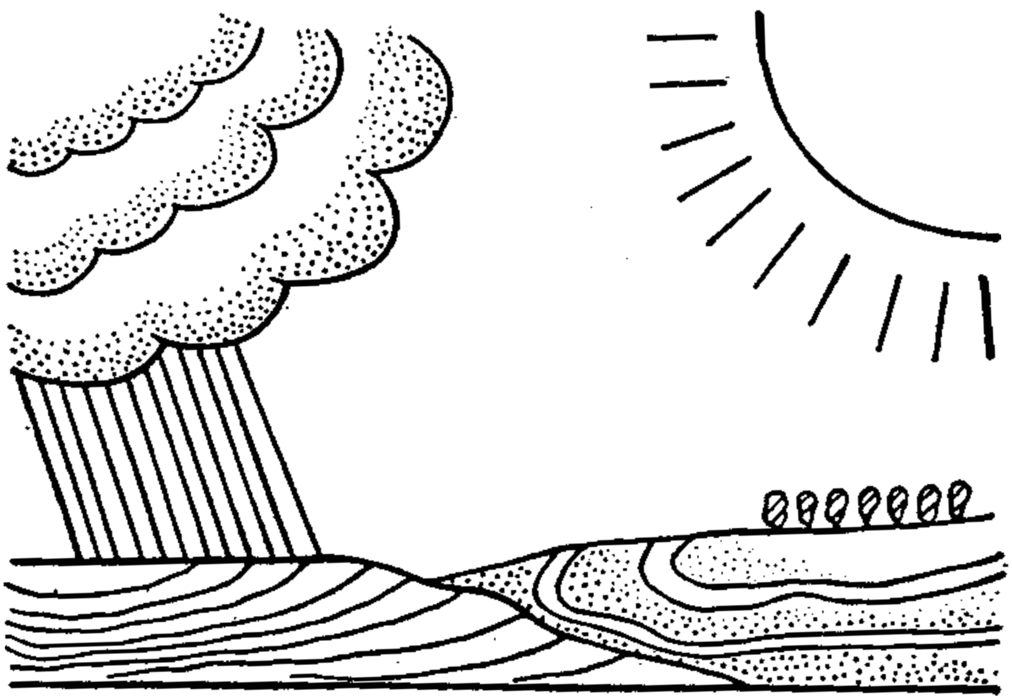
The Multiple Benefits of Agriculture

An Economic, Environmental & Social Analysis



By

George Boody & Mara Krinke

for the Multiple Benefits of Agriculture Project Team

Land Stewardship Project

White Bear Lake, Minnesota

November 2001

Funding

The Multiple Benefits of Agriculture Project was made possible by the generous support of three different entities, each funding different aspects of the project:

• ***The Joyce Foundation***. Funding from the Joyce Foundation supported the analysis and economic valuation of multiple environmental and community benefits attributable to various farming systems, and the measurement of consumer preferences and willingness to support the production of these benefits. The Joyce Foundation also supported the development of policy proposals that reflect the results of this project.

• ***Legislative Commission on Minnesota Resources (LCMR).*** Funding by the LCMR supported work to characterize existing land management in the chosen watersheds, develop scenarios for future farming systems in these watersheds, calculate economic benefits attributable to different scenarios, and analyze, interpret and report on the results. Funding for this project was approved by the Minnesota Legislature, 1999 Minnesota Laws, Ch. 231, Sec. 15, Subd. 7(n) as recommended by the Legislative Commission on Minnesota Resources from the Future Resources Fund.

• The ***USDA's Sustainable Agriculture Research & Education (SARE) Program.*** Funding by the SARE Program supported policy development based on the results of watershed modeling and analysis.

This material is based upon work supported by the Cooperative State Research, Education and Extension Service, U.S. Department of Agriculture, and the Nebraska Agricultural Experiment Station, University of Nebraska-Lincoln, under Cooperative Agreement number 99-COOP-1-7686. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the U.S. Department of Agriculture.

Project Direction & Input

The Project Team was composed of researchers, farmers and rural professionals. The steering committee met up to six times per year and provided continuing input and expertise for the project.

Team Members

• George Boody, Land Stewardship Project
• Jan Flora, Department of Sociology and Community Development Extension, Iowa State University
• Cornelia Butler Flora, North Central Regional Center for Rural Development, Iowa State University
• Dan French, Dairy Farmer, Mantorville, Minnesota
• Larry Gates, Minnesota Department of Natural Resources
• Mary Hanks, Minnesota Department of Agriculture
• Julie Henry, Department of Fisheries and Wildlife, University of Minnesota
• Frances Homans, Department of Applied Economics, University of Minnesota
• Paul Homme, Crop and Livestock Farmer, Granite Falls, Minnesota
• Mara Krinke, Land Stewardship Project
• Steve Light, Institute for Agriculture and Trade Policy
• Mark Schultz, Land Stewardship Project
• Kathleen Storms, School Sisters of Notre Dame, Mankato, Minnesota
• Bruce Vondracek, Department of Fisheries and Wildlife, University of Minnesota
• Pat Welle, Bemidji State University
• John Westra, Department of Applied Economics, University of Minnesota
• Wynne Wright, West Central Research and Outreach Center

Additional Researchers

• Cecilia Berg, Water Resources Center, Minnesota State University, Mankato, Minn.
• Marin Byrne, Institute for Agriculture and Trade Policy
• Kristen Corselius, University of Minnesota (with Jan and Cornelia Flora during their appointment as Endowed Chairs at the Minnesota Institute for Sustainable Agriculture)

Consultants

• Gordon McIntosh, Department of Physics, University of Minnesota-Morris (greenhouse gas report)
• Jim Vincent, Department of Economics, University of St. Thomas (advice on contingent valuation survey)
• The following individuals conducted in-person interviews for the contingent valuation survey: Kevin Bellmont, Jason Edens, Carole Johnson, Karen Shepard and David Strunk.

Technical Advisory Group

- Jim Anderson, Minnesota Pollution Control Agency
- Audrey Arner, farmer and Land Stewardship Project organizer
- Julie Bunn, formerly with Macalester College's Department of Economics, St. Paul
- Paul Faeth, World Resources Institute
- Prasanna Gowda, Department of Soil, Water and Climate, University of Minnesota
- John Ikerd, College of Agriculture, Food and Natural Resources, University of Missouri
- Paul Johnson, farmer and former chief of the Natural Resources Conservation Service, Decorah, Iowa
- Beth Knudsen, Wells Creek Watershed Partnership
- Ken Meter, Crossroads Resource Center
- David Minge, policy expert and former member of Congress
- David Mulla, Department of Soil, Water and Climate, University of Minnesota
- Kent Olson, Department of Applied Economics, University of Minnesota
- Kylene Olson, Chippewa River Watershed Project
- Bob Rupp, agricultural journalist, Stillwater, Minn.
- Terry VanDerPol, farmer and Land Stewardship Project organizer
- Bill Vorley, International Institute for Environment & Development (IIED)

Special Acknowledgments

The Multiple Benefits of Agriculture Project would also like to express its appreciation to the many people who provided help in the form of ideas, comments and editing: Brian DeVore, Dana Jackson, Beth Knudsen, Dick Levins, Steve Light, Susan Maas, David Minge, Kylene Olson, Bob Rupp, Caroline van Schaik, Bill Vorley, LSP's Federal Farm Policy Committee, and focus group participants.

Thanks to Marin Byrne (costs from flooding), Kristen Corselius Jan Flora and Cornelia Flora (social and economic indicators), Brad DeVries (multifuctional agriculture), Julie Henry (fish effects and birds), Gordon McIntosh (greenhouse gases), Pat Welle (contingent valuation), and John Westra (environmental and economic indicators) for their written contributions to this report, taken from other prepared reports.

This is a publication of the Land Stewardship Project. For more information, contact the Land Stewardship Project at 2200 Fourth Street, White Bear Lake, MN 55110; phone: 651-653-0618; fax: 651-653-0589; e-mail: lspwbl@landstewardshipproject.org;
Web site: www.landstewardshipproject.org.

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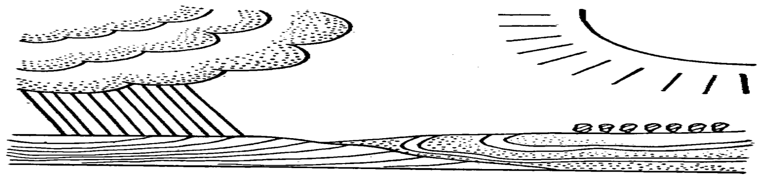
An Economic, Environmental & Social Analysis

Table of Contents



It is economically and environmentally beneficial to shift agriculture toward more diverse systems on actively farmed land—and if financial incentives motivate change, citizens are very willing to pay.

These are some of the key findings of the Multiple Benefits of Agriculture Project. This analysis, which was conducted in two Minnesota watersheds over a two-year period, concludes that the value of nonmarket goods, such as reduced soil erosion and improved wildlife habitat, merits significant changes in U.S. farm policy. This modeling study also confirms that if present land use trends continue, environmental, social and economic problems will worsen.

American agriculture produces bin-busting yields of a handful of commodities. However, this analysis shows that it can do much more for local communities and society at large. There is a growing recognition among farmers, policy makers, environmentalists and the public that agriculture can produce food and fiber while creating other, nonmarket "goods" such as environmental and social benefits, including rural prosperity.

How does society encourage agriculture to produce multiple goods beyond high yields? With financial incentives. And by calculating the value of certain goods, society can better determine what incentives are needed to foster and support a farming system that will bring about these goods.

That's why the Multiple Benefits of Agriculture Project was launched. A 15-member working group used modeling to predict the environmental and social benefits that could result from changing agricultural land use practices in two Minnesota watersheds. These quantitative and qualitative public (nonmarket) benefits include improved water quality, less soil erosion, enhanced soil quality, increased wildlife habitat and social capital formation, as well as toxic chemical and greenhouse gas reductions.

The analysis found that significant improvements could be attained through a combination of land use changes, ranging from individual practices (e.g. adoption of minimum tillage) to more comprehensive systems (e.g. establishment of perennial plant systems and wetlands).

This analysis shows that there is no one cookie-cutter method for bringing about positive results in all watersheds. For example, in the less row-cropped watershed studied, adoption of best management practices—

Key Findings

Soil Erosion

✔ Switching from conventional tillage to conservation tillage reduced the amount of soil eroding into streams by 25 percent to 31 percent, depending on the watershed studied.

✔ Switching to an agricultural system that is more reliant on perennial plant systems reduced the amount of soil eroding into streams by 50 to 80 percent, depending on the watershed.

Water Quality

✔ In the Wells Creek study area, adoption of best management practices—100-foot grass buffers, conservation tillage on all cropland and nutrient application at recommended rates—would help meet national goals for reduction of the hypoxic zone in the Gulf of Mexico (40 percent in-stream reduction of nitrogen). In Wells Creek, there are many small tributaries, the land is hilly and significant tree and grassland cover is part of the current land use. Dairy farming is a major part of the agricultural economy.

✔ In the Chippewa River study area, however, adoption of best management practices would not produce results adequate to meet national goals for hypoxia reduction. In this case, meeting such goals would require adoption of more diverse farming systems that involve the use of perennial plant systems and natural drainage features such as wetlands. The land near the Chippewa River is relatively flat and includes significant artificial drainage. The Chippewa River study area, with its intensive tillage of corn and soybeans, is representative of the way the Corn Belt as a whole is farmed.

Financial

✔ Substantial levels of environmental benefits could be achieved for little more and possibly less than what taxpayers currently pay into federal farm programs.

✔ On average, Minnesota citizens are willing to pay annually an additional $201 per household for specific and substantial public benefits that are produced under

Key Findings *continued on page 2…*

…Key Findings *from page 1*

diversified land use and farming systems.

✔ The annual downstream costs of sedimentation could be cut 50 to 84 percent, depending on the watershed, by switching to a more diverse farming system that includes perennial plants and wetland habitat. Other significant "avoided costs" could reduce the need for such things as minor flood damage mitigation and trout stream habitat renovations.

✔ Based on 2000 market prices, hay and other perennial plant enterprises are more profitable in the study areas than corn and soybeans. However, federal subsidies often make it uneconomical to raise anything other than corn and soybeans. That is a significant disincentive for diversifying farming operations. Society needs to replace those subsidies with incentives for creating public goods.

Greenhouse Gas Reductions

✔ Greenhouse gas emissions, in carbon equivalent, would be reduced as much as 36 percent in the Chippewa River watershed if more perennial plant cover were used on the working landscape.

✔ Based on a $20-per-ton "price" for storing carbon to reduce greenhouse gas emissions, the average Minnesota crop farm (318 acres) could receive $1,000 per year for using conservation tillage. Pasture and grazing systems should benefit even more because they hold even greater potential for capturing and retaining carbon in the soils.

Wildlife Benefits

✔ In the Wells Creek watershed, diversifying the agricultural system would reduce lethal fish events by more than half. A scenario where a diversified agriculture is combined with the presence of increased wetlands and other characteristics of natural landscapes would decrease lethal fish events by almost 100 percent.

100-foot grass buffers, conservation tillage on all cropland and nutrient application at recommended rates—would go a long way toward meeting national goals for reducing the contaminant runoff that contributes to the hypoxic zone in the Gulf of Mexico. However, in the more row-cropped watershed, adoption of best management practices would not be enough to meet those national goals. In this case, meeting such goals would require more diverse farming systems that involve the use of perennial plant systems.

Different types of geography, climates, soil types and even social infrastructures require a variety of strategies for bringing about public goods in different watersheds. If farmers were to adopt more crop diversity and perennial cover in the watersheds, rather than simply improving management of the dominant row crops, more environmental benefits would result. The policy recommendations that emerge from the Project's analysis focus on creating incentives for farmers to use their own creativity to produce results that benefit the public while fitting local situations best.

Minnesotans are willing to provide those incentives. On average, Minnesota households would be willing to pay an additional $201 per year, per household, or a total of $362 million, for significant improvements in environmental performance, according to a random statewide survey conducted by the Project. That shows citizens put an economic value on "goods" that may not be available for purchase in the marketplace. The Project's survey of local watershed residents shows an urgent need to develop public policy, research, education and marketing strategies to promote greater diversification of food and fiber production in ways that yield clear environmental and social benefits. Local, state and federal institutions, along with the residents they serve, must adapt if they are to provide the support needed to develop a "multiple benefits" agriculture.

Considerable levels of environmental benefits could be achieved for no more than and possibly less than the current public costs, after transition expenses are overcome, according to an analysis of farm financial data conducted by the Project. Redirecting stewardship incentive payments would lead to environmental improvements for little or no extra cost to the taxpayer.

But redirecting such payments will mean major changes in policy. Current federal agricultural policies subsidize the production of a selected set of commodities. Production of those commodities through monocultural systems has contributed to serious environmental problems. Moreover, there has been a significant decrease in the number of agricultural producers, inflicting major damage on rural economies. Conservation policies have attempted to mitigate environmental problems through technical assistance and cost-share programs to improve farming practices. In recent years, acreage retirement programs have become a major tool for environmental mitigation on agricultural lands. In fact, about 70 percent of conservation spending since 1985 has been for land retirement programs. However, these programs do not address agricultural working lands, which represent approximately half—excluding Alaska—of the privately held acreage in this country.

The results of this study clearly point to the need for new farm policies that produce benefits on working lands by rewarding real results. This will require the harnessing of imagination and creativity—the products of thought and thoughtful practice.

The Project is recommending further development of a policy framework that differentiates between agricultural market and nonmarket public goods. The results of Phase I research strongly suggest seven key policy elements that need to be further developed:

☛ ***Pay farmers for public environmental and social benefits from their farms, including those resulting from ongoing and newly adopted practices and farming systems.***

☛ ***Provide incentives to farmers through programs that graduate payments according to increasing levels of stewardship on working lands.***

☛ ***Move toward paying on the basis of environmental results, not simply the installation of practices.***

☛ ***Create and expand new markets for crops used in diversified farming systems through rural development and marketing program funding.***

☛ ***Redirect research, education, extension and conservation technical assistance to more effectively promote stewardship, integrated farming systems and diversified marketing.***

☛ ***Create conditions for fair market prices and fair access to markets.***

☛ ***Develop a process for national and local goal-setting and public involvement.***

About the Research

The study areas were the entire Wells Creek watershed in southeast Minnesota, and the lower Chippewa River Basin in western Minnesota. The Wells Creek watershed includes 40,172 acres in Goodhue and Wabasha counties. Sixty-one percent of the acres are cultivated. There are many small tributaries, the land is hilly and significant tree and grassland cover is part of the current land use. The Chippewa River study area is 44,445 acres. Eighty-one percent of the acres are cultivated. The land is relatively flat and includes significant artificial drainage.

