising a research assistant on project work.

AGENCY PERSONNEL

Each has been involved in proposal development. These staff will continue as Core Working Group members and in the execution of the project through presentations (depending on availability) and other dissemination activities. Larry Gates will supervise GIS data processing.

Dr. Mary Hanks received her Ph.D. from Iowa State University in Plant Pathology. She is supervisor of the Energy and Sustainable Agriculture Program at the Minnesota Department of Agriculture. She is the author of publications about pathogens in corn and alfalfa.

Mr. Larry Gates is a program manager in the Department of Natural Resources, Section of Fisheries in southeastern Minnesota. He is a leader in the DNR's Integrated Resource Management project and in watershed coordinator and fisheries management positions within the Department. He received a B.S. from the University of Minnesota in Wildlife. He will supervise GIS work within the department.

FARMERS / RURAL PARTICIPANTS

Two farmers are participants. Each has been involved in proposal development. Farmers will continue as Core Working Group members and in the execution of the project through presentations (depending on availability) and other dissemination activities.

Mr. Dan French farms near Mantorville Minnesota. He and his family have a seasonal grass dairy farm. He is active in Holistic Resource Management training in the state and participates on national and state agricultural advisory committees including the technical committee of Sustainable Agriculture Research and Education Program in the North Central Region.

Dr. Paul Homme is a retired farmer with land on the Minnesota River. He previously served as a microbiologist with USDA and the Air Force. He completed his Doctorate of Veterinary Medicine in 1954 from the University of Minnesota, St. Paul.

Sister Kathleen Storms is a member of the order School Sisters of Notre Dame in Mankato Minnesota. She is co-founder of the Center for Earth Centered Spirituality. She participates on LSP's federal farm advisory committee. She brings an understanding of rural community impacts and connections.

APPENDIX

Part One Watershed Selection Criteria

- Level of pollutant impacts in each watershed.
- Presence or level of urbanization.
- Watersheds with significantly different agriculture (agroecosystems management zones).
- Kind and level of agricultural impacts on people and communities within the watershed.
- Opportunities to pay for multiple functions to avoid higher costs elsewhere.
- Opportunities to reward multiple functionality, not only to pay "bad actors."
- Sustainable agriculture practitioners in the watershed.
- Venues for active community involvement within the watershed.
- Available data to use in models.
- Includes a small community.
- Include an area experiencing significant financial losses due to low commodity prices.
- Moderate heterogeneity in watershed geomorphology.
- Perceived need for change by people in watershed.
- Perceived as agriculture watersheds by agriculture establishment.

Part Two Prioritized Benefits (Impacts) to Evaluate

We have prioritized indicators from each major section.

A. Environmental Benefits

1. Water quality
   sediment loading (WRI)
   discharge and runoff quantity (ADAPT)
   nutrient and pesticide runoff, leaching, (WRI/ADAPT in part)

2. Soil quality
   organic matter
   soil erosion rates (WRI/ADAPT)
   nitrogen deposition off-site (WRI/ADAPT)

3. Greenhouse gas balance (WRI/ADAPT)
   Carbon sequestration/release potential
   methane
   nitrogen oxides
   carbon dioxide

4. Land's capacity to hold water (depending on model outputs)
   flood water retention (ADAPT)
   speed and volume of water transfer (ADAPT)

B: Landscape values (aesthetic, recreational or inherent value)

- Habitat, recreational opportunities and tourism(USFWS habitat modeling/SCORP data plus DNR Madelia Station game modeling)

C. Resilience of local communities

1. Public costs
   - Avoided mitigation costs

@data collected from county/state/watershed agencies)

2. New economic opportunities for members of the community
   - $ net profit from sale of commodities, food or other products from farms
   - Potential Future levels of employment (Calculate using Boone county study approach)

@ IMPLAN model

3 Social capital
   - People have a say in community (active citizenry and volunteers)
   - People building strong relationships
   - Vibrancy of local institutions including churches
   - Viable functioning services (schools, hospitals, the arts, libraries)

@Flora and Monitoring Project methods

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