BOARD OF WATER AND SOIL RESOURCES

Working Lands Watershed Restoration Feasibility Study and Program Plan

Report to the Minnesota Legislature

February 1, 2018

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Acronyms and Common Terms

ACEP: Agricultural Conservation Easement Program

BCAP: Biomass Crop Assistance Program

BMP: Best management practices

CIG: Conservation Innovation Grants

CREP: Conservation Reserve Enhancement Program

CRP: Conservation Reserve Program

CSP: Conservation Stewardship Program

CTA: Conservation Technical Assistance

DNR: Minnesota Department of Natural Resources

EQIP: Environmental Quality Incentives Program

FSA: Farm Service Agency

MASWCD: Minnesota Association of Soil and Water Conservation Districts

MDA: Minnesota Department of Agriculture

MPCA: Minnesota Pollution Control Agency

NACD: National Association of Conservation Districts

NRCS: Natural Resources Conservation Service

RCPP: Regional Conservation Partnership Program

RIM: Reinvest In Minnesota

RMA: Risk Management Agency (USDA)

USDA: United States Department of Agriculture

Executive Summary

Improving the quality of Minnesota's waters can be a slow and frustrating process. In spite of decades of investment in conservation programs and the efforts of many individual farmers and landowners, many rivers, streams, and lakes do not meet water quality goals. Changes in weather patterns bring more intensive rainstorms, increasing the risks of flooding and soil loss. Economic pressures and fluctuating commodity prices create incentives for farmers to increase the acres planted to corn and soybeans.

There is growing recognition among conservation professionals, researchers, farmers and other engaged citizens that in order to increase the pace of progress on water quality, more vegetation is needed on the land for longer periods of time. Programs such as the federal Conservation Reserve Program, the Minnesota Conservation Reserve Enhancement Program, and the Reinvest in Minnesota conservation easement program all protect environmentally sensitive land by restoring it to perennial vegetation, temporarily or permanently. But is it possible to increase this "conservation footprint" on the landscape without taking additional land out of production?

One of the answers that is now emerging is diversification of the agricultural landscape through introduction of perennial grain, forage, and biomass crops and increased use of annual cover crops that build soil health, capture pollutants, and hold water during heavy rains, while providing an economic return to those farming the land. By developing or enhancing markets for these alternative crops, it may be possible to improve both water quality and Minnesota's agricultural economy.

Conservation on private land has most often relied on two paths: voluntary approaches, with incentives provided by state cost-share and federal programs, and regulatory, such as the requirement to establish riparian buffers on public waters and public ditches or the regulations that govern manure management. An approach that harnesses market forces has the potential to create a new third pathway to promote conservation practices that benefit both the producer and the environment.

In 2015 and 2016, a coalition of renewable energy, environmental and agricultural organizations promoted a bill that would incentivize planting of perennial crops to improve water quality. This plan and feasibility study report for a Working Lands Watershed Restoration Program has been prepared for the Minnesota State Legislature by the Board of Water and Soil Resources (BWSR), in fulfillment of the requirements of Laws of Minnesota 2016, Chapter 189, Article 3, Section 4. Table 1 lists the elements of the legislation and the responses by BWSR and its partners as laid out in this report.

Table 1. Summary of Working Lands Legislation and Project Activities

Elements of the Legislation	Project Activities
Develop a detailed plan to implement a working lands watershed restoration program to incentivize the establishment and maintenance of perennial crops, including:	Detailed below
• a process for selecting **pilot watersheds** that are expected to result in the greatest water quality improvements and exhibit readiness to participate in the program;	Six major watersheds were selected for study based on defined criteria; minor watersheds within each major watershed were selected for more detailed modeling based on local partner recommendations.

Elements of the Legislation	Project Activities
• an assessment of the **quantity of agricultural land** that is expected to be eligible for the program in each watershed;	Assessed in terms of predominant crops and soil productivity, with a focus on identifying lands less suitable or less economically rewarding for row crop production.
• an assessment of **landowner interest** in participating in the program;	Assessed through a survey of landowners and operators in each of the major watersheds and meetings with local conservation organizations.
• an assessment of the **contract terms** and any recommendations for changes to the terms, including consideration of variable payment rates for lands of different priority or type;	Being assessed through development of a spreadsheet tool that generates comparisons of farm income and expenses of current annual row crop systems compared to alternative crops, for different locations within each watershed that vary by soil productivity.
• an assessment of the opportunity to **leverage federal funds** through the program and recommendations on how to maximize the use of federal funds for assistance to establish perennial crops;	Assessed through discussions with federal agricultural agencies and agricultural interests. Evaluation of federal farm bill programs and potential adjustments or new initiatives is included in Section VIII and Appendix 3.
• an assessment of how **other state programs** could complement the program;	Assessed through discussions with state agencies that manage easement programs, incentive programs, cost-share programs, and wildlife habitat management programs. See Section IX.
• an estimate of **water quality improvements** expected to result from implementation in pilot watersheds;	Assessed through modeling of water quality impacts of land use/land cover changes in selected watersheds. See discussion in Sections V and VII and Appendix 4.
• an assessment of how to best integrate program implementation with **existing conservation requirements** and develop recommendations on harvest practices and timing to benefit **wildlife production**;	Assessed through discussions with state wildlife and biomass managers. See discussion in Section IX.
• an assessment of the potential viability and water quality benefit of **cover crops** used in biomass processing facilities;	Assessed through literature review and discussions with researchers, Extension specialists, and agricultural interests. There is a growing level of interest in cover crops for managed grazing and for relay or double cropping with row crops.
• a **timeline for implementation**, coordinated to the extent possible with proposed biomass processing facilities;	See Section XI, Implementation
• a projection of **funding sources** needed to complete implementation.	See Section XI, Implementation

Challenges and Changing Attitudes

Participants in this project recognize the significant challenges of shifting the crop mix away from the well-established row crops to alternative crops and livestock operations. The biofuel market presents particular challenges at present. That market is focused on a search for the cheapest feedstock, which is typically a waste product or residue of another crop or process – for example, corn stover, distillers' grains, used cooking oil, or wood waste. Crops grown specifically for biofuel have not been able to compete against these cheaper and widely available feedstocks.

Many of the most promising crops still need significant research and development in agronomic, plant breeding, food science, and environmental impacts. Some crops have generated great market interest, but are still at least two or three years from being fully scalable. BWSR and project stakeholders are keenly aware of the "chicken or the egg" problem: large-scale processors of biomass crops will not invest in Minnesota facilities without a guaranteed supply chain, while farmers are unlikely to grow biomass crops for which a guaranteed market does not yet exist.

It is important to recognize that establishing and maintaining perennial cover on sensitive lands is part of a suite of best management practices, ranging from riparian buffers to no-till or strip till cultivation, to controlled drainage and stream restoration. The effects of these practices can't be viewed in isolation.

In spite of these caveats, we see increasing interest in more sustainable agricultural practices that benefit soil, water, and wildlife. Interest in and awareness of cover crops is high, as indicated in the landowner survey. Awareness of newer crops, such as Kernza, a perennial grain crop, and winter annual oilseeds, is still limited, but will increase as market opportunities are identified. Keeping the agronomic, supply chain, and marketing efforts moving forward in a coordinated way will be challenging but necessary.

The following are among the most promising implementation strategies for initiating a working lands program, as well as some of the challenges that a program would need to address. Section X. Findings and Recommendations, contains a more detailed discussion of these strategies.

Landowner Incentive Payments

The central objective of the Working Lands Watershed Restoration Program is to define the parameters of a contract program that will, as specified in the enabling legislation, create incentives for the establishment and maintenance of perennial and cover crops to improve water quality, while protecting landowners' income and managing risk.

How could a working lands program lead to more widespread adoption of alternative crops that improve water quality and soil health, but currently lack dependable markets? Essentially, the program needs to subsidize the alternative crops while working to create or improve their markets, with the goal of achieving a fully market-based program where subsidies are unnecessary.

Different contract terms for different "classes" of crops: The program would establish different contract terms for 1) perennials (where the primary crop is replaced), 2) cover crops (where the primary crop remains) and 3) cash cover crops (where the primary crop remains but its yields may be reduced).

Livestock enterprises, such as grass-fed beef, cow-calf enterprises, or grazing dairy, could fall into one or more of these categories, depending on the mix of forage and feed crops. These enterprises could be categorized based on the crop mix or on other factors to be determined.

Flexibility on What to Plant: Landowners should have the ability to choose which alternative crops to plant in any growing season, so long as living cover is maintained – that is, soil is not left bare during critical spring and fall periods, and is protected as much as possible against extreme rainfall events.

Flexibility on End Uses of Crops: An important factor in developing markets for alternative crops is freedom for producers to experiment and pursue a variety of market opportunities with those crops, provided the program's goal of continuous living cover is maintained. For example, a producer might choose to pursue Kernza in a wide riparian buffer or mixed perennials and cover crops for a grazing enterprise without needing to renegotiate the terms of a contract.

Watershed or "Supplyshed" Focus: To be able to model and monitor water quality improvements, a continued focus on specific watersheds is preferred. The watersheds analyzed and surveyed throughout this project offer a starting point for a pilot program, although other watersheds with landowner interest and organizational capacities could also be considered. However, if a potential processing facility wanted to work with producers to establish a reliable supply chain, a "supplyshed" spanning multiple watersheds could be considered.

Prioritize environmentally-sensitive lands and multiple benefits: Many questions about program priorities have been discussed. Should the program be structured similar to CRP, with rates based on cropland productivity? Or should it be designed to prioritize water quality and other ecosystem benefits? Project stakeholders and advisors strongly recommend assigning the highest rates to those lands that contribute the highest loads of pollutants to waterways. Lands that offer multiple benefits in addition to water quality, such as wildlife and pollinator habitat, should also be prioritized.

Risk management: A contract should provide assurance of a base level of payment for a defined period (e.g., 5 or 10 years to protect the landowner's income and investments in new crops and methods). Because perennials and cover crops can take several years to establish, a five-year contract is likely the minimum that would be effective. In addition to providing a guaranteed payment for the length of a contract, future eligibility for the federal crop insurance program should be maintained if feasible. (See the related recommendations below regarding the federal crop insurance program.)

Federal Farm Bill Opportunities

As discussed in Sections VIII and X, there are two primary opportunities to leverage federal Farm Bill programs that emerged from discussions with agricultural and conservation organizations.

Use Crop Insurance to Provide Incentives for and Gather Data on Conservation Practices: Work with the Risk Management Agency and state agencies to develop a program similar to the Iowa Cover Crop – Crop Insurance Demonstration Project, under which participating farmers will receive a $5.00 discount on their crop insurance premiums for "new" acres on which they establish cover crops. A Minnesota program could incentivize a wider range of conservation practices and could make aggregated data

available to crop insurance providers to develop new insurance policy products or risk pools that reward conservation practices. Iowa's discount program is funded by the state at $21.7 million for an initial three-year demonstration period. A Minnesota program would also require a state funding source.

Improving Opportunities and Incentives for Working Lands in CRP Contracts: Allow greater flexibility in the use of Conservation Reserve Program (CRP) land—specifically increased ability to harvest or graze lands under CRP contract—in exchange for a reduced payment. CRP could be modified in several ways:

- Changes to allowed land uses – for example, allowing harvesting and grazing as a designated use within an existing CRP conservation practice or creating a new conservation practice specific to grazing and harvesting.
- Changes to contract terms – for example, allowing a wide number of markets and uses by not specifying the end use for harvested vegetation.
- Changes to payment rates – for example, reducing penalties for harvesting or grazing so that the rates more accurately reflect the value of these practices.

Establishing pilot areas for testing these approaches would likely be more feasible than seeking to change national program rules.

State Program Opportunities

Revise the RIM-Clean Energy Program legislation as a basis for a working lands RIM program. The RIM-CE statute (§103F.518) establishes priorities for selection of land as "bioenergy crop production, water quality, soil health, reduction of chemical inputs, soil carbon storage, biodiversity, and wildlife habitat." It limits agricultural crop production and harvest to "native, perennial bioenergy crops." The statute could be revised to encompass the full range of perennial and cover crops discussed in this report, as well as other crops still under development, and to establish the other parameters of a "RIM-Working Lands" program.

Integrate working lands concepts into existing water quality programs. Evaluate and modify existing water quality programs where feasible, to ensure that perennial and cover crops are eligible for cost-share and other incentives. This evaluation should identify the need for and benefits of additional state support, along with the criteria under which perennial and cover crops can be established, maintenance and harvest requirements, duration of practices, and disposition of any revenue earned from harvest.

Integrate working lands concepts into soil health initiatives. Work to ensure that the development of the Soil Health Action Plan, to be developed by the new State Office of Soil Health, includes priorities and actions to increase the establishment of perennial and cover crops to improve soil health and resilience, and protect water quality. Among the components of soil health are runoff volume control, water holding capacity, organic matter, and crop productivity.

Create linkages between public conservation lands and working lands. Grazing of livestock on public lands such as wildlife management areas, establishment of perennial crops on conservation lands currently in row crop agriculture, or requiring the use of cover crops on leased Wildlife Management

Area (WMA) lands are all strategies that could enhance wildlife and pollinator habitat while increasing public awareness of perennial and cover crops.

Coordinate with existing and planned water quality trading programs. Water quality trading has been coordinated by the MPCA between point sources and nonpoint sources on a case-by-case basis since 1997. Typically, the point source – an industrial processor or wastewater treatment plant – purchases credits from upstream nonpoint sources in order to offset an increase in the discharge of a pollutant or to avoid the need for an upgrade to its wastewater treatment facility. While water quality trading is usually viewed as limited and temporary in nature, it has the potential to accelerate establishment of perennial and cover crops, along with other Best Management Practices (BMPs), in watersheds with high levels of pollutant loading.

Focus on vulnerable Drinking Water Supply Management Areas (DWSMAs) as pilots for a working lands program. There is increasing interest in protecting DWSMAs in areas with high risks for nitrate contamination of groundwater. Several rural water systems, community water suppliers, and the Minnesota Rural Water Association are actively exploring the potential for planting Kernza, other harvestable perennials, and cash cover crops in vulnerable DWSMAs. These areas offer significant opportunities for piloting a working lands program at a focused and measurable scale.

Local Partner Opportunities

Explore options for sharing equipment for interseeding of cover crops and cultivation and harvesting of hay and other perennial crops. Since haying for on-farm consumption has become less common, many farmers now lack the necessary equipment. Interseeding equipment, likewise, is a costly investment, although interseeding can increase the success rate of cover crops. Private or public entities such as farmers' co-ops and SWCDs could lease or loan out equipment or contract for its use, creating new economic opportunities. Some local partners are already operating such programs. Local partners will also continue to serve as essential conduits for information on conservation practices and as trusted advisors to the farm community.

I. Introduction and Overview

Minnesota has made a significant commitment to clean water and habitat through the Clean Water, Land and Legacy Amendment and decades of investment in conservation programs. While the quality of Minnesota's lakes, rivers, streams, and groundwater is improving, the pace of progress is not as fast as hoped. The Minnesota Nutrient Reduction Strategy, the Nitrogen Fertilizer Management Plan, and numerous other studies show that excess phosphorous, nitrogen, and sediment are impairing water quality. Runoff from agricultural and urban land and lakeshore development raises the amount of phosphorus in Minnesota lakes, which in turn causes algae to grow. Nitrate pollution from septic systems, fertilizers, and manure threatens public and private water supplies.

Changes in farm policy and agricultural practices have greatly reduced the diversity of crop rotations. Small grains and hay, once common parts of the farming system, have largely been replaced by corn and soybeans, and subsurface tiling has altered hydrologic systems. Both corn and soybeans leave farmland essentially bare from November through June, making it vulnerable to wind and water erosion and nutrient leaching. The timing and intensity of precipitation are changing, increasing the risks of destructive flooding and soil loss. In spite of improvements in agricultural practices, such as conservation tillage, improved manure and nutrient management, and land set-aside programs, water quality is increasingly threatened by these trends.

There is growing recognition among conservation professionals, researchers, farmers and other engaged citizens that in order to increase the pace of progress on water quality, more vegetation is needed on the land for longer periods of time. But is it possible to increase this 'conservation footprint' on the landscape without taking additional land out of production?

One possible solution is to increase production of perennial crops as energy feedstocks for multiple uses, including advanced biofuels that could supplement or replace ethanol. In 2015 and 2016, a coalition of renewable energy, environmental and agricultural organizations promoted a bill that would incentivize planting of perennial crops to improve water quality. This plan and feasibility study report for a Working Lands Watershed Restoration Program has been prepared for the Minnesota State Legislature by the Board of Water and Soil Resources (BWSR), in fulfillment of the requirements of Laws of Minnesota 2016, Chapter 189, Article 3, Section 4.

Multiple Solutions

> "In the face of low petroleum prices, continuing policy support and investment in research and development will be needed to allow biofuels to reach their full potential." *Dovetail Partners, Global Production of Second Generation Biofuels: Trends and Influences. January 2017.*

While the original legislation was based on the expectation of biofuel development, to be deployed in conjunction with existing ethanol plants, it became apparent to the BWSR project team that there are significant technical and policy barriers to widespread production of ethanol from perennials, termed "cellulosic ethanol" or "advanced biofuel." These barriers range from the falling prices of conventional fuels to difficulties in processing the tougher plant fibers of perennial grasses for ethanol. Several pilot projects using switchgrass as a feedstock have now ended, and have been replaced with a few larger plants now producing ethanol from corn stover, an agricultural residue composed of corn stalk remains following harvest. While corn stover can be sustainably harvested under certain conditions, it does not provide the same water quality and soil health benefits as perennial grasses.

BWSR and project partners are therefore looking beyond ethanol production to other potential uses for perennials, as well as for winter annual cover crops that provide year-round ground cover, hold the soil in place, and can uptake excessive fertilizer nutrients. New technologies for interseeding cover crops such as winter rye and camelina into corn and soybean crops are making it more feasible to maintain living cover outside of the relatively short growing season. Innovations in crop breeding and production methods by the University of Minnesota's Forever Green Initiative are developing a new generation of crops, including camelina and pennycress, winter annual oilseed crops, and Kernza, the first perennial grain crop.

Potential end uses for these alternative crops include bio-jet (biodiesel) fuel, combustion for heat and power, products such as animal bedding and plant-derived packaging material, animal feed and forage for beef and dairy cattle, and food products and alcoholic beverages such as those made from Kernza wheat. Not all crops can feasibly be grown in all watersheds, but each of the initial pilot watersheds has conditions appropriate for some crops. Potential crops and their end uses are discussed further in Section V of this report.

Project Design and Schedule

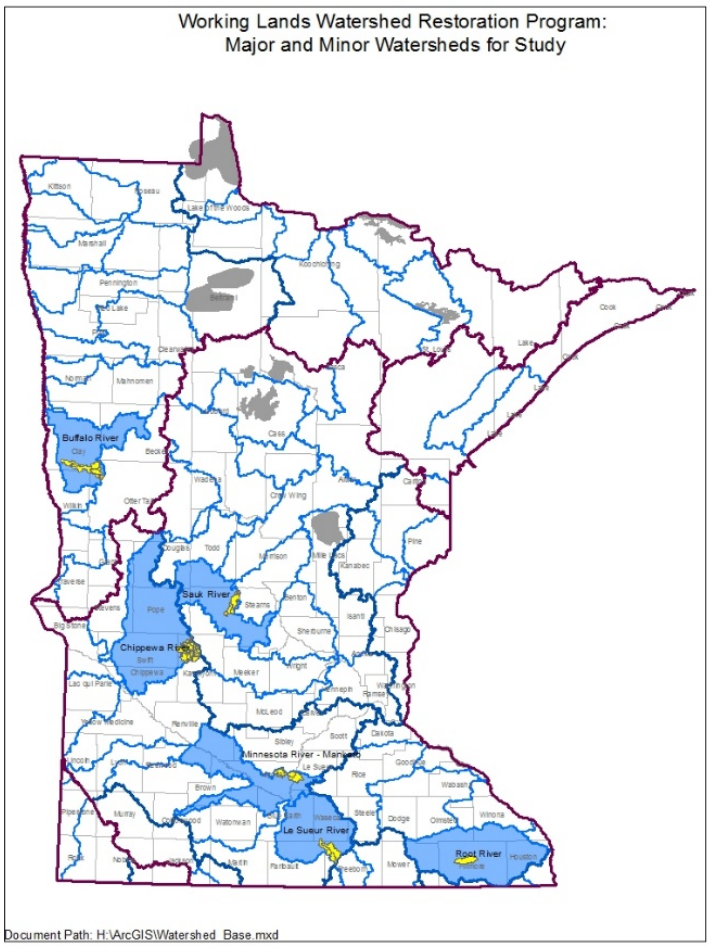
BWSR has worked closely with other state agencies, University of Minnesota researchers, agricultural and commodity groups, environmental organizations, local governments, and other groups engaged in water resource management. A stakeholder group that includes these interests has met seven times over the course of the project. Meetings included a half-day workshop on grazing, forage, and animal feed as strategies for encouraging establishment of perennials and cover crops and a full-day workshop in December focused on emerging market opportunities for biomass, including biofuels, biothermal energy, food and beverages, and other products.

A project web page was established and has been regularly updated with meeting notes and presentations, at http://www.bwsr.state.mn.us/planning/WLWRP/wlwrp.html .

Sample watersheds were selected for study based on their geographic and physical diversity, diversity of cropping systems, previous planning efforts and level of community engagement. Given the high level of engagement in watershed-scale planning across Minnesota, many other watersheds could have been selected, but the scale and time frame of this study limited it to six. Within each major watershed, one or more minor watersheds were selected for water quality modeling, based on recommendations from watershed districts, soil and water conservation districts, and other local partners. Major and minor watersheds are:

- Minnesota River – Mankato Watershed (Nicollet County) – Rogers Creek and Saint Peter area
- Le Sueur River Watershed – Upper Cobb River and Cobb Creek
- Chippewa River Watershed – Shakopee Creek Headwaters
- Sauk River Watershed – Getchell Creek / County Ditch 9
- Root River Watershed – Watson Creek
- Buffalo–Red River Watershed – Whiskey Creek

Figure 1. Major and minor watersheds for study



BWSR contracted with the University of Minnesota's Water Resources Center (WRC) to identify and quantify the economic and social factors affecting farmers' willingness to grow alternative crops on lands currently in annual row crops. The WRC's research efforts include:

- A survey of up to 500 landowners in each of the six major watersheds, from August through November, 2017.
- Development of a spreadsheet decision tool that addresses what financial incentives would be required to induce agricultural producers to convert cropland in selected Minnesota watersheds to perennial crops or to add cover crops. The spreadsheet enables the user to compare returns from current crops to potential returns from fourteen scenarios for perennial crops, cover crops, and grazing-based animal agriculture. Budget information for existing crops are drawn from

FINBIN, a farm financial database that summarizes actual farm data from thousands of agricultural producers who use FINPACK for farm business analysis.[1]

Other major elements of the project include:

- Modeling of impacts to water quality that would result from conversion of land in the selected watersheds from conventionally-farmed row crops to perennial grasses and/or cover crops. Modeling was conducted by MPCA staff.
- Assessment of existing federal Farm Bill programs that relate to working lands and perennial cropping systems, including conservation title programs and other policies that impact farm decision-making and present opportunities and/or barriers to establishment of perennials and other living cover crops. The Environmental Initiative conducted this assessment, which included outreach to agricultural interests, non-profits, and state agencies.

The outcomes of these tasks are discussed in Sections III through XI.

[1] FINPACK is a comprehensive farm financial planning and analysis software system used by agricultural producers, professionals, educators and lenders to help over 50,000 producers analyze their farm business each year. FINPACK is developed and supported by the Center for Farm Financial Management at the University of Minnesota.

II. Related Programs and Planning Efforts

The Working Lands initiative is not the first effort to examine the potential for biomass crops to provide clean energy and environmental benefits. Both previous pilot studies and existing state programs have advanced Minnesota's interest in promoting renewable energy from biomass. State initiatives have also evolved in response to changes in related federal programs and in economic and market conditions for biofuels.

The RIM-Clean Energy Program (2008)

In 2007 the Minnesota Legislature directed BWSR to prepare a Reinvest in Minnesota (RIM) – Clean Energy Program – a working lands conservation program for growing native perennial crops for bioenergy. The legislative directive, Minnesota Statutes, Section 103F.518, stipulates that selection of land for the program must be "based on its potential benefits for bioenergy crop production, water quality, soil health, reduction of chemical inputs, soil carbon storage, biodiversity, and wildlife habitat."

Elements of the proposed RIM-clean energy easement program included:

- A competitive allocation process for project area selection, targeting acres in proximity to an energy facility. The assumption was that a bioenergy facility would be able to use multiple feedstocks, with an emphasis on native perennial plants.
- An easement period of at least 20 years.
- A tiered payment system structured to encourage landowners to grow native perennial plants, both herbaceous and woody. The payment rate would be based on the estimated market value of the land, with the highest per-acre payments for lands producing the greatest diversity of species.

Program guidelines and standards were developed and submitted to the legislature in January, 2008, but the program did not receive funding for implementation, although the authorizing legislation remains in place.

The NextGen Energy Board (2008 – 2014)

The Next Generation Energy Board was established by the Governor and the Minnesota Legislature in 2007 as part of the Next Generation Energy Act. The "NextGen" Act established nation-leading requirements on Minnesota's electric utilities, expanded and strengthened the state's commitment to the development of locally-owned renewable energy projects and put Minnesota as one of the top states leading the way toward reducing greenhouse gas emissions.