Four scenarios were developed for this analysis:

Scenario A

The ***extension of current trends scenario*** is characterized by fewer and larger farms with increasing acreage in row crops and no significant trend toward the application of best management practices.

Scenario B

The ***adoption of best management practices (BMPs) scenario*** includes conservation tillage, 100-foot buffers along streams, and recommended nutrient application rates on all farmland.

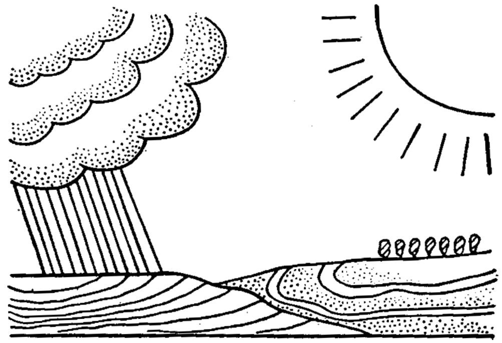
Scenario C

The ***expanded community and economic diversity scenario*** focuses on increased agricultural diversity.

Scenario D

The ***managed year-round cover*** scenario is characterized, when possible, by continuous plant cover on working farms.

Using the Agricultural Drainage and Pesticide Transport (ADAPT) model and the four citizen-shaped land use scenarios, researchers were able to model “what if” scenarios. The ADAPT model was used to predict in-stream environmental benefits, including impacts on fish for each scenario. Potential wildlife effects and greenhouse gas emissions were calculated based on reviews of other scientific literature. Social scientists used research on current demographic trends, interviews with farmers, focus group discussions and an institutional analysis to calculate social and farm economic impacts. Economists estimated nonmarket economic values for environmental benefits by calculating avoided costs and by performing a contingent valuation survey of Minnesota citizens.



1 Baseline

This chapter contains four sections that introduce the two watersheds and provide an overview of the environmental, social and economic baselines in each study area.

1.1 Wells Creek watershed

Almost three-quarters of the Wells Creek watershed is in agriculture; 61 percent of Wells Creek is in crops—mostly corn and soybeans managed with conventional tillage. Approximately 10 percent of the Wells Creek land is in grass.

Wells Creek is located in southeastern Minnesota and is a tributary of the Mississippi River (Exhibit 1). The Wells Creek watershed includes 40,172 acres in Goodhue and Wabasha counties. It winds through 18 miles of blufflands and empties into the Mississippi near Old Frontenac, southeast of Red Wing. The overall average slope in Wells Creek is 6.5 percent and average rainfall per year is 29.5 inches.

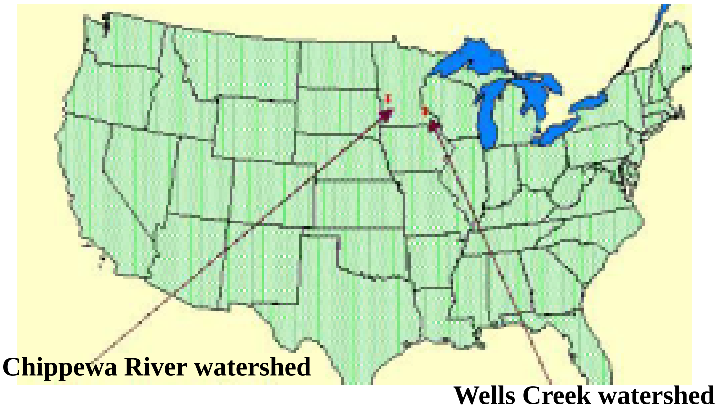
The Wells Creek watershed consists of forests, blufflands and cultivated lands. The top of the watershed has rolling croplands interspersed by many small tributaries draining into Wells Creek, which then drop steeply through forested valleys with scattered goat prairies atop cliffs. The creek drains directly into the Mississippi River just as the Mississippi widens into Lake Pepin. Lake Pepin, which is 25 miles long and two to three miles wide, has multiple recreation and transportation uses. Wells Creek is only 50 miles southeast of downtown St. Paul. As a result, the watershed is subject to development pressures.

As shown in Appendix E, agriculture dominates the landscape, with 71 percent of the land in agricultural uses. Sixty-one percent of Wells Creek is in crops—mostly corn and soybeans managed with conventional tillage. Approximately 10 percent of the Wells Creek land is in grass. Corn and soybeans make up over half the tilled acreage of the area, with barley, oats and pasture land present. Forage production is strong because of the large number of dairy cows in the region. Of the grassland, 90 percent is in pasture and 6 percent is in a management intensive rotational grazing system. Three percent of the agricultural land is in some sort of government program. Most of the remaining acreage (26 percent of the watershed) is deciduous forest. Frontenac State Park and Lake Pepin are large natural resources that provide recreation and revenue in the region.

Glaciers, water and wind shaped the land in the watershed. Before European settlement, the vegetative types in the watershed included oak forest, maple-basswood forest, floodplain forest, oak woodland brush, bluff prairie and willow swamp. Permanent vegetative cover held water and soil on the land, maintained high water quality, and minimized fluctuations in water temperatures in the creek. Almost two-thirds of the watershed is composed of soils in the Seaton-Chaseburg association, which is a silty-loam, well drained to moderately well-drained with an average slope of 8.3 percent. Twenty percent of the watershed is composed of Seaton-Chase-Timula soil, a silt loam with a rocky/flinty texture and an average slope of 5.7 percent.

An estimated 39,615 tons of sediment, 3,001 tons of nitrogen and 7,547 pounds of phosphorus reach the mouth of the watershed each year (Exhibit 4). These numbers represent a modeled 50-year average, as described in Section 1.3 and Appendix B.

***Exhibit 1*: Watershed areas studied**



The Wells Creek watershed is home to 1,500 people. Farmers make up 54 percent of the residents, an additional 16 percent of residents live in an incorporated area, and the remaining 30 percent of residents live in the rural area. Fewer people are directly involved on farms or in the logging industry than in the past, but family farms continue to dominate the Wells Creek landscape. Recent struggles include increasing land prices and farm size, which have driven some farmers out of business and deterred prospective farmers.

Goodhue County, home of most of the Wells Creek watershed, has seen a 5 percent increase in population over the past 10 years. This is a homogenous region, with 96 percent of the population defined as Caucasian. Goodhue County's estimated population for 1999 was 43,367. The proportion of youth has grown, while the elderly population has declined by 1 percent over the past five years. Despite these shifts, total school enrollment has declined by 16 percent over the past five years. On average 78 percent of the watershed's residents are high school graduates, and 14 percent graduated from college. These education levels are both below the state averages of 82 and 22 percent, respectively. Residents of the Wells Creek area face increased demand for their property, as new and potential residents see the area as attractive for residential development.

Agriculture, wholesale trade, retail trade and recreation are the main industries in Goodhue County. Median household income is $43,192 and per capita income is $26,774. Minnesota median income is $41,591 and the per capita income is $29,263. The number of farms fell 12 percent over 10 years, from 1,700 in 1987 to 1,500 in 1997. Consolidation in the dairy industry has occurred. Full and part-time employment grew by 5,844 from 1990 to 1998 and private nonfarm establishments have increased by 15 percent over the past eight years.

1.2 Chippewa River Watershed Study Area

The Chippewa River is located in western Minnesota and is a tributary of the Minnesota River (Exhibit 1). The Chippewa River watershed study area is 44,445 acres immediately upstream from the confluence of the Chippewa and Minnesota rivers in Chippewa and Swift counties.

The Chippewa River study area has a greater proportion of farmland than Wells Creek, with 82 percent in agricultural practices. Seventy-five percent of the Chippewa River study area is planted to crops, with corn and soybeans under conventional tillage dominating, followed by corn and soybeans in conservation tillage. Corn and soybean systems total 85 percent of the cultivated land. Approximately 7 percent of the land is in grasses, mostly as pasture. Some farmers are practicing management-intensive rotational grazing. Seven percent of the study area is in some sort of government program, 6 percent in grassland-shrub-tree classification, 3 percent in development, and 2 percent in water or wetland.

This watershed typifies what is found throughout the Corn Belt, where 81 percent of the farmed acres are cultivated. The Chippewa River landscape is relatively flat and includes a significant amount of artificial drainage. The average slope of the Chippewa study area is 2.2 percent and average rainfall per year is 25.3 inches. It is a former prairie area interspersed with trees along the stream corridors and pothole wetlands. Historically, the river levels were stable enough to support wild rice and abundant wildlife populations. The study area is the lowest part of the Chippewa River watershed, comprising about 3.3 percent of the Chippewa basin.

Approximately 2,000 tons of sediment, 13,966 pounds of nitrogen and 5,108 pounds of phosphorus reach the mouth of the watershed from the study area annually (Exhibit 5). Taking into account differences in topography across the watershed, these estimates equate reasonably with measurements made by the Minnesota Pollution Control Agency (1997).

Dominant agricultural practices are row crop production: corn, soybeans and sugar beets. This study is focused on the southwestern portion of the watershed to create a study area comparable to Wells Creek. Alternative farmers are turning to grass-based livestock feeding rather than row crops for livestock and poultry production. During the past decade, Chippewa County has seen a decrease in acres in farmland. In Appendix E, a map shows the current land use in the Chippewa River watershed study area.

Soil textures range from silty clay to silt loam. A third of the soils in the study area are in the Rothsay-Sverdrup-Egeland association, characterized by nearly level to rolling hills and well or somewhat excessively drained loamy soils. A quarter of the watershed is in the Waybay-Glyndon-Quam association, characterized by silty soils that are moderately well-drained, somewhat poorly drained and very poorly drained. Water erosion potentials in this agro-ecoregion are high on 25 percent of the land. Wind erosion potentials are high on 40 percent of the land.

Seventy-five percent of the Chippewa River study area is planted to crops, with corn and soybeans under conventional tillage dominating, followed by corn and soybeans in conservation tillage. Of the cropped acreage, 85 percent is dedicated to corn and soybean production.

Unlike Wells Creek, most of the residents in this study area live in town—over three-quarters of the households lie within the city limits of Montevideo in Chippewa County. Others are in Watson, a town of approximately 200 people located on a bluff west of the Chippewa River. The rest live in rural areas of the watershed. Chippewa County has a population of approximately 13,028. It lost population between 1990 and 2000, declining 5 percent (following a 12 percent loss between 1980 and 1990). The area is homogenous, with 97 percent of the population defined as Caucasian. Unlike many parts of the state, ethnic diversity has declined slightly over the past five years. Chippewa County is an aging population—21 percent of the residents are considered elderly. Primary and secondary school enrollment continues to decline. Seventy-four percent of the residents are high school graduates and 11 percent have college degrees. Those education levels are below the state averages of 82 and 22 percent, respectively.

Besides agriculture, the three largest industries in Chippewa County are manufacturing, retail, and the lodging and food service industry. The unemployment rate in 1997 was 5 percent—higher than the state average of 2.8 percent. Median household income was $34,301. Full- and part-time employment rose by 1,261 between 1990 and 1997, indicating positive employment growth in the region. Agriculture, the area's major industry, has shifted dramatically over the past 10 years. Between 1987 and 1997, average farm size increased, while numbers of full time farmers decreased by 15 percent. Private non-farm establishments in Chippewa County have increased by 2.9 percent during 1990 and 1998, indicating a switch to non-agriculture-related industries.

1.3 Environmental

The delivery of sediment, nitrogen and phosphorus varies widely on different soil types under different farming practices.[1] Exhibits 2 and 3 show the edge-of-field loss estimates from different existing farming systems in both the Wells Creek and the Chippewa River studies. The differences are due to variations in soil types, weather, geography and variations in farm management techniques (e.g., tillage, nutrient application, etc.) between the two study areas. The erosion numbers reflect only water-based erosion, which is a more significant contributor to sedimentation in Wells Creek than in the Chippewa River study area.

Estimated sediment losses (via water) in the Wells Creek watershed range from 12.5 tons per acre under conventional tillage to less than 100 pounds per acre under different pasture systems. Shifting from conventional tillage to conservation tillage in a continuous corn system reduces sediment by almost half. Nitrogen does not decrease substantially under conservation tillage, although phosphorus dropped by over 60 percent. Continuous corn systems showed better soil retention under conventional tillage than corn and soybean systems, but have significantly higher nitrogen losses, due to intensive fertilizer application during spring runoff.[2] Estimated sediment and nutrient losses from water are much lower in the Chippewa River study area than in the Wells Creek watershed, due primarily to the different soil types, drainage systems, and slope of the land. As in Wells Creek, there are dramatic differences among existing farming systems in sediment and nutrient losses (Exhibits 2 and 3).

Estimated sediment losses (via water) in the Wells Creek watershed range from 12.5 tons per acre under conventional tillage to less than 100 pounds per acre under different pasture systems. Estimated sediment and nutrient losses from water are much lower in the Chippewa River study area than in the Wells Creek watershed.

Aggregated losses in the baseline for the Wells Creek watershed are shown in Exhibit 4.[3] In the baseline, Wells Creek loses an average of 39,615 tons of sediment to the Mississippi each year. The range of loss varies by year due to factors such as annual rainfall and the timing of field operations. Depending on the year, between 1,419 tons and 98,841 tons might be lost to the Mississippi River. Aggregated losses in the baseline for the Chippewa River study area are shown in Exhibit 5. Approximately 2,817 tons of sediment are lost each year to the Minnesota River. The range of sediment losses is between 11 and 11,670 tons per year.

Comparing the data between the study areas, total sediment losses are substantially lower in the Chippewa region (1,956 tons per year) than in Wells Creek. However, overall nitrogen losses are higher in the Chippewa, due partially to the higher proportion of conventionally-tilled acres in the Chippewa River study area than the Wells Creek watershed. Looking at the data based on losses per farmed (crop or pasture land use) acre, nitrogen losses in the Chippewa River study area are almost four times higher than in Wells Creek—0.39 pounds per acre per year compared to 0.11 pounds per acre per year.

Bird Populations

Wells Creek supports a wide diversity of birds, including eagles, hawks and ducks. Game birds in the watersheds include turkey and pheasants.

In the Chippewa River study area, native tallgrass prairie, wetlands and prairie potholes have been converted to cropland and forested areas. The study area supports a number of grassland species, although savannah sparrows and bobolinks are among the species in decline. The purple martin and barn swallow are among the species increasing in the region but declining overall.

[1] Modeling was conducted using the Agricultural Drainage and Pesticide Transport (ADAPT) model. Farmer surveys of local practices, soil and drainage data and 50-year weather records were used to construct these results. Details on the methodology employed for this study can be found in Appendix B.

[2] A full list of the edge-of-field losses for each farming system and soil type can be found at www.landstewardshipproject.org.

[3] A full list of the annual losses for each study area can be found at www.landstewardshipproject.org.

Exhibit 2: Edge-of-Field Losses—Comparison between Farming Systems in the Wells Creek Watershed*

	Sediment Loss (tons per acre)	Nitrogen Loss (pounds per acre)	Phosphorus Loss (pounds per acre)
Grazing	0.00	0.00	0.02
Pasture	0.00	2.20	0.20
Small Grain/ Alfalfa Hay	0.93	0.27	1.63
Corn/Soybean Conventional Tillage	12.51	6.25	0.36
Corn/Soybean Conservation Tillage	6.65	5.28	0.14
Corn/Corn Conventional Tillage	10.00	40.21	0.14
Corn/Corn Conservation Tillage	9.79	37.34	0.12

* Numbers represent area weighted averages for a selected sample of farming systems. Systems shown are based on farmer interviews. A full list of the edge-of-field losses for each farming system and soil type can be found at www.landstewardshipproject.org.

Exhibit 3: Edge-of-Field Losses—Comparison between Farming Systems in the Chippewa River Watershed*

	Sediment Loss (tons per acre)	Nitrogen Loss (pounds per acre)	Phosphorus Loss (pounds per acre)
Grazing	0.00	0.00	0.01
Pasture	0.00	1.00	0.09
Small Grain/ Alfalfa Hay	0.00	.635	.258
Corn/Soybean Conventional Tillage	0.27	4.15	0.03
Corn/Soybean Conservation Tillage	0.51	3.37	0.01
Corn/Sugar Beets Conventional Tillage	0.40	2.00	0.02

* Numbers represent area weighted averages for a selected sample of farming systems. Systems shown are based on farmer interviews. A full list of the edge-of-field losses for each farming system and soil type can be found at www.landstewardshipproject.org.

***Exhibit 4*: Wells Creek Watershed Losses**
Annual Delivery of Sediment, Nitrogen & Phosphorus to Watershed Outlet

	Sediment	Nitrogen	Phosphorus
Annual Watershed Loss	-39,615 tons	-3,001 pounds	-7,547 pounds
Losses per farmed acre (27,413 farmed acres in watershed)	-1.45 tons/acre	-0.11 pounds/acre	-0.28 pounds/acre
Losses per acre averaged over watershed (40,172 total acres)	-0.99 tons/acre	-0.07 pounds/acre	-0.19 pounds/acre

***Exhibit 5*: Chippewa River Study Area Losses**
Annual Delivery of Sediment, Nitrogen & Phosphorus to Watershed Outlet

	Sediment	Nitrogen	Phosphorus
Annual Watershed Loss	-1,956 tons	-13,966 pounds	-5,108 pounds
Losses per farmed acre (36,272 farmed acres in watershed)	-0.05 tons/acre	-0.39 pounds/acre	-0.14 pounds/acre
Losses per acre averaged over study area (44,435 total acres)	-0.04 tons/acre	-0.31 pounds/acre	-0.11 pounds/acre

Fish Populations

In both study areas, land use has led to a change in stream structure, altering the relative abundance of species and resulting in fish communities dominated by species tolerant to increased temperature and sediment concentrations.

Goodhue County's Wells Creek is in the driftless area of southeastern Minnesota. Fed mainly by groundwater, it historically supports a cold water fish community, with low species diversity and naturally reproducing trout populations. Its headwaters originate in relatively flat agricultural fields, flowing through a valley bordered by steep bluffs and draining into the Mississippi River. A Minnesota Department of Natural Resources stream survey (DNR 1999) identified nine fish species in Wells Creek, which is fairly high for a cold water stream. White sucker (Catostomus commersoni) was the most common species, with creek chub (Semotilus atromaculatus) also present. Both are tolerant of high temperature and high sediment concentrations (Lyons 1996). Brown trout (Salmo trutta) were present in low numbers, although some natural reproduction was noted. Overall assessment for the 1999 stream survey was that stream habitat conditions were fair, with minimal adult fish cover. Bank erosion was severe in many sections, with some eroding banks nearly 40 feet high (DNR 1999).

The Chippewa River is a warm-water river, with a diverse fish community and temperature ranges of 23 to 26 degrees C in August (DNR 1998). It drains relatively flat cropland, which was primarily prairie and wet prairie prior to European settlement, and empties into the Minnesota River near Montevideo. In a 1998 survey (DNR 1998), 19 fish species were identified, with silver redhorse (Maxostoma anisurum) and carp (Cyprinus carpio) being the most common species. Walleye (Stizostedion vitreum), northern pike (Esox lucius) and channel catfish (Ictalurus punctatus) were present, although in low numbers.

Chippewa River water quality measurements indicate some sublethal effects to fish may be occurring due to current sediment concentrations. Chippewa stream surveys indicate three top carnivores (northern pike, channel catfish and walleye) are present, although in low numbers.

The Minnesota River Citizens' Advisory Committee's report to the Minnesota Pollution Control Agency concluded that:

> "*What can be said with reasonable certainty is that the river was a cleaner, more healthy system before Europeans settled in the valley. The explorers' journals described river water that was safe for drinking and human contact. The river system at that time supported healthy populations of fish and wildlife. Wild rice, which requires stable water levels and clear water to grow, was commonly found along the river above Mankato"* (MPCA 1994).

"Land values seem to be connected to big changes in the river. When I was a kid, I spent every day fishing the river. Erosion really accelerated with increases in land values in the early eighties. Draining wetlands was common with the high land values at that time. However, due to these changes, we can no longer fish in the river and the bottom is really muddy." —Mike Berven, Chippewa River farmer

During a Multiple Benefits of Project focus group session, Mike Berven, living on a three-generation family farm along the Chippewa River, made this comment about land values, farming and the quality of the river's fishing and swimming waters:

> "*Land values seem to be connected to big changes in the river. When I was a kid, I spent every day fishing the river. Erosion really accelerated with increases in land values in the early eighties. Draining wetlands was common with the high land values at that time. However, due to these changes, we can no longer fish in the river and the bottom is really muddy."*

1.4 Human, Social & Financial Capital

Human capital is described as the skills, health, values, leadership and education of people. The ability of people to obtain and process information is influenced by human capital. Sources of human capital include neighbors, local elevators, the extension service, crop consultants, trade and agricultural journals, and veterinarians. Farmers who grow crops for commodity markets rely on traditional sources of agricultural information to help them with their management decisions. Farmers who grow crops or raise livestock for direct-to-consumer sales or niche markets mention a lack of local information and resources to help inform their management decisions. Most turn to outside sources, including Appropriate Technology Transfer for Rural Areas (ATTRA), the organic industry and grazing networks (farmer interviews, October 2000).

Focus group participants commented on the strong out-migration of young people under the current scenario. Their comments are supported by data that show lower-than-average education levels. This suggests that few young people return home after obtaining an education. While it might be advantageous to a community for its young people to "go out in the world" to gain experience, an education, or life and work skills, focus group participants expressed a desire to keep their communities vital with a strong population of young adults (Chippewa focus groups, April 2000).

Social capital involves mutual trust, reciprocity, groups, collective identity, a shared future vision and working together. Social capital contributes to the formation of financial and human capital. Social capital that forms between like people or groups is called ***bonding*** social capital. Social capital that forms between or among groups with different interests is called ***bridging*** social capital.

For alternative farmers in both the Wells Creek and Chippewa River study areas, building bonding social capital through strong direct marketing connections is central to the financial health of their agricultural systems.

Conventional farmers, on the other hand, rely on formal contracts as a source of bonding capital. Focus group members suggest that there is a lack of bridging capital in the Chippewa River study area (focus groups, April and May 2000; farmer interviews, October 2000).

Alternative or sustainable farmers have developed strong bonding capital, evidenced by frequent meetings, support in buying each other's products and networked relationships. Conventional farmers and related businesspeople have also developed strong bonding capital, evidenced by close marketing arrangements. Some Chippewa River study area residents, however, expressed great frustration over the lack of diversity and acceptance of innovation in their community. This may demonstrate a lack of sufficient bridging social capital, as different groups are not likely to be accepted or encouraged to communicate within the community (Chippewa focus group, April 2000). An effort to enhance bridging social capital in the region is the Chippewa River Watershed Partnership (CRWP), which was initiated to protect the health of the watershed. The CRWP includes government, business, citizens, and elected officials. Residents are invited to attend meetings and encouraged to engage in citizen monitoring of water quality in the watershed.

Residents who participate in the Wells Creek Watershed Partnership are a tightly bonded group, focusing on a shared vision of improving water quality and related environmental outputs in the watershed. Together, they have raised money to conduct stream monitoring, generated interest in the watershed through tours and other social and educational activities and generated investments in structures that will slow water on its way to Wells Creek and its tributaries. The watershed partnership was initiated in 1993 by the Minnesota Department of Natural Resources. The watershed partnership is an example of bridging social capital (Chippewa and Wells Creek focus groups, April and May 2000).

Some Chippewa River study area residents expressed great frustration over the lack of diversity and acceptance of innovation in their community.

Financial capital includes structures that support the economy. Farmers from both study areas expressed concern about the consolidation of elevator companies and the decrease in farmers' marketing options. Alternative farmers have turned to resources outside of the region for seed, livestock and inputs because the current local infrastructure does not adequately supply their needs. Similarly, products from alternative farmers that are not sold locally through direct markets are moved to markets outside the region (Chippewa and Wells Creek focus groups, April and May 2000).

Farm and Population Dynamics

Farming in general has been undergoing rapid change, from shifting crop mixes to numbers of people managing private land. In 1972 in 12 Corn Belt states, 97 counties had over 55 percent of their land area planted to corn and soybeans. By 1998, 267 counties had over 55 percent planted to corn and soybeans. Of those 55 counties with 80 percent of land in corn and soybeans, 51 lost population between 1980 and 1990. The four counties with increases in population were near urban centers (Sperbeck 1999).

Farms in both watersheds studied by the Project continue to grow in size, with existing farmers buying out their neighbors, who switch professions or retire. Leasing of land has become more common in recent years, with management companies operating on large, not necessarily contiguous, acreage. In nearby areas of the state, producers report some management companies lease over 10,000 acres—one-fourth of the size of the Wells Creek watershed.

In Goodhue County, 1,500 farms operated in 1997, down 12 percent from 1,700 in 1987. During the same period, acres planted to corn grew by 22 percent and acres in soybeans by 84 percent. Southeastern Minnesota has a long tradition of dairying. Numbers of milk cows in Goodhue County held constant between 1987 and 1997, but numbers of farmers taking care of those cows fell by 28 percent. Overall county population has grown by approximately 5 percent over the past 10 years.

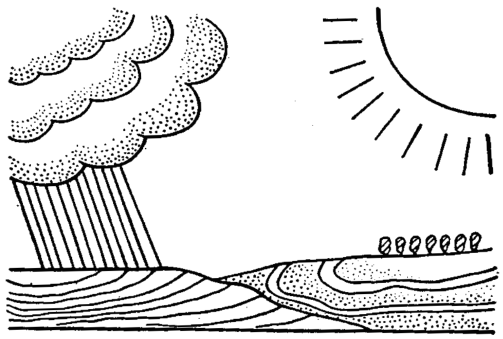
Similar trends hold for Chippewa and Swift counties, although they do not have as many young people remaining or returning to maintain population numbers. The lower portion of the Chippewa River is home to more cropping operations than Wells Creek and is more likely to have leased land. The number of farms in Chippewa County fell 25 percent, from 820 farms in 1987 to 618 farms in 1997. During the same period, the acres planted to corn increased by 62 percent and the acres planted to soybeans increased by 37 percent. Livestock operations decreased during the 10-year period for all types of animals. The number of farms with hogs dropped 64 percent, with inventory dropping by 34 percent. The size of the average hog farm almost doubled, from an average of 494 hogs in 1987 to 920 in 1997. Chippewa County was one of the few counties in Minnesota to lose population (-1 percent) between 1990 and 2000. Residents suggest that the smaller towns in western Minnesota have suffered in recent years, with growth occurring in new regional centers such as Willmar.

The number of farms in Chippewa County fell 25 percent, from 820 farms in 1987 to 618 farms in 1997. During the same period, the acres planted to corn increased by 62 percent and the acres planted to soybeans increased by 37 percent over 1987 levels. Livestock operations decreased during the 10-year period for all types of animals.

Watershed residents, particularly those in western Minnesota, named diversity as an important indicator of a desirable social structure. Neither community has very diverse ethnic backgrounds, as measured by the percentage of nonwhite residents: 4 percent in Goodhue County (Wells Creek) and 3 percent in Chippewa County (Chippewa River study area).

Marketing and Institutions

Social scientists reviewed documents and/or interviewed people from 30 organizations or institutions (e.g., governments, universities, nonprofits and businesses) influencing the Wells Creek watershed and 35 organizations or institutions influencing the Chippewa River study area. Most institutions in both watersheds tend to support currently dominant production and marketing systems. Based on a review of written documents, primary input dealers, processors or marketers are not explicitly involved in the pursuit of enhanced ecological and environmental outcomes. Alternative organizations exist but those interviewed say they are not sufficiently linked to major educational, social and business institutions to serve community needs for information and services. Most alternative farmers turn to institutions outside the local watershed to get information and, sometimes, inputs for their farms.



2 Results & Discussion

This study found that shifting farming practices to more diverse, environmentally sound methods and systems can result in a wide range of economic, environmental and social benefits for local producers and communities. For a summary of these results, see Appendix items C and D on pages 44 and 45.

2.1 Environmental Benefits

Environmental consequences evaluated included sediment and nutrient runoff, fish health, bird populations and greenhouse gas effects.

Watershed Level Estimates and Scenario Results

For this analysis, the Project compared different scenarios to the baseline for each study area. The four scenarios are:

- Scenario A: Extension of Current Trends
- Scenario B: Adoption of Best Management Practices
- Scenario C: Community and Economic Diversity
- Scenario D: Managed Year-Round Cover

Based on the edge-of-field estimated losses for the different systems and the varying shares of each agricultural system in the watershed, aggregated loss values were calculated for each study area. Under current conditions, approximately 39,615 tons of water-borne sediment, 3,001 pounds of nitrogen and 7,547 pounds of phosphorus are estimated to reach the mouth of Wells Creek each year (Exhibit 4). Changing farming practices, as demonstrated in scenarios A through D, change the sediment, nitrogen and phosphorus added to Wells Creek. Exhibit 6 presents estimated total watershed losses for different land use scenarios in the Wells Creek watershed. Adoption of Scenario D, with its increased crop diversity, higher proportions of managed grassland and 300-foot buffer strips, leads to more than 80 percent less sediment deposition in the river from water-based erosion. Adoption of best management practices (Scenario B, with 100-foot buffers, conservation tillage on all cropland and nutrient application at recommended rates) would help meet national goals for hypoxia (40 percent in-stream reduction of nitrogen).

Exhibit 7 contains the aggregated results for the Chippewa River

This study found that shifting farming practices to more diverse, environmentally sound methods and systems can result in a wide range of economic, environmental and social benefits for local producers and communities.