The NextGen Board's role was to develop bioenergy policies and recommendations to the Minnesota Legislature, working toward energy independence, agricultural and natural resources sustainability, and rural economic vitality. From 2008 through 2015, the Board awarded grants to about 17 projects, with a 50% local match required. The NextGen Energy statute expired on June 30, 2015.

The Bioincentive Program (2015)

The Minnesota State Legislature established the Bioincentive Program in 2015 to encourage commercial-scale production of advanced biofuels[2], renewable chemicals, and biomass thermal energy through production incentive payments. (Minnesota Statutes, sections 41A.15 to 41A.18).

Production facilities within Minnesota[3] must:

- begin producing biofuels, renewable chemicals, or biomass thermal energy before June 30, 2025,
- meet quarterly minimum production levels,
- use renewable biomass from agricultural or forestry sources, or the organic portion of solid waste,
- source 80 percent of renewable biomass from Minnesota, and
- harvest agricultural and forestry biomass in ways that do not harm the environment.

Production facilities may receive payments for up to ten years on a first-come, first-served basis while funding lasts.

- For the advanced biofuels program, biofuels using agriculture biomass must include a minimum percentage of perennial or cover crop source material: 10 percent in years one and two, 30 percent during years three and four, and 50 percent in years five through ten. Responsible biomass sourcing provisions apply to ensure sustainable harvest of crop residues.
- For the renewable chemical program, production must constitute at least 750,000 pounds per quarter. Payments are higher for cellulosic biomass than for sugar or starch sources.
- For the biomass thermal energy program, thermal energy produced from biomass combustion, gasification, or anaerobic digestion qualities for the incentive. Facilities must produce at least 250 MMBtu per quarter. Payments are higher for perennial or cover crop biomass than for other feedstocks.

As of November 2017, one biochemical producer has made claims under the renewable chemicals program. The company uses corn starch to make n-butanol and acetone. Another butanol company, a number of ethanol plants (corn-fiber cellulosic ethanol) and a biomass thermal energy producer (wood) are projecting sufficient production in 2018.

Other State Programs

Many state programs focus on the relationship between agriculture and water quality, including the Source Water Protection Program (MDH), the interagency Minnesota Agricultural Water Quality

[2] Advanced biofuel must meet the definition of the national Renewable Fuel Standard (RFS) program to be eligible for the production incentive. (The RFS program states that renewable fuel, other than ethanol made from cornstarch, must improve greenhouse gas emissions over the petroleum-based fuel it replaces by at least 50%.)
[3] If production facilities are 50 miles or less from the state border, materials may be sourced within a 100-mile radius of the facility.

Certification Program (MAWQCP), and multiple watershed-scale planning, monitoring and modeling efforts; those programs most relevant to this study are discussed in Section IX.

Other Related Plans and Studies

A number of other reports lay the groundwork for the approaches recommended in this report. These include:

- The ***Minnesota Prairie Conservation Plan*** (2011) lays out a vision for the future of Minnesota's prairie region that includes protecting remaining native prairie and associated habitats, reconstructing additional grasslands, expanding perennial crops, and increasing the implementation of conservation practices. The plan calls for providing opportunities for sustainable grass-based agriculture such as grazing and haying. "These functioning landscapes will also contribute clean water, fish and wildlife habitat complexes, high quality recreational opportunities, and thriving rural communities where Minnesota's citizens will want to live and visit." The plan is discussed in more detail in Section IX, State Programs.

- The Environmental Quality Board's 2015 report, ***Climate Solutions and Economic Opportunities: A Foundation for Minnesota's State Climate Action Planning*.** The report identifies the following action step, among others, to meet Minnesota's climate goals: "Modify agricultural production to prevent the additional loss of soil carbon, increase carbon storage in soils, and avoid emissions from fertilizer. These changes will also greatly improve soil health and water quality."

- The Environmental Quality Board's report, ***Beyond the Status Quo: 2015 EQB Water Policy Report***, includes as a central goal, "Increase and maintain living cover across watersheds." "Living cover" is broadly defined to include perennial crops, cover crops, prairie and grasses, wetlands, forests, and no till/minimum till practices. Proposed solutions to achieve this goal include:
    - Use living cover around wellheads to prevent groundwater contamination.
    - Enhance existing markets for perennial-fed beef and dairy products and bioenergy from perennial crops.
    - Enhance Minnesota's certification system for responsibly produced agricultural products.
    - Conduct research to improve cover crop technology.
    - Integrate social science to help us understand what motivates landowners and businesses to take voluntary actions.

III. Overview of Perennial and Cover Crops and Their Uses

The Water Resources Center team and BWSR staff conducted a literature review of research on potential perennial and cover crops, including their:

- agronomic feasibility for different regions in Minnesota,
- expected yields
- end uses and their economic values
- input requirements
- costs and returns
- onsite environmental impacts (e.g., soil health)
- offsite environmental impacts (e.g., water quality).

The Great Plains Institute also conducted research into the end uses and market potential of these crops, drawing on the expertise of the Minnesota Bioeconomy Coalition and other national experts. These assessments included a number of factors: the cost and effort involved in establishing these crops, the benefits they provide to water quality and soil health, any disadvantages or obstacles to their establishment, current research initiatives, and current and potential uses.

This section includes brief profiles of selected crops, their existing and potential uses, and the values assigned to them in the Six Watershed Comparison spreadsheet. More detailed data on costs of establishment and potential revenue are also incorporated into the spreadsheet (Appendix X).

Definitions of Terms

The crops discussed below include those commonly termed “perennial” as well as a number of “annual cover crops.” These terms often overlap. Minnesota Statutes § 41A.15, which established the Bioeconomy Production Incentive Program, includes definitions of both terms (see sidebar).

Definitions from Minnesota Statutes § 41A.15

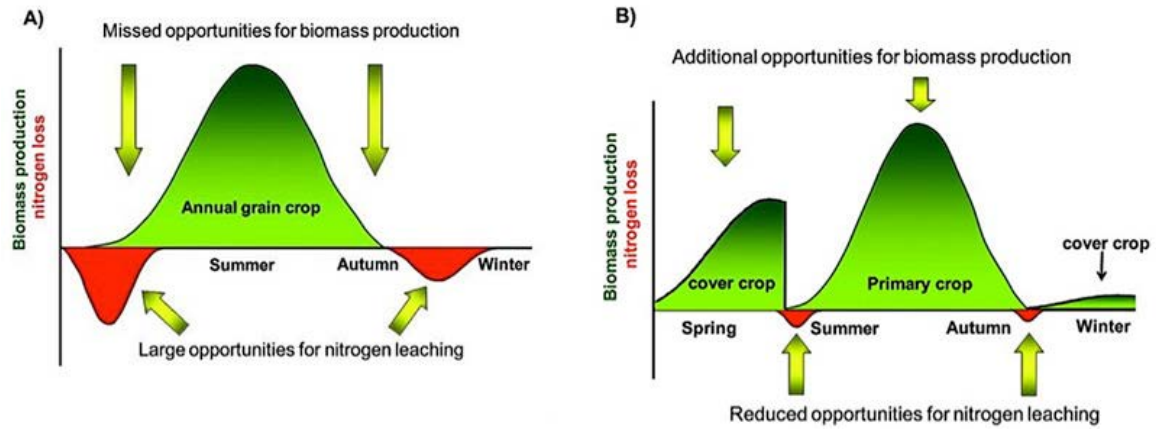
- **"Perennial crops"** means agriculturally produced plants that are known to be noninvasive and not listed as a noxious weed in Minnesota and that have a life cycle of at least three years at the location where the plants are being cultivated. Biomass from alfalfa produced in a two-year rotation shall be considered a perennial crop.
- **"Cover crops"** means grasses, legumes, forbs, or other herbaceous plants that are known to be noninvasive and not listed as a noxious weed in Minnesota and that are either interseeded into living cash crops or planted on agricultural fields during fallow periods for seasonal cover and conservation purposes.

In practice, these definitions overlap, since many perennials are grown as cover crops – for example, alfalfa can be used as an annual cover crop, as can winter (cereal) rye and some clover species. Both types of crops provide “living cover,” a term frequently used in discussions of agriculture and water quality. The amount of “cover” provided varies depending on when and how the crops are grazed or

harvested. As with perennials, cover crops can produce biomass during the "shoulder seasons" when soils are typically bare, as shown in Figure 1.

Another term used in this report is **"cash cover crops,** which are planted like other cover crops, but produce a harvestable and potentially marketable product. The crops discussed in this report are two types of oilseeds, winter camelina and pennycress, which produce oils similar to soybean oil. Cash cover crops can supplement, but do not replace, the primary cash crop. The oilseeds are currently being grown in Minnesota as **relay crops** – that is, they are planted into a standing crop such as soybeans before harvest.

Figure 2. Opportunities for biomass production with cover crops. From Chopra et. al., 2017.



Perennial Grasses and Legumes

Switchgrass

Switchgrass (*Panicum virgatum L*.) is a North American native perennial warm-season grass. Along with big bluestem and Indiangrass, it is one of the three dominant species of the North American tallgrass prairie. In its native habitat, switchgrass is generally found in the more humid zones of the tallgrass prairie. Switchgrass has attracted attention as a potential biofuel feedstocks because of its high productivity and broad adaptability. In studies funded by the US Department of Energy, switchgrass emerged as a leading perennial herbaceous candidate for biomass production and, as a result, its characteristics are well documented. (Mitchell, et. al., 2016). More than 12 cultivars are currently available for a variety of growing conditions across the Midwest (Kaiser et al., 2011).

Switchgrass is well-suited to marginal sites, but also flourishes on more productive land. Other benefits include its ability to capture excess nitrogen, reduce erosion, increase soil carbon sequestration, and provide wildlife habitat, as switchgrass stands tend to become more diverse over time.

According to *Switchgrass Agronomy,* a guidebook by the Ontario Biomass Producers Cooperative, "Switchgrass is a farmer-friendly crop with exciting market opportunities. It requires low investment and minimal labor. In Ontario, switchgrass has been successfully grown on both prime agricultural land and

on more marginal class 3 soils that are stony, gravelly or relatively shallow. It is relatively easy and inexpensive to establish from seed, and can be grown and harvested off-season from other baling activities."

Switchgrass

In Minnesota, yields vary depending on the quality of the soil and the amount of fertilizer used. Field trials in 2007-2013 showed an average of 3 tons per acre, varying with the crop productivity index (CPI) and whether fertilizer was used. Averaged over nine locations and seven years of production in Minnesota, a native ecotype produced 2.3 tons per acre without nitrogen fertilization, and 3.0 tons per acre when fertilized with 60 pounds of N per acre (Jungers et al., 2015). Another study found that switchgrass yielded 4 tons per acre when fertilized at an optimum rate of 65 tons of N per acre (Jungers et al., 2015). Switchgrass yields are improving as new varieties are developed. The new "Liberty" variety has yielded 4.6 tons per acre at three Wisconsin locations during 2009-2011. However, University of Minnesota research has found the Liberty will not reliably overwinter in Minnesota.

Switchgrass uses

Switchgrass has been used as a biofuel in several pilot programs. It was grown on about 5,000 acres in Eastern Tennessee to supply a pilot biofuel refinery in Vonore from 2010-2015. The refinery was closed in 2015 by DuPont; the company focused on corn stover as a feedstock for cellulosic ethanol at its plant in Nevada, Iowa, which also closed in 2017.

An earlier demonstration project in Iowa, the Chariton Valley Biomass Project, used locally grown switchgrass co-fired with coal to generate electricity at the Ottumwa Generating Station over a ten-year period from 2001 through 2010, with funding from the U.S. Department of Energy. While these pilots were considered successful, switchgrass is not currently being widely grown as a biofuel feedstock, due to the challenges of developing a supply chain and the high cost of production and transport, compared to the low costs of both conventional fuels and more widely available agricultural residues such as corn stover.

Other uses for switchgrass include the following:

- Switchgrass is currently being grown in eastern Ontario for animal bedding and as a constituent of dairy cattle feed.
- Research at the University of Nebraska indicates that switchgrass and other perennial grasses can be used as forage for beef cattle, particularly if energy density and digestibility are improved.
- Researchers at Pennsylvania State University report that animal bedding is a well-established market for grass material, with farm gate prices for bedding straw ranging from $80 to $100 per

dry ton. The University of Delaware is testing switchgrass as a chopped bedding for poultry farms.

- Agricultural Utilization Research Institute is researching treatment of switchgrass and other perennial grasses with calcium hydroxide to increase nutrient content and sugar extraction, increasing suitability as livestock feed.
- Switchgrass can be co-fired, usually with coal, to produce steam for heating. However, its combustion can create slag in boilers, and must be carefully blended with other feedstocks to reduce this negative effect.
- Emerging uses for switchgrass include biochar, a byproduct of pyrolysis (heating in the absence of oxygen). Biochar can be used as a soil amendment and is currently being used in a new cat litter product.
- Switchgrass and cellulosic biomass from other native prairie plants is being mixed with swine manure and anaerobically digested to produce renewable natural gas at a new facility in northern Missouri.

It appears that switchgrass is not currently being grown in Minnesota for any of the uses discussed here, although it may be in use as a forage crop. The Six Watersheds Comparison spreadsheet tool treats it as equivalent to small grain straw such as wheat straw, and assigns it a value of $40/ton.

Miscanthus

Giant Miscanthus *(Miscanthus x giganteus)* has been widely studied as a highly productive bioenergy crop. Like switchgrass, it requires very little nitrogen fertilizer, captures excess nitrogen; sequesters carbon, prevents erosion; and performs well on marginal lands. Originally an Asian grass, it has been used in Europe for biomass and in North America as a horticultural specimen plant. The bioenergy variety of the plant is a sterile triploid hybrid, planted via rhizomes rather than seed. Miscanthus yields range from 12 to 15 dry tons per acre (Johnson, et. al., 2013). Characteristics such as low moisture at harvest, low free sugar content, low nitrogen content and high lignin content make it better suited for thermochemical conversion (combustion) than switchgrass (Heaton, et. al., 2016). Unlike switchgrass, it is not suitable for animal feed or forage, although it can be used for animal bedding.

Concerns as to its potential invasive qualities in North America have not yet been borne out by research. However, limited plant material and limited planting equipment have slowed its use. Since miscanthus is a sterile hybrid, the crop cannot be planted from seeds, but instead must be established with vegetative materials such as rhizomes or plugs. There are currently few sources for miscanthus rhizomes. In addition, plants established from rhizomes are susceptible to winter injury in Minnesota during the first winter.

Miscanthus for biofuel

The primary example of miscanthus use for biofuel is the partnership between the University of Iowa (UI) and Iowa State University (ISU) to grow miscanthus as a renewable feedstock for the UI power plant. The project's goal is to establish the crop on 2,500 acres in Southeast Iowa to produce 22,500 tons

of the feedstock. As of 2016, 300 acres had been established through 10-year contracts with farmers, at a rate of approximately $200/acre, similar to Conservation Reserve Program payments.

Other uses for miscanthus

Miscanthus is being grown and processed for animal bedding, particularly for poultry bedding, in Ontario, Pennsylvania and Illinois. Green Flame Energy, an Illinois biomass-sourcing company, reports that the best market for miscanthus in that area is currently turkey bedding, but suggests that heating of livestock barns with miscanthus fuel chips can be competitive with propane. Like switchgrass, miscanthus is not currently being grown in Minnesota for biomass. As with switchgrass, the Six Watershed Comparison spreadsheet assigns it a value of $40/ton.

Kernza (Intermediate wheatgrass)

Kernza, the trademarked grain from intermediate wheatgrass *(Thinopyrum intermedium)* was developed through a partnership of the University of Minnesota's Forever Green Initiative and Kansas-based The Land Institute. Intermediate wheatgrass was introduced into dryer regions of the United States for use as a winter-hardy perennial forage in the early 20th century. Its domestication as a grain crop was initiated by the Rodale Institute in 1989 and continued by The Land Institute and Forever Green. Because of its extremely dense and deep root system and rapid regrowth after harvest, crop residue and regrowth can be harvested for biofuel or forage use while the plant continues to build soil carbon and control soil erosion.

Like the other perennial grasses, Kernza removes excess nitrogen from the soil. Studies have shown that nitrate in soil water under Kernza is about four times lower than that found under corn (Culman et. al., 2013). This characteristic has stimulated a great deal of interest in Kernza as a suitable crop for wellhead protection areas in Minnesota, especially for those that are vulnerable to nitrate leaching.

Limitations of Kernza in its current state include its small seed size, which leads to challenges in harvesting and processing, and the fact that yield declines rapidly after the third year of production. Research at the University of Minnesota showed declines from as much as 900 kilograms of grain per hectare (about 800 lbs./acre) to as little as 200-300 kilograms (180 - 270 lbs./acre) (Jungers et. al., 2017). Agronomic practices being investigated include row spacing, inter-row tillage, and use of grazing to disrupt and prevent sod-bound stands. The effect of stand disturbance on carbon sequestration and soil health needs to be quantified. Breeding initiatives are also focusing on shatter resistance, seed size, and grain quality.

Uses for Kernza

Kernza is attracting a high level of interest as a niche-level food crop. It can be blended with annual wheat flour to make bread and used on its own to make quick breads, cookies, crackers, and pasta. The supply of seed is being limited to ensure that potential growers are adequately trained and equipped and to avoid a "boom-and-bust" scenario. General Mills, through its Cascadian Farms enterprise, is working with The Land Institute and Forever Green to gradually increase Kernza production to commercial scale, and has committed to incorporating the grain in a snack product or cereal in 2018.

Kernza wheat at Roseau. Photo: Jim Anderson, Forever Green Initiative

Kernza grain has also been used in the production of fermented beverages such as beer. Two breweries in Minnesota have a commercially available Kernza beer, and multiple others across the nation. Kernza is also being distilled for spirits (see https://landinstitute.org/our-work/perennial-crops/kernza/ for more information).

Kernza also has potential as a bioenergy crop, but this aspect has received relatively less attention than its food potential. A cropping system could incorporate all these uses: grain would be harvested in late July- mid August. Right after harvest farmers would remove the residue, which could be used as low-quality hay, but would be better suited for a biofuel scenario. Regrowth could be grazed by cattle in November.

The logistics of Kernza grain distribution are being handled by Plovgh (pronounced "plough"), a company that connects farmers, buyers and producers. As of July, 2017, Plovgh reported that Kernza is being grown on seven sites in Minnesota, as well as on test plots; demand greatly exceeds supply. The slow-growth strategy employed by the Land Institute and Plovgh means that the crop is unlikely to occupy significant acreage in the short term, but it may be particularly well-suited to vulnerable locations such as wellhead protection and buffer areas.

The Kernza grain price assigned in the Six Watershed Comparison spreadsheet budget is $0.75 per pound. The amount of commercial production and sale of Kernza to date is insufficient to establish an

estimate of a market price that is likely to prevail if and when economically significant acreages are grown in the future. Prices as high as $1.00 to $2.00 per pound are currently being mentioned, but it is not clear whether prices this high are sustainable long term. In addition, Kernza production will provide an opportunity for development of a dual revenue stream from grain plus grazing of the forage in the summer and late fall. In this system fall yields of 1-2 tons/acre can be expected, as well as a real opportunity to extend the grazing season.

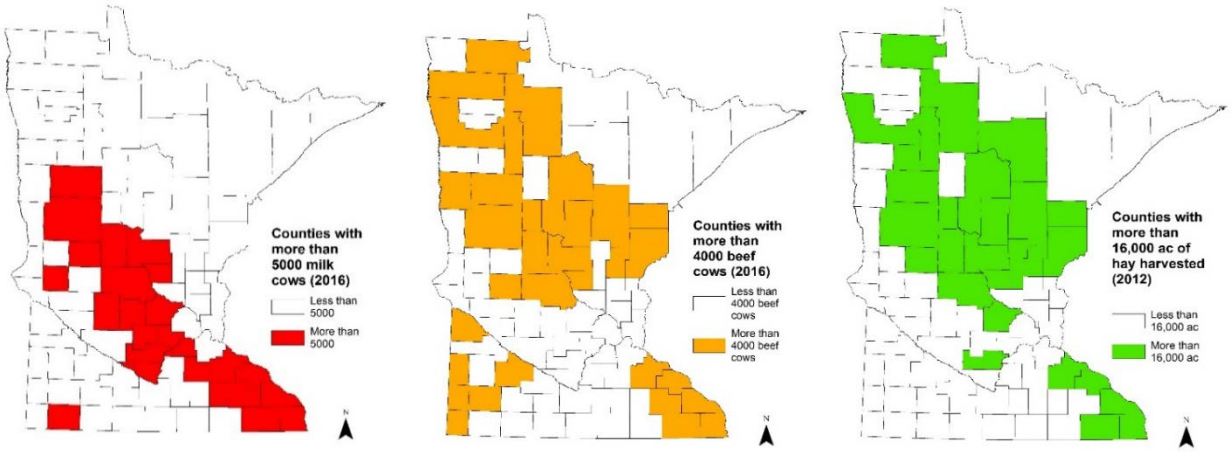
Alfalfa

Alfalfa is a small seeded legume typically grown in a three-to four year rotation, and is defined in statute (see Definition of Terms above) as a perennial crop. Its primary use is for livestock feed. High-quality alfalfa is considered "the cornerstone of any dairy farm forage ration," according to the University of Minnesota Extension. Of 1.5 million acres of hay produced in Minnesota in 2016, about two-thirds consisted of alfalfa (NASS, 2017) and over three-quarters of the alfalfa crop is baled as dry hay. Some alfalfa is also harvested as silage,"haylage" and "baleage."

Alfalfa fixes substantial amounts of atmospheric nitrogen in nodules attached to the roots (a process known as biological nitrogen fixation) and also scavenges nitrogen in the soil. It can be highly productive, with potential maximum yields from established stands averaging 6-7 ton/acre. Its benefits include erosion control, reduction in the population of annual weeds, and an increase in the yield of crops that follow in a rotation, as the stored nitrogen is released into the soil. Use of alfalfa in a corn rotation has been shown to lower production costs, since less nitrogen fertilizer is needed. Alfalfa is typically harvested three to four times per year during a growing season. The cut forage must be dried in the field to moisture levels adequate for safe aerobic storage (<20%), which exposes the crop to risk of rain damage.

In spite of its many advantages, the amount of alfalfa grown in Minnesota is declining. As shown in Figure 3 below, both alfalfa and other hay supplies are localized to demand, and fewer cattle on the landscape mean that less hay is being grown. Other challenges can come with wet weather (as in 2017) resulting in lower-quality hay and a decline in hay prices. Transportation costs make it impractical to ship hay long distances. Moreover, alfalfa production simply requires more labor and more equipment than corn and soybean production.

Figure 3: Relationship of Milk Cows, Beef Cows, and Hay Production. From Goplen, 2017



The Minnesota Department of Agriculture is developing a study and related outreach work beginning in spring of 2018 to evaluate the economic viability of expanding the acreage of year-round vegetative cover, including perennial crops and cover crops for livestock feed, in areas with highly vulnerable groundwater in Minnesota. Familiar perennial forage crops like alfalfa, oats and winter wheat will be evaluated, as well as winter annuals and other cover crop systems.

Potential Uses of Alfalfa

Private alfalfa breeders and marketers provide a diversity of varieties with winter hardiness and disease resistance adapted to most soils in Minnesota. Cultivating alfalfa in mixed stands with grasses produces hay that is higher in fiber and with greater yield stability. Horses represent an underutilized market for alfalfa.

AURI is researching methods for extracting the soluble protein from alfalfa, which could present opportunities for livestock and poultry feed. Alfalfa is also a key constituent of pasture-based grazing systems for livestock.

Alfalfa-grass forage mixture. Photo: U of MN Extension

Alfalfa hay prices fluctuate from year to year depending on weather and market conditions, and have declined in the past few years like other commodity crops. Alfalfa hay is sold at hay auctions based on its forage quality, which correlates to its feed value. Therefore, producers are rewarded for good management and harvest timing practices. Current price for the 2016-17 marketing year reported by USDA-NASS was $81/ton, a significant reduction from the 2012-16 average price of $144/ton. However, most farms reporting alfalfa enterprises in FINBIN feed the alfalfa to their own livestock; alfalfa for hay fed to cow-calf enterprises was valued at $120/ton in FINBIN in 2016.

Annual Cover Crops

Oilseeds: Camelina

Camelina plot at U of MN - Morris

Camelina (*Camelina sativa* L.) is a short-season annual crop native to parts of Asia and Europe, now being recognized in North America as an oilseed crop. According to the Forever Green Initiative, "camelina has great potential for use as a cash cover crop that can provide both ecosystem services and economic benefits to farmers in the Upper Midwest." Research shows that winter camelina can feasibly be double- and relay-cropped with traditional food and forage crops such as soybean and sorghum. These cropping systems require little fertilizer and water, remove excess nitrogen from the soil, prevent soil erosion, and provide needed early spring forage for pollinators.

Camelina is grown in the Pacific Northwest primarily as an early summer annual oilseed crop. Research in Minnesota and the Dakotas focuses on its use as a winter annual suitable for northern climates. The winter camelina currently grown at Morris is integrated into a three-year rotation of corn grain, spring wheat and soybeans that is typical of western Minnesota. The camelina is planted after spring wheat harvest using a common drill. Soybean is planted the next spring into the camelina in 24 or 30 inch rows. The camelina is then harvested using a combine over the tops of the young soybean plants. Camelina also can be established successfully after harvest of sweet corn, soybean, dry edible beans, sunflower, and sugar beet. Establishment within standing field corn is still being investigated.