Exhibit 6: **Watershed Changes—Scenario Comparisons**
Change from Baseline in Wells Creek Watershed

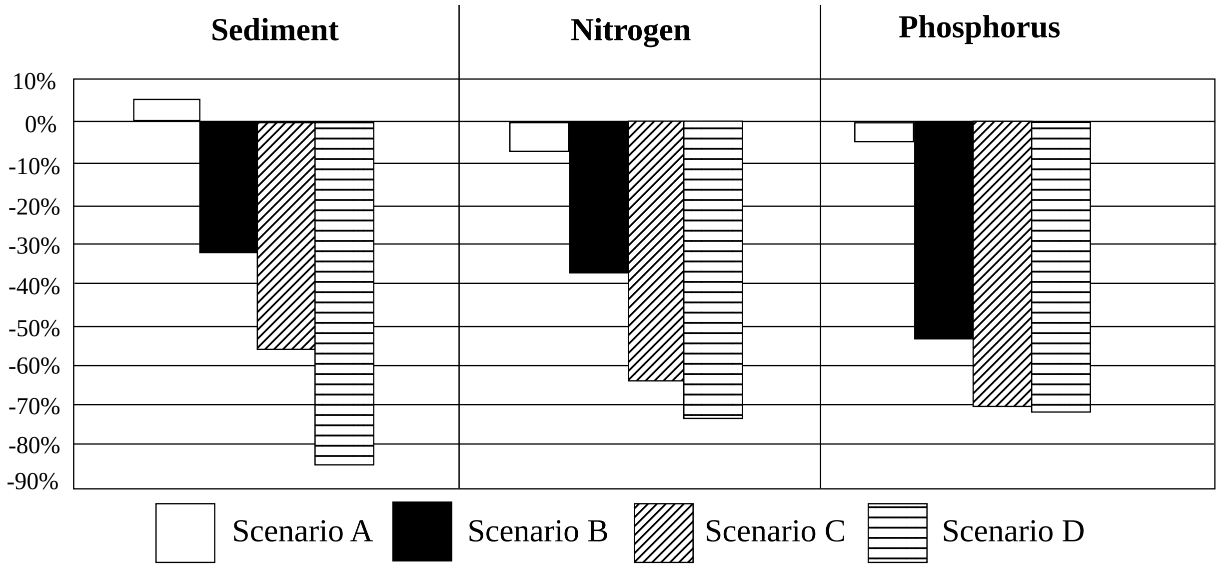
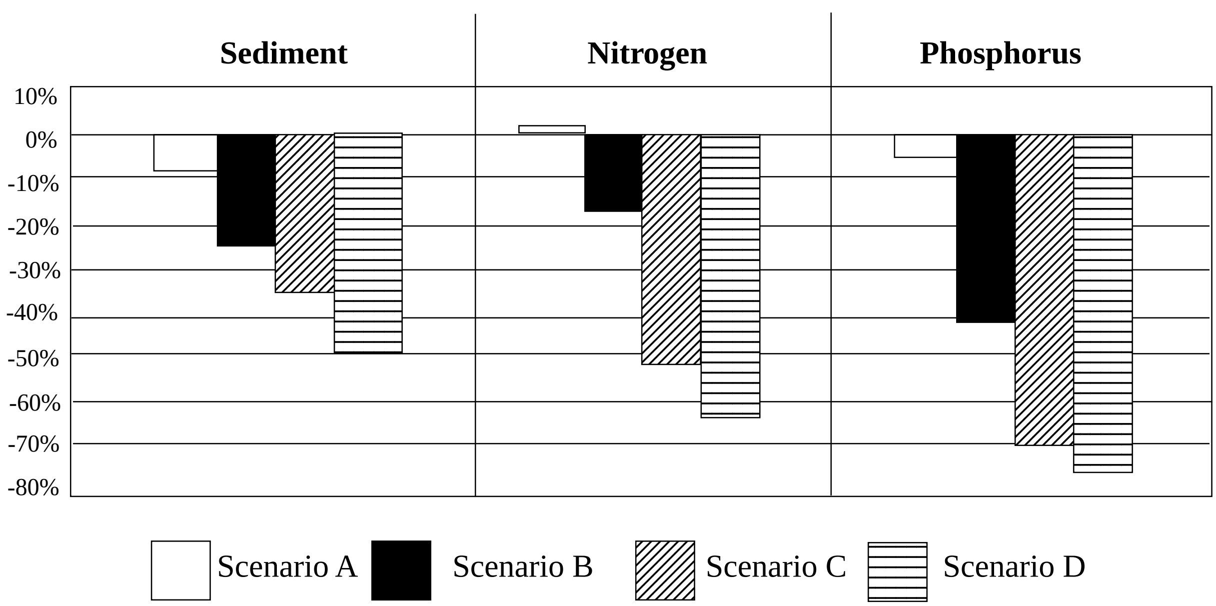


Exhibit 7: **Watershed Changes—Scenario Comparisons**
Change from Baseline in Chippewa River Study Area



watershed 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 (Exhibit 5). Changing farming practices, as demonstrated in scenarios A through D, generally leads to reductions in the sediment, nitrogen and phosphorus added to the Chippewa River each year. As shown in Scenario C, increasing diversity, managed grassland and judicious use of buffer strips decreases sediment deposition from water-based erosion by 50 percent. Adoption of best management practices (Scenario B) would not be adequate to meet national goals for hypoxia (40 percent 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, which would provide considerable phosphorus reduction potential. Scenarios B, C and D would each meet goals for reduction of phosphorus in the Minnesota River.

In Wells Creek, adoption of best management practices (Scenario B, with 100-foot buffers, conservation tillage on all cropland and nutrient application at recommended rates) would help meet national goals for hypoxia (40 percent in-stream reduction of nitrogen).

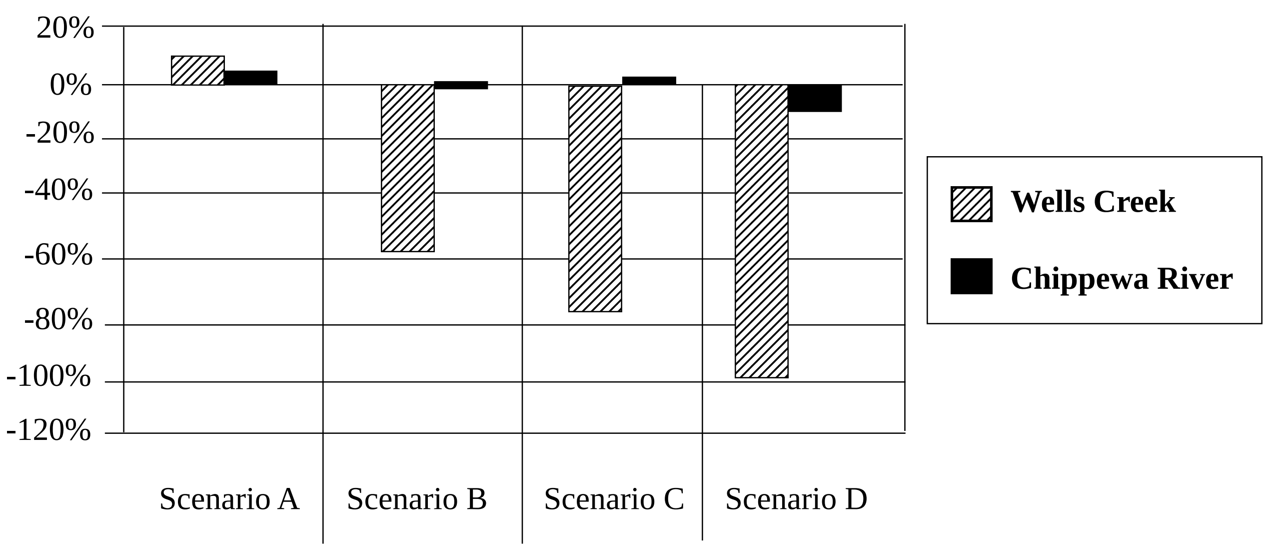
Fish Populations

Mean annual numbers of days with sediment concentrations high enough to cause fish to die or get extremely sick were slightly higher in the Chippewa River than Wells Creek. Days per year lethal to fish ranged from 10.2 to 11.6 in the Chippewa, depending on the scenario, compared to 0.2 to 7.6 days in Wells Creek. Mean sublethal days in the Chippewa River ranged from 31.1 to 40.8 per year, compared to 25.8 to 32.4 in Wells Creek. (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.) A multiple comparison test in Wells Creek among different situations (baseline and four scenarios) demonstrated that the baseline and Scenario A had significantly more mean annual days with lethal sediment concentrations than scenarios B or C (Exhibit 8). Also, the mean for Scenario D was lower than for Scenario B. Differences among treatments were also apparent for mean annual days with sublethal sediment concentrations in Wells Creek. Scenario A exhibited significantly fewer mean days with sublethal effects than did scenarios C and D.

In the Chippewa, adoption of best management practices (Scenario B) would not be adequate to meet national goals for hypoxia.

In the Chippewa River study area, lethal events did not significantly change with any of the scenarios. The number of modeled sublethal events did fall

***Exhibit 8*: Predicted Changes in Lethal Fish Events in the Wells Creek Watershed & the Chippewa River Study Area**



across the scenarios in the Chippewa River study area, although not enough to test at a statistically significant level.

Effects of watershed land use on fish communities and on patterns of sediment and nutrient runoff are site-specific, depending on physical attributes of different watersheds. Severity of sediment concentration effects on fish in different watersheds depends on the fish community present, as well as other stressors that may impact fish populations. In this analysis, mean numbers of days with lethal and sublethal sediment concentrations were greater in the Chippewa River than in Wells Creek. This is likely the result of the combined influences of different fish communities, differences in watershed land use and differences in watershed topography between the two areas. In general, the Chippewa River fish community is more sensitive to sediment concentration exposure longer than one day when compared to the cold water community in Wells Creek (Newcombe and Jensen 1996). Because of the flat topography of the Chippewa River watershed, sediment concentrations were often lower than those in Wells Creek. However, high sediment concentrations in the Chippewa lasted more consecutive days when compared to Wells Creek.

In Wells Creek, land use changes that provide more permanent cover 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.

In Wells Creek, land use changes that provide more permanent cover 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. In the Chippewa River, lowering sediment concentrations should benefit the warm water 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 River drainage area to see a measurable change in the fish community.

Bird Populations

Effects of land use on breeding songbirds (passerines) are similar in both watersheds, with a few exceptions (Exhibit 9). In the Chippewa study area, habitat change involved a loss of native tallgrass prairie, wetlands and potholes as grassland was converted to cropland and forests. Increase of cropland in both watersheds leads to direct and indirect mortality of birds. Farm equipment (nest destruction) and ingestion of pesticides cause direct mortality. Indirect mortality is caused by loss of nesting habitat and food (fewer insects due to pesticide use and fewer seeds from herbicide application), increased predation because of lack of cover, and less nesting success due to smaller remaining habitat patches. Cover and tillage practices affect number, variety and nesting successes of different passerine species.

Agricultural landscapes seem to be beneficial to many game birds as long as they still provide large amounts of grassland and cover. Studies show a strong correlation between grassland and pheasant abundance. Pheasants

Exhibit 9: Benefits to Bird Populations

Bird responses to habitat changes (sightings per 160 ares)*

- Tilled row crops=>**18 species**
- Tilled row crops, herbaceous fencerow, grassed waterway, pasture and alfalfa=>**25 species**
- Tilled row crops, herbaceous fencerow, grassed waterway, pasture and alfalfa, and marsh=>**52 species**
- Tilled row crops, herbaceous and wooded fencerows, grassed waterway, pasture and alfalfa, marsh and farmstead shelterbelt=>**93 species**

"I used to take my four-wheeler to do chores. Now I leave it in the barn because I might miss something." **— Farmer, after learning how to observe birds**

*Source: Best, L. K. Freemark, J. Dinsmore and M. Camp. "A Review and Synthesis of Habitat Use by Breeding Birds in Agricultural Landscapes of Iowa." *The American Midland Naturalist,* Vol. 134, No. 1, July 1995 (1-29) should benefit from an increase in grassland in both watersheds. Weather conditions and competition from pheasants may have a greater effect on partridge populations than abundance of grassland habitat. However, if grassland habitat were greatly reduced, partridge populations would likely decrease in response. Wild turkeys prefer the interspersed woodland and agricultural habitats found in Wells Creek, where some farmers consider the thriving populations a nuisance.

Some evidence suggests that well managed grasslands (e.g., pasture) are better for bird populations than unmanaged grasslands, such as most conservation set-aside areas (Best 1995). Grass-based farms might outperform the current slate of conservation programs, particularly in the long term (Mueller et al. 1998; Kimmel and Haroldson 1998; Klute and Robel 1997).

Grass-based farms might outperform the current slate of conservation programs, particularly in the long term.

Greenhouse Gases

Agriculture in Minnesota contributes 5.28 million metric tons (between 14 and 19 percent of the total state emission) of carbon equivalent to the atmosphere. The breakdown of emissions between gases is in Exhibit 10.

Nitrous oxide, or N_2O, generated by overuse of nitrogen fertilizer, is agriculture's largest contributor to Minnesota greenhouse gases, based on carbon equivalency. In 1997, 0.58 million metric tons of N-based fertilizers were used on Minnesota farms, resulting in the release of 0.038 million metric tons of N_2O (3.2 MMT carbon equivalent). That is 61 percent of agriculture's contribution. Reducing nitrogen applications will significantly decrease releases of this potent greenhouse gas.

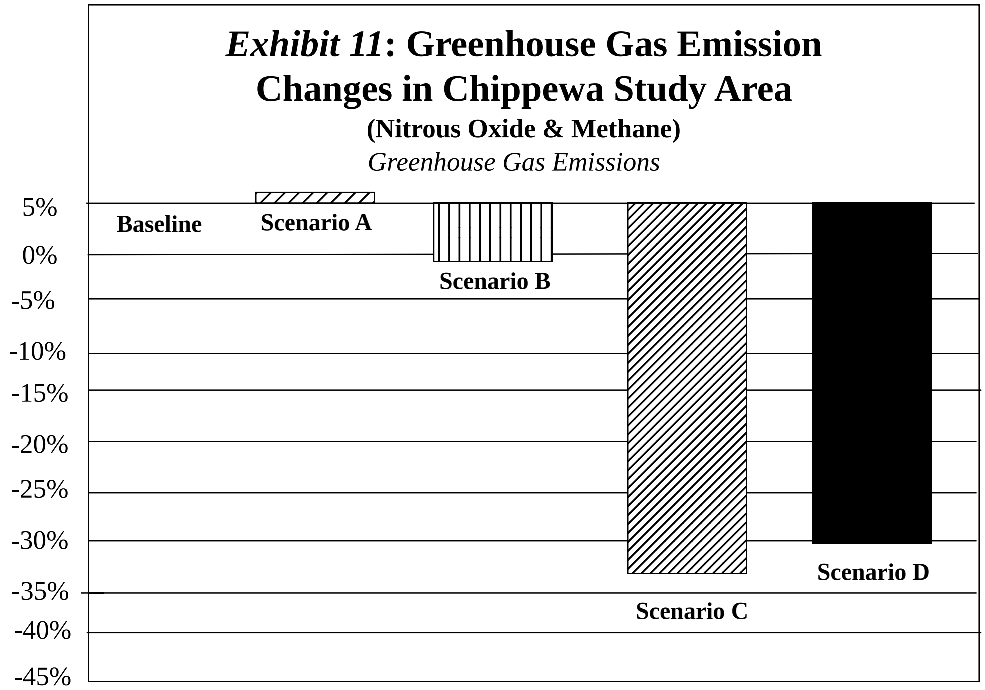
Methane (CH_4), a by-product of ruminant digestion and the decomposition of manure, is the second largest contributor to greenhouse gases from Minnesota agriculture. Minnesota livestock farms produce an estimated 2.5 million metric tons of methane per year, equivalent to 1.4 million metric tons of carbon and 27 percent of the total greenhouse gas emissions in Minnesota from agriculture. Milk cows and hogs produce 33 and 26 percent, respectively (McIntosh 2000).

Carbon dioxide is produced by the combustion of fossil fuels. Minnesota farmers cause the release of 2.5 million metric tons of carbon through use of fossil fuels each year. This was 13 percent of the total released from all Minnesota agricultural sources in 1997. The rest was generated by transportation, processing or commercial energy consumption. Carbon released from the soil through

Exhibit 10: **Greenhouse Gas Emissions, Minnesota Agriculture (1997)**

Gas	Million metric tons (MMT)	Global Warming Potential	MMT Carbon Equivalent	Percent of Total Agricultural Emissions
Nitrous Oxide (N20)	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



transition of land between uses (e.g., 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 N_2O and CH_4 emissions, in carbon equivalent, for current and potential farming practices in the Chippewa River study area are presented in Exhibit 11. A reduction in greenhouse gases of as much as 34 percent is predicted in the Chippewa River study area if Scenario C is adopted. In the Wells Creek watershed, reductions would be smaller because dairy animals generate more methane than beef cattle. If the number of dairy animals were increased by 15 percent in the Wells Creek Watershed, greenhouse gas emissions would increase by almost 56 percent in the study area.

A reduction in greenhouse gases of as much as 34 percent is predicted in the Chippewa River study area if Scenario C is adopted.

2.2 Social Benefits

Human Capital

Continuation of row crop production or even modification of the commodity system to make it more environmentally friendly using "best management practices" will probably not fundamentally change the course of out-migration. To reduce out-migration and encourage young people to stay or migrate to rural areas, communities may not want to rely on the growth of industrial agricultural systems. A 1992 University of Missouri study found that for every $5 million of new investment in contract swine production, between 40 and 45 new jobs would be created throughout the state's economy. However, a follow-up study found that those jobs would come at the cost of three times that number of independent producers (Ikerd 1994).

Subsidies to individual farmers for commodity production do not necessarily lead to rural development. In fact, it has been suggested that rural communities need to forgo agriculture for other approaches to rural development, because U.S. agriculture cannot compete in the world market (Stauber 2001). Scenarios C and D redirect agriculture towards activities that would more effectively support local communities through enhancing the natural resource base (e.g., needed for tourism) and providing more local economic activity.

Health care, which is central to full utilization of human capital, is problematic under all scenarios. Farmers in the focus groups commented that the lack of affordable health care coverage is a main reason many farm families have at least one member working off-farm. The lack of health care coverage is named as a barrier that is keeping young people away from farming as a viable career option (Chippewa and Wells Creek focus groups, May 2000).

Social Capital

Social capital is particularly important to the success of scenarios C and D. If alternative agricultural strategies are to be successful, they will depend on a base of bonding social capital. Bridges must be carefully built to link producers with consumers and provide a reasonable share of consumer expenditures to producers and local small-scale processors and service providers. Collective economic activities will need to grow and allow the collection of small-scale production systems so grocery stores, restaurants and other end users will have a predictable and uniform quality supply of the products grown in the watershed.

Social elements, including relationships with employees, trust with small-scale meat processors or fellow graziers, production agreements with fellow growers and, in some cases, good personal relations with consumers, will be more extensive than those that occur with corn or soybean producers. Corn and soybean growers not only do not have to directly deal with consumers; they need not, and generally do not, know what happens to their crop after they deliver it to the local elevator. However, some corn and soybean growers are increasingly called upon to develop relationships with employees or with companies they are raising commodities for on contract.

The greatest contrast between scenarios A and B, the commodity approaches, and C and D, the producer-fashioned-product approaches, is at the community level. Focus group members who considered themselves as innovators noted repeatedly that they were viewed with suspicion, were the subjects of gossip and even were ostracized for daring to do farming, marketing or resource conservation in a new way. That point is illustrated in these quotes selected from one focus group discussion in the Chippewa River study area:

Focus group members who considered themselves as innovators noted repeatedly that they were viewed with suspicion, were the subjects of gossip and even were ostracized for daring to do farming, marketing or resource conservation in a new way.

• *"I am sure you need support groups if this is to happen. People can't go against the dominant pattern on their own."*

• *"They are really talking about you in town. It's all those trees you are planting."*

• *"You need people to share the misery with."*

• *"It's not the misery—[it's] the excitement. I believe that rotational grazing could be a regional benefit to many people. [But] I haven't got the courage up to put a mobile hen house out there yet"* (Chippewa focus group, April 2000).

Farmers who have sought approval to construct large-scale livestock confinement facilities with lagoons holding millions of gallons of liquid manure have also complained about being ostracized by people from within—as well as from outside—their communities.

The size of the facilities and the potential for poor air quality from them creates concerns among citizens, including neighboring farmers. Odor complaints have been found to be most frequent among new, large or recently expanded operations located near residential or shopping areas (Miner 1980; Sweeten and Miner 1993). The risks of pollution are higher if an accident should happen at larger facilities, and that, too, raises concerns among citizens. Finally, large-scale facilities are usually planned to make use of the crops from dominant commodity systems and thus prevent diversity in cropping systems.

If changes in agriculture are planned, bridging social capital must be established among different members of the community during the conceptual stages so that larger community concerns and interests can be better understood and considered in the development of plans. Behavior that goes against the grain of "formula" farming is an eminently social act. If others are going to try their own innovations on their fields or in their pastures for all their neighbors to see, social capital must be consciously built in support of such behavior. Support group networks have been shown to be important ingredients for people to make change (Northwest Area Foundation 1994).

2.3 Economic Benefits

Behavior that goes against the grain of "formula" farming is an eminently social act. If others are going to try their own innovations on their fields or in their pastures for all their neighbors to see, social capital must be consciously built in support of such behavior.

Increasing farm size and the concentration within agriculture create conditions of unequal power among different participants along the value chain. These trends would likely continue under either Scenario A or B. While B would be somewhat more benign environmentally, continuation of commodity production will contribute just as certainly as in Scenario A to the ongoing and increasing inequalities in agriculture. One participant explained the current system this way:

• *"Some people out here like out-migration because it leaves more land for them. They say, 'Guys like you, who farm for a hobby, make it harder for us who have to make a living off farming' "* (Chippewa focus group, April 2000).

Another illustrated the inequalities which result from changes in agriculture and from other recent changes in policy and the economy:

• *"[I] see increases in inequity. Appleton now has a ghetto— one small corner of town. People don't want to deliver things there—think about the young man who lives there! For the Head Start program, we are not invited into homes. It is hard for people to visit"* (Chippewa focus group, April 2000).

Concentration within agriculture creates fewer and more specialized farmers who, to get inputs at a cheaper unit price, bypass local input suppliers. A larger number of moderate-sized farms would make for a healthier main street (Flora and Flora 1987). The decline of agricultural input firms and consumer businesses prompts city and county officials to seek economic development via outside firms. These firms often provide low-wage manufacturing or service jobs. This was particularly true during the farm crisis of the 1980s. Local and state officials turned from the slower, less risky path of growing jobs locally, partly because they did not want to offend one local merchant or manufacturer by favoring another. Thus, effective skills were not developed locally and resources were not mobilized for aiding local merchants and entrepreneurs, although the cost per job created was lower than for an absentee-owned firm (Flora, et al. 1997). With absentee-owned firms, the principal bargaining of rural localities is cheap labor. Often firms will promise to hire local people, but when workers are not available at the price the firms offer, they recruit workers who will work for that low price. This is particularly true in the meat processing industry (Flora, et al. 2000). Management-intensive agriculture practices, such as rotationally grazing animals or increasing diversity of crop farms (scenarios C and D), are more likely to fully engage the farm operator and family than is monocrop agriculture.

Scenario D could mean a reduction in intensive purchased-input agriculture, but would not be likely to fully stop out-migration. How the change is accomplished would make a great deal of difference. The increase in grass-fed livestock would offer an attractive economic alternative—particularly an offering of labeled antibiotic- and hormone-free grass-fed beef, lamb and other specialty meats to regional customers. If social and financial capital were brought together to develop modest-sized, farmer-controlled packing plants, with products certified as having certain characteristics and marketed in a sophisticated manner, quality employment in the region (e.g., skilled butchers) could be increased and farmers might increase profitability. Studies show a reduced input system that is more management-intensive can generate greater farm income and more local employment opportunities (Chism 1993; Ikerd 1998).

Marketing and Institutions

Farmers pursuing alternative systems have, by and large, found innovative ways to find and share information beyond traditional government and extension systems. That is necessary because current governmental programs, including those coordinated by the Land Grant University system, are designed mostly to help producers growing traditional commodities such as corn, soybeans and meat.

This limits opportunities for farmers to make a living from the marketplace. Both crop and livestock processing industries are controlled by a small number of companies, leaving farmers with few choices. Five companies control three-quarters of the corn processing and five companies control 80 percent of the soybean processing. An enormous infrastructure exists to move corn and soybeans from farm to markets. Those markets are integrally linked with large-scale confined livestock. About two-thirds of total corn production and almost all soybean meal is fed to livestock. Seventy-eight percent of cattle are finished through large feedlots. Farmers' options are also limited in livestock sales, with four major firms handling the slaughter and processing of cattle (Heffernan et al. 1999).

Focus group participants made it clear that present commodity programs discourage diversified agriculture and conservation efforts.

Conventional and alternative farmers in both study areas expressed a need for more institutional and market choices. In one case, a larger farm exchanged resources with a smaller one. Farmers implied that innovation on the farm is more likely to occur if local institutions are willing to change along with the farmers.

Policy is central to the kind of agriculture and rural community that is developed. Focus group participants made it clear that present commodity programs discourage diversified agriculture and conservation efforts. Some focus group participants had a number of policy suggestions to remedy current farm policy, including ending farm subsidies, making transition payments to farmers who are converting to organic or sustainable production, and replacing commodity payments with "green" payments to reward the production of ecological benefits. There were also expressions of support for aid to small businesses, including small farms.

Farm Input Costs

Adoption of any of the scenarios would lead to changes in input use and associated changes in production expenses (Exhibits 12 and 13). For example, under the baseline, almost 1.4 million pounds of nitrogen is applied each year in Wells Creek and almost 1.8 million pounds is applied in the Chippewa River study area. Over-application often occurs as a result of not counting the nitrogen credit provided by manure and legume crops. That overapplication can result in higher than needed production costs. In Wells Creek, nitrogen use could decline by 60 percent in Scenario B (BMPs). Nitrogen use in the Chippewa River study area could decline by 21 percent for Scenario B.

Production costs under the scenarios generally would decrease in both watershed study areas.

Production costs under the scenarios generally would decrease in both watershed study areas compared to the baseline. This assumes that: 1) prices for agricultural commodities would remain constant despite a higher level of production of crops such as hay from the watersheds and lower levels of row crop production, and 2) depreciation of major expenditures for equipment needed to grow small grains and hay would not eat into profits. Exhibits 12 and 13 show

Exhibit 12: **Total Cost of Production for all Farm Operations in Wells Creek Watershed**

	Baseline	Scenario A	Scenario B	Scenario C	Scenario D
Estimated $ Spent	$13,521,781	$13,416,770	$13,111,364	$12,458,085	$19,556,767
Change from Baseline		-.78%	-2.98	-7.87%	+144.63%

In economic terms, the marginal cost to the taxpayer for environmental improvements is likely to be zero.

costs of production for the Wells Creek watershed and the Chippewa River study area. This is not to imply that no corn would be raised under these more diverse scenarios. But the focus on grain-based livestock feed production would shift as grass-based operations become more prevalent.

Income & Profits

This analysis has already shown that by moving from the baseline and scenario A to Scenarios B and especially C and D, many environmental benefits accrue at significant levels. The data from farm income sales in Exhibits 14 and 15 show that high levels of environmental benefits could be achieved for little more, and possibly less, than the current costs, after transition costs are overcome. In economic terms, the marginal cost to the taxpayer for environmental improvements is likely to be zero. This finding is consistent with the results of other studies (SFS, in press).

In 2000, the federal government provided $28 billion in payments to U.S. farmers. About 9 percent of that was for conservation enhancements, mostly to retire farmland through the Conservation Reserve Program (Green and McElroy 2001). The payments included what the 1996 Farm Bill called "market transition payments." Because crop prices for corn and soybeans and other crops were so low, the bulk of the $28 billion in 2000 was for commodity and emergency income assistance paid to landowners who grew corn, soybeans and a few other program crops, not including hay or grass (Williams-Derry and Cook 2000). These transition and income support payments averaged 75 percent and 85 percent of farmers' net farm income in the Southeastern Minnesota and West Central Minnesota Farm Business Management programs, respectively. The stated goal for these payments has been to keep producers on the land. While the payments have been critical for many small- to medium-sized farmers, overall the number of mid-sized independent producers continues to decline as more row crops are grown.

Exhibit 13: **Total Cost of Production for all Farm Operations in Chippewa River Study Area**

	Baseline	Scenario A	Scenario B	Scenario C	Scenario D
Estimated $ Spent	$9,201,615	$9,291,169	$8,927,092	$7,414,388	$5,748,499
Change from Baseline		+100.97%	-2.98%	-19.42%	-37.53

Carbon Sequestration

Minnesota's agricultural soils have the potential to capture and hold great quantities of carbon. Prior to tillage and adoption of cropping systems, Minnesota's two million

Exhibit 14*: Current & Hypothetical Total Income Sources for all Farm Operations in the Wells Creek Study Area as a Whole (**based on 2000 prices**)

	Baseline	Scenario A	Scenario B	Scenario C	Scenario D
Net farm income from sales of farm products	$2,089,045	$2,061,049	$2,072,219	$2,330,850	$4,277,802
Additional income needed to achieve baseline level		$27,996	$16,825	-$241,806	-$2,188,757
% additional income needed to achieve baseline		1%	1%	-12%	-105%

*****Does not include government payments

acres of fields held 320 million metric tons of carbon, around 10 times the amount released annually from all sources in Minnesota, and over 60 times that released or generated by Minnesota's agricultural system each year. Several proposals are in place to give credit to farmers for sequestration of carbon through less-intensive tillage practices. This might rebuild a base of carbon in agricultural soils and help control greenhouse gas emissions. Based on a $20 per ton "price" for carbon, the average Minnesota crop farm (318 acres) could receive $1,000 per year for using conservation tillage. Pasture and grazing systems should benefit even more because they hold even greater potential for capturing and retaining carbon in soils.

Avoided Sedimentation Costs

Avoided costs are calculated using ADAPT outputs for sedimentation under the baseline and four scenarios, and by using a value of $538 per ton of waterborne sediment as assigned by Ribaudo (1989). In Wells Creek, the baseline costs of $213,131 per year were estimated to decrease by as much as 84 percent if Scenario D were adopted. In the Chippewa River study area, the baseline of $10,525 could be reduced by as much as 50 percent under Scenario D.

Exhibit 15*: Current & Hypothetical Total Income Sources for all Farm Operations in the Chippewa River Study Area as a Whole** (based on 2000 prices)**

	Baseline	Scenario A	Scenario B	Scenario C	Scenario D
Net farm income from sales of farm products	$979,255	$958,794	$952,552	$1,545,207	$1,289,744
Additional income needed to achieve baseline level		$20,461	$26,703	-$565,952	-$310,489
% additional income needed to achieve baseline		2%	3%	-58%	-32%

*****Does not include government payments

Costs from Flooding

Numerous reports and studies agree with the assessment that land use and land use changes can affect flooding. In one such study, Miller and Nudds argue that flood magnitudes in the Mississippi River Valley over the past several decades have increased at least partially due to extensive land use change in the watershed, in conjunction with greater channel confinement and climate change (Miller and Nudds 1996). They cite increased agricultural land use and accompanying reduction of natural upland vegetation and wetland drainage in the upper reaches of the watershed as the culprits. They also found similar changes in the hydrology of the Minnesota River Basin (Miller et al. 2001).

Runoff contributes significantly to flooding. It occurs when precipitation is greater than losses due to evaporation and plant transpiration, and is measured by overland flow and saturated overland flow (Brooks 2001). As runoff contributes to stream flow, especially during and immediately following precipitation, reducing runoff is likely to reduce resultant hydrologic peaks for a river. Modeling has shown that reducing runoff by 10 percent within a watershed may reduce the flood peaks with a two- to five-year return period by 25 percent to 50 percent, and might reduce a 100-year flood by as much as 10 percent (U.S. Army Corps of Engineers 1995).

In Minnesota, an estimated 42 percent to 50 percent of the state's original wetlands have been destroyed in the past 200 years (Miller et al. 2001). This decline has been linked with increasing flood intensities (Miller and Nudds 1996; Miller et al. 2001).

The effect of a wetland on flooding depends on a wide array of factors and conditions, and not all wetlands perform the same functions equally well (De Laney 1995; SAST 1994). Factors that have been considered include size and placement of the wetland, area of wetland relative to area of the watershed, volume and duration of flooding and presence of other wetlands nearby (De Laney 1995).

Many of the options posed in the scenarios have potential to reduce runoff and flooding.

Recently, wetland reconstruction has received the most attention in regard to potential flood reduction benefits. Multiple studies have shown that the flood attenuation benefits of wetlands increase as the area of wetland within a watershed increases (De Laney 1995). Demissie and Khan (1993) determined that peak flow and flood flow volumes are decreased 3.7 and 1.4 percent for each 1 percent increase in wetland area within a watershed. Several studies suggest that a ratio of wetlands to watershed of less than 10 percent can be enough to produce a noticeable effect on annual events (De Laney 1995). Wetlands also provide water filtration and wildlife habitat while capturing pollutants from runoff.

The SAST (1994) study suggests wetlands are limited in their ability to reduce peak flooding by the amount of water they can store. That makes the wetland-to-watershed ratio important (as well as the nature of the flood event). In a large-volume or long-duration event, wetlands' effect on overall flooding will be negligible. However, in a smaller event of shorter duration, they may have a pronounced beneficial effect. This is echoed by the Floodplain Management Assessment (1995) analysis, which concluded that restoration of wetlands in the Mississippi River floodplain would have had little effect on the enormous flood of 1993, but would have provided localized flood reduction benefits in upland regions and for frequent flood events. In cases such as the 1993 flood event, even these local benefits would have been reduced due to extremely wet antecedent conditions which lowered available storage capacity.