In the Pacific Northwest, the average yield of spring camelina is 1,600 pounds of seeds per acre. Tests of winter camelina at Morris and elsewhere in Minnesota showed that yields can be as high as 2,000 pounds per acre, and the seeds have a higher oil content than spring-types of camelina.

Ongoing breeding work on camelina in Minnesota is focused on earlier maturity so that it can be used as a double crop rather than a relay crop, as well as breeding for reduced seed shatter, higher oil content, larger seeds and higher yields.

Winter camelina harvest. Photo: Forever Green

Camelina for biojet fuel

The Commercial Aviation Alternative Fuels Initiative (CAAFI) is a coalition of airlines, aircraft and engine manufacturers, energy producers, researchers, international participants, and U.S. government agencies. CAAFI seeks to promote the development of alternative jet fuel options that are comparable to petroleum-based jet fuel in safety and cost, while also offering environmental improvement and security of energy supplies. There are many different production methods; camelina and other plant oil crops are most suitable for hydro-processing. Hydro-processed renewable jet fuels are typically blended at about a 50:50 ratio with traditional petroleum fuels. They are resistant to microbial growth and able to be stored effectively. Conventional aircraft engines are able to use these fuels without modifications.

CAAFI's director, Steve Csonka, reports that there is clear interest in camelina as an alternative jet fuel, especially the winter varieties. Studies indicate that camelina-based biojet fuel reduces CO_2 emissions by 75 percent compared to traditional petroleum-based jet fuel, as well as reducing particle emissions in engine exhaust. The primary obstacle to widespread adoption, as with other biofuels, is the low price of conventional jet fuels. A recent study at Oregon State University found that a gallon of camelina-based jet fuel would cost about 60 cents more than conventional jet fuel. However, this biofuel sector is expected to grow; refineries are currently under development in Ohio and Indiana. The presence of the MSP International Airport may improve the prospects for a similar facility in Minnesota (Csonka, 2017).

Other uses for camelina

- Camelina oil was used historically for food, medicinal use, and lamp oil. It is being marketed in Europe in salad dressing and cooking oil, and is used in skin care products and detergents. It is an excellent source of *omega*-3 fatty acids, and its high tocopherol (antioxidant) content promotes a long and stable shelf-life compared to other *omega*-3 vegetable oils.
- Camelina feed is approved for salmon and trout feed in Canada and as a feed for layer hens and broiler chickens, comparing favorably to canola. It is farmed in Saskatchewan, where the oil sells for around $2,200 a ton.
- Camelina shows promise as an early spring forage for pollinators, particularly for honeybees, since it flowers from late April through early May when there is little other food available. Camelina planted at Morris produced 100 pounds of nectar sugar and 60 pounds of pollen per acre, enough to meet the entire annual needs of one beehive.
- Camelina meal can be used as a constituent of beef cattle protein source, similar to distiller's dried grains with solubles (DDGS), a byproduct of ethanol production.
- There is interest in camelina as a constituent of bio-based plastics, with ongoing research at AURI.

Camelina is assigned a price in the spreadsheet of 15 cents per pound, equivalent to soybean prices.

Oilseeds: Pennycress

Field pennycress (*Thlaspi arvense* L.) is a winter annual oilseed similar to camelina, with comparable benefits for erosion control and soil nitrate removal. It provides good weed control, reducing herbicide

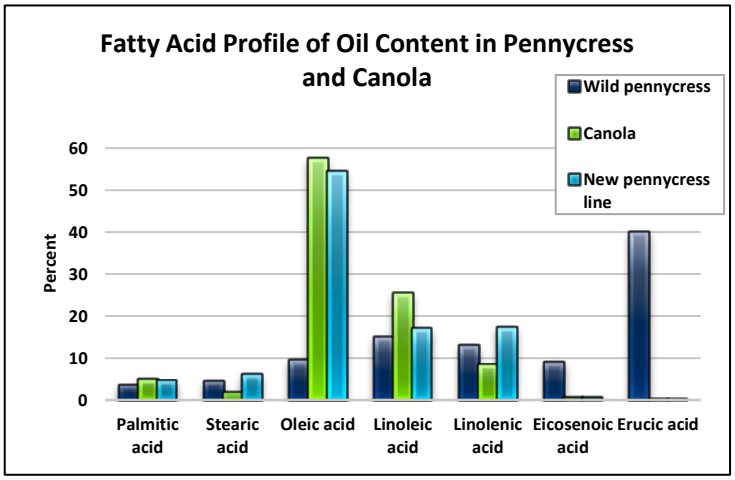
inputs by up to two-thirds. In Minnesota the most productive lines are producing around 1,500 lbs/acre (25 bu/acre) of seed with 40% oil by weight.

Pennycress is well suited to the corn, spring wheat, and soybean rotation described for camelina and is suitable for establishment following sugar beet, sweet corn, dry edible bean, and sunflower. Research in Illinois and Missouri also suggests that pennycress' shorter growing season makes it suitable for a corn and soybean rotation – it can be aerially seeded over standing corn in August to September, then harvested in late May. The applicability of this rotation in Minnesota has yet to be determined.

As a joint effort between the University of Minnesota and USDA-ARS-Morris, researchers in the Departments of Agronomy and Plant Genetics and Plant and Microbial Biology have initiated a breeding program to develop domesticated varieties of pennycress. Using the latest techniques in genomic research, researchers have identified target genes for most agronomic traits such as early flowering, reduced seed shatter, and seed size as well as for oil quality traits that will improve market value. This information has allowed researchers to greatly accelerate the breeding program using non-GMO approaches.

The rapid development of improved pennycress lines suggests that pennycress can be adapted to many potential uses. For example, wild pennycress contains high levels of erucic acid. Although erucic acid is useful for industrial oil purposes, it is not suitable for human or animal consumption, limiting the value of the oil and seed meal. New pennycress lines have been developed that produce a canola-like oil with no erucic acid content. Industrial use pennycress lines with increased erucic acid content have also been developed. Similar research has reduced the amount of glucosinolates (a natural component of pungent plants such as mustard, horseradish, and cabbage) in wild pennycress, making pennycress seed meal more palatable.

Figure 4. New reduced erucic acid content pennycress line compared to unimproved wild pennycress line and canola. Source: Forever Green Initiative.



Potential uses for improved domesticated pennycress

- Biodiesel fuel: pennycress is comparable in viscosity and other characteristics to soy-based biodiesel and may perform better in colder climates.
- Like camelina, pennycress is also being researched as a constituent of bio-based plastics.
- High oleic pennycress oil can be used for many food applications.
- Increased erucic acid pennycress lines can be used as a feedstock for industrial applications.
- Pennycress protein can be used as a plant protein resource for human or animal food applications.

- Increased glucosinolate pennycress lines could be used for bio-herbicides.

All new pennycress lines are undergoing testing at sites planted throughout Minnesota to determine yield, oil quality, winter hardiness, and ecosystem benefits. UMN researchers are working to breed a pennycress line that includes all newly discovered traits, a process that is expected to take the next two to four years.

Pennycress, like camelina, is assigned a price in the spreadsheet of 15 cents per pound, equivalent to soybean prices.

Cover Crop Mixtures for Soil Health

Conventional wisdom regarding cover crops in Minnesota was that the short growing season made cover crops too difficult to establish. However, there is increasing interest in cover crops for seasonal grazing and for soil health and improved yield of associated row crops. Potential benefits of cover crops include reduced soil compaction, additional soil water holding capacity due to greater soil organic matter, nitrogen fertilizer savings from mineralized soil organic matter, cooler soil temperatures during the growing season, and herbicide cost savings.

Cover crops require some trial and error to establish, but seem to be the most successful when a mixture of crops is planted, including brassicas (e.g., radishes, turnips), legumes (e.g., clovers), and annual grasses (e.g., oats or annual ryegrass).

A number of potential economic benefits of cover crops have been identified in the literature. A legume cover crop species can provide nitrogen, which can benefit a following crop such as corn that needs nitrogen. A benefit of $15 per acre is used in the spreadsheet model to account for reduced soil erosion. Cover crops can also be grazed in the spring or fall, depending on the planting date and the timing of the cash crop harvest, but the number of variables involved makes it difficult to generalize the results.

A number of other potential benefits of cover crops can be identified, but they appear to be too site-specific to generalize them to an entire watershed as would be needed for this analysis. They are listed here but not included in the budgets in the current version of the spreadsheet:

- Reduced weed pressure, which may make it possible to reduce herbicide applications.
- Reduced crop disease, especially in the case of sclerotia or white mold in soybeans.
- Increased water infiltration and reduced runoff, which can increase the water available to the crop as well as reducing flooding.
- Better support for farm equipment when the soil is wet, allowing more working days.

Winter Rye (Cereal Rye)

Winter rye (*Secale cereale*) is a common winter annual cover crop in Minnesota, particularly in conjunction with sugar beets and potatoes, reducing their vulnerability to wind erosion.[4] It is the only

[4] The words rye and ryegrass cause much confusion. Rye (*Secale cereale*) typically refers to the cereal or small grain plant. It produces a grain with strong flavors and colors. Flour made from it is used to make rye breads, and it

small grain that meets the standards for winter hardiness to overwinter in Minnesota. Winter rye can be interseeded into corn or planted after small grain harvest and can be grazed in fall as a forage crop. It requires termination in the spring prior to planting corn. Its decomposition leads to chemicals being released that suppress weeds. Farm-scale studies in Minnesota have shown that winter rye effectively reduces surface runoff, sediment loss and nitrate-nitrogen loss in fall and spring, and phosphorus loss in spring (Herges, 2013).

Winter rye varieties currently don't fit well into a soybean rotation, since all commercial rye varieties mature in late June nearly a month later than the recommended soybean planting dates. In both corn and soybean systems, winter rye needs to be terminated before grain crop planting to prevent competition and nutrient tie-up.

Breeding efforts are focused on developing varieties that increase early season biomass and allow for easier seeding of the subsequent crop varieties. There is demonstrated market interest in malting rye for distilling and craft brewing. North Dakota State University is testing new varieties to meet these demands.

Forage Crops for Managed Grazing, Beef and Dairy Enterprises

Dairy grazing herd walks to pasture. Photo: Dairy Grazing Apprenticeship Program

There is increasing interest in managed grazing, also known as rotational grazing, for beef cattle production and, to some degree, for dairy cattle. As described on the MDA website, "Rotational grazing is a livestock production system where livestock graze in one portion (a paddock) of a pasture that has been divided into several paddocks. Livestock are systematically moved from paddock to paddock based on the stage of growth of the forages and on the objectives of the grazing system. While one paddock is being grazed, the rest of the pasture rests. This rest and recovery time maintains forage plants in a healthy and vigorous condition." The trampling and manure fertilization of the soil through managed grazing mimics the ecosystem processes historically present on bison-grazed native prairie.

Beef cattle can be moved around the landscape, allowing them to graze for short periods on different tracts of land. The Cropland Grazing Exchange, developed by MDA with partners from NRCS and Sustainable Farming Association have developed a website which is intended to match up livestock

is distilled to make rye whiskey. Annual and perennial ryegrasses (*Lolium multiflorum*) are very palatable, high quality forage grasses. There are several types of ryegrass cultivars with varietal differences within each type. https://www.agweb.com/article/rye_and_ryegrass_whats_the_difference_naa_university_news_release/

farmers with crop farmers who have forage to harvest. Grazing is increasingly being used as a management tool on Wildlife Management Areas and other conservation lands, since it offers many of the same benefits as controlled burning but is less weather-dependent.

The economics of dairy grazing are somewhat limited by the distance that cows can be expected to travel to pasture. However, organizations such as the Dairy Grazing Apprenticeship Program are promoting a small-scale dairying model that relies on pasture for much of the year. Most dairy grazing operations in Minnesota are organic, which makes it difficult to generalize to all operations.

The Six Watershed Comparison spreadsheet includes models for grass-fed beef finishing, cow-calf operations using grazing, and dairy grazing, both organic and conventional.

Grass-fed beef finishing: This scenario is intended to reflect the grazing of a cover crop or other use of cropland primarily dedicated to some conservation use. However, a cover crop would only provide grazing for a few weeks in the spring and possibly in the fall, so other pasture or hay acreage would be needed for the rest of the growing season and the winter months.

The grass-fed beef scenario here is assumed to consist of four separate enterprises as characterized in the FINBIN data: 1) pasture, 2) grazed cover crop planted to corn and soybeans, 3) grass hay, and 4) grazed beef or beef finishing. Pasture yield is described in terms of animal unit months (AUMs) of grazing provided per acre per year. An animal unit is usually defined as an animal weighing 1,000 pounds and an AUM is assumed to be equivalent to around 1,000 pounds of forage dry matter. Higher yields can be obtained with more intensive management practices, such as daily rotation of paddocks.

This enterprise is compared to beef-finishing operations that use corn and other grains. Much of the reported data for this scenario is from North Dakota or the Upper Midwest in general, since few Minnesota operations provide data to FINBIN.

Beef cow-calf production: More operations in Minnesota provide data to FINBIN compared to grass-fed beef. These enterprises incur feed expenses for alfalfa hay along with grass hay and pasture. They show higher returns per head than the grass-fed beef enterprises, although prices for both types of enterprises are lower than the five-year average.

Dairy production, organic and/or grazing: Recent volatility in dairy markets makes it difficult to assess trends. The organic price "premium" almost doubled between 2012 and 2016, when it reached $18.53/hundredweight, but now appears to be declining again, in response to increased competition from non-dairy "milk" products. Organic feed costs are higher and milk production is lower than conventional dairy, and because of a three-year transition period from conventional to organic, it can take up to seven years to break even, depending on the organic premium.

The small number of grazing dairies for which data are available are more profitable on a per-cow basis than non-grazers, but herds are smaller. Long-term studies of grazing dairy in Wisconsin indicate that, for non-organic grazers, "a grazing system is more economically flexible than a confinement system because of a lower investment requirement," and "Grazing systems may be the only viable (vs.

confinement) choice for a beginning farmer starting "from scratch" at herd sizes less than 300 cows" (Kriegl 2015).

Dairy heifer production: Dairy operations have traditionally raised their own replacement heifers. However, many dairy operations purchase a few replacement heifers or cows occasionally, and anecdotal evidence suggests that some have now chosen to purchase all of their heifers or contract with other producers to raise the heifers for them. That suggests that raising dairy heifers may be an attractive enterprise for expansion under this program, because the heifers can graze on pasture or cover crops during the growing season and would utilize hay in winter. Dairy heifer enterprises show higher returns at present compared to the 2012-2016 average.

Other Perennial Crops for Food and Biomass

A number of other perennial crops were reviewed as part of this study but are not explored in detail in this report. For some, research into the potential end uses of the crop is lacking, while for others the economics of production appear unfavorable. Other crops require further breeding and genomic research before they can be released to producers for field testing.

- **Short-rotation woody biomass crops** – there has been considerable research into the use of poplar and willow species for biofuel. However, the current status of the forest products sector in Minnesota means that there is a declining market for woody biomass in general. Recent efforts by the Natural Resources Research Institute at University of Minnesota – Duluth are producing solid fuel from woody materials and plant biomass that can reduce or replace fossil coal in existing power and industrial plants. These efforts may increase the demand for woody biomass, but primarily in Minnesota's forest regions.
- **Cattails** – there have been some promising efforts to harvest invasive cattail species for biomass in Manitoba and in the Red River Basin in Minnesota. Specifically, Manitoba has actively pursued harvesting of cattail from Lake Winnipeg and other nutrient-stressed waters, pelletizing of the cattails, and supplying them as biofuel for residential pellet stoves and industrial uses. The province's energy mix (phasing out coal stoves) and available subsidies make these uses uniquely feasible. Likewise, the North Ottawa flood control project in the Bois de Sioux watershed of the Red River Basin successfully harvests cattail after seasonal drawdowns of water in part of the impoundment and uses it as green manure. As yet, this project is unique and highly localized, although the process is worth exploring for other flood control projects.
- **Other warm-season grasses**, such as prairie cordgrass and little bluestem, may be appropriate for use in combination with a perennial biomass crop such as switchgrass. Research at South Dakota State University indicates that higher yields of biomass are obtained by planting cordgrass at the foot of a slope, little bluestem at the highest point, and switchgrass everywhere else. Greater diversity will yield greater habitat benefits, similar to native tallgrass prairie communities. This is another topic deserving of further research.
- **Hybrid hazelnuts** combine the winter-hardiness and disease tolerance of local wild American hazelnuts with the higher yields and larger nut size of domesticated European hazelnuts. The kernels are a flavorful human food that can be eaten fresh, added to numerous other foods, or

pressed into a heart-healthy oil with properties similar to olive oil. University of Minnesota researchers have identified germplasm that could potentially produce 800 pounds of kernel per acre, which is equivalent to 520 pounds of oil per acre, but difficulties in propagating this germplasm remain an obstacle.

- **Other annual and perennial crops** – Researchers with the Forever Green Initiative are developing many additional crops, including improved winter barley, an annual cover crop that will support malting and brewing industries, and other perennial crops, including perennial sunflower, perennial flax and silphium, for specialty oil and seed products. Many of these crops, once released for field trials, have great potential for inclusion in a future working lands program.

IV. The Economics of Potential End Uses

A major component of the Working Lands initiative is a quantitative assessment of biomass supply and farm economics. Dr. William Lazarus, of the University of Minnesota's Department of Applied Economics, has led the effort to develop a spreadsheet tool to generate quantitative outputs for each of the six sample watersheds. The spreadsheet and accompanying documentation addresses the following research question:

> "Based on the commercial value of a number of alternative perennial crops and cover crops, how would a typical producer's net income per acre compare to that of the annual row crops grown in several pilot watersheds in Minnesota?" Assuming that the alternative crop income is less than with the current crops, what subsidy would be required to bring the alternative crop income up to a level equal to the current crop income?

The income measure used in the analysis is net return to land. That means that the cost inputs include labor and typical expenses such as seed and fertilizer, but omit land rent or land ownership expenses such as real estate taxes. Land cost is omitted to simplify the calculations and because it is assumed that the cropland is a sunk cost and will remain under the same ownership and control regardless of the crop grown.

Crop productivity index and marginal land

Crop income for a given crop tends to vary with soil quality as it affects yield, while the environmental sensitivity of different soils varies with factors such as erodibility.

- The crop productivity index (CPI) provided in the USDA-NRCS soil survey is used to calculate crop yields. The CPI is translated to yields of existing crops based on the ratio of county average crop yields (reported by the USDA National Agricultural Statistics Service) to the average CPI for cropland planted to that crop in the county.
- The soil survey land capability classes are used as a measure of environmental sensitivity. Land Capability Classification (LCC) is a national system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time. Class 3 with a slope of over 6% and Classes 4 through 8 with any slope are defined as marginal agricultural land, consistent with other Minnesota studies (Javens and McCutcheon, 2015) and referred to as "LCC3+."

Crop income was evaluated at three levels of analysis:

1) average CPI for the cropland in the current crops in the entire watershed,
2) average CPI for cropland in the current crops on marginal land (LCC 3+, as discussed above), and
3) CPI for individual soils as described by the soil survey mapping units. The results for level 1 and 2 are included in the Six Watershed Comparison Spreadsheet. The results for level 3 were calculated for two watersheds – Shakopee Creek (Chippewa River) and Watson Creek (Root River) in separate spreadsheets.

The Six Watershed Comparison Spreadsheet

The six watersheds differ markedly in the amount of marginal land they contain, as shown in Table 2, ranging from only 7 percent in the Rogers Creek (Middle Minnesota River) watershed, to 46 percent in the Whiskey Creek (Buffalo River) watershed. The average CPI is highest in the Freeborn Lake – Cobb River (Le Sueur River) watershed, both for all cropland and for marginal land. The CPI for marginal land is lowest in the Getchell Creek/Co. Ditch 9 (Sauk River) watershed.

Table 2. CPI and marginal lands by watershed

Watershed	Average CPI	% marginal land (LCC 3+)	CPI, marginal land
Rogers Creek	87	7%	55
Shakopee Creek	82	20%	63
Getchell Cr/Co. Ditch 9	79	20%	31
Freeborn Lake-Cobb R	91	22%	77
Watson Creek	80	41%	68
Whiskey Creek, parts of the lower & upper reaches	71	46%	50
Counties surrounding each watershed	81		

Crop and livestock enterprises considered

The current annual crops selected for analysis were those that made up at least 90 percent of the annual crop acreage in the counties surrounding each watershed. For five of the six watersheds only corn and soybeans met this criterion. In the Whiskey Creek watershed, spring wheat and sugar beets along with corn and soybeans were the primary annual crops.

The alternative crops considered are the ones discussed in the previous section. Livestock enterprises that include grazing of pasture and cover crops were also developed, drawing on FINBIN and research in other states.

Table 3. Alternative Crops and Animal Enterprises Evaluated

General category	Specific crop and rotation
Perennial crops for biomass energy	Switchgrass
	Miscanthus
Dual purpose perennial crop for grain and biomass	Kernza

Cover crop providing soil health benefits but not a product for cash sale	Covercrop in a rotation of corn, soybeans, and a small grain
	Covercrop in a corn-soybean rotation
"Cash" cover crop with a product for cash sale	Camelina in a corn-soybean rotation
	Camelina in a corn-wheat-soybean rotation
	Pennycress in a corn-wheat-soybean rotation
Livestock enterprise including grazing of perennial pasture and cover crops	Grass-fed beef
	Beef cow-calf operation
	Grazing dairy (organic)
	Dairy heifers in a production contract or for cash sale
Perennial crop for cash sale as livestock feed	Alfalfa hay for sale

Prices and Costs for Current and Alternative Crops

A set of crop enterprise budgets was developed in Microsoft Excel 2016 for use in the evaluation. The main data source for the current crops, the livestock enterprises, and alfalfa is the FINBIN farm business and financial database. The data for the other alternative crops comes from a variety of sources.

Some of the alternative crops are already in production in Minnesota: the livestock enterprises, alfalfa, and the cover crops for soil health. For these crops, the goal of a Working Lands program would be to expand their acreage, since current acreage is limited by market conditions, cost, or producer awareness and interest. A small market has already developed for Kernza, but it is still a few years away from scaling up to enough acreage to yield significant environmental benefits. For these crops, actual price information is used in the spreadsheet.

On the other hand, the perennial biomass crops and the cash cover crops are "hypothetical" in the sense that processing plants and significant markets do not yet exist in the state. They are included in order to show what the potential might be if markets do develop. For these crops, the spreadsheet assumes a hypothetical price based on prices for similar crops or prices in other markets. However, because the values in the spreadsheet can be modified, these prices could easily be set to zero or another value, changing the results. To determine the per-acre costs of subsidies for a future program, discussed in Section XI, the subsidies for those crops were in fact set at zero.

The crop yields for all of the crops should vary with the CPI. It turns out that yields are not perfectly correlated with CPI. A perfect correlation of corn grain yield to CPI would be 2.0. Based on the average yields for 2012-16, the ratio ranges from 1.96 for the Rogers Creek watershed to 2.27 bushels for Getchell Creek. Soybean yields varied similarly. These ratios of corn grain and soybean yields to CPI were weighted by their percentages in the crop mix and used to calculate the adjustment factors shown in Table 4. The yields of the alternative crops are varied in the budgets based on the CPI times those adjustment factors, in order to be consistent with the corn and soybean yields in the current crop mix.

As of late 2017, the prices of most agricultural commodities are depressed compared to where they were a few years ago. Two price scenarios are included in the spreadsheet: 1) current and 2) five-year average of 2012-16. Users can toggle between them to see how the calculated subsidies and other

results are affected. The "current" scenario is based on our best estimate of prices for next year (2018) derived mainly from 2017 except where price forecasts differ from 2017. The "current" price scenario may be the most realistic one to expect for the next year or two. The spreadsheet and additional documentation are included in Appendix 2.

Summary of Results

Subsidy comparisons

Given the two soil categories (entire watershed and land capability classes 3-8) and two price scenarios (current and 2012-16 average), there are four comparisons that can be made. The subsidy levels suggested by the budgets are shown below. Negative numbers mean that the alternative crop appears to be more profitable than the current crop mix in the watershed – of course, this analysis uses the assumed prices for some of the alternative crops. The bolded numbers in the first table indicate enterprises that the project team thought might provide for a desirable distribution of enterprises across the six watersheds, also considering the current agricultural infrastructure. Tables showing the results using 2012-16 average prices are included in Appendix 2.