An effect of wetland drainage, pointed out by Miller et al. (2001), is that drainage often takes numerous smaller, locally drained basins (largely composed of wetlands) which "seldom discharged runoff to stream channels" and links these basins to the larger watershed, thereby increasing the contributing area for the watershed. This increased contributing area will also lead to higher peak flows.

Many of the options posed in the scenarios have potential to reduce runoff and flooding. For example, scenarios B, C and D include increased conservation tillage. Less invasive tillage would have the runoff-reducing effect of increasing soil infiltration capacity. Other scenarios include increased use of cover crops, which also help increase infiltration and reduce runoff. Substantially increasing acres that are managed through grazing, which happens under scenarios C and D, further improves these outputs.

Perhaps the strategy most likely to mitigate flooding would be to increase the area dedicated to wetlands. This strategy is proposed in scenarios C and D for both watersheds. In Wells Creek, which covers 40,172 acres, this involves increasing the wetland area from 52 to 587 acres. This would be an increase of about 1.3 percent, to a total of 1.5 percent of the total acreage in wetlands.

In the Chippewa area, which covers 44,445 acres, this involves increasing wetland area from 381 to 1,614 acres, an increase of 1,233 acres. This would be an increase of about 2.8 percent, to a total of 3.6 percent of the acreage in wetlands.

Using the Demissie and Khan (1993) estimates, such wetland restoration could reduce peak flow and flood flow volumes by approximately 4.8 and 1.8 percent respectively for Wells Creek, and 10.4 percent and 3.9 percent respectively for the Chippewa River study area. Exhibit 16 presents the estimated reduction in peak flow in the two study areas under selected scenarios.

Wetland restoration could reduce peak flow and flood flow volumes by approximately 4.8 and 1.8 percent respectively for Wells Creek, and 10.4 percent and 3.9 percent respectively for the Chippewa River study area.

A large incentive for reducing flood levels is economic. Large floods can do enormous damage, as in the 1993 Mississippi River flood, which the National Weather Service estimated cost $964 million in Minnesota alone. Floods with more frequent occurrence intervals can also do damage and, while damages from these events may not cause the astounding one-time costs created by the 1993 flood, expenses for maintenance and repair do add up.

In Minnesota, agricultural losses are a common type of flood damage. These can be destroyed crops, reduced yields, delayed planting due to excessive soil moisture, or loss of a year’s production. Agricultural infrastructure may also be harmed (SAST 1994).

Residential structures, both urban and rural, may suffer damage or loss to both the structure and its contents. Damage may be to commercial and industrial structures, public buildings, recreational spaces, transportation facilities and public utilities, such as wastewater treatment plants which are often located in low-lying areas. Bridges may be damaged or rendered inaccessible. Unemployment or reduced employment, loss of business and emergency response costs may also result (SAST 1994).

Finally, there will often be damage from scour and deposition. Drainage and roadside ditches may fill with sediment and need to be cleared; sand or other sediments may be deposited on agricultural fields. Debris on roadways and in open spaces needs to be removed and road shoulders repaired (SAST 1994).

In 1998, Goodhue County, the location of the Wells Creek watershed, spent over $5,000 to clean up minor flood damage. Along three county roads within the watershed, county costs were $173 to inspect and identify damage, $5,381 to clear debris and $167 for shoulder repair.

In Chippewa County, which contains the majority of the Chippewa River Watershed, the county ditch inspector said that many costs are hidden because damages are not addressed. 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 (Nash 2001). Chippewa County as a whole spent $54,000 in cleanup and repair after a 1997 flood, of which approximately $15,000 was attributable to work in the Chippewa River watershed.

Another cost reported by Chippewa County Emergency Management was replacement of culverts from a significant rain (over seven inches) in July 1995. This cost may occur on a semi-regular basis. Spring floods often back up across roads if culverts are still frozen. This sometimes requires gravel to be hauled to the culvert at additional public cost (Kubista 2001).

Exhibit 16: **Potential Reductions in Peak Flows Due to Land Use Changes in Scenarios C&D**

	Wetland Peak Flow	Grassland Peak Flow	Total Peak Flow Change
Chippewa River C	-4.8%	-17%	-21.8%
Chippewa River D	-5.8%	-28%	-33.8%
Wells Creek C	-10.4%	-15%	-25.4%
Wells Creek D	-10.4%	-26%	-36.4%

Tourism Benefits

Frontenac State Park sits on the eastern edge of the Wells Creek watershed. Characterized by bluffs, woods and savanna, it has hiking trails, river access and a campground. Over a three-year period, Frontenac State Park visitors spent almost $2 million a year. On average, 107,500 visitors travel to Wells Creek each year, spending approximately $18.50 each (overnight visitors spend $22 each, day visitors $18). On average, there are now 94,000 day-visitors each year and 13,500 overnight visitors (Roberts 2000).

There is no state park in the Chippewa River study area, but the Lac Qui Parle recreation area is near the watershed. There are bike trails in Montevideo and several groups, led by the Audubon Society, are developing a state birding trail through the area. Focus group participants indicated a desire to build a tourism economy based on diverse working farms. At least one bed and breakfast is located on an area farm and a second was recently opened on Main Street in Montevideo.

Scenarios C and D, with increased emphasis on developing birding habitat, diverse land uses, hunting, regional food systems and tourism opportunities, would allow these parks and related businesses to strengthen and grow.

The random survey shows a willingness to pay $201 annually for environmental improvements. On a statewide basis, this translates to $362 million annually. This shows the high value state residents place on the public benefits agriculture can produce.

Contingent Valuation

What will residents pay for agricultural benefits to their watersheds? This study evaluated the benefits respondents derived from two different levels of multiple environmental benefits, or impacts. Attention centered on a "baseline" policy scenario yielding a 50 percent reduction in most negative environmental impacts from agriculture. This 50 percent level was described in interviews and half the mail surveys, with the other mail surveys describing a 10 percent reduction in negative environmental impacts. See Exhibit 17 for a sampling of survey statements and questions.

For the baseline policy scenario, the mail survey shows a willingness to pay an estimated $201 annually per household. Personal interview results show a much higher willingness to pay up to $394 annually, possibly indicating "yea-saying" behavior from the personal nature of the interview procedure.

Using the more conservative mail-survey estimate, a statewide total willingness to pay can be computed by multiplying the per-household $201 by the number of households (1.8 million in 1999) to yield an annual state willingness to pay $362 million. Given a state population of 4.75 million (1999 estimate), this translates to approximately $76.21 per person annually, or 21 cents per person per day (Welle 2001).

Exhibit 17: **Sample statements and questions from the Multiple Benefits of Project contingent valuation: *Environmental Benefits from Agriculture: The Minnesota Survey***

COSTS OF THE PROGRAM and COSTS TO YOUR HOUSEHOLD

Currently estimates are being generated on how much this program would cost the typical Minnesota household. While economists can estimate the cost to the typical household, the cost to specific households will vary based on:

- the household's tax bracket and
- the households's spending pattern on some foods.

Funding the program could cause higher taxes or lower rebates.
If this program were implemented, the state would have to fund it by either spending less money on other programs (such as those mentioned at the start of the survey) or by increasing taxes or decreasing rebates.

Prices of some foods would increase.
This program would encourage conservation practices more than current policy and would likely result in a slight increase in the prices of some foods. Price increases would result from factors such as increases in the costs of production, lower production or the idling of some lands. The level of price increases would depend on differences in markets for various foods. Costs would be lower for households that purchase fewer of those foods that have the highest price increases.

The cost estimate has been calculated as a fixed annual payment over many years (at least a decade), similar to a fixed annual mortgage payment.

If this proposal passes, your household will have less money to spend on other things for at least the next ten years due to higher prices for some products, higher taxes or lower rebates.
Because costs will vary across households, we are asking different households about different costs within the expected range of costs. Please answer the questions carefully even if you view the cost stated in Q-13 as very high or very low. It is important that you tell us whether you would vote "For" or "Against" this proposal based on whether you view the environmental effects of the policy to be worth the stated cost to your household. Please consider how you would vote based on your current level of household income.

Next please return to the survey booklet to answer how you would vote in Q-13.

Q-13 If this farming program would cost households like yours $_____every year for the foreseeable future, would you vote "For" or "Against" it?

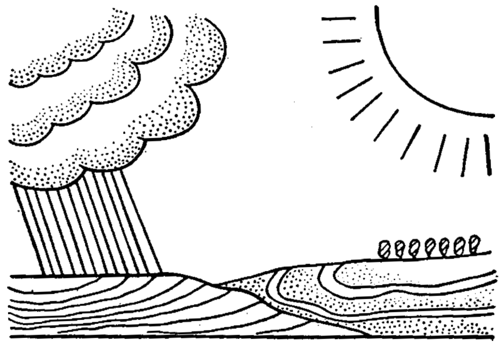
1 FOR, I would vote yes on the proposal.
2 AGAINST, I would vote no on the proposal.

IF AGAINST, go to Q-14B on next page

Q-14B What if the cost per year to your household was lower that the dollar amount shown in Q-13? Is there a lower cost your household would be willing to pay each year at which you would favor the proposal?

1 ***YES, there is a lower cost to my household at which I would favor the proposal.*** (Please write in the highest cost your household would be willing to pay per year, for the foreseeable future: $______.)

2 ***NO, I would oppose the proposal even if it had no cost to my household***



3 Policy

International, federal and state policies have significant impacts on the structure and production of farms. Internationally, trade policies may increasingly define what types of subsidies are acceptable. Some countries are promoting policies that call for support of multifunctional agriculture to encourage farming that results in multiple environmental and social benefits. U.S. federal farm income and commodity policy affects the decisions of landowners as they choose whether or how to utilize agricultural technologies, and how to respond to volatile commodity markets (Levins 2001). States also play key roles in providing support to farmers, in large part through research, education, outreach and technical assistance. In addition, states maintain regulatory agencies relevant to farmer practices..

In the United States, conservation and production policies are created separately, producing perverse incentives for farmers seeking to maximize environmental and social benefits on their farms. Conservation policies encourage setting aside land. Tax incentives and low grain prices (resulting in part from subsidies) encourage animal production in large feedlots, with feedlot operators purchasing grain from off-farm, rather than growing animal feed as an integrated enterprise. Only selected crops—cotton, corn and soybeans for example—are supported by government programs. Farmers seeking to increase rotations (as shown in Scenario C) are not rewarded for the environmental benefits which result. In fact, they feel themselves punished when emergency payments are made only for program acreage.

In the United States, conservation and production policies are created separately, producing perverse incentives for farmers seeking to maximize environmental and social benefits on their farms.

This section reviews international and national policies and recommends an integrated approach to farm policy, structured to reward the production of multiple benefits on U.S. farms. Based on the results of Phase I, we recommend development and testing of a new framework that would provide public support for nonmarket public benefits, including ecosystem services, produced on farms.

3.1 International Review of Multifunctional Agriculture

An early recognition of the multifunctional character of agriculture appeared in the documents of the Rio Earth Summit in 1992. Countries in the Organisation for Economic Co-operation and Development (OECD) expanded upon this idea in 1998, noting:

> "*Beyond its primary function of producing food and fibre, agricultural activity can also shape the landscape, provide environmental benefits such as land conservation, the sustainable management of renewable*

natural resources and the preservation of biodiversity, and contribute to the socio-economic viability of many rural areas. Agriculture is multifunctional when it has one or several functions in addition to its primary role of producing food and fibre." (OECD 1998).

While it may not have originated as a major discussion point, multifunctional agriculture has risen to prominence in trade negotiations. Individual countries use the concept in attempts to preserve policies which support farmers and rural communities against attacks under international trade agreements.

Most active proponents of domestic laws that recognize and promote multifunctional characteristics of agriculture are the European Union (both jointly and as individual countries), Norway, Denmark, Japan and South Korea. These countries have long argued for the importance of farming—particularly moderate-sized, independent farms—in the economic and social health of rural areas, and in the cultural heritage of the nation. Japan has also been particularly adamant about the importance of domestic food security. Following World War II, Japan promoted total self-sufficiency in rice production, directly and indirectly blocking rice imports from other countries. That market has opened only to a limited degree in recent years.

While it may not have originated as a major discussion point, multifunctional agriculture has risen to prominence in trade negotiations.

Traditional farming practices and foods are highly valued in these countries, and are often backed by government support. Because market forces alone are not sufficient to induce farmers to produce other, non-food benefits, these countries argue that they must be able to promote these beneficial outcomes without interference from international trade bodies.

Given the nature of proponent policies on food trade, perhaps it is not surprising that the multifunctional agriculture concept has met with opposition by major food exporting countries. Cairns Group countries—Argentina, Australia, Bolivia, Brazil, Canada, Chile, Columbia, Costa Rica, Fiji, Guatemala, Indonesia, Malaysia, New Zealand, Paraguay, the Philippines, South Africa, Thailand and Uruguay—have vehemently opposed inclusion of the word "multifunctional" in trade documents. Their representatives pass up few opportunities to speak disparagingly of the idea.

A substantial portion of the effort put into multifunctional agriculture by Non-Governmental Organizations (NGOs) around the world has been to reconcile the support of multifunctionality on a domestic level with efforts to enhance food security, economic opportunity and environmental protection in developing countries. Outside of trade discussions, traditional agriculture in the developing world often shows a high degree of complexity, environmental sustainability, community interchange and other "goods" which are supposed to result from support of multifunctional agriculture.

Outside of trade discussions, traditional agriculture in the developing world often shows a high degree of complexity, environmental sustainability, community interchange and other "goods" which are supposed to result from support of multifunctional agriculture.

3.2 An Overview of Agricultural Policies in the United States

For more than 60 years, beginning in the 1930s, government commodity policies have focused on the production of selected crops. That system was modified in 1996, when Congress passed the Federal Agricultural Improvement and Reform Act—known most commonly as the "Freedom to Farm" bill. It was to have changed federal farm commodity policy to separate the amount of farm payments from the kinds and amounts of crops grown. The featured component of the program was a subsidy for farmers linked to the number of acres they had enrolled in past farm programs, but not linked to particular crops, so farmers could plant whatever they wanted. These Agricultural Market Transition Act payments (AMTA) were to be gradually decreased to zero over seven years (Hoffman 1996).

However, during the late 1990s, farmers experienced extraordinarily low commodity prices. To help farmers, Congress gave them billions of dollars in additional "emergency" money. For example, farmers were eligible to receive a loan deficiency payment (LDP), which was directly tied to how many acres of program crops were grown. Six crops—soybeans, corn, wheat, upland cotton, rice and sorghum—received 97 percent of the $6.78 billion in loan subsidies. Just two crops, soybeans and corn, accounted for $4.74 billion, or 70 percent, of those dollars (Williams-Derry et al. 2000). More corn and soybeans are being grown than ever (Price 2001). The farm program paradigm based on maximizing yields and production of a few crops underlies these elements of the farm program.

Congress has also attempted to address the environmental costs of agriculture since 1935. Conservation programs do everything from funding land retirement to providing cost-share funds for farmers who voluntarily establish environmentally-friendly structures. These programs have proven popular within the farming and environmental communities. In addition, conservation compliance was implemented in 1985 and played a big part in reducing erosion by nearly 38 percent between 1982 and 1997. However, beginning in 1995 erosion reductions leveled off, with about 29 percent of crop fields "excessively eroding," say government soil experts (NRCS 2001).

In terms of overall spending, conservation programs are only funded at about half of their 1937 level (NRCS 1996). In 2000, they were only about 7 percent of the total federal outlay for farms (Green and McElroy 2001). Conservation programs designed to operate within a system of income and commodity support programs that are focused on maximizing production. About 70 percent of conservation spending since 1985 has been for retirement programs, which, at the rural community level, sometimes exacerbate negative economic impacts from the loss of independent family farmers.

About 70 percent of conservation spending since 1985 has been for retirement programs, which, at the rural community level, sometimes exacerbate negative economic impacts from the loss of independent family farmers.

Current Policy Proposals in a Multiple Benefits Context

Several policy proposals are being developed and could be implemented in ways that will help farmers adopt farming systems that result in increased public benefits to society.

The Conservation Security Act provides a set of mechanisms that Phase I results suggest are worth repeating in the development of other policy approaches (Kemp 2001). Important components of new programs and policies include sensitivity to national and local goals; inclusion of stakeholders in planning and development; increased focus on performance-based measures; graduated payments for increasing benefits; payment of current performers, not just those who switch practices; and provision of marketing funds. Other programs that will include the imposition of TMDLs (total maximum daily loads) for water pollutants do not offer graduated payments or benefits to current environmental achievers. Similarly, programs such as the Conservation Reserve Program (CRP), require that land be exposed to intensive cropping use, rather than grazing or other farming uses, to become eligible for the program. Landowners who are currently providing environmental benefits cannot participate in these programs.

3.3 Policy Recommendations

These data speak to the need to develop farm programs that reward farmers for the nonmarket benefits they produce. Public income support could be redirected through stewardship incentive payments to achieve high levels of public benefits while also producing a greater diversity of products. The results of this study clearly point to the need for new farm policies that help create these options, provide safety nets for all farmers, and offer incentives for pilot and demonstration projects that can help restore vibrancy and heterogeneity to the working landscape. This will require the harnessing of imagination and creativity, the products of thought and thoughtful practice.

The Multiple Benefits of Agriculture Project is recommending further development of the policy framework so it purposefully differentiates between agricultural market and nonmarket public goods. By nonmarket public goods we mean those benefits society deems it needs but are not paid for by the exchange of goods and money through the marketplace. The results of the Project's Phase I research strongly suggest several key policy elements that need to be further developed:

Recommendation 1: *Pay farmers, including existing environmental stewards, for public environmental and social benefits from their farms.*

Project data predict that important environmental benefits would accrue from adoption of best management practices and changing farming systems, with the magnitude of benefits depending on the ecosystem and the kind of farming system. However, current farm policy that supports production of a few program crops is a major disincentive for farming systems changes.

The Project's analysis of the social impacts of agriculture also suggests that the current system has significant negative impacts on rural communities. It is less clear that changing farming systems would be sufficient to cause positive improvements in rural community economies and social systems. However, changes implied in Scenario C would help achieve a diversification of the economy as it relates to agriculture, which may lead to greater resilience on the community level.

The results of this study clearly point to the need for new farm policies that clearly differentiate between market and nonmarket public goods.

Recommendation 2: *Provide income, as well as cost-share payments, to farmers through graduated payment programs to promote incentives for significant improvements in stewardship.*

The data show that under current conditions, farmers could earn more income from utilizing the practices outlined in Scenarios C and D than they do in the baseline. However, transition costs for the purchase of new equipment and the adoption of new management systems would need to be addressed. When current government income payments are taken into account for Midwestern farmers, most would lose net income or drop into a negative income status without government income payments. There are few incentives to change.

Policy mechanisms must be developed to provide incentives for farmers to adopt farming systems that result in nonmarket environmental and social public goods above a reasonable minimum standard. Incentives should include reimbursing farmers for changing farming systems, land retirement where needed and ongoing income supplement for the provision of public goods. Farmers who already use stewardship-based systems should have access to the income provisions, not just those who are changing systems to meet the new standards (Dobbs and Pretty 2001).

Achieving significant nonmarket environmental improvements from agriculture may require income to substitute for payments farmers forgo by not raising commodities. Cost-share payments to help cover the cost of installing new systems will also be needed. It will be important to clearly distinguish between public benefits provided by farms that reduce potential market income and benefits that result from adopting farming systems that also reduce the costs of producing marketable products. It will also be important to find effective ways to decouple these incentives from land values (Dobbs and Pretty 2001).

The results of this study clearly show that there are more public benefits gained by moving from best management practices in dominant crop systems in the Corn Belt to more diversified systems that include perennial components. A graduated payment approach to stewardship incentives would recognize and reward increasing benefits.

Recommendation 3: ***Pay on the basis of results, because the effects of BMPs or changes in farming systems depend on local conditions and management.***

The scenario data show that the impacts of farming systems will depend on the local ecology, topography, climate, drainage patterns, etc. We need to develop approaches that provide income payments on the basis of results, not simply the installation of practices. Such approaches will need to be administratively feasible (which also means feasible for farmers), cost-effective and replicable. It may be a useful to utilize modeling and valuation of selected nonmarket benefits as a way to assess progress (Pretty et al. 2001).

Recommendation 4: ***Create new markets for diversified crops through rural development funding.***

Instead of subsidizing a given crop or farming system for marketable commodities, rural development programs could help create markets for alternative crops such as small grains or biomass fuels grown in rotations that are good for the land. Re-emphasizing or recreating regional markets as part of the total trading mix would offer an opportunity for farmers to market their story and thus more effectively sell their food products (Kirschenmann 2001). New cooperative and other business arrangements must be promoted to help independent farmers participate in volume-based markets (Flora 2001).

Recommendation 5: ***Change and redevelop institutions to more effectively promote stewardship and diversified marketing.***

The policy changes proposed here are significant and cannot be achieved without changes in institutional structure and function. Farmers interviewed were clear about the need for assistance to change to more diversified production and/or marketing. They are more likely to change if they see the institutions changing along with them.

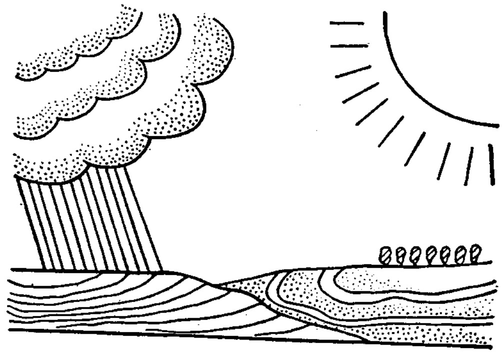
Government policy should be based on a clear set of national goals and adapted to local conditions with local goals. The latter will require the participation by a wider variety of stakeholders than usually participate in current government farm programs. In part, this has begun with Natural Resources Conservation Service's state technical committees.

Recommendation 6: ***Create conditions for fair market prices and fair market access.***

As is evident in this study and elsewhere, farmers are receiving extremely low prices for some products through the marketplace. To survive economically, farmers must be able to sell products for an adequate profit. Changes in how the marketplace is regulated are needed to make it fair and accessible for independent family-based farms.

Recommendation 7: ***Develop a process for national and local goal setting and public involvement.***

U.S. agricultural policy is set by Congress with considerable input from the farm commodity groups, agribusiness interests and, to a lesser extent, environmental groups and other members of civic society. Yet non-farming citizenry are increasingly engaged in and affected by the nonmarket consequences of farming. In this changing climate, it is time for more transparency and dual responsibility in the relationship between the national/local governments and farmers. Citizen involvement in determining the goals for agricultural policy nationally and locally will be needed to achieve a higher level of transparency. The Land Management Contract (LMC), developed in France, provides an example of how to reward farmers for the production of social and environmental benefits that are not fully compensated through the market. Citizens help set local goals in the context of the national policy. Farmers then propose a LMC to meet those goals. LMCs are agreed to at the local level and evaluated by a local agricultural policy committee that includes nature conservation groups, consumer groups, governmental officials as well as business and trade organizations (DeVries 2000; Vorley 2001).



4 Conclusions

Results of this study demonstrate that significant environmental benefits would result from diversification of working farms in two Minnesota watersheds. Scenarios for different agricultural land uses were developed by citizens and then used with a predictive model to estimate environmental benefits. The scenarios incorporated best management practices, longer crop rotations, animals raised in well-managed grass systems, buffer strips and wetland restoration. The benefits included substantial reductions in soil erosion, as well as reduced runoff of nitrogen, phosphorous and water, and reduced nitrogen oxide emissions. Improved fish populations and healthier bird habitat also resulted from the modeling.

The economic values of these nonmarket benefits are significant. Minnesota citizens are willing to pay an additional $342 million in taxes or marketplace costs per year to achieve significant environmental improvements from agriculture. Additionally, avoided costs, such as flood reductions, appear substantial, and would be larger still if avoided treatments of drinking water and other negative externalities were calculated.

Current policies and marketing structures that reward agricultural concentration and monocultural systems are barriers to change in land use and management. Overproduction encouraged by yield-determined commodity payments has led to low market prices and billions of dollars in taxpayer-financed government payments. These payments boost farm "income," but also finance environmental and social degradations. If policy priorities were changed to reflect measured consumer interest, the already large public financial contribution could instead foster significant environmental improvements and support independent producers. High levels of environmental benefits could be achieved for little more, and possibly less, than current costs to society. In economic terms, the marginal cost to the taxpayer would be zero.

More diversified systems would require higher levels of social capital and assistance from institutions. Farmers and other entrepreneurs will need help to create new marketing outlets and strengthen social and economic links with other communities. Diversified systems are less vulnerable to market swings and rely more heavily on local resources, thereby making them more reliable engines of rural development than current agricultural trends.

The project recommends several policy changes that include: paying farmers for the public services they provide, assuring access and fair pricing for marketable products raised by small to mid-sized independent farms, diversifying markets to accept a wider range of products, redirecting dollars for technical support and research to systems that produce environmental and social benefits, and more effectively involving the public at national in agricultural policy.

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Appendix B: Project Information & Methodology

The Multiple Benefits of Agriculture Analysis explores scenarios developed through citizen involvement. Four scenarios were developed by citizens of the watersheds through multiple focus groups. The results rely on modeling, expert advice and literature review. The scenarios were analyzed to describe environmental, social and economic benefits:

- **Environmental analysis:** Modeling was conducted to estimate the sediment and nutrient losses and effects on fish populations. Surveys of bird populations and a literature review formed the basis for analysis of the benefits to bird populations.
- **Social analysis:** Institutional effects were estimated based on interviews with farmers and other watershed residents. Analysis of social and other forms of capital was extracted from transcripts of the focus groups held in both watersheds.
- **Economic analysis:** On-farm productivity was estimated using reports from farmer surveys. Returns and profitability were estimated based on current prices, reported yields and government payments. Other effects, such as tourism and flooding, were based on literature reviews and published estimates.

This section describes the methodology for the scenario development, outlines the major modeling techniques used in the analysis and describes other calculations used in the development of the estimates presented in Chapter 2.

Scenario Development

The scenarios for possible land use provide the basis for the Project's analysis. The scenarios provide varying levels of environmental, economic and social benefits that would result from alternative futures. The scenarios are citizen-driven, based both on written materials created by watershed residents and in-person focus groups and interviews. The focus groups were also assembled to provide project team members with general outlines of desires and expectations for future agricultural land use in each watershed. Residents were asked to describe how their watershed might look in the future. They were also asked to predict what would happen to the environment and communities under the different scenarios. From these discussions, the team developed four main scenarios, which vary slightly between the watersheds to account for local conditions.

The scenarios were developed using a four-step process: 1) study past materials compiled by watershed residents; 2) assemble citizens in multiple focus groups to provide broad outlines of their desires and expectations for future agricultural land use in the watersheds; 3) reconvene focus groups to identify what landscape changes are needed to create different futures for the watersheds; and 4) use the Project's steering committee to create more detailed descriptions of the scenarios for the analysis.

Step 1) Documents were gathered and analyzed for themes of desired future options as they relate to agriculture. Beth Knudsen, Wells Creek Watershed Partnership coordinator, and Kylene Olson, Chippewa River Watershed Project coordinator, assisted in collecting materials from their respective watersheds.

Step 2) Focus group participants were recruited beginning with one key contact. Each contact was asked to refer another person who was active in the area. The list grew until no new names were introduced. Rural sociologists Cornelia Flora and Jan Flora proposed and led this "snowball sampling" method. Each contact was asked to send their current documents, including plans, newspaper articles, minutes of meetings and other materials. After the documents were analyzed, focus groups were set up with the institutional players to help teach the Project team the story of natural resource management in the watershed. More than 40 people participated in watershed focus groups.

Approaches to the focus groups varied between the watersheds. After completing Step 1, the project team determined that Step 2 in Wells Creek had already been completed by the local watershed partnership. Step 2 was therefore bypassed in Wells Creek. The project team relied on a vision statement developed by Wells Creek residents that specified their goals and objectives for the watershed, dividing those goals along themes of environmental, social and economic outcomes.

Step 3) After completing the first focus groups in the Chippewa River watershed, the project team divided the comments on social, economic and ecological capital into themes (e.g., government services, hopes for the future, diversity, etc.). This was done through the division and regrouping of comments on social, economic and ecological capital. The Project's analysis from the Wells Creek watershed vision statement was carried forward into this step. The next focus groups, conducted both in the Chippewa River study area and the Wells Creek Watershed, were designed to develop concrete scenario descriptions.

In this vision process, the Project team presented information on the varying level of environmental outputs (sediment, nutrients) that result from different farming systems. The team then gave participants large maps of the watersheds and markers, and asked the participants to draw some of the changes in land use and related outcomes they envisioned under the different scenarios.

Step 4) The steering committee took the ideas and scenario outlines from the citizen focus groups and developed more detailed descriptions that were used as the basis of the analysis.

Environmental Analysis

The assessment of environmental changes under the baseline and four scenarios provides the basis for the analysis. Each scenario is analyzed and compared to the baseline to gauge the environmental benefits that the public will enjoy due to changes in agricultural management in the watersheds. Results from the watersheds are compared to illustrate the range of benefits that might occur on Minnesota's diverse agricultural landscape.

Field-Edge Sediment and Nutrient Losses

Field-edge sediment, nitrogen and phosphorus losses were estimated for each current farming system using the Agricultural Drainage and Pesticide Transport (ADAPT) model. The model was utilized by University of Minnesota agricultural economists, with the advice of soil scientists. 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, topography and 50 years of daily weather data. A 50-year average is presented. Estimates for these parameters are developed for the four scenarios by running the model with different proportions of each type of land use or farming practice. Buffer strips, wetlands and government set-aside lands are modeled as grassland not being grazed by livestock. This methodology is likely to create conservative estimates of the erosion- and nutrient-reduction potential of scenarios that include these types of conservation practices. Sensitivity analyses were conducted on each of the four scenarios to test variations in the assumptions regarding land use changes. Surveys of local farmers provided the data for the baseline and subsequent analyses.

The model is calibrated to Minnesota soils. Numerous adjustments to the model were initiated in response to repeated reviews by academics, farmers and nonprofit staff to make this model suitable for analyzing grazing and pasture systems. These intensive meetings focused on comparing the results with reviewers' understanding of systems, monitoring data from other studies and published estimates calculated by the ADAPT model. For example, data from the modeling were compared to results from the Sustainable Farming Systems Project, a concurrent research effort coordinated at the University of Minnesota.

Watershed Level Sediment and Nutrient Changes

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

Loss of sediment and nutrients in surface runoff, and through the drainage system (where appropriate), was estimated for a given system on all three soils in the simulated system. The proportion of pollutants that actually reached the mouth of the sub-watershed depended on the delivery ratio associated with the location of that system. Soil types with drainage had a delivery ratio for surface water of 100 percent for sediment, nutrients and phosphorus. Soil types had surface water delivery ratios as noted in Exhibits 4 and 5. Modeled data from fields in management-intensive rotational 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 staff.

The aggregated values are a prediction of how much sediment, nitrogen and phosphorus would reach the mouth of the watershed under the baseline and four scenarios. The aggregated values for the scenarios are compared to the baseline estimates for each watershed in Chapter 1 and in Appendixes C and D.

Watershed Level Estimates of Fish Populations

The potential impact on fish populations under the scenarios was calculated for each watershed. Daily suspended sediment concentrations were used to determine effects of these sediment levels on fish communities in each stream by calculating the total number of days 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 that the severity of effects increases 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. These analyses quantitatively related the biological response of various fish communities to suspended sediment concentrations and duration of exposure.