Table 4. Amount of subsidy, if any, required for net returns to land comparable to current crops on ALL land with current prices and costs:

	Freeborn Lake-Cobb R	Rogers Creek	Shakopee Creek	Watson Creek	Getchell Cr/Co. Ditch 9	Whiskey Cr, part L & U	Surrounding counties
Crop productivity index	91	87	82	80	79	71	81
Subsidy required, $/A							
Land retirement	217	165	162	178	176	81	161
Switchgrass	83	50	50	57	**58**	-2	48
Miscanthus	176	153	154	157	160	81	151
Kernza	117	86	**86**	92	94	**36**	83
Covercrop Sm Grain	4	-3	-4	-5	-1	-6	-4
Covercrop Corn Soy	**39**	39	39	**39**	39	24	35
Camelina Corn-Soy	-23	**-21**	**-16**	-30	-18	-17	-22
Camelina Corn-Wht-Soy	-10	-16	-16	-19	-14	-27	-20
Pennycress	**-10**	-16	-16	-19	-14	-27	-20
Grass-fed beef	148	106	106	120	120	**39**	105
Beef cow-calf	134	97	97	108	109	36	95
Grazing dairy (organic)	266	219	215	**228**	227	138	213
Dairy heifers	151	111	111	124	124	46	109
Alfalfa hay for sale	127	**114**	116	114	**119**	93	113

Table 5. Amount of subsidy, if any, required for net returns to land comparable to current crops on MARGINAL land with current prices and costs:

	Freeborn Lake-Cobb R	Shakopee Creek	Watson Creek	Rogers Creek	Whiskey Cr, part L & U	Getchell Cr/Co. Ditch 9	Surrounding counties
Crop productivity index	72	57	54	48	45	27	81
Subsidy required, $/A							
Land retirement	129	41	100	-20	-45	-137	151
Switchgrass	28	-27	8	-64	-81	**-136**	48
Miscanthus	129	41	98	-20	-45	-137	151
Kernza	65	**13**	46	-23	**-39**	-90	83
Covercrop Sm Grain	-2	-12	-12	-18	-4	-22	-4
Covercrop Corn Soy	**39**	39	**39**	39	24	39	35
Camelina Corn-Soy	-18	**-15**	-26	**-10**	-24	-2	-22
Camelina Corn-Wht-Soy	-15	-23	-25	-28	-46	-32	-20
Pennycress	**-15**	-23	-25	-28	-46	-32	-20
Grass-fed beef	80	7	57	-44	**-66**	-147	105
Beef cow-calf	73	8	52	-39	-60	-136	95
Grazing dairy (organic)	184	98	**153**	39	12	-91	213
Dairy heifers	85	15	63	-36	-58	-139	109
Alfalfa hay for sale	106	84	95	**69**	61	**44**	113

Subsidies shown in this table are much lower, or even negative, indicating that the alternative cropping scenarios may be more competitive with existing crops on marginal land. The challenge, however, is whether the marginal land can feasibly be converted to alternative crops at the sub-field scale.

As noted above, the prices for many of the alternative crops are hypothetical. For the livestock enterprises, prices are based on FINBIN data and similar information from neighboring states. Oilseed prices are set to be comparable to soybean prices, and perennial grasses are priced based on a typical forage value for grasses, at $40/ton. Kernza prices are based on recent price reports.

Table 6. Crops requiring the lowest subsidy, current prices and costs					
Average of all cropland in the entire watershed					
Freeborn Lake-Cobb R	Rogers Creek	Shakopee Creek	Watson Creek	Getchell Cr/Co. Ditch 9	Whiskey Cr, part L & U
CPI: 91	87	82	80	79	71
Camelina Corn-Soy	Camelina Corn-Soy	Pennycress	Camelina Corn-Soy	Camelina Corn-Soy	Pennycress
Pennycress	Pennycress	Camelina Corn-Wht-Soy	Pennycress	Pennycress	Camelina Corn-Wht-Soy
Camelina Corn-Wht-Soy	Camelina Corn-Wht-Soy	Camelina Corn-Soy	Camelina Corn-Wht-Soy	Camelina Corn-Wht-Soy	Camelina Corn-Soy
Severely erosive or poorly drained cropland (Capability class 3+)					
Freeborn Lake-Cobb R	Shakopee Creek	Watson Creek	Rogers Creek	Whiskey Cr, part L & U	Getchell Cr/Co. Ditch 9
CPI: 72	57	54	48	45	27
Camelina Corn-Soy	Switchgrass	Camelina Corn-Soy	Switchgrass	Switchgrass	Grass-fed beef
Pennycress	Pennycress	Pennycress	Grass-fed beef	Grass-fed beef	Dairy heifers
Camelina Corn-Wht-Soy	Camelina Corn-Wht-Soy	Camelina Corn-Wht-Soy	Beef cow-calf	Beef cow-calf	Land retirement

When all cropland in a watershed is evaluated, the results are more uniform. The current price for alfalfa hay is lower than its average price over the five-year period. Therefore, the oilseed crops (priced equivalent to soybeans) appear to have the greatest potential. However, if we use the five-year average, grazing and haying appear more profitable.

Looking at marginal land, there is greater variability among watersheds. For those watersheds where marginal land shows the highest CPI (i.e., more productive), the oilseeds require lower subsidies (again, assuming a market). For those watersheds with lower CPI rates for marginal land, animal agriculture appears more profitable.

It should be noted, however, that this analysis does not include all the spatial and cultural constraints on adoption of some crops or types of animal agriculture. For example, in regions where there are few dairy or beef cattle operations, producers are less likely to establish new ones. Where markets for hay are lacking, alfalfa is a less attractive crop. And unfamiliarity with the oilseed crops, as shown in the landowner survey, means that those crops will take longer to gain acceptance.

To estimate the likely start-up costs for a working lands contract program, we assume that prices for the oilseeds and perennial grasses, with the exception of Kernza, are set at zero. This analysis is included in Section XI, Program Implementation.

The Soil Map Unit Spreadsheet

This spreadsheet is being developed to address the question: what per-acre rate should a policymaker offer to producers to enroll specific soils in a CRP-type program that allows harvesting of perennial crops or cover crops (referred to as "alternative crops" below)? While many criteria could be considered, the criteria used here is "the greatest environmental benefit per dollar of public funding." If funding were unlimited, one possible decision rule would be to accept soils where the environmental benefit is greater than the subsidy required – that is, a 1:1 ratio of environmental benefit to subsidy. If funding is limited, the cutoff could be set at some ratio greater than 1:1 at the point where the funding runs out.

What is the most reasonable way to calculate the subsidy? We assume that: 1) a given alternative crop provides a positive return to the producer (revenues that exceed growing costs) and 2) the producer is currently achieving a greater return to land in the current land use. Given those assumptions, it seems reasonable to calculate the subsidy/acre as:

Subsidy/acre = return in current land use – return in alternative crop

For the better soils in the watershed, the calculated subsidy is a positive number, meaning that producers would require a subsidy to switch to an alternative crop, as we would expect. The analysis considers only cropland currently in corn and soybeans. Given that producers are growing those crops currently, it seems reasonable to assume that they are achieving positive returns from those crops. However, that assumption is somewhat problematic because our current crop budgets show negative returns for the marginal soils (defined as soils with low crop productivity index values), especially with current low commodity prices. We may be underestimating the crop yields on those marginal soils or including some costs that producers ignore on those soils – since in many cases those soils make up only small portions of larger productive fields.

While still in prototype form, this spreadsheet begins to quantify five potential environmental benefits of the perennial crops and cover crops:

- Reduced soil erosion (as measured by less sediment to surface waters)
- Reduced phosphorus (P) loading to surface waters
- Reduced nitrogen (N) loading to surface waters
- Improved wildlife habitat
- Carbon sequestration

The primary goal of the proposed working lands program is improved water quality as measured by the first three indicators. Improved wildlife habitat and carbon sequestration, while critically important, are ancillary benefits. Improved soil health, as indicated by increased water-holding capacity, organic matter and microbial activity, is closely linked to the other benefits, but is not directly quantifiable in this spreadsheet. The soil map unit spreadsheet will be further refined and released as part of the follow-up work to this report.

V. Water Quality Modeling

One of the requirements of the enabling legislation for the working lands initiative is "an estimate of water quality improvements expected to result from implementation in pilot watersheds." A question central to the modeling effort is "What level of water quality improvement is both desirable and achievable?" In other words, what is the water quality improvement goal?

A variety of models for water quality and quantity are available to assess the impacts of changes in land cover and defined BMPs. The MPCA uses the Hydrological Simulation Program – FORTRAN (HSPF) model for this purpose. (FORTRAN is the computer language used by the model.) HSPF can simulate water flow rates as well as sediment (including sand, silt, and clay), nutrients, and other substances found in a water body. The model uses real-world historic meteorological data as input to the hydraulic and biogeochemical equations used to represent the interconnected processes at work within a watershed. After confirming the model's accuracy with a process called calibration, agency scientists and local partners can use it to model different scenarios of land-use change and how those changes might affect water quality.

HSPF models currently simulate data from 1995 – 2009 or 1995 – 2012. Water quality is calibrated and validated by using observed data from multiple stream gauges spread throughout the watershed. The quality of the calibration can be viewed in terms of model performance during "wet" or "dry" years or on a seasonal basis.

Sediment and nutrient loading rates, including those coming from agricultural acres, are simulated by a set of process-based equations and the interaction of meteorological inputs with land characteristics. Simulated per acre loading rates are compared to the range of values reported in scientific literature for reasonableness. Types of tillage are simulated by changing model terms relating to infiltration, surface roughness, and other land-cover factors that mirror the effects of a tillage type. Tile drainage, stormwater, and other artificial drainage features are simulated by parameters that determine the speed water enters shallow groundwater and the amount of time those water inputs are maintained in the shallow groundwater after a storm event.

For this project, two 'implementation' scenarios were run for each of the six selected watersheds using the HSPF water quality model. Both of these scenarios involved two implementation strategies: 1) conversion of marginal row crop acres to perennial grasses and 2) adoption of cover crops on a given percent of remaining row crop acres.

Essentially, conversion of land in row crops to a perennial crop or pasture for grazing, or addition of a cover crop, results in a change in the amount of surface runoff and subsurface drainage, with resulting changes in **sediment, total phosphorus, and total nitrogen** entering the adjacent stream or lake segment, and with effects on water quality further downstream.

It is important to note that the model essentially treats all perennial grasses the same: switchgrass, Kernza, alfalfa, or mixed native prairie all have the same effects on streamflow and loading of sediment, nitrogen and phosphorus. Each of the six HSPF models was originally built and calibrated with land use

acres that are representative of the physical characteristics of perennial grasslands. In the modeling scenarios, conversion of marginal row crop acres to perennial grasses was simulated by reducing the number of acres in row crops and increasing the number of acres in perennial grasses by an equivalent amount. Where necessary, the existing perennial grass land-use category was recalibrated to reflect the focus of the study on a HUC-12 spatial scale.

Cover crops are typically treated as a best management practice without changing the underlying land use. It was determined that treating cover crops as a unique land cover type could more accurately capture their effects on sedimentation.

In order to reasonably capture the changes in physical processes that one would expect with the successful adoption of cover crops, the MPCA modelers created new land-use categories within each model to represent the changes to hydrology and nutrient uptake that would occur with cover crops. During the growing season, the new cover crop land-use category was parametrized to mimic the existing row crop land-use category. In the spring and late fall, the cover crop land-use category was parameterized to capture the hydrologic and biologic benefit of having living cover on the landscape when it would otherwise be bare earth. This unique approach included increasing rates of infiltration during the spring and late fall, reducing the ability of rain drops to directly impact the land surface and increasing the roughness of the land surface which inhibits surface runoff.

What is a reasonable goal for a water quality improvement? The goals of the Minnesota Nutrient Reduction Strategy (NRS) offer a good starting point. The NRS establishes basin-wide nutrient reduction goals for phosphorus and nitrogen. For the major river basins, the NRS establishes milestones to be achieved by 2025:

- Red River Basin/Lake Winnipeg:
    - Phosphorus: 10% reduction from 2003 conditions
    - Nitrogen: 13% reduction from 2003 conditions
- Mississippi River Basin:
    - Phosphorus: 45% reduction from average 1980-1996 conditions
    - Nitrogen: 45% reduction from average 1980-1996 conditions: milestone of 20% reduction by 2025

In addition to nitrogen and phosphorus, sediment is another major source of water quality impairments. Excess sediment — primarily clay and silt — contributes to cloudy, murky water, which degrades habitat for fish and aquatic life, and lowers the aesthetic quality of rivers for recreation and tourism. The *Sediment Reduction Strategy for the Minnesota River Basin and South Metro Mississippi River* (MPCA, 2015) establishes a Minnesota River milestone reduction target of 25% by 2020. According to the report:

> "Sediment loading reductions to rivers can be achieved from a combination of traditional conservation practices that reduce soil erosion on cropland and urban development areas, activities directly controlling near-channel sources, and practices to reduce stream flow during high flow periods.

A priority initiative for this strategy is to reduce peak streamflow magnitude and duration, since the cause of much of the near-channel erosion is high flows that exert erosional energy on streambanks and bluffs. River flow goals include reducing the two-year annual peak flow by 25% by 2030, and to decrease the number of days that the two-year peak flow is exceeded by 25% by 2030. Temporary storage of upland waters will be needed to accomplish the flow reduction objectives. An additional priority includes reducing upland erosion through soil health enhancement techniques. Vegetative buffers and grassed waterways also continue to be important strategies to reduce sediment transport to waters."

Another way to assess water quality improvements is the removal of a water quality impairment from a particular stream segment. There are different water quality standards used to identify impairments.

- The *total suspended sediment (TSS)* concentration must be less than 60 mg/L on 90% of the days between April and September (or no greater than 60 mg/L on 10% of the days.
- *Total phosphorus* concentration must not exceed a long-term average of 0.15 mg/L between June and September.
- A specific water quality standard for *total nitrogen load* has not been established in Minnesota. Nitrate levels in source water supplies are evaluated based on the federal drinking water standard for nitrate, 10 mg/L of nitrate-nitrogen, which provides newborns with reasonable protection against blue baby syndrome. This level is mandatory for all public water systems, is recommended for private wells, and provides a reference point for the purpose of this study. The MDA's Township Testing Program identifies private wells with nitrate levels 5 mg/L and 10 mg/L for more frequent monitoring, since these levels can indicate a source of groundwater contamination.

Two scenarios were modeled for each watershed:

1) A **long-term scenario** that includes:

- all marginal cropland (defined as the LCC3+ lands) converted to a perennial crop (grasses, alfalfa, kernza, etc.), or a livestock enterprise, and
- 50% of the remaining cropland seeded to cover crops, including oilseeds.

This scenario is an aggressive one that is likely to be achievable only in the long term, but it represents a goal that could be incorporated into ongoing watershed planning.

2) A **medium-term scenario** that could be anticipated within the next five to ten years, based on the responses received to the landowner survey. The survey indicates that about 30 to 40% of respondents anticipated planting alfalfa or grazing and forage crops on their farm in the next five years, while another 20% to 40% (depending on the watershed) indicated an interest in planting annual cover crops or small grains for soil health or grazing. Therefore this scenario includes:

- 30% of marginal cropland converted to perennial grasses, and
- 40% of the remaining row crop acres seeded to cover crops, including oilseeds

Removal of water quality impairments is challenging. For example, modeling results for the Whiskey Creek watershed show that applying the long-term scenario results in a reduction of 31% in total phosphorus load, but does not remove the impairment. Shakopee Creek is one of the only watersheds in which the sediment impairment is removed under the long-term scenario. The maps in Section VII highlight the medium-term scenario results for each watershed. Full details on both scenarios will be provided as part of the follow-up work to this report.

VI. Survey of Farm Owners and Operators

A survey of farm owners and operators in the six major watersheds was developed and administered by the Water Resources Center team, led by Dr. Amit Pradhananga. The survey is a mailed questionnaire that assesses socio-economic factors influencing landowner conservation behavior, including local capacity of private and public entities. It inquires about landowner sociodemographics (e.g., age, income), property characteristics (e.g., size, tenure), motivations (e.g., information sources, efficacy, social influences, beliefs, norms) for conservation practice adoption and program participation, and current and future conservation behaviors. The survey also assesses landowner awareness of perennial and cover crops and their interest in and support for a potential working lands program. The questionnaire was developed based on a review of existing research on community capacity and landowner conservation decision making conducted in Minnesota's watersheds, previously tested instruments, and insights from project partners.

In August, 2017, 500 surveys were sent to owners of agricultural property (identified based on property tax codes) in each of the six major watersheds, for a total of 3,000 surveys. Two additional waves of mailings followed in early October and early November. When the survey closed in mid-December, 430 responses had been received, for a response rate of 17.4%.

Property tax records indicate ownership, not land use, so the survey went to many landowners who do not farm their own land, although some passed the survey along to their operators.

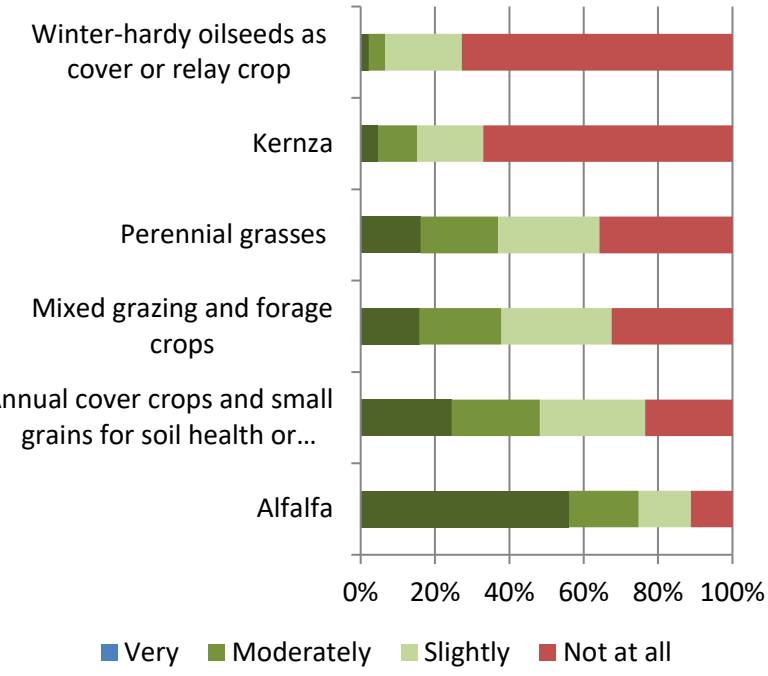
Survey results are summarized in Appendix 1.
Key findings include the following:

- Most respondents were male (91%), and white (100%) with a median age of 63.
- Almost two-thirds of respondents (64%) make their own decisions on their farm, and 43% of respondents reported that over 50% of their income is dependent on agricultural production.
- Median acres farmed in 2016 was 185 acres.

Familiarity with perennial and cover crops

- On average, respondents are most familiar with alfalfa, followed by annual cover crops

Figure 5. Familiarity with perennial and cover crops.



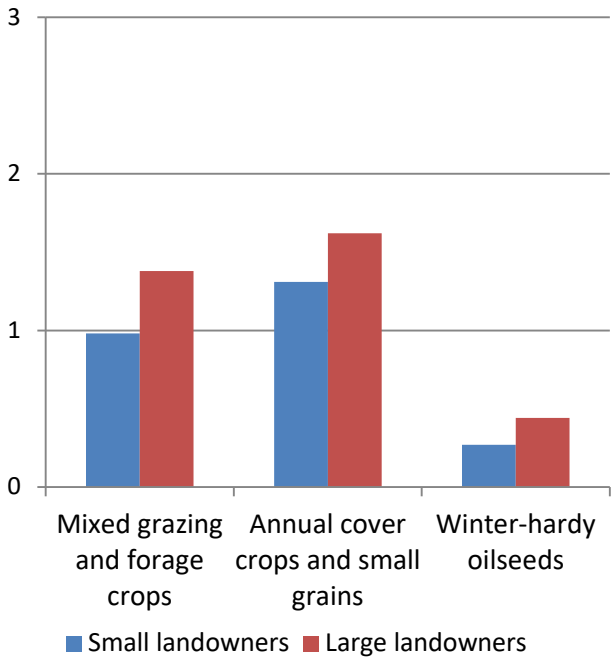
and small grains. Over three-fourths of respondents reported that they are moderately to very familiar with alfalfa (75%).

- In contrast, a majority of respondents reported that they are not at all familiar with Kernza (73%) and winter-hardy oilseeds such as camelina and field pennycress (73%).
- On average, respondents who depend on agricultural production for 50% or more of their income are more familiar with alfalfa and annual cover crops and small grains than respondents who depend on agricultural production for less than 50% of their income.
- Renters are more familiar with mixed grazing and forage crops and annual cover crops and small grains than farm owners. Likewise, large landowners (200 acres or more farmed) are more familiar with these crops than small landowners.

Past use of perennial or cover crops

- A majority of respondents in Chippewa River (51%), Root River (68%), and Sauk River (63%) watersheds reported that they have planted alfalfa on their farm in the past 10 years.
- A greater proportion of respondents between the ages of 28 to 63 reported planting mixed grazing and forage crops (32%) , and annual cover crops and small grains (36%) than respondents who are 64 years or older.
- A greater proportion of respondents who depend on agricultural production for 50% or more of their income (35%) reported planting annual cover crops and small grains on their farm than respondents who depend on agricultural production for less than 50% of their income (22%).

Figure 6. Past use of perennial and cover crops



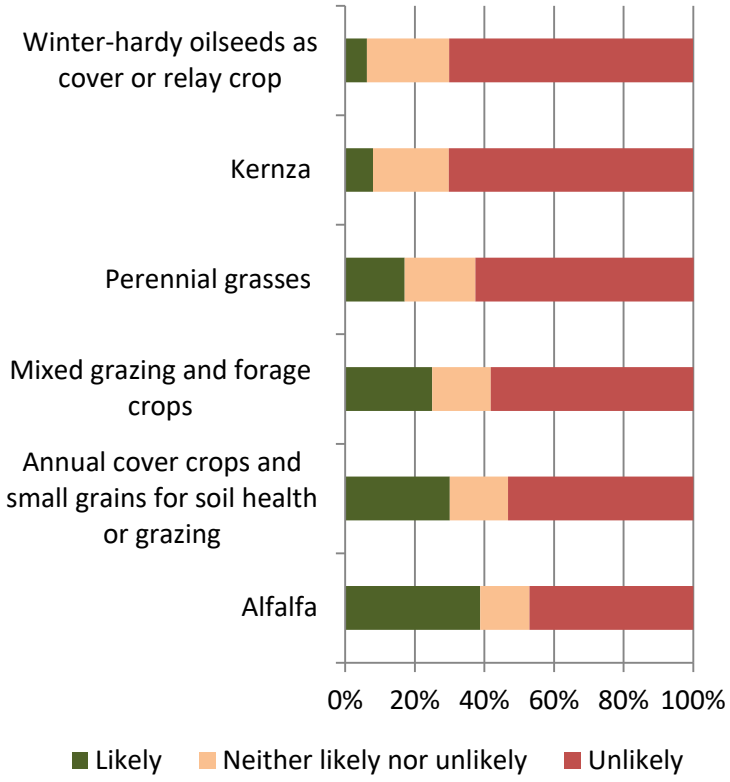
- Statistical differences also emerged between respondents who own and rent their land. A greater proportion of respondents who rented their land for farming (34%) reported planting annual cover crops and small grains than respondents who own the land they farmed (24%).
- From 12% (Buffalo River) to 40% (Chippewa River) of respondents reported planting perennial grasses on their land in the past 10 year. This may indicate past participation in CRP or easement programs.

Likelihood of planning perennial or cover crops

The responses to this question vary by watershed.

- The highest percentage of respondents are likely to plant alfalfa in those watersheds where it is already common – the Root River and Sauk River.
- The greatest likelihood of planting perennial grasses is found in the Chippewa River watershed, at 27%.
- Respondents from the Chippewa and Root River watersheds were most likely to plant mixed grazing and forage crops, as well as annual cover crops and small grains.
- Respondents in the Le Sueur River watershed showed the greatest interest in the oilseeds and Kernza (12% for each).

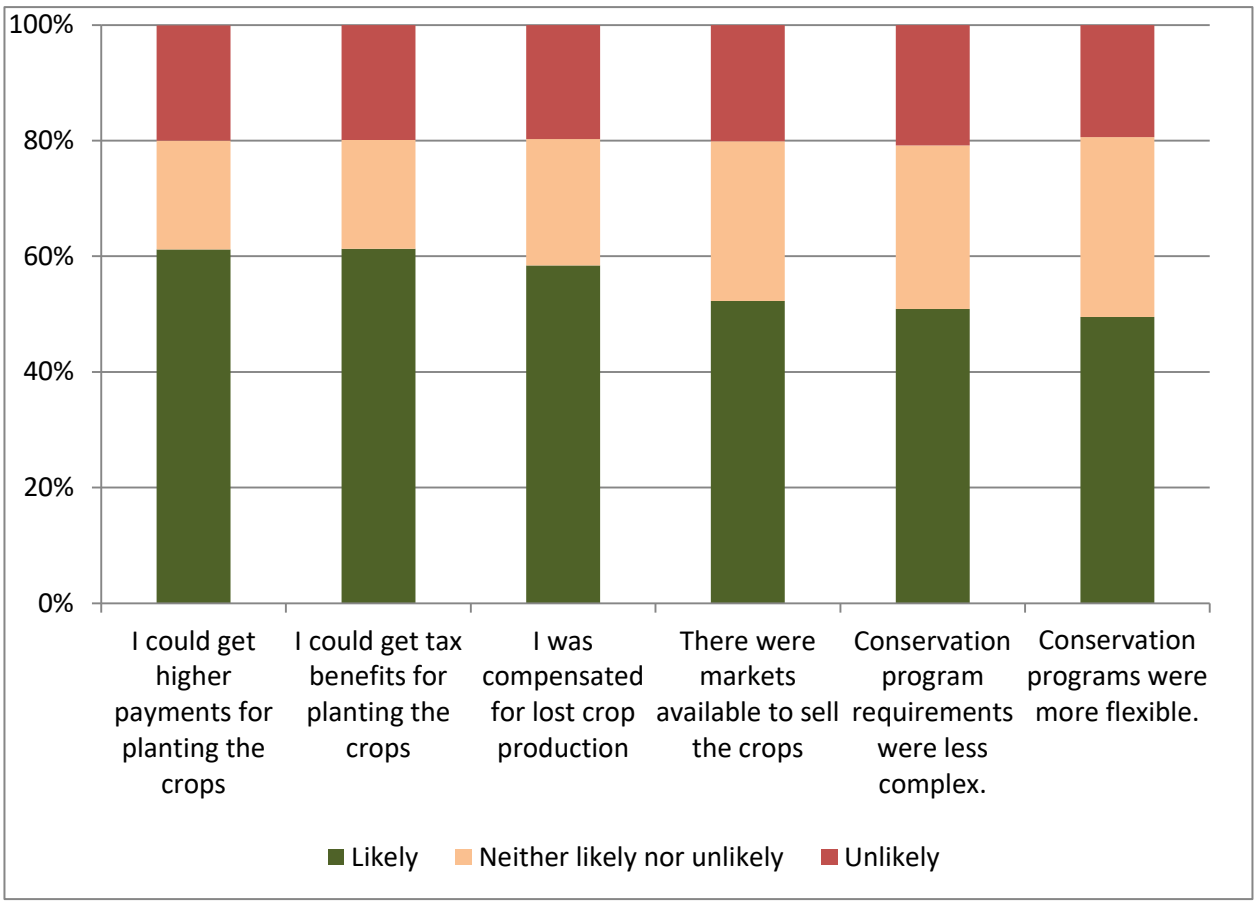
Figure 7. Respondents' likelihood of planting perennial or cover crops on their farm in the next five years (n ≥ 399)



Incentives for future use of perennial or cover crops

On average, financial incentives appear to be the most important motivation for future use of perennial or cover crops. A majority of respondents reported that they are somewhat to very likely to plant perennial or cover crops if they could get higher payments (61%) and tax benefits (61%) for planting the crops, and if they were compensated for lost crop production (58%). Most respondents were also more likely to plant perennial or cover crops if there were markets available to sell the crops (52%). Reducing complexity and increasing flexibility of conservation programs also appear to be important motivators for respondents. Most respondents were somewhat to very likely to plant perennial or cover crops in the next five years if conservation program requirements were less complex (51%). About half of the respondents (50%) were more likely to plant perennial or cover crops if conservation programs were more flexible.

Figure 8. Respondents' motivations for planting perennial or cover crops on their farm in the next five years (n ≥ 371)



The survey provided information on potential crop subsidy programs and collected data on whether survey takers would be willing to participate in programs of varying subsidy amount and contract length. Specifically, survey takers were asked three questions comparing two different programs. For example, one question that some survey takers received asked if they would choose a program for $50/acre with a 5 year contract length, a program for $150/acre with a 15 year contract length, or none. We also collected data on which alternative crop(s) survey takers would be likely to grow on their unproductive land.

Overall, there was no statistical difference between the likelihood of choosing a long (15 year), higher paying ($100 to 150) contract with a shorter (5 year), lower paying ($50 to 100) contract when crops were not considered.

However, when survey-takers would consider growing perennial grasses vs. not, they were more likely to choose longer contract lengths. Shorter contracts were preferred when survey-takers considered growing mixed forages or Kernza (these results were only for those who would choose to participate in specific subsidy programs).

VII. Overview of Sample Watersheds, Potential Crop Scenarios, and Water Quality Impacts

Sample watersheds were selected to meet the requirements of several elements of the Working Lands initiative's enabling legislation:

- a process for selecting pilot watersheds that are expected to result in the greatest water quality improvements and exhibit readiness to participate in the program;
- an assessment of the quantity of agricultural land that is expected to be eligible for the program in each watershed; and
- an estimate of water quality improvements expected to result from implementation in pilot watersheds.

These elements call for a two-level process. "Readiness to participate" is a quality best measured through a social science assessment at the major watershed scale (8-digit hydrologic unit codes or "HUC8"), where most public engagement, intergovernmental coordination, and planning take place.

The landowner survey discussed in part VI of this report was conducted in each of the major watersheds. Estimating water quality improvements, however, is most practical at the minor watershed scale – in most cases, the "HUC10" or "HUC12" scale, where changes in land use and addition of best management practices can be modeled more precisely.

The project team developed a set of preliminary criteria to be used in selecting watersheds from among Minnesota's delineated major watersheds for analysis:

- Broad geographic distribution across Minnesota's agricultural regions, extending from northwest to southeast.
- Landscape-scale diversity representing Minnesota's varied agricultural ecoregions, including those with beef and dairy cattle, those with steep slopes and other types of marginal land, those subject to frequent flooding, and those with the highest percentage of row crop agriculture and the highest land values.
- Proximity to refiners, processors, and other potential end-users – including a full range of biomass processing options beyond ethanol. Processing options range from grazing and animal feed to biothermal energy (heat and power) to biofuels. Proximity to campus-scale or small-community power plants is of particular interest.
- Prior planning efforts, through development of Watershed Restoration and Protection Strategies (WRAPS), watershed plans (1W1P), county water plans, and related studies.
- Demonstrated interest, social capacity, and local leadership, as demonstrated through evaluations by state and regional partners and/or community engagement studies.
- Availability of adequate data and models to assess potential water quality improvements.
- Opportunities to achieve multiple benefits identified in other environmental or economic studies or plans, such as wellhead and groundwater protection, wildlife benefits, pollinator benefits, economic diversification, etc.

- Opportunities to achieve results in "borderline" watersheds – those exhibiting a downward trend or close to the "tipping point" of impairment.

Some of these criteria are fairly subjective, and not all can be maximized in the same locations. Several previous analyses were reviewed and adapted for this study:

- A web tool was developed in 2011 to calculate an Environmental Benefits Index (EBI) for more effectively pricing land to be targeted for enrollment in the Conservation Reserve Program.

- An evaluation tool originally produced by the University of Minnesota in 2013 for the MDA's Sentinel Watersheds Project provides watershed-scale assessments within major river basins based on user-selected attributes. The tool was recently updated for BWSR's One Watershed One Plan initiative, using the current publicly available GIS data layers.

For each major basin, a variety of criteria can be prioritized as a way to rank the HUC-8 scale watersheds. The three primary criteria for this analysis were the risks of soil erosion, risks to wildlife habitat, and water quality, plus additional criteria designed to assess the degree of runoff, nitrogen and phosphorus yield, and steam impairment. Other criteria were added based on basin characteristics, including dominance of row crops and/or animal units, land use conversion to row crops, and drinking water supply vulnerability, depending on the location. In each case, the selected watersheds fell into the "top three" within the river basin. The team also considered additional information on previous and ongoing watershed studies and planning efforts. Each of the selected watersheds has either a completed Watershed Restoration and Protection Strategy (WRAPS) or extensive water quality monitoring and assessment reports, to be used in preparation of WRAPS and Total Maximum Daily Load (TMDL) reports.

Within each major watershed, one or more minor watersheds were selected for water quality modeling based on recommendations from watershed districts, soil and water conservation districts, and other local partners. Each of the minor watersheds was identified for various reasons: as a source of specific impairments, a focus area for potential improvements, an area where local governments and the agricultural community are particularly engaged, or an area considered to have potential for biomass crops. All the selected watersheds are located

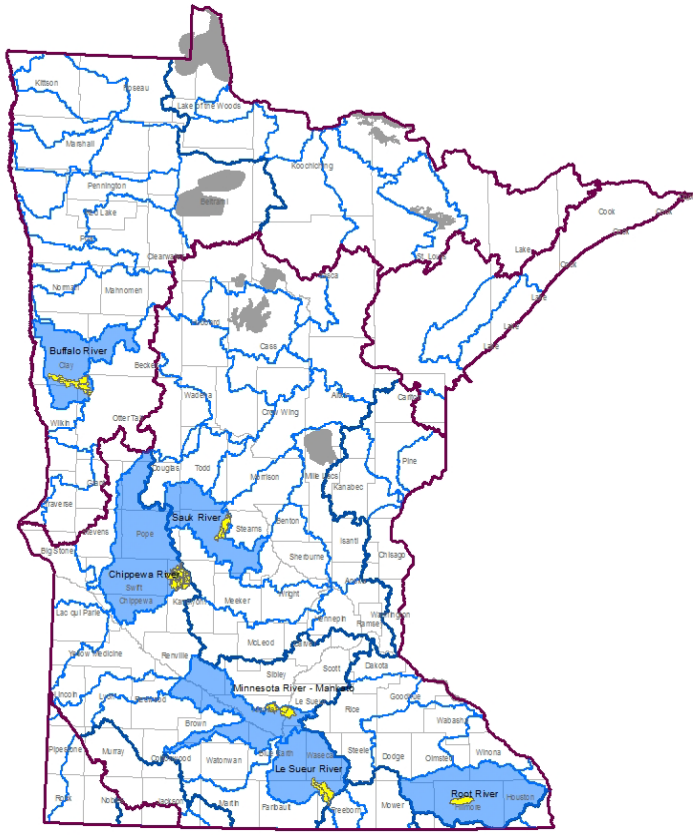


Figure 9. Major and minor watersheds identified for study

within 50 miles of one or more ethanol plants, and many are close to institutions such as college campuses that offer potential for localized bioenergy initiatives.

Conditions and issues in the major and minor watersheds are summarized below, along with a snapshot of one or more alternative crops that seem to have potential in each watershed, and the likely impacts of these changes in land use on water quality.

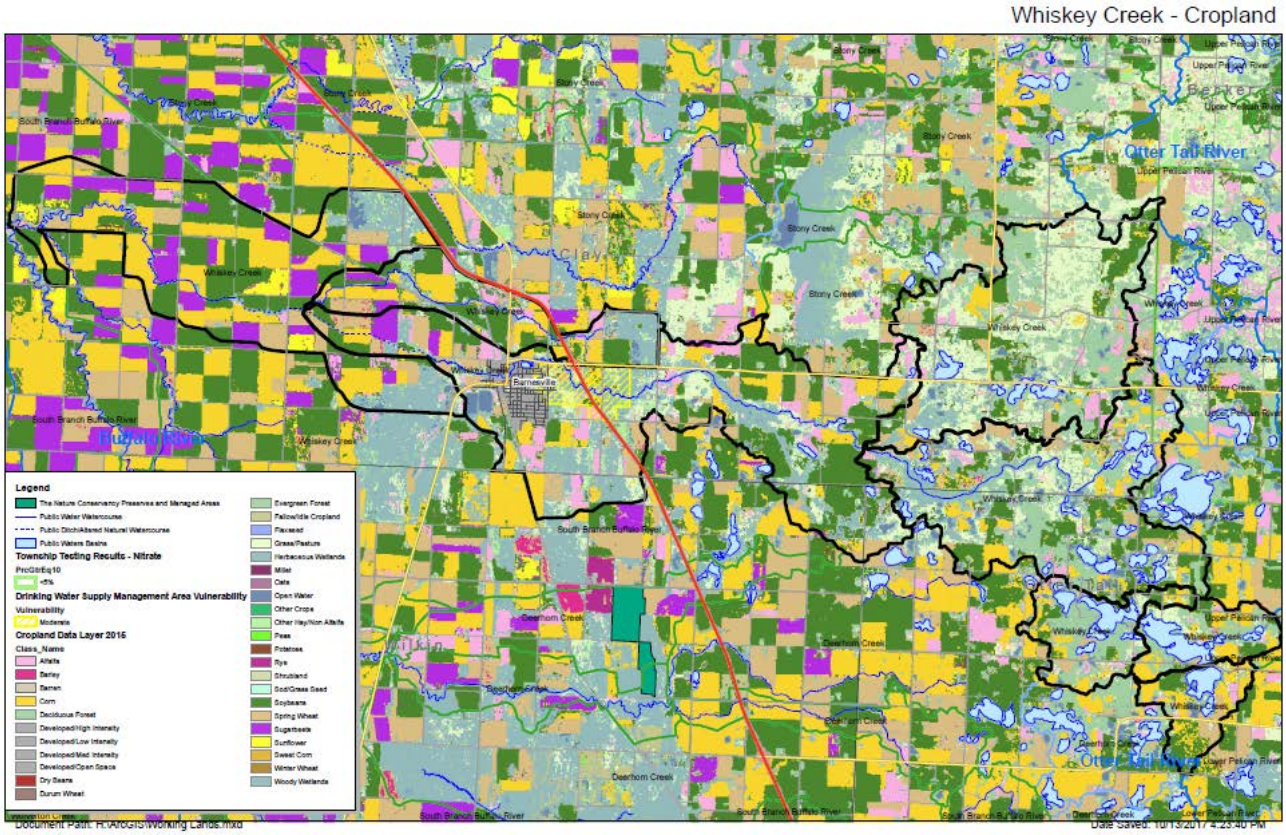
Buffalo River – Whiskey Creek

The Buffalo River watershed covers more than 1,100 square miles in portions of Clay, Becker, Wilkin and Otter Tail counties. The watershed is located in the Red River Basin and spans three ecoregions: the Lake Agassiz Plain, the North Central Hardwood Forests, and the Northern Lakes and Forests. Land use in the west and central portions – mainly the Lake Agassiz Plain – is predominantly agricultural. The eastern portion of the watershed is mostly forested, with more rugged topography; this area is shaped by the Lake Agassiz beach ridges, ancient shorelines shaped by the receding waters of the glacial lake. Corn, soybeans and sugar beets are the primary crops; wheat is also cultivated. There is still some grazing on the beach ridges.

Water quality problems in this area include excess nutrient levels, bacteria levels, and sediment. According to the 2015 WRAPS, "The poor water quality conditions reflect the intensely farmed landscape, human changes to hydrology, intensive drainage, and lack of buffers around lakes and streams. Restoration strategies will need to focus on reducing phosphorus, sediment, and bacteria through livestock management, nutrient management, wind breaks, buffers, and other best management practices." A One Watershed One Plan initiative began in the watershed in 2017.

The Whiskey Creek watershed (one of several "Whiskey Creeks" in this area) is located to the east and west of the City of Barnesville. It spans an area extending downstream from the beach ridge, where soils are rocky and less productive, to the south branch of the Buffalo River. This area is part of the Minnesota Prairie Plan corridor, and some landowners have expressed interest in perennial cultivation. Barnesville's drinking water supply management area (DWSMA) extends outside the city limits in the Whiskey Creek watershed; it is considered moderately vulnerable to contamination. Whiskey Creek itself is impaired for aquatic life (turbidity) and aquatic recreation (E. coli).

Figure 10. Whiskey Creek: Cropland (2016)



Potential Alternative Crops

Whiskey Creek is the only watershed of the six where wheat and sugar beets are significant crops in addition to corn and soybeans. It includes the largest percentage of marginal land, and that land has the lowest CPI. The marginal land is located primarily in the upper portion of the watershed on the Agassiz beach ridges, while the nearly level valley floor contains highly productive soils. In general, because of the amount of marginal land, subsidies for alternative crops would be lower in this upper watershed. Grass-fed beef or beef cow-calf operations are potential uses – beef cattle are still present in significant numbers in Clay, Becker, and Otter Tail counties. Given the vulnerability of the City of Barnesville's DWSMA in the central part of the watershed, Kernza would be another attractive option.

Preliminary Costs: Using the price assumptions in the Six Watersheds Comparison Spreadsheet, neither Kernza planted on marginal land nor grass-fed beef grazed on marginal land would require a subsidy. However, if all land in the watershed were included, Kernza would require a subsidy of $36/acre and grass-fed beef would require a subsidy of $39/acre.

Water Quality Modeling Results

The modeling result shown below are based on a medium-term scenario in which 30% of marginal (LCC3+) land currently in row crops is converted to perennials and 40% of the non-marginal cropland is planted with cover crops. The results differ by stream segment, with the greatest effects furthest upstream. These levels are averages; results can fluctuate dramatically from year to year depending on rainfall or drought conditions.

Figure 11. Whiskey Creek: Percent Reduction in TSS under Mid-term Scenario

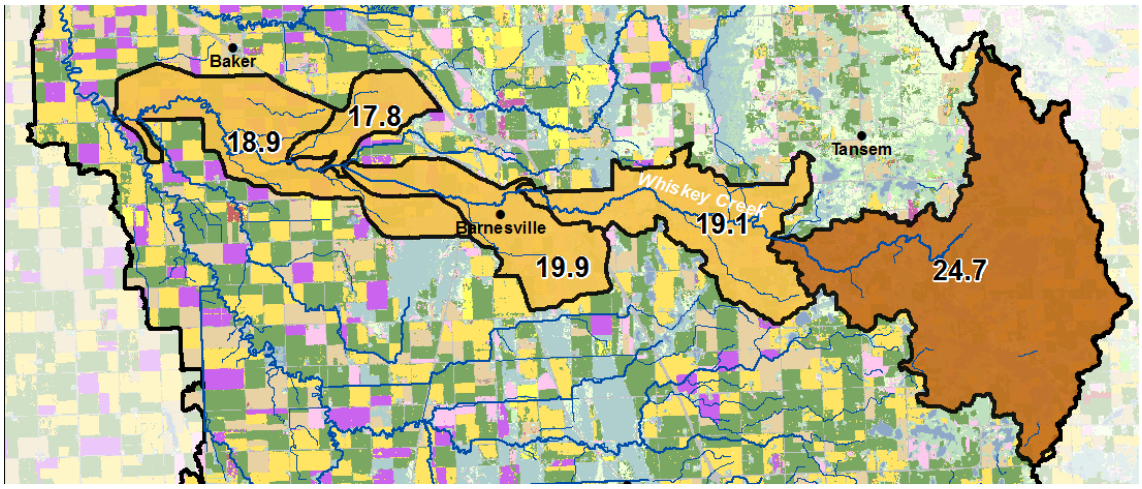


Figure 12. Whiskey Creek: Percent Reduction in Total Phosphorus under Mid-term Scenario

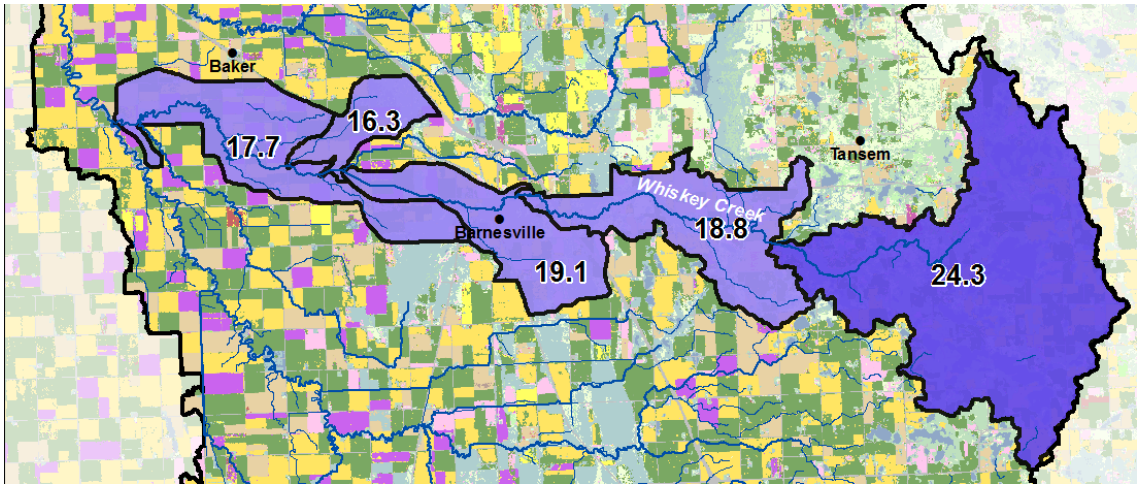
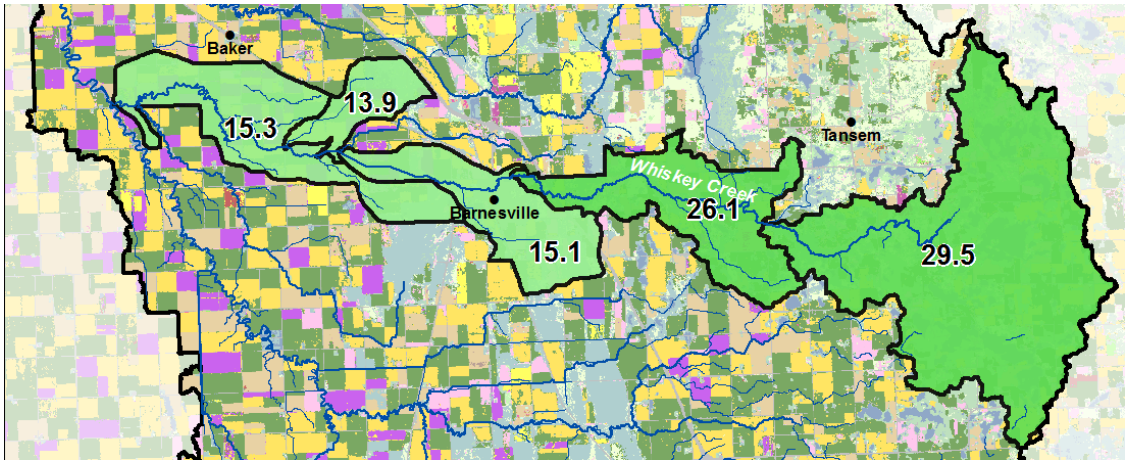


Figure 13. Whiskey Creek: Percent Reduction in Total Nitrogen under Mid-term Scenario



Given the less heavily cropped nature of this watershed's upper reaches, all the stream segments already fall below the TSS impairment threshold of 10% of days between April and September. Nitrogen levels are also relatively low.

Chippewa River – Upper Shakopee Creek

The Chippewa River is the largest tributary to the Minnesota River. Its watershed covers 2,085 square miles and drains portions of eight counties in west central Minnesota extending from the southern part of Otter Tail County to Montevideo, where the Chippewa joins the Minnesota River. The northeast part of the watershed tends to be hillier, wooded, and more easily eroded, while the southwest portion tends to be flatter with more agricultural land. About 80 percent of the land is in agricultural use. Corn and soybeans are the primary crops, with small grains, hay, and grasslands making up the balance. Crops are more diverse in the upper reaches of the watershed, which includes multiple lakes and Sibley State Park. The uppermost part of the watershed falls within a large Minnesota Biological Survey-identified core area for the 2011 Minnesota Prairie Conservation Plan.

The geology of the Chippewa River watershed includes a complex mixture of moraines and till, lake deposits, and outwash plains. The hilly moraines result in a high potential for erosion of sediment into streams.

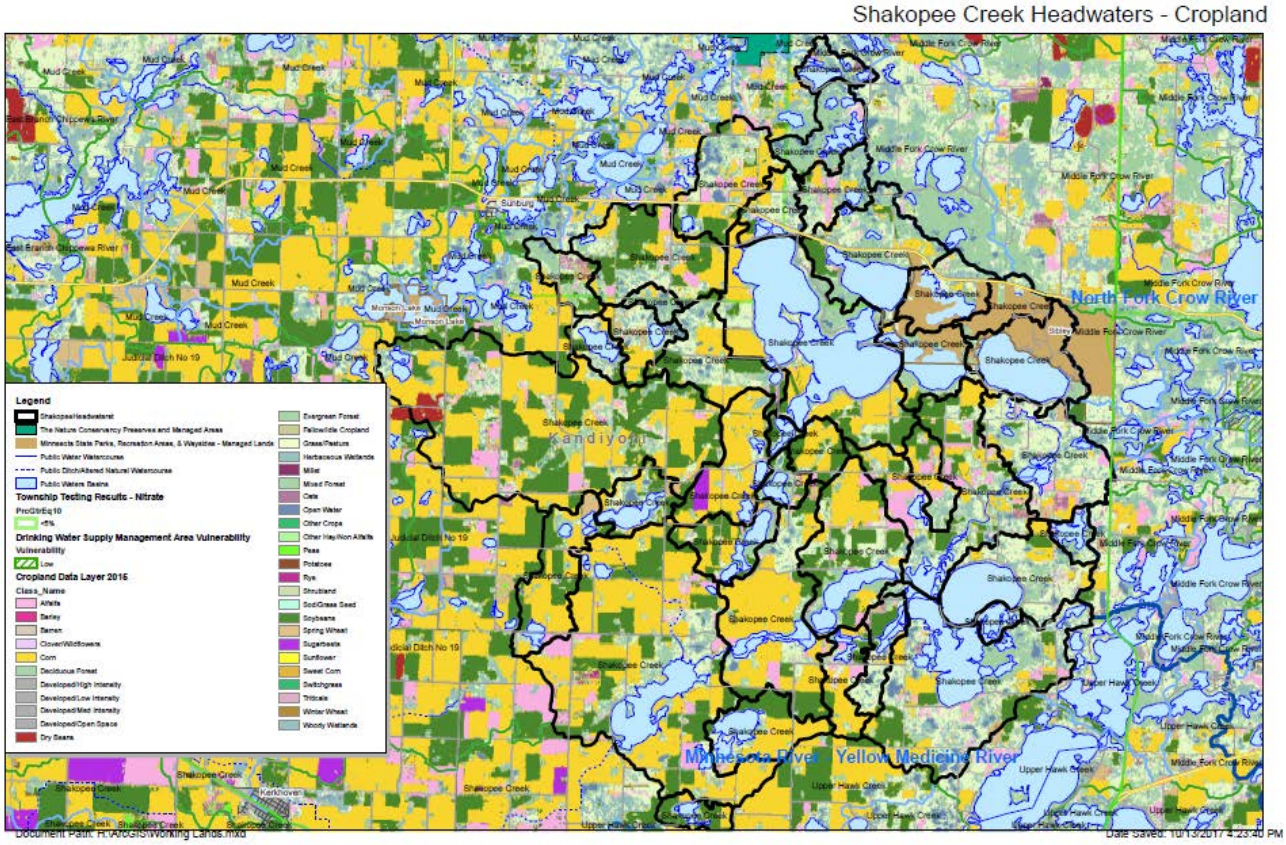
The watershed is the site of the Chippewa 10% Project, developed by the Chippewa River Partnership and the Land Stewardship Project, which has involved extensive monitoring, modeling, and outreach to farmers and landowners. The concept behind the project is that changing farming practices on just an additional 10 percent of the watershed's sensitive agricultural land can be enough to correct water quality impairments, reduce flood potential, restore wildlife habitat, and potentially produce energy crops. Project tools include a 10% Cropping Systems Calculator that allows farmers to explore the financial implications of various alternatives, including more diversified rotations, covering fields beyond the growing season of the main cash crops, integrating perennials and establishing grazing systems.

The minor watershed of Upper Shakopee Creek is actually a cluster of over thirty small catchments that form the creek's headwaters. Several of these watersheds have been extensively modeled by the DNR using the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) method, which models surface water and groundwater hydrology, erosion, and sediment transport. Additional modeling in HSPF was completed in three minor watersheds as part of the Chippewa 10% Project: the East Branch, Middle Mainstem, and Shakopee Creek in its entirety. Several scenarios were modeled, including five that involved an increase in perennial cover.

Because of its mix of land uses and terrain, the Chippewa River watershed includes many lakes and stream segments that are not impaired, or have not yet been assessed. However, Shakopee Creek directly south of the selected headwaters area is impaired for aquatic life based on aquatic macroinvertebrate and fish bioassessments, turbidity and fecal coliform, and some of the lakes in the

watershed, including Norway Lake, are impaired for aquatic life and aquatic recreation due to excess nutrients.

Figure 14. Upper Shakopee Creek Watershed - Cropland



Potential Alternative Crops

The upper reaches of the watershed, a Core Area for the Minnesota Prairie Conservation Plan, are diverse in character, with wooded hills, recreational lakeshore development, and high-quality natural areas, all of which have generated interest in landscape-scale conservation by the DNR, The Nature Conservancy, and others. Kernza, which can be grown as both a forage crop and a specialty grain, could provide wildlife habitat benefits as well as water quality improvements in this area.

Preliminary Costs: Using the price assumptions in the spreadsheet, if grown on marginal land, a minimal subsidy of $13/acre would be needed for Kernza. Averaged across all land, a subsidy of $86/acre would be needed. Camelina, in a corn-soybean rotation on non-marginal land, would not require a subsidy and would not replace the primary rowcrops. However, assuming that a market for camelina does not yet exist (price set to zero), a subsidy of $67/acre would be required.

Water Quality Modeling Results

As noted above, Shakopee Creek has been the site of the most detailed modeling, including several previous modeling efforts by the Land Stewardship Project and the DNR. The HSPF model has some interesting features:

- Three of the reaches, at the upper end of the watershed, are modeled as lake reaches. There is no TSS standard for lakes so the sediment exceedance standard is not applicable to those reaches.
- The phosphorus impairment standard for lakes is 0.9 mg/L, compared to 0.15 mg/L for streams, so those segments are considered separately.
- The long-term scenario removes the TSS impairment for the two impaired non-lake reaches, bringing the days of exceedance below 10%. The mid-term scenario reduces but does not remove the impairment.

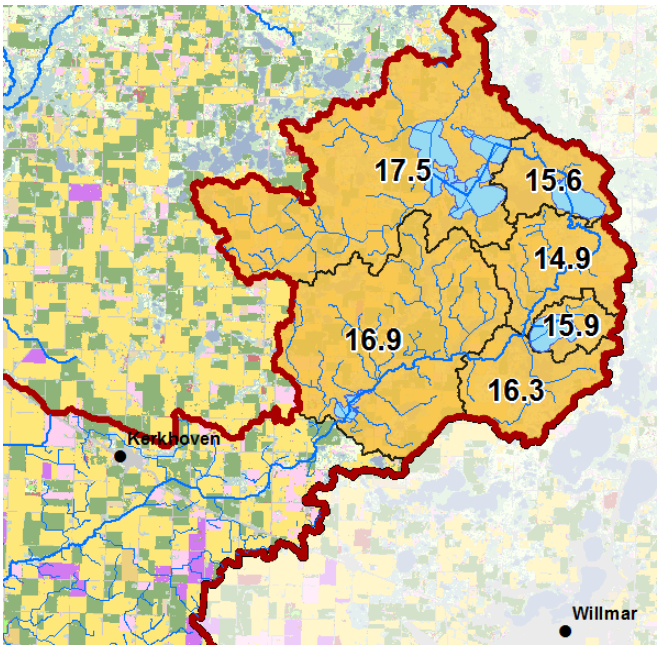


Figure 15. Shakopee Creek: Percent Reduction in TSS under Mid-term Scenario

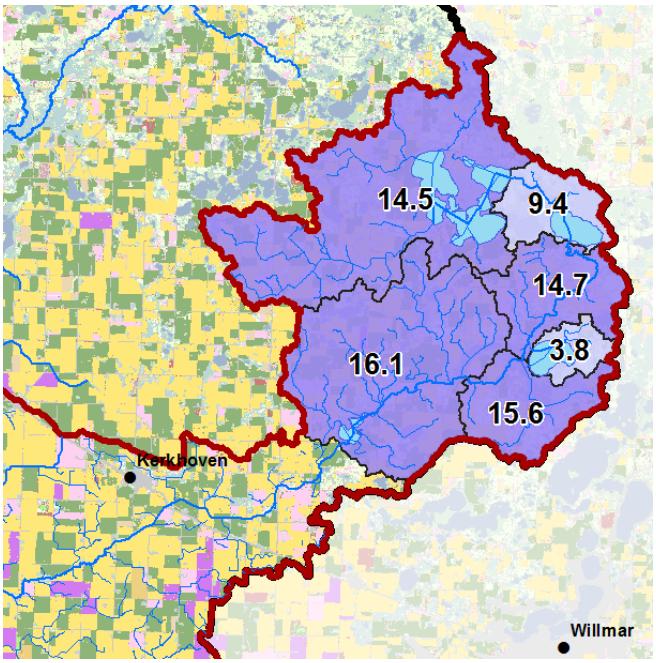


Figure 16. Shakopee Creek: Percent Reduction in Total Phosphorus

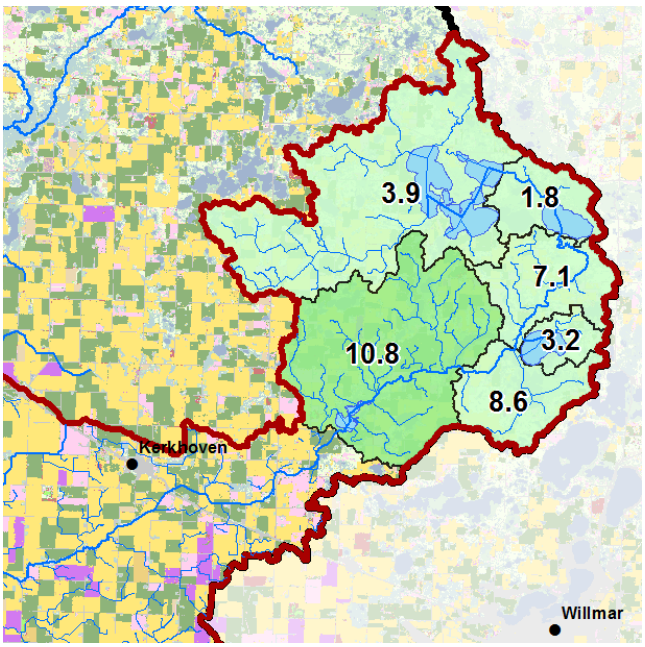


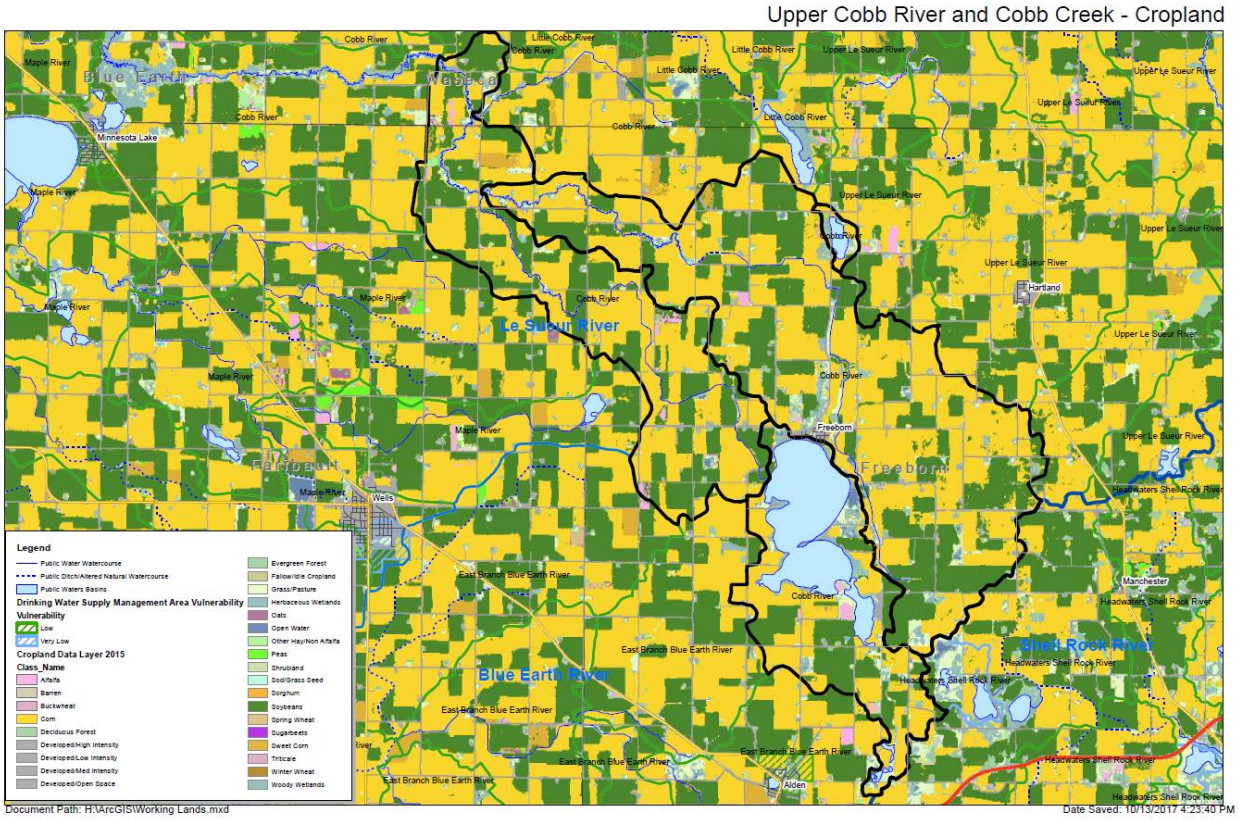
Figure 17. Shakopee Creek: Percent Reduction in Total Nitrogen

Le Sueur River: Freeborn Lake – Cobb River – Cobb Creek

The Le Sueur River major watershed is located in south central Minnesota and drains approximately 711,000 acres (1,110 square miles), joining the Blue Earth River west of Mankato. The watershed is largely rural with 84% of the land in agricultural use, of which approximately 93% is planted in corn and soybeans. Lakes and wetlands currently comprise 3% of the watershed. About 89% of the wetlands have been drained since European settlement. Many of the lakes are shallow and provide wildlife habitat while others are deeper and popular for recreation. Soils in the watershed are fertile but poorly drained, and much of the farmland is now drain tiled.

The Le Sueur watershed is a major source of sediment and nutrients to the Minnesota River. The topography of the river valley, carved during the massive drainage of glacial Lake Agassiz by the glacial River Warren, is marked by steep ravines with knick points (also called incision points) that move upstream as the channels erode downward through fine-grained glacial deposits. These processes increase river flows and sediment loading to the Minnesota River. Water quality monitoring shows some modest improvements in water quality in the Le Sueur River over the past 10 years, though several sections of the river and its streams continue to suffer from turbidity, low dissolved oxygen, and excess nutrients.

Figure 18. Cobb River, Cobb Creek and Freeborn Lake - Cropland



The Cobb River and Cobb Creek watersheds were selected for study based on the recommendations of the Le Sueur Watershed Network, a farmer-led effort coordinated by the Water Resources Center at Minnesota State University -Mankato. The group identified issues with phosphorus impairment of Freeborn Lake, which is impaired for aquatic recreation. The Cobb River is impaired for aquatic life based on aquatic macroinvertebrate bioassessments, fish bioassessments, and turbidity; it is also impaired for aquatic recreation (E. coli).

Potential Alternative Crops

Soils in this watershed have an average CPI of 91, the highest among the six study watershed, and even the marginal land has a relatively high CPI of 77. Therefore, cover crops are likely to be more acceptable to producers in this area than conversion of highly productive row crops to an alternative crop. However, an oilseed such as pennycress appears profitable if added as a winter cash cover crop in a corn/soy rotation, assuming markets were available.

Preliminary Costs: Based on the assumptions in the Six Watersheds Comparison spreadsheet, cover crops on non-marginal land would require a subsidy of $39/acre, while pennycress would not require a subsidy. Under current market conditions however, with a price set to zero, pennycress would require a subsidy of $53/acre.

Water Quality Modeling Results

Two models were developed for this watershed: the standard HSPF model and a more targeted model based on soil characteristics to identify the most environmentally sensitive land. In both models, Freeborn Lake has the capacity to trap both sediment and nutrients, dampening the effects of land conversion on downstream reaches.

Figure 19. Freeborn Lake/Cobb Creek: Percent Reduction in TSS under Mid-term Scenario

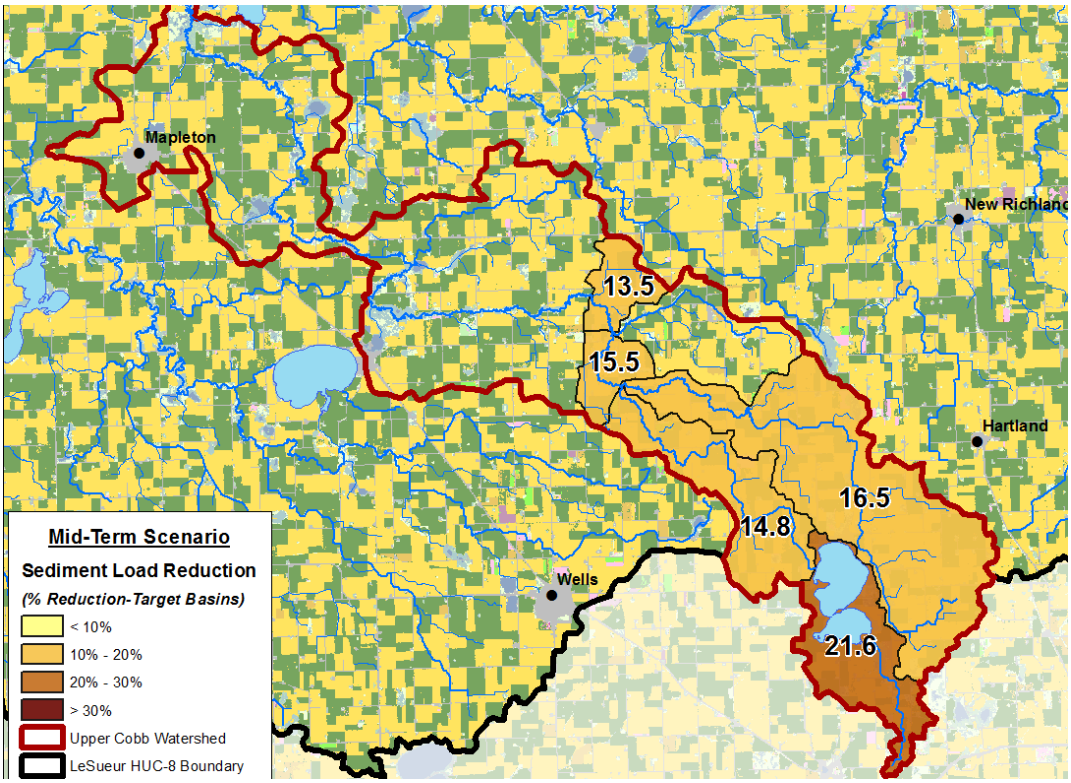


Figure 20. Percent Reduction in Total Phosphorus

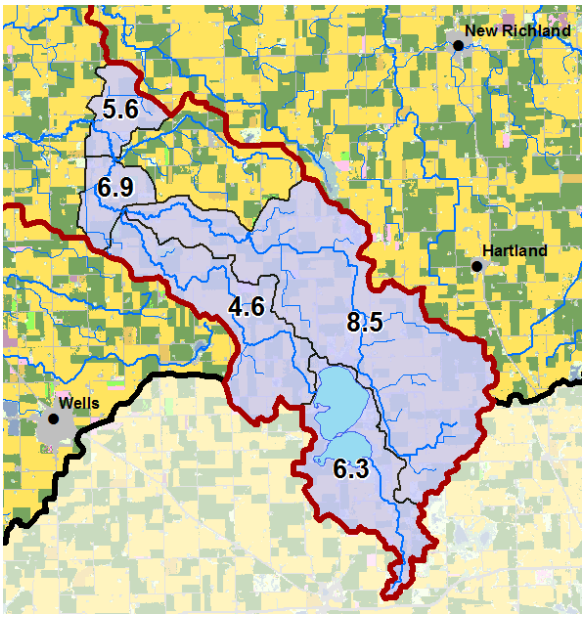
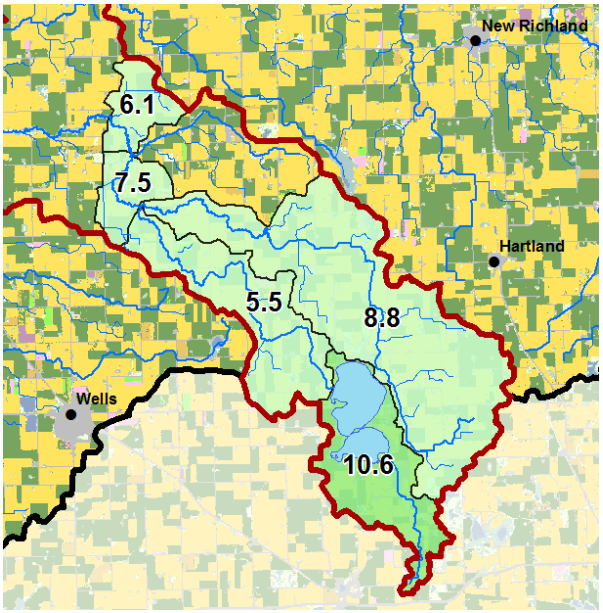


Figure 21. Percent Reduction in Total Nitrogen



A Targeted Model: An alternative methodology for the Freeborn Lake – Cobb Creek watershed, prepared by RESPEC Consulting, is based on the environmental sensitivity of the soil types within the watershed, building on models developed for the Chippewa 10 Percent Project.

The objective of the targeting methodology is to focus implementation on areas with higher pollutant loading rates. Sediment and nitrogen loads were calculated at a 30 meter resolution over 320 square miles within the Le Sueur watershed target basins. These loads were grouped into three categories representing Low, Moderate, and High loading areas. Sediment loads were estimated using the RUSLE (Revised Universal Soil Loss Equation) equations and nitrogen loads were estimated using regression equations developed based on the University of Minnesota's Nitrogen BMP tool (NBMP). Phosphorus loads were estimated as a function of the sediment and nitrogen loads. The load distributions between groups were used to calculate an adjusted efficiency to account for implementing BMPs in areas with higher loading rates. The adjusted efficiencies were then used to simulate the effect of a targeted implementation strategy using the same number of implementation acres used in the mid-term scenario, using the HSPF SAM tool.

This technique has important implications for development of a working lands incentive program, since it indicates that much greater water quality improvements can be achieved by targeting the most sensitive lands, rather than by simply categorizing land as marginal or non-marginal.

Figure 22. Freeborn Lake/Cobb Creek: Percent Reduction in TSS under Targeted Scenario

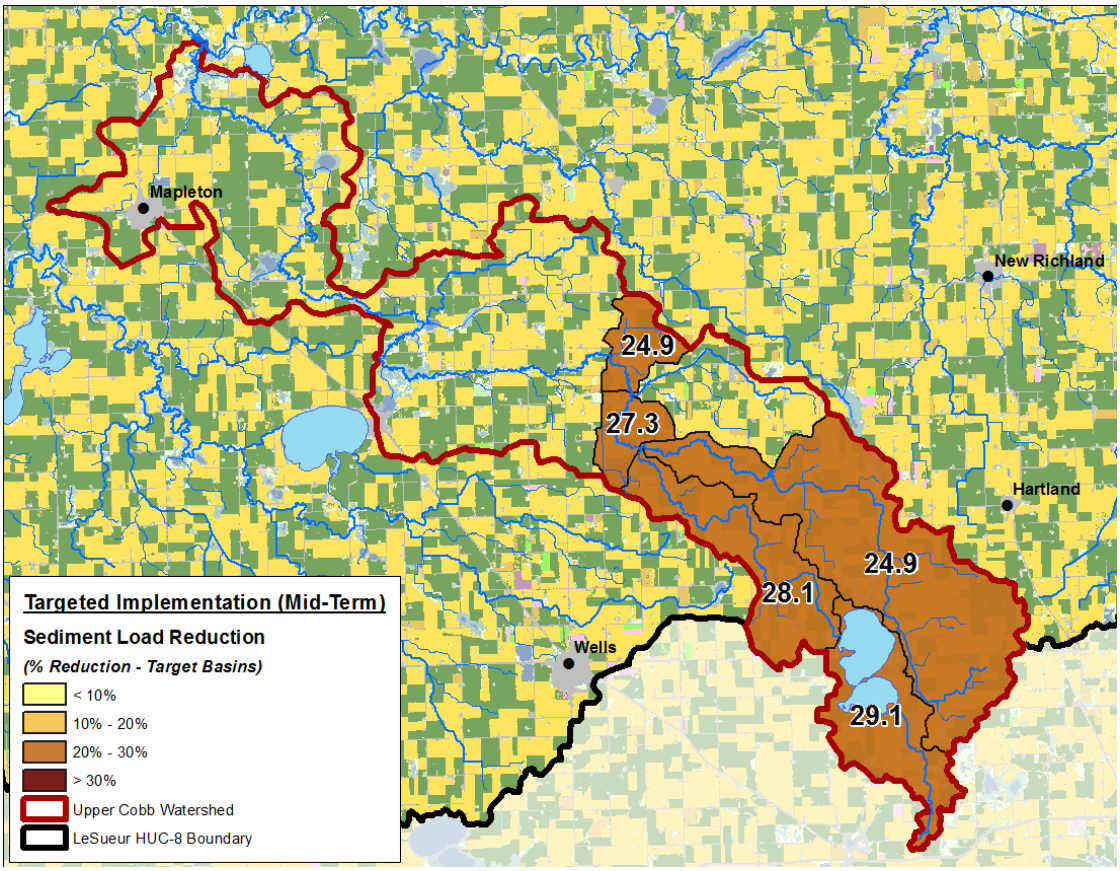


Figure 23. Freeborn Lake/Cobb Creek: Percent Reduction in Total Phosphorus under Targeted Scenario

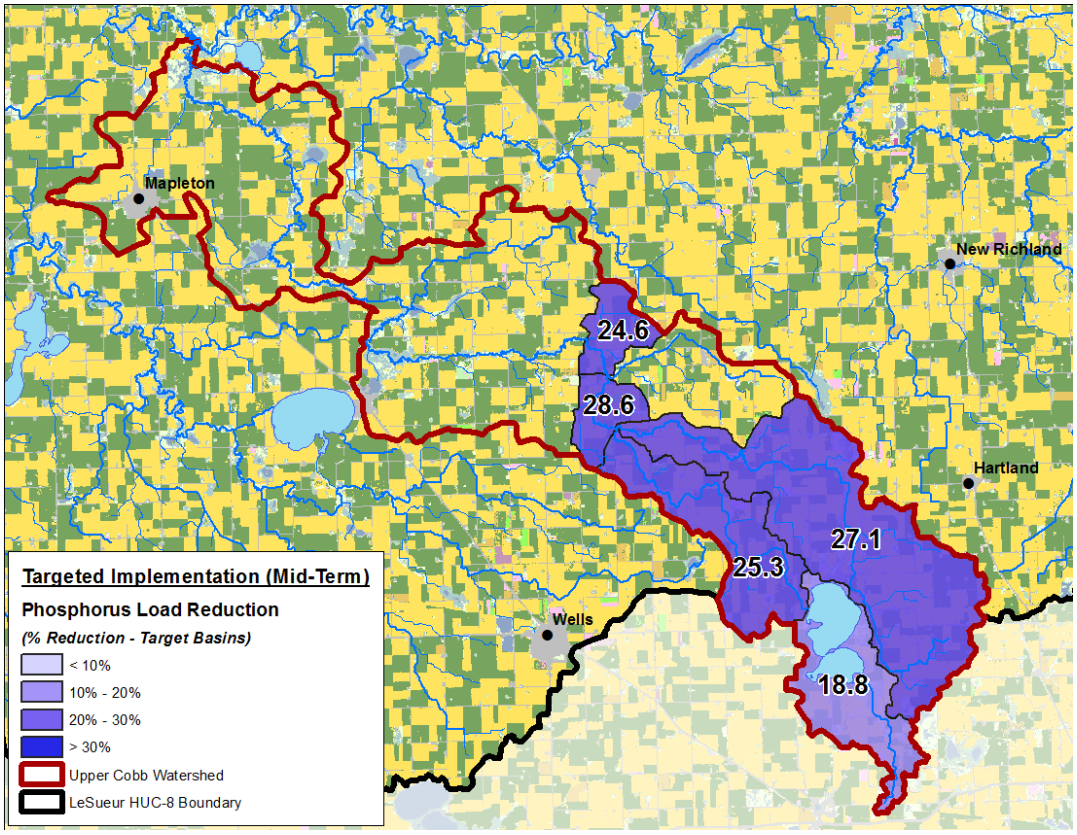
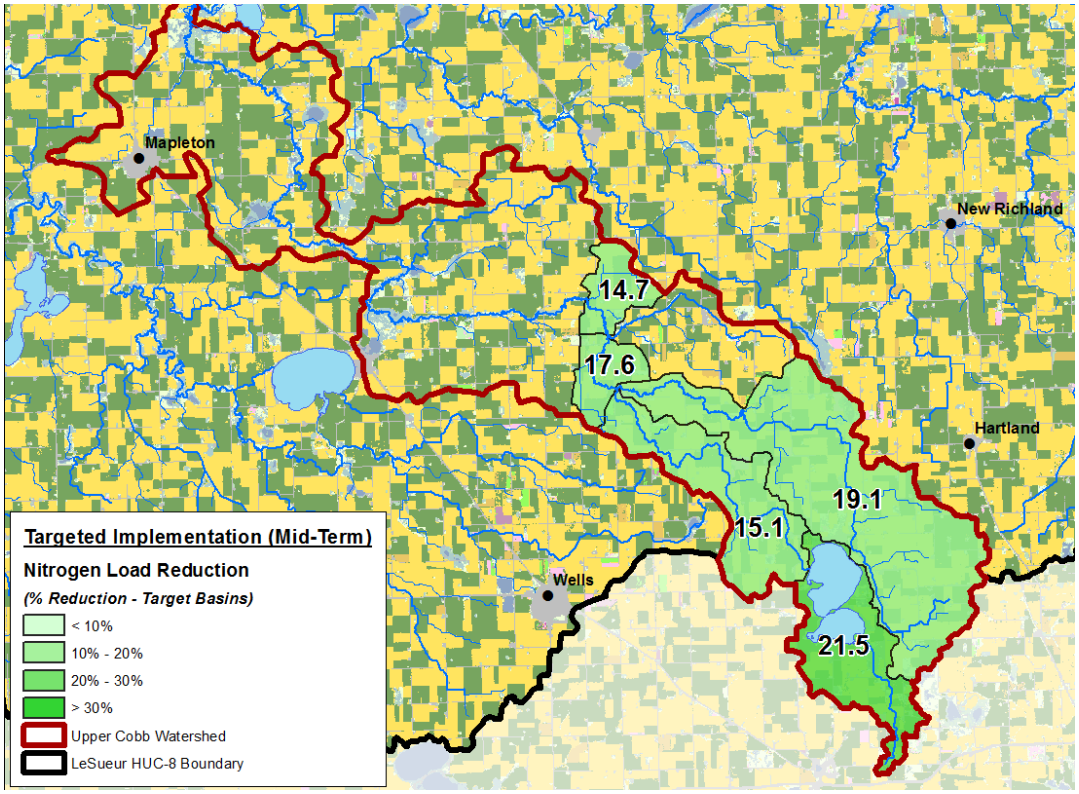


Figure 24. Freeborn Lake/Cobb Creek: Percent Reduction in Total Nitrogen under Targeted Scenario



Sauk River – Getchell Creek Area

The Sauk River watershed covers 667,200 acres (1,043 square miles) and extends from the Mississippi River near St. Cloud to within three miles of Alexandria. The overall watershed is about 75 miles in length. The Sauk River itself meanders for 120 miles in a northwest to southeast direction.

The watershed is located in the north central forest ecoregion, the transitional zone between the state's northern forestlands and southern agricultural lands. It contains 371 established lake basins and 586 perennial and intermittent streams. The watershed is affected by agriculture and urban development with phosphorus and sediment as the primary stressors. It is the only one of the sample watersheds where a significant amount of alfalfa is being grown and sold for hay. Stearns County is a major center of dairying. However, larger dairies are shifting away from alfalfa to corn silage as feed, while the number of smaller dairies still using alfalfa is declining. The Sauk River Watershed District encourages establishment of riparian buffers for haying through a program offering cost share funds for hayed buffers. Groundwater-surface water interaction has been identified as a factor within the Sauk River watershed. A pattern of decreasing average summer flows in the river's main stem indicate groundwater-surface water interaction – that is, surface flows are being affected by groundwater withdrawals for irrigation and drinking water supplies.

The Getchell Creek watershed was recommended for study by the Sauk River Watershed District staff based on the high nutrient volumes it contributes to the Sauk River. The creek is channelized along almost its entire course; first dug in 1907, it has since been maintained by local landowners periodically and is classified in part as public water and in part as public ditch. The adjacent watershed of County Ditch 9, west of the Sauk River mainstem, was included in the analysis in order to include the drinking water supply management areas (DWSMAs) for the cities of Meire Grove and Greenwald, both of which show moderate levels of vulnerability. Additionally, results of the MDA township nitrate testing program indicate that in Grove Township, where County Ditch 9 is located, over 10% of the private wells tested show nitrate levels above 10 milligrams/liter, which is the established health risk limit.[5]

Getchell Creek is impaired for aquatic life, based on aquatic macroinvertebrate bioassessments, and for aquatic recreation (E. coli).

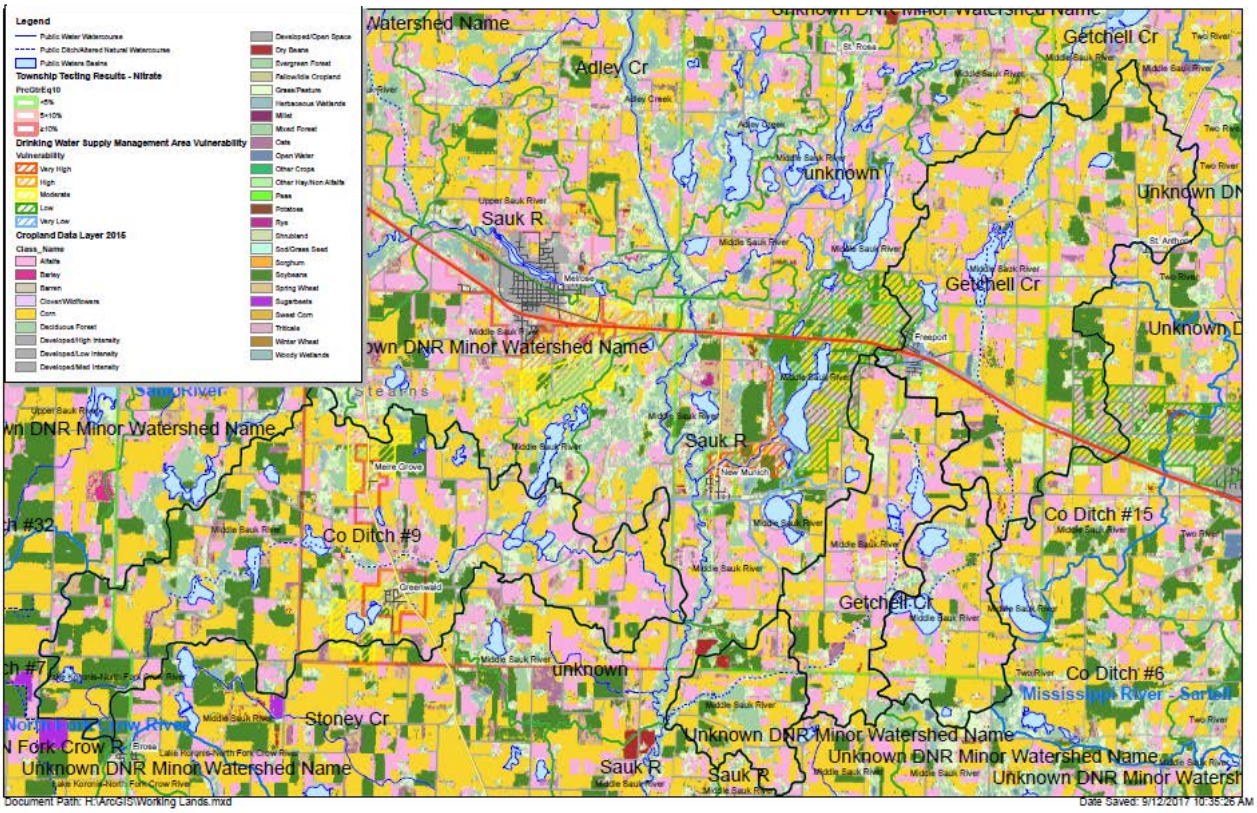
Potential Alternative Crops

Soil productivity in this watershed is the lowest of the six, and the amount of the required subsidy is minimal. Given the amount of alfalfa already being grown in this watershed, and the fact that Stearns County is Minnesota's leading dairy producer, alfalfa cultivation seems feasible.

The vulnerability of the DWSMAs in this watershed, as well as the high nitrate levels in private wells in the surrounding townships, point to the potential for Kernza as a food and forage crop, or switchgrass as a forage, bedding, or energy crop.

[5] http://www.mda.state.mn.us/~/media/Files/chemicals/nfmp/stearnsfinal201415.pdf

Figure 25. Getchell Creek and County Ditch 9 - Sauk River: Cropland



Preliminary costs: Based on the assumptions in the Six Watersheds Comparison spreadsheet, switchgrass on marginal land would not require a subsidy, even if the price is reduced to zero. Alfalfa hay for sale on marginal land would require a subsidy of $44/acre.

Water Quality Modeling Results

Because the two watersheds are not connected but are separated by the Sauk River mainstem, results are shown separately. The highest density of marginal lands and resulting conversion to perennials was in the upper portion of the Getchell Creek watershed.

Figure 26. Getchell Creek/Co. Ditch 9: Percent Reduction in TSS under Mid-term Scenario

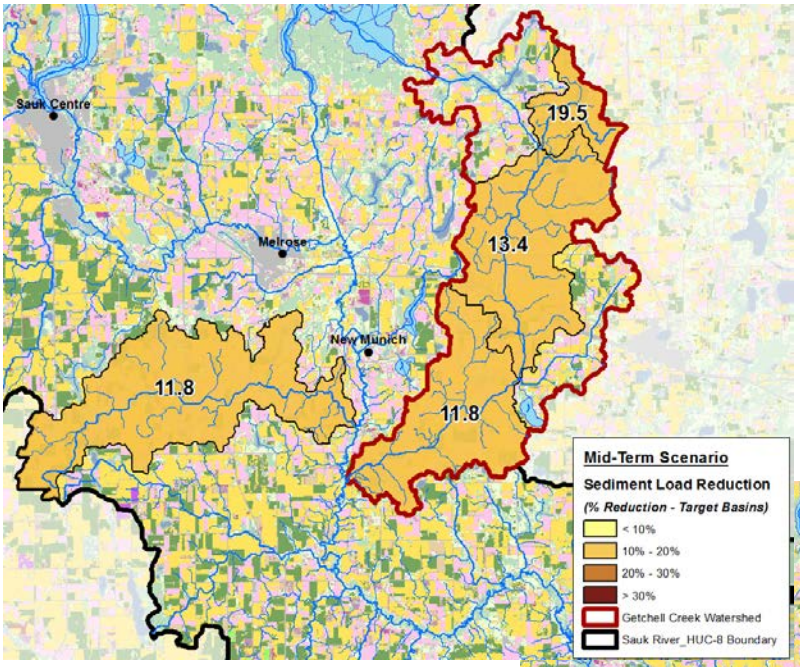


Figure 27. Percent Reduction in Total Phosphorus under Mid-Term Scenario

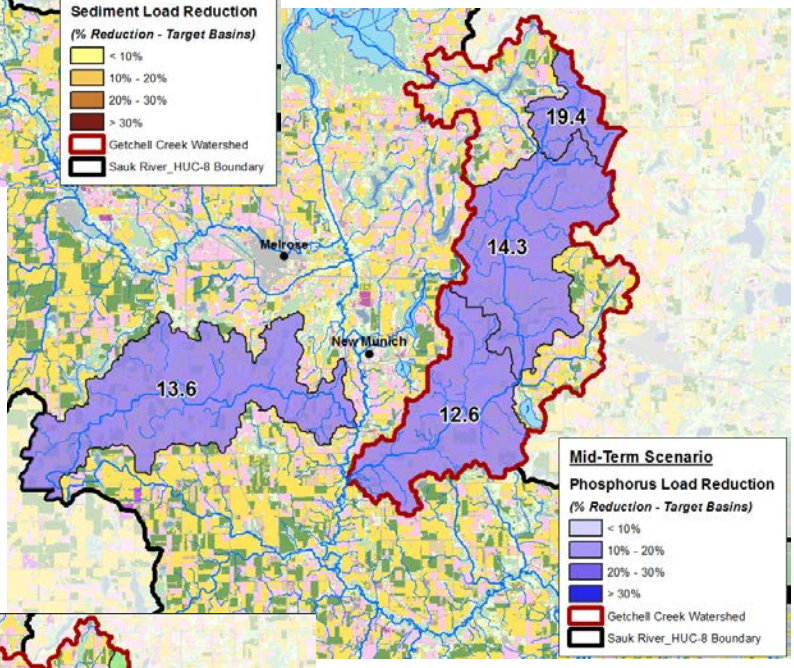
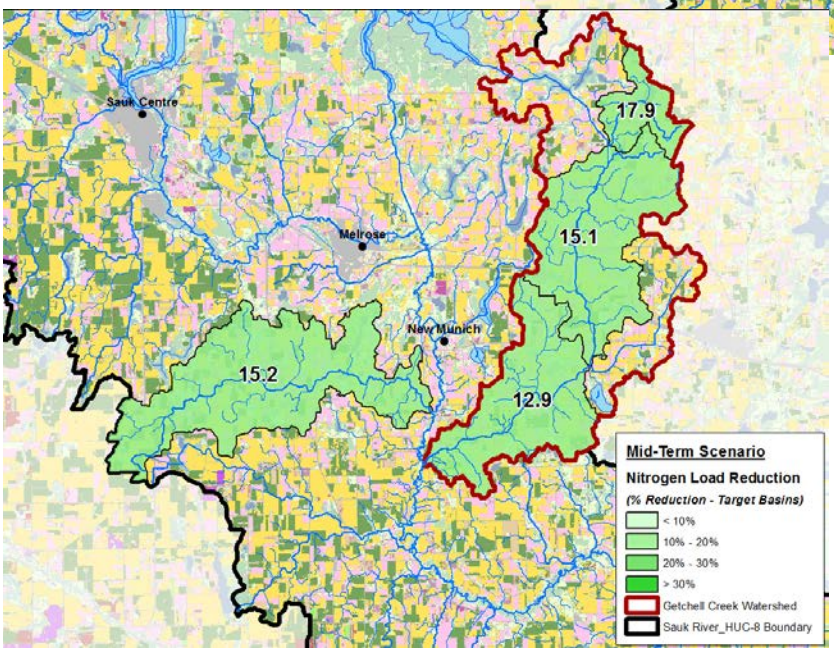


Figure 28. Percent Reduction in Total Nitrogen under Mid-term Scenario



Minnesota River – Mankato – Rogers Creek and St. Peter Area

The Minnesota River - Mankato watershed covers 861,886 acres across Cottonwood, Brown, Redwood, Renville, Sibley, Nicollet, Blue Earth, and Le Sueur counties in south-central Minnesota. The watershed's landscape is diverse, with flat cropland in the west and bluffs and lakes in the east. As in the Le Sueur watershed, steep slopes and bluffs bordering the valley of the historic Glacial River Warren contribute to significant erosion. Land use is dominated by row crop agriculture, which occupies about 76% of the watershed, with corn and soybean production accounting for about 90% of cropped lands. County Soil and Water Conservation Districts have identified the primary resource concerns to be sediment and erosion control, stormwater management, drinking water and source water protection, drainage management, waste management, nutrient management, surface water quality and wetland management.

The Rogers Creek watershed was selected for study based in part on local knowledge and interest. Extensive outreach and engagement efforts in the nearby Seven Mile Creek watershed were organized through the University of Minnesota's Humphrey School of Public Affairs in 2014-2016, in partnership with the Nicollet County SWCD and Great River Greening. This effort, termed the New Ag Bioeconomy Project, included research on potential biomass crops and modeling of different crop scenarios through an interactive GeoDesign web-based tool. Additionally, the Nicollet County SWCD received a Targeted Watershed grant from BWSR in 2015 for expanded outreach and conservation practices, including promotion of cover crops.

The NRCS identified Seven Mile Creek as one of three priority watersheds in Minnesota to receive technical assistance under the National Water Quality Initiative (NWQI). In priority watersheds with impaired streams. NRCS is helping producers implement conservation and management practices through a systems approach to control and trap nutrient and manure runoff. Qualified producers receive assistance for installing conservation practices such as cover crops, filter strips and terraces.

Rather than continuing to focus on the relatively small and heavily-studied Seven Mile Creek watershed, the project team identified the nearby Rogers Creek watershed as having similar conditions. Rogers Creek is impaired for aquatic life based on fisheries bioassessments and for aquatic recreation. Rogers Creek is also located adjacent to the City of St. Peter, where the vulnerability of drinking water supplies has been a continuing challenge, requiring expensive new treatment facilities. Therefore, the small Minnesota River watershed that encompasses the city and its DWSMA is also included in the analysis.

Potential Alternative Crops

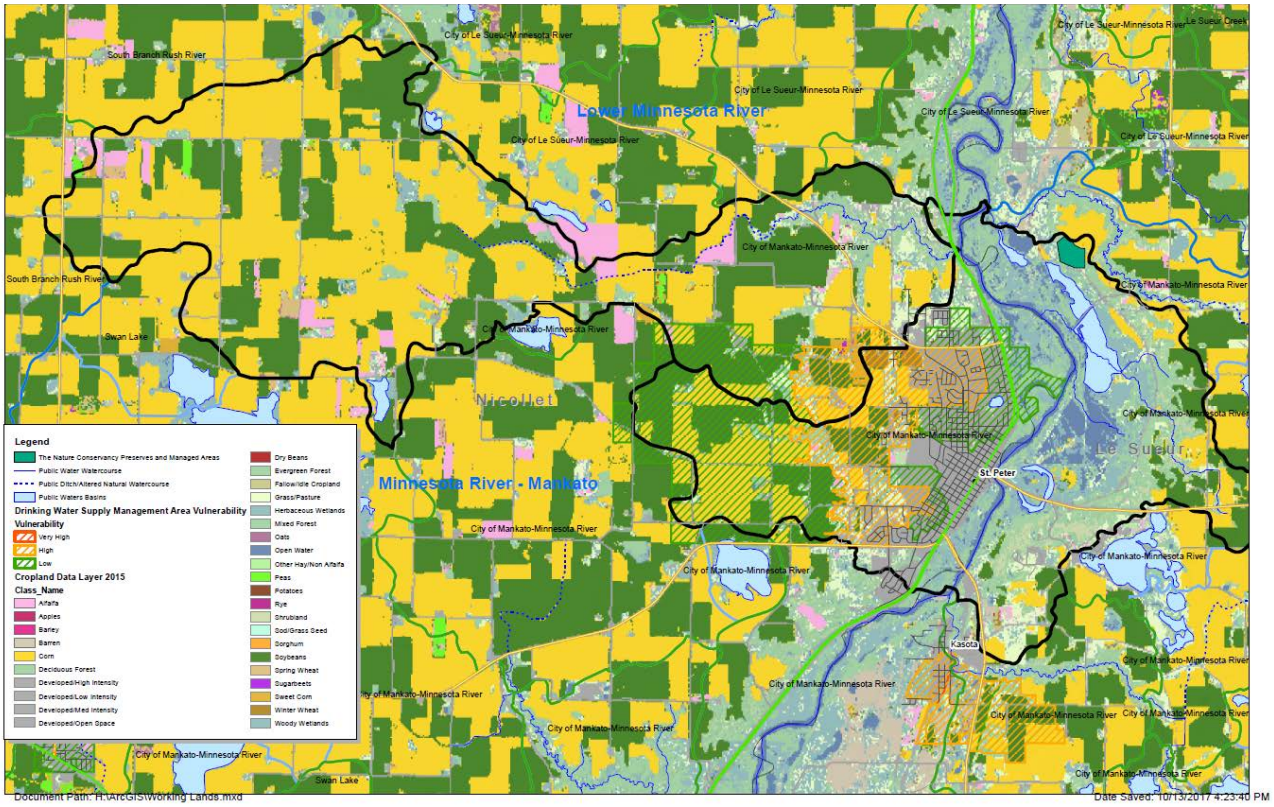
Of the six watersheds surveyed, Rogers Creek contains the smallest amount of marginal land. Opportunities in the area include several large dairies that currently import their hay from western states. Obstacles include the high productivity and high prices of cropland, making conversion to alternative crops difficult. However, there is some potential for supplying hay to the large dairy operations, if a reliable supply could be guaranteed. Camelina in a corn-soy rotation would be profitable, if price assumptions in the spreadsheet are realized. Given the source water protection

concerns in this watershed, Kenza should also be considered as a specialty crop in targeted wellhead protection areas. Alfalfa on marginal land would require a subsidy of $69/acre

Funding from the LCCMR will be available beginning in 2018 for a new program to test a farmer-led, market-based working lands approach to open new markets for alfalfa in the Seven Mile Creek watershed near St. Peter. The program will also investigate prospects for new value-added uses for alfalfa, including sustainably produced aquaculture feed for farming high-value fish and shellfish, and other high-value bio-products.

Preliminary costs: The Six Watersheds Comparison spreadsheet identifies alfalfa hay for sale (on marginal land) and camelina in a corn-soy rotation as potential crops. Using the price assumptions in the spreadsheet, camelina would not require a subsidy, while alfalfa hay on marginal land would require a subsidy of $69/acre. However, this watershed has so little marginal land (based on land capability classifications) that this may be unrealistic. If camelina is assumed to have no market value, a subsidy of $72/acre would be required.

Figure 29. Rogers Creek and St. Peter area - Middle Minnesota River: Cropland



Water Quality Modeling Results

The subwatershed maps include the City of St. Peter. However, because it spans the Minnesota River, the large volumes of water in the river are virtually unaffected by changes in land cover in this location.

The Rogers Creek subwatersheds include a minimal amount of marginal land, so most of the land use change would come from cover crops.

Figure 30. Rogers Creek: Percent Reduction in TSS under Mid-term Scenario

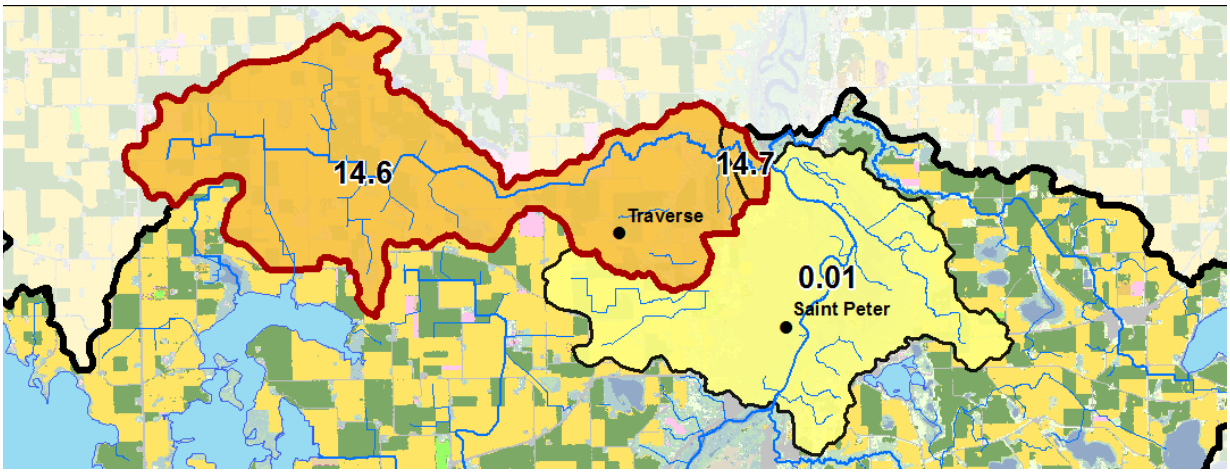


Figure 31. Rogers Creek: Percent Reduction in Total Phosphorus

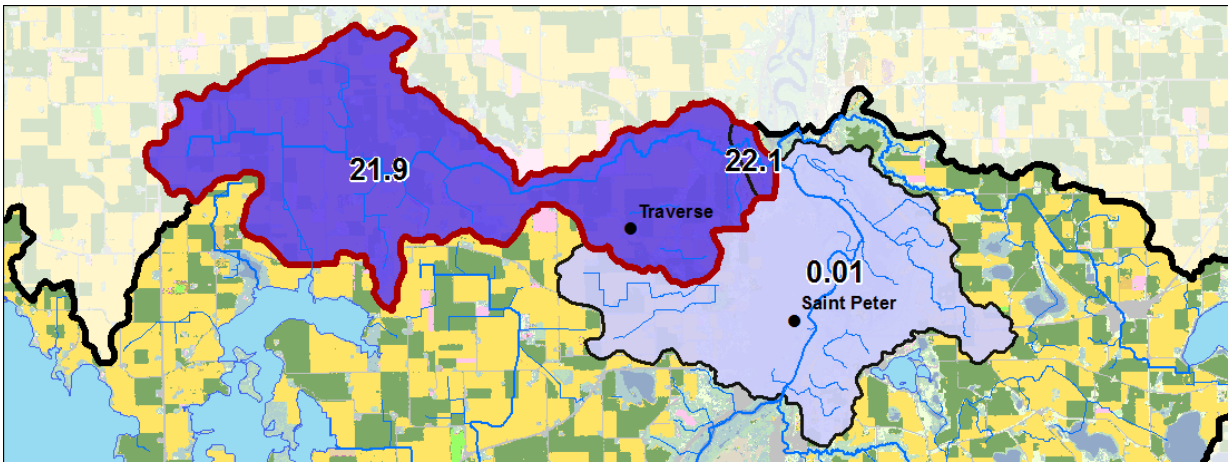
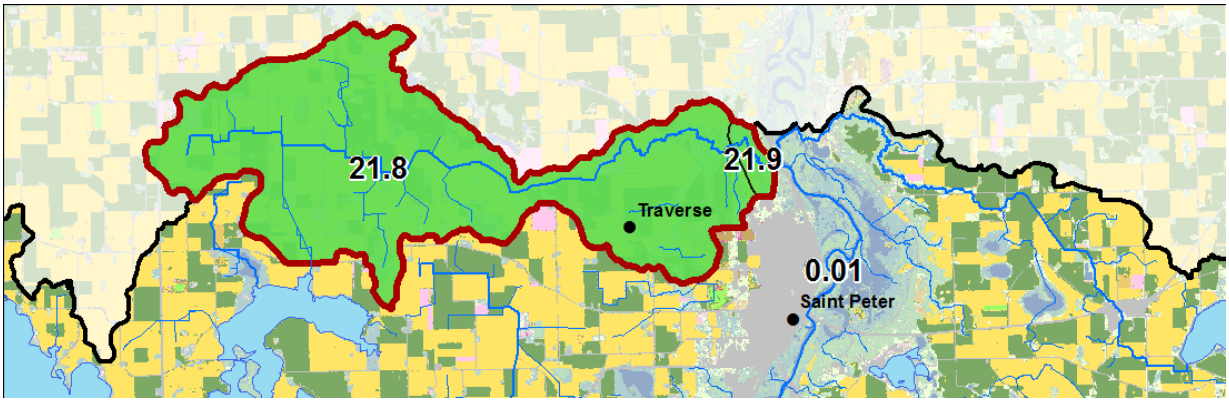


Figure 32. Rogers Creek: Percent Reduction in Total Nitrogen



It is important to note that Rogers Creek is a tributary to the Minnesota River. Most of Rogers Creek watershed area is several hundred feet in elevation above the mainstem Minnesota River. The lower reach of Rogers Creek flows over the River Warren Bluffs and into the river valley. This channel incision into the knickpoint is a significant source of sediment to the in-channel sediment load of the lower reaches of Rogers Creek. The simulated land conversion changes have a direct impact on the amount of sediment that is delivered to the channel from the watershed area but a lesser impact on in-channel scouring processes.

Root River – Watson Creek

The Root River watershed covers 1,064,961 acres in southeast Minnesota within the Lower Mississippi River Basin, draining west to east before joining the Mississippi River approximately five miles east of the small town of Hokah. The watershed primarily lies within the Driftless Area ecoregion, with a small portion of its headwaters in part of the Western Corn Belt Plains ecoregion. The distinctive karst (limestone) topography of the region means that the land has limited capacity to retain water.

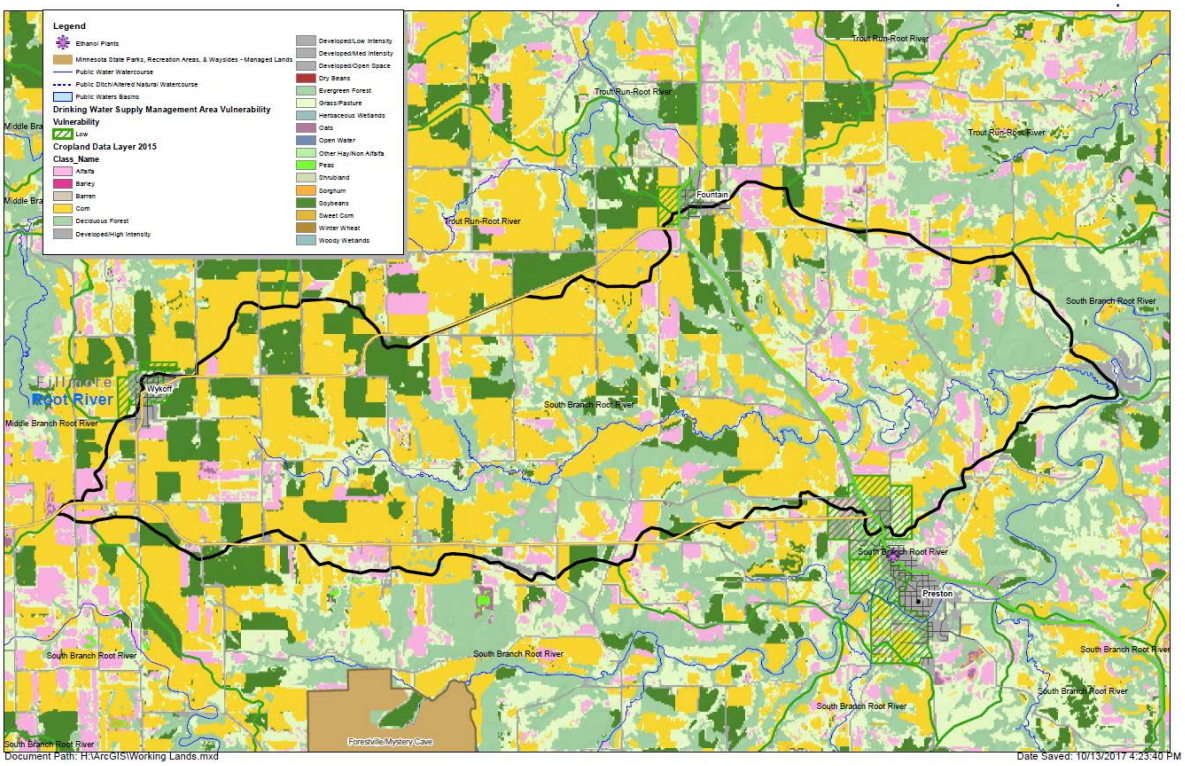
Cropland generally occupies the fertile plains area in the western portion of the watershed, but also the river valleys located throughout the Driftless area, comprising about 41% of the watershed. Pasture (31%) and forest/shrubland (22%) are found primarily in the rolling hills and bluff regions located in the eastern half of the watershed. However, in the past decade, high prices for row crops have led to conversion of land has been converted from pasture to cropland, while cattle have become more scarce.

The Root River contributes substantial amounts of nitrogen and phosphorus to the Mississippi River, and sediment and erosion control have been identified as a primary threat to area waters. Drinking water/source water protection is also a key concern. The Root River region is particularly susceptible to groundwater contamination as a result of its permeable soils and karst features.

The Watson Creek watershed (HUC-12) is part of the South Branch Root River HUC-10. Watson Creek is impaired for aquatic life (through fish and aquatic macroinvertebrate bioassessments), aquatic recreation (E. coli), and drinking water (nitrates).

The Fillmore County SWCD has a long history of working with landowners in the Watson Creek watershed to address pollution problems. The watershed was one of three pilot study areas for the Minnesota Nutrient Reduction Strategy, developed as part of the statewide effort in 2013-2015, so considerable modeling of impairments and potential BMPs has been completed. The SWCD staff have identified a need for cover crops and perennial crop establishment. The watershed is also home to a large ethanol refiner, POET Biorefining in Preston, which has expressed interest in working with the SWCD on some type of environmental initiative.

Figure 33. Watson Creek area - Root River: Cropland



Potential Alternative Crops

The Watson Creek watershed still contains significant acreage of pasture and alfalfa, and was the site of more livestock production in the past. The steep slopes and highly erodible soils in the lower reaches of the watershed are not ideal for row crops. Options for alternative crops include expansion of cover crops to improve soil health and lessen erosion. Dairy and beef enterprises could also be successful in this area, especially on marginal land, where the spreadsheet indicates that no subsidy would be required. Switchgrass could also be grown on marginal land, particularly on steep slopes, for forage and other uses.

Water Quality Modeling Results

The Root River, with the presence of karst features in the subsurface, is unique among the six watersheds modeled. The Root, as well as the Sauk, have more dairy operations on the landscape than the other modeled watersheds and as a result the use of manure on agricultural fields is more prevalent in these two watersheds. Agricultural fields that apply manure tend to have higher total nitrogen application rates than fields that rely solely on chemical application. Some of these high-nitrogen-loading lands fall into the marginal category and were thus candidates for conversion to perennial grasses. In Watson Creek, it appears that removal of some of these lands resulted in significant water quality benefit, with reductions in Nitrogen load exceeding 50% in the case of the Long-Term scenario and roughly 22% in the case of the Mid-Term scenario. The Watson Creek watershed also shows the smallest amount of reduction among the six

watersheds in sediment load: only 2.5%. However, sediment concentrations in the watershed are already below the impairment threshold.

Figure 34. Watson Creek: Percent Reduction in TSS under Mid-term Scenario

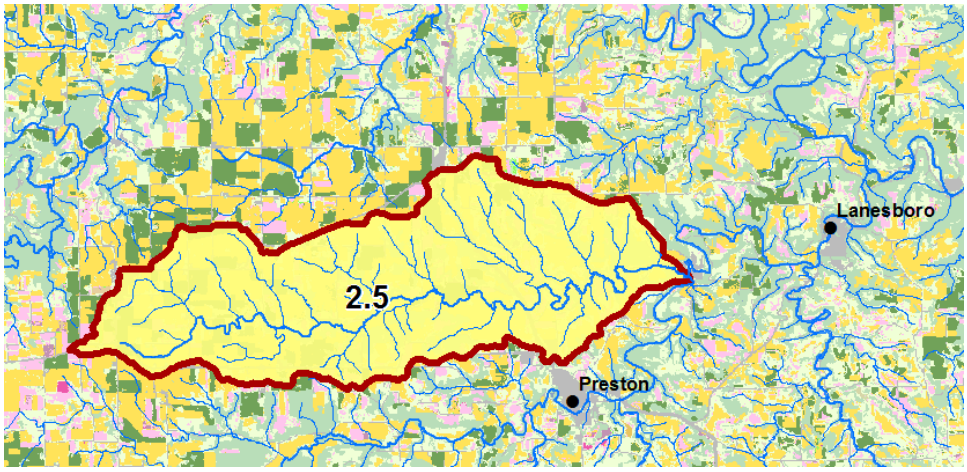


Figure 35. Watson Creek: Percent Reduction in Total Phosphorus

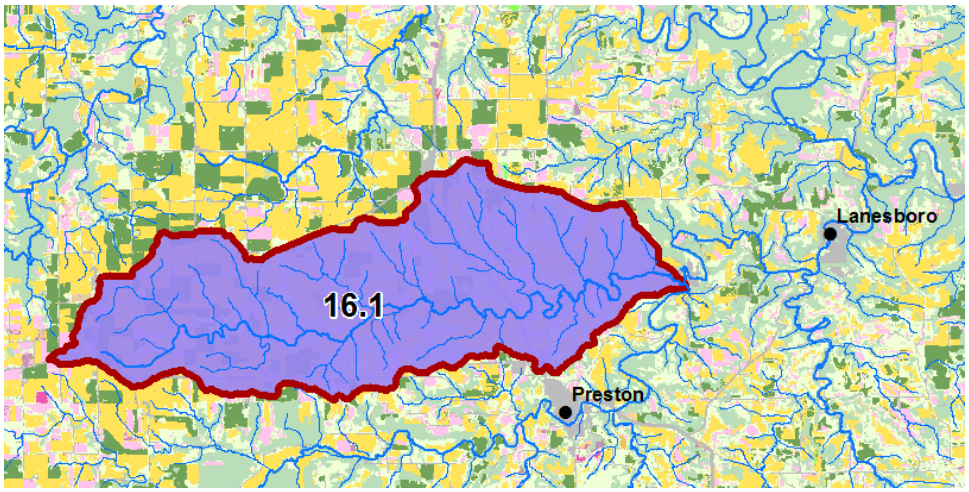
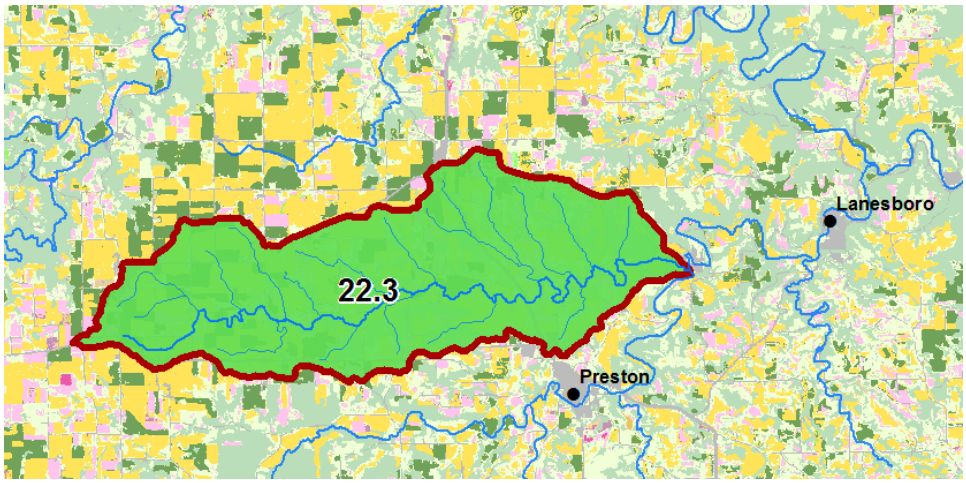


Figure 36. Watson Creek: Percent Reduction in Total Nitrogen



VIII. Federal Programs.

The enabling legislation for this project directs BWSR to make "an assessment of the opportunity to leverage federal funds … and [make] recommendations on how to maximize the use of federal funds for assistance to establish perennial crops." Recognizing that there may be important opportunities to not only leverage existing programs, but also advocate for changes to the Farm Bill that support the establishment of continuous living cover, BWSR contracted with Environmental Initiative to compile information on:

- Existing Farm Bill programs that relate to working lands and perennial cropping systems, including conservation title programs and other policies that impact farm decision making.
- Existing Farm Bill programs' ability to be leveraged to support a working lands program in Minnesota, including the barriers in the existing federal Farm Bill that discourage establishment of perennials and other living cover crops.
- Potential changes to existing Farm Bill programs that would increase their ability to support a Minnesota working lands program.

Conservation and the Farm Bill

While the Farm Bill is primarily focused on the farm safety net and nutrition programs, not conservation, it authorizes funding for many key programs that help to protect and improve natural resources, especially soil and water. There are four main types of programs under the Conservation Title (Title II) of the Farm Bill:

- **Working lands programs**, which allow land to remain in production (grazing and crop) while addressing local natural resource concerns through cost-share and financial assistance
    - Includes the Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP)
- **Land retirement programs**, which provide payments for temporary changes in land use or management that result in environmental benefits
    - Includes the Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP) (a federal-state partnership)
- **Easement programs**, which impose long-term or permanent voluntary restrictions on land use for payment
    - Includes the Agricultural Conservation Easement Program (ACEP)
- **Partnership programs**, which offer opportunities to target funds to address the resource concerns of a specific area
    - Includes the Regional Conservation Partnership Program (RCPP)

Over time, changes in commodity prices, land rental rates, and new conservation technologies have led to a shift in Farm Bill conservation policy, with an increasing focus on working lands programs. Specifically, in the 2014 Farm Bill, the percentage of program funding for land retirement programs

declined relative to working lands programs. If commodity prices remain low, the 2018 Farm Bill could see further shifts in this funding.

The 2014 Farm Bill consolidated conservation programs for flexibility, accountability, and adaptability and linked basic conservation practices to crop insurance premium subsidies—commonly referred to as "conservation cross-compliance." At the same time, the Conservation Title took a 10 percent cut in funding.

There are other components of the Farm Bill, as well as additional federal programs, that impact water quality and the implementation of cover crops and perennials on the landscape. Some of the most important ones include the Biomass Crop Assistance Program (BCAP), crop insurance, regional initiatives, and the Conservation Technical Assistance Program (CTA).

Table 7 summarizes the primary Farm Bill programs that are used, or could potentially be used, in Minnesota. The recommendations that follow the table highlight specific programs that seem to hold the greatest promise for this working lands initiative. Appendix _ includes detailed descriptions of all listed programs.

Table 7: Primary Federal Farm Bill Programs of Interest

Program	Current Use	Levers/Opportunities
Agricultural Conservation Easement Program (ACEP) protects wetland and agricultural land through permanent, 30-year, or term easements.	• Only 14 to 16 percent of applications are funded nationally • In Minnesota in 2016, $3.42 million was spent on 16 contracts covering 119 acres	• Including some state cost-share funding could entice farmers to enroll in ACEP and install permanent or long term non-harvestable perennial cover. • Could consider developing a program that targets similar areas and priorities as ACEP, as there is more demand than available funding
Biomass Crop Assistance Program (BCAP) supports the establishment of non-commodity crops for conversion to bioenergy and provides incentives for the supply of material to biomass conversion facilities. Crop producers and processors can submit proposals to USDA to establish new project areas. Goal is to spur development of next-generation bioenergy and biofuels crops.	• Funding of $25 million per year between 2014 and 2018 nationally • There are no project areas in Minnesota and no new project areas are expected to be created in 2018.	• An increased budget would allow for new projects • A higher subsidy rate for establishment costs and lower percentage of funds allocated to the matching payments have been identified as opportunities elsewhere. • Impact of the program could increase if an efficient selection mechanism for enrolling land in the program was clearly specified.

Program	Current Use	Levers/Opportunities
Conservation Reserve Enhancement Program (CREP) targets state-identified, high-priority conservation issues, enrolling up to 100,000 acres per project. Minnesota is the only state that requires permanent easements (through the Reinvest In Minnesota program.) Acres are removed from production and cropping and grazing are prohibited unless specifically approved by BWSR for habitat management purposes. Program goals are to take marginal land out of production, replacing it with natural vegetation that protects water quality.	• Funding must be matched by non-federal funds. • New CREP was created in Minnesota to protect up to 60,000 acres, with $350 million from USDA and $150 million from the State.	• A completely new CREP could include a working lands component that expands some haying and grazing. • A new CREP could also separate from the permanent easement requirements that currently exist with RIM, which may attract a different demographic of farmers.
Conservation Reserve Program (CRP) targets the implementation of conservation practices on ecologically sensitive cropland and pastureland adjacent to water by paying landowners to establish vegetative cover and maintain it for 10-15 years. Payments are determined based on soil types and rental rates for cropland. Primary program goals are to conserve and protect soil, protect water quality, and provide wildlife habitat. No haying, grazing, or other income-producing activities are generally allowed, though some emergency haying and grazing is possible.	• National cap was reduced from 32 million acres to 24 million acres in fiscal year 2018 • Only 11 percent of landowner applications were accepted • Statewide CRP acres have declined from 1.83 million in 2007 to 1.06 million acres in 2016	Could support: • Offering tiered payments related to different land use options • Allowing harvesting and grazing as a designated use within an existing conservation practice (“CP”) in exchange for a small reduction in payment or a lower penalty • Creating a CRP conservation practice specific to harvesting and grazing (without prescribing the end use) • Creating a new CRP category (like CRP Grasslands but with a higher payment) and particular rules that allow for farmers to use the land for economic gain while maintaining identified environmental benefits • Allowing shorter contract extensions, which may keep more farmers enrolled in the program after their original contracts expire.

Program	Current Use	Levers/Opportunities
Conservation Stewardship Program (CSP): provides financial and technical assistance to improve and conserve ecological services such as soil, water, and plant and animal life on working lands with payments provided for practices. CSP assistance can be used to establish cover crops, convert cropland to grass-based agriculture, improve and establish forage, establish habitat, etc. Contracts are five years in length with an option to renew.	• Nationally, 81 million acres enrolled at the end of fiscal year 2016 • Typically, only one in three applications are accepted. • Minnesota had one of the highest funding obligations among all states in fiscal year 2016, with $84.08 million spent on 1,019 contracts covering 815,964 acres	• Could consider developing a state program that is similar to CSP, as there is more demand than available funding.
Environmental Quality Incentive Program (EQIP): provides cost share assistance for agricultural best management practices, with five percent of funds dedicated to wildlife improvements and 60 percent to livestock production. EQIP assistance can be used to establish cover crops or establish and improve grazing and forage for livestock production.	• Annual funding ranges from $1.35 to $1.75 billion • In Minnesota, $29.4 million was spent in 2016 on 7,800 contracts covering 204,794 acres	• At the state level, the NRCS has the ability to dedicate EQIP funds to priority activities and could create a state Conservation Innovation Grant specific to the implementation of perennials and cover crops.
Regional Conservation Partnership Program (RCPP): supports the formation of regional partnerships to implement innovative conservation projects across an agricultural landscape. Flexible funding from multiple sources allow funds to be targeted to address specific conservation priorities within a geographic area.	• Funded at approximately $100 million per year, plus seven percent of funding from EQIP, CSP, and ACEP, with approximately $1.2 billion in total funding over five years • Has provided $39.4 million to projects within Minnesota, engaging 93 partners	• Could form a new project that focuses specifically on increasing continuous living cover.
Crop Insurance: provides risk management options for farmers and ranchers through federally subsidized insurance products for cash crops.	• Crop insurance premium subsidies in 2012 were roughly $6.7 billion	• Could fund a pilot similar to the Iowa Department of Agriculture and Land Stewardship's Cover Crop – Crop Insurance Demonstration

Program	Current Use	Levers/Opportunities
Insurance policies are established between farmers and private insurance brokers.	• In Minnesota, over 90 percent of principle cropland is insured.	Project by offering insurance premium discounts for cover crops or other conservation practices through normal RMA crop insurance processes. • Could work with partners to establish a pilot for one or more new insurance products covering double or relay crop systems that do not yet have standard policies for Minnesota. • Could support efforts that connect risk ratings and premium subsidies to stewardship practices that protect soil health and water quality
Conservation Technical Assistance Program (CTA): provides conservation planning and implementation assistance through field staff.	• CTA was funded at $759 million in fiscal year 2017 and set to be funded at $668 million for fiscal year 2018. • In 2016, $11.88 million was spent on assisting 4,504 tracts of land covering 375,902 acres across Minnesota.	• Could take steps to ensure that cover crops and perennials are included in plans (where needed and when possible)
Regional Pollinator Initiatives and Water Quality Initiatives: coordinate the delivery of assistance where it can have the most impact through partnerships.	• Several initiatives cover sections of Minnesota	• Could add state funds to payments that support pollinator habitat and water quality improvements through continuous living cover

Opportunities to Leverage Farm Bill Programs

Through conversations with stakeholders, Environmental Initiative and BWSR staff identified several opportunities to utilize federal Farm Bill programs in new and innovative ways to support Minnesota's efforts to improve water quality through an increase in continuous living cover on agricultural landscapes. The ideas that emerged from these conversations represent the ripest and most specific opportunities that speak to broad interests across agricultural and conservation organizations, rather than being a comprehensive set of options.

Using Crop Insurance to Provide Incentives for and Gather Data on Conservation Practices

The Iowa Cover Crop – Crop Insurance Demonstration Project provides an appealing model that could be explored and adapted for use in Minnesota. Undertaken through a memorandum of understanding between the Iowa Department of Agriculture and Land Stewardship (IDALS), the United States Department of Agriculture's Risk Management Agency (RMA) and approved insurance providers in the State of Iowa, the program will deliver subsidies through the federal crop insurance program for planting cover crops. Participating farmers will receive a $5.00 discount on their crop insurance premiums for acres on which they establish cover crops, excluding those acres where cover crop establishment is supported by other federal or state programs. The benefits of this program include:

- Introducing cover crops to a wider community of farmers in Iowa, including those who were unable to receive federal cost share for cover crop practices on some or all of their land.
- More efficient delivery of state-funded incentives using existing crop insurance program infrastructure.
- The ability to collect data on the relationship between cover crops, yield risk, and overall field resilience.

A Minnesota version of this program could:

- Incentivize a wider range of conservation practices (e.g. perennial crops, cover crops, conservation tillage, etc.) intended to improve water quality, soil health, or both.
- Gather data that can be used to evaluate how a variety of conservation practices affect crop resilience.
- Make aggregated data available to crop insurance providers (or others in the private sector) that could be used to devise new insurance policy products or risk pools that recognize the benefits of conservation practices in making farms less susceptible to crop failures
- Target priority areas of Minnesota's agricultural landscape, such as groundwater protection areas, source water protection areas, or highly erodible soils.

Improving Opportunities and Incentives for Working Lands in CRP Contracts

Allowing greater flexibility in the use of Conservation Reserve Program (CRP) land—specifically increased ability to