Fish in the analysis included juvenile and adult salmonids, which represented the Wells Creek coldwater stream community, and adult freshwater non-salmonids, which represented the fish community tolerant of warm water, such as in the Chippewa River. Previously published sublethal and lethal thresholds of sediment concentration have been based on total amounts of suspended sediment and duration of exposure for each fish community. These thresholds were used to calculate the total number of days where the sediment concentrations and duration of exposure met or exceeded the sublethal or lethal levels for fish populations 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 defined as reduced growth rate, delayed hatching, reduced fish density, increased predation, severe habitat degradation and mortality.

Base flow is 16 cubic feet per second (cfs) for the Chippewa River and 35 cfs for Wells Creek. The estimated proportion of in-stream sediment concentration due to stream bank erosion is 20 percent in Wells Creek, based on estimates for the Whitewater River watershed, a similar watershed in southeast Minnesota (NRCS 1998), and 40 percent in the Chippewa River study area (based on an average estimate from Joe Magner, Minnesota Pollution Control Agency, and Dave Mulla, University of Minnesota Department of Soil, Water and Climate). Bank erosion estimates were held constant for the baseline and all scenarios to separate the effects of changing watershed land use on in-stream sediment concentrations from those due to stream bank stabilization. However, stream bank erosion would likely decrease for the scenarios that included increases in riparian buffers and permanent cover along streams.

The number of lethal and sublethal events between current conditions and each of the four land use scenarios were compared. This helped determine how changes in sediment concentrations—brought on by changes in land use and farming practices—affected fish health in the watersheds. Differences between the mean annual days with lethal and sublethal sediment concentrations were tested using Analysis of Variance (ANOVA). Individual means among treatments were compared to determine if a significant difference ($p<0.05$) was detected. See Henry and Vondracek (2001) for further details.

Bird Populations

The assessment of the potential changes in bird populations for this report is based on a literature review from bird research in the Midwestern United States. The baseline information was gathered from local sources. See Henry (2001) for further details.

Greenhouse Gas Emissions

Greenhouse gas emissions were calculated using the international protocol for each emissions source, including crop (nutrient application) and animal (digestion and manure) agriculture. The ADAPT model and other summary data provided the basis for analysis.

Social Analysis

The analysis of social benefits has four components: 1) research on current demographic trends using different survey data; 2) interviews with watershed farmers to assess their resource flows; 3) analysis of social and human capital based on focus group discussions in each watershed; and 4) institutional analysis to assess the need for change to support the alternative scenarios.

Demographics

Watershed populations, income, farmer income and other demographic data were gathered from the United States Census and the Minnesota Census of Agriculture. State demographic data were used to supplement the research.

Farmer Interactions

The assessment of farmer interactions, i.e., patterns of input purchases, on-farm activity and marketing options, is based on intensive interviewing with nine local farmers using a resource flow methodology. Production operations ranged from a corn and soybean crop farmer to a diversified livestock and organic crop producer.

Analysis of Human, Social and Financial Capital

Alternative futures regarding human, social and financial capitals derive from the four alternative biophysical scenarios. Human capital includes the skills, health, values, leadership and education of the people who live in the community. Information is key to influencing human capital because it provides individuals with options—true in any area of life, including agriculture. Social capital involves mutual trust, reciprocity, groups, collective identity, a sense of shared future and working together. Social capital contributes to other forms of capital, including financial and human. Financial capital includes built structures which support the economy.

Based on researchers' knowledge of rural communities and development patterns and trends, each of the four scenarios was evaluated for potential impacts on social, human and financial capital. Other inputs into the design of these scenarios included focus groups carried out in each watershed. While efforts were made to obtain a representative sample of leaders from all segments of local society, most participants had a more "sustainable" perspective. See Corselius (2001b) for further details.

Institutions

Examination of the social context for agriculture in the Wells Creek and Chippewa River watersheds includes analysis of networks and institutions. In some cases, desired policy changes may require changes in existing networks or institutions. Project team members worked with residents of the watersheds to make such determinations. Jan and Cornelia Flora, rural sociologists associated with the Minnesota Institute for Sustainable Agriculture and Iowa State University, designed a resource-flow mapping methodology to address the presence and status of networks and institutions in the watersheds. See Corselius (2001a) for further details.

Farm Level Economics

Farm level income and profits under the baseline and scenarios are estimated to show the range of income levels expected under each of the scenarios. Government payments, based on data from farm insurance, conservation and emergency payment programs, are included in total farm income.

Impacts on net farm sales income for the study areas as a whole were estimated by holding constant the 2000 crop and animal product market prices:

• While hay prices were not decreased due to increasing production in scenarios C and D, corn and soybean prices were not increased with decreasing production. In real market conditions the impacts would be far more complex, but those predictions were not part of this study. We also did not increase income due to increased entrepreneurial activities such as sales of high-value food into niche markets (e.g. organic or other eco-labeled food), sales of carbon or nutrient trading credits or hunting revenue.

• In Scenario D, the number of dairy and beef cattle in both watersheds increase. In the Wells Creek study area 5,000 dairy animals and about 1,700 beef animals were added within management-intensive rotational grazing systems. Management considerations may lead to an increase in the number of dairy farms for this scenario. Again, prices for animal products were held constant.

• In the Chippewa River study area, the number of dairy animals increased slightly in Scenario C and by another 600 animals for Scenario D. The number of beef animals in the Chippewa increased in Scenario D by about 700 animals.

• Other than including the price of equipment in depreciation and interest payments, the one-time cash cost of making a transition was not included in the above figures.

Production Costs

Production costs for each system for each producer simulated were calculated, using information from producer surveys combined with data from the West Central Farm Business Management Association and the Southeastern Farm Business Management Association.

Fertilizer, agrichemicals and equipment costs for each crop in each system were calculated from survey responses. Fertilizer cost was derived from input level and input price (averaged over 1995-1998 from USDA figures) summed across all inputs. Agrichemical cost was calculated in the same manner (pounds of active ingredient applied multiplied by the pesticide price). Machinery cost for a crop in a given system was the product of the number of uses of the equipment (per acre) and total cost of machinery (per acre) as obtained from University of Minnesota agricultural economist William Lazarus. Machinery costs from Lazarus were not adjusted to reflect potential differences in hours of annual use. It was assumed that costs estimated by Lazarus corresponded to those typical for a farming operation of similar size and scale in the watershed.

To determine all other production costs, crop enterprise budgets were used. Data for these budgets were obtained from producers in the study area counties who provided records to the Southeast and West Central Minnesota Farm Business Management Associations for analysis (note that these producers were not necessarily the same producers surveyed for this research project.) Remaining costs for a particular crop enterprise were calculated as the weighted average of the owned and rented crop budget, based on the proportion of land each farmer rented or owned. Consider a producer who rented half the land on which crops (both corn and soybeans) were grown: the remaining production costs (other than chemicals and machinery) for each enterprise were calculated as the sum of half the crop production costs on rented land and half the crop production costs on owned land.

Production costs were adjusted to reflect changes in the current set of production activities. For example, to calculate production costs for a change in nutrient application rate, a new application rate (such as 15 pounds of phosphorus) was substituted for the original application rate and costs were adjusted accordingly. A similar method was used to adjust production costs to reflect changes in tillage (fewer operations or different equipment), or in nitrogen application rates.

Farm Income

Farm income was estimated from yield information provided through the producer survey, current crop prices, input costs and government payments. Input costs include an allocation for land and fixed machinery costs. Revenues are based on 2000 prices with an assumption that changes in watershed level crop production will not affect market prices.

Carbon Sequestration

Estimates of potential income resulting from carbon sequestration were based on data from Minnesota cropland and estimated valuation of a carbon credit of $20 per ton.

Economic Benefits

Off-farm economic benefits from changes in farming practices include potential reduction in the costs of sedimentation, potential decreasing costs from small-sized floods, and increasing local revenue from tourism. Contingent valuation—an alternative means of calculating the economic benefit from improved environmental performance from farms by asking citizens to place dollar values on their preference for change—was used to develop an estimate of the economic value of the change.

Avoided Sedimentation Costs

The avoided sedimentation costs were calculated by multiplying the amount of sediment reaching the mouth of the study area by $5.38 per ton. This figure was from Ribaudo (1989) and was adjusted to current dollars. Ribaudo estimated the impacts of sedimentation on downstream navigation and recreation.

Avoided Flooding Costs

Small- or medium-sized floods can be reduced by increasing the cover on the land and by restoring wetlands and water retaining structures. Recent flood cleanup cost data from small flooding events was gathered from representatives in the Wells Creek watershed and the Chippewa River study area. These numbers are presented as examples of how local cleanup costs might change under the different scenarios. See Byrne (2001) for further details.

Tourism

Focus group participants discussed their desire to increase tourism in their watersheds, particularly in the Chippewa River study area. Participants predicted that shifts in farming practices, with increasing diversity in farming systems, could inspire more travel and recreation in their areas. Based on these ideas, a survey of current and planned tourism options was conducted.

Contingent Valuation

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 (nonmarket) data. A stated-preference estimation technique known as contingent valuation is used.

Contingent valuation employs a survey which describes the prospective policy and its effects. The survey also indicates how much adoption of the policy would cost a respondent's household in higher taxes and higher prices for goods and services. Citizens' willingness to pay for the benefits of the policy are elicited from 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.

For this study, a mail survey was sent to a randomly selected sample of Minnesota households. Screening of an initial sample of 1,000, excluding businesses, deceased, non-residents and those without a valid mailing address, yielded 834 potential respondents. From there, 394 booklets were completed and returned, yielding an effective response rate of

47.2 percent. Personal interviews, conducted in the two watersheds that were studied intensively in the other components of this project, were also part of the analysis. Sixty-four personal interviews were conducted in the Wells Creek Watershed and 61 were conducted in the Chippewa River Watershed for a total of 125 additional responses from Minnesota citizens.

This study evaluated the benefits respondents derived from two different levels of multiple benefits. Attention was devoted mostly to a “baseline” policy scenario yielding a 50 percent reduction in most environmental impacts from agriculture. This was the level described in the interviews and half the mail surveys. The other half of the mail surveys described a 10 percent reduction in environmental impacts. See Welle (2001) for further details.

Appendix C: Estimated Amount and Percent Change in Environmental & Economic Performance Compared to Baseline Indicators

Wells Creek Watershed Study Area

	Baseline	A	B	C	D
Delivery to Mouth of Stream (based on ADAPT output):					
Sediment (tons/yr)	39,615	41,349	27,321	17,292	6,148
		+4%	-31%	-56%	-84%
Nitrogen (lbs/yr)	3,001	2,783	1,878	1,098	788
		-7%	-37%	-63%	-74%
Phosphorus (lbs/yr)	7,547	7,262	3,495	2,281	2,180
		+4%	+54%	+70%	+71%
Reduction in Inputs (based on surveys and other studies):					
Total Nitrogen Fertilizer Use (lbs/yr)	1,872,773	1,746,656	999,804	496,415	276, 665
		-7%	-47%	-73%	-85%
Water Flow (% only): [1]		0	-1%	-25%	-36%
Greenhouse Gas Emissions (based on reduced N fertilizer use and methane from animals):					
Nitrous Oxide from Soil Management (lbs/yr)	37,689	35,266	20,789	12,832	7,191
		-6%	-45%	-66%	-81%
Greenhouse Gas (MT of carbon equivalents/yr)	5,003	4,911	4,358	4,037	7,695 [2]
		-2%	-13%	-19%	+54%
Wildlife Impacts:					
Lethal Fish Total Events/yr	6.7	7.4	2.9	1.9	.2
(Based on estimated sediment delivery to streams and other studies)		+10%	-57%	-72%	-98%
Economic Impacts					
Downstream Costs from Sediment in Streams	$213,131	$222,456	$146,989	$93,033	$33,076
@ $5.38/ton eroded/yr (based on ADAPT output and Ribaudo 1989)		+4%	-31%	-56%	-84%
Total Cost of Production for the Study Area	$13,521,781	$13,416,770	$13,111,364	$12,458,085	$19,556,767 [3]
		-.8%	-3%	-8%	+45%
Current and Hypothetical Net Farm Income from Sales [4]					
Additional Income Needed to Achieve Baseline Net Farm Income from Sales	$2,089,045	$27,996	$16,825	-$241,806	-$2,188,757
		+1%	+1%	-12%	-105%

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[1] Water flow reductions were due to increased acres of hay, buffers, management-intensive rotational grazing and wetlands in scenarios C and D.

[2] This increase in methane production from digestion was due to adding about 2,000 dairy cattle to the watershed. However, it's believed the net effect on greenhouse gas emissions would be smaller. Based on comparisons with CRP land by Huggins et al. (1998), the added grass-based acreage could accumulate as much as 1/3 higher soil organic carbon than Gurney (2000) predicted for croplands.

[3] The large number was due primarily to an increase in the number of dairy cattle.

[4] This was based on 2000 prices. The cost of transition on a one-time cash basis was not included. Prices were held constant despite increased or decreased acres devoted to a given crop.

Appendix D: Estimated Amount and Percent Change in Environmental & Economic Performance Compared to Baseline Indicators

Chippewa River Watershed Study Area

	Baseline	A	B	C	D
Delivery to Mouth of Stream (based on ADAPT output):					
Sediment (tons/yr)	1,956	1,788 -9%	1,473 -25%	1,275 -35%	995 -49%
Nitrogen (lbs/yr)	13,996	14,068 +1%	11,555 -17%	6,882 -51%	5,267 -62%
Phosphorus (lbs/yr)	5,108	4,852 -5%	2,974 -42%	1,524 -70%	1,261 -75%
Reduction in Inputs:					
Total Nitrogen Fertilizer Use (lbs/yr)	1,925,452	1,942,031 +1%	1,771,224 -8%	732,094 -62%	191,102 -90%
Water Flow (% only): [1]		+1%	-3%	-22%	-34%
Greenhouse Gas Emissions (based on reduced N fertilizer use and methane from animals):					
Nitrous Oxide from Soil Management (lbs/yr)	38,718	38,919 +1%	35,613 -8%	18,340 -53%	6,521 -83%
Greenhouse Gas (MT of carbon equivalents/yr)	2,065	2,072 0	1,946 -6%	1,267 -39%	1,326[2] -37%
Wildlife Impacts:					
Lethal Fish Events Total Events/yr (Based on estimated sediment delivery to streams and other studies)	11.2	11.4 +2%	11.1 0%	11.1 0%	10 -10%
Economic Impacts					
Downstream Costs from Sediment in Streams @ $5.38/ton eroded/yr (based on ADAPT output and Ribaudo 1989)	$10,525	$9,617 -9%	$7,925 -25%	$6,858 -35%	$5,355 -49%
Total Cost of Production for the Study Area	$9,201,615 +1%	$9,291,169 -3%	$8,927,092 -19%	$7,414,388 -38%	$5,748,499[3]
Current and Hypothetical Net Farm Income from Sales[4]					
Additional Income Needed to Achieve Baseline Net Farm Income from Sales	$979,255	$20,461 +2%	$26,703 +3%	-$565,952 -58%	-$310,489 -32%

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[1] Water flow reductions were due to increased acres of hay, buffers, management intensive rotational grazing and wetlands in scenarios C and D.

[2] Scenario D included a small increase in the number of dairy cattle and an increase in the number of beef cattle.

[3] This was due to an increase in the number of dairy and beef cattle in the study area.

[4] This was based on 2000 prices. The cost of transition on a one-time cash basis was not included. Prices were held constant despite increased or decreased acres devoted to a given crop.

Appendix E: Maps

Chippewa River Study Area

- Hydrographic and Cultural Features
- Baseline: Current Land Use and Cover

- Scenario A: Extension of Current Trends
- Scenario B: Best Management Practices

- Scenario C: Community and Economic Diversity
- Scenario D: Year-Round Cover

Wells Creek Watershed

- Hydrographic and Cultural Features
- Baseline: Current Land Use and Cover

- Scenario A: Extension of Current Trends
- Scenario B: Best Management Practices

- Scenario C: Community and Economic Diversity
- Scenario D: Year-Round Cover

This is a publication of the Land Stewardship Project, a private nonprofit organization. For more information, contact the Land Stewardship Project at 2200 4th Street, White Bear Lake, MN 55110; phone: 651-653-0618; fax: 651-653-0589;
e-mail: lspwbl@landstewardshipproject.org;
Web site: www.landstewardshipproject.org.

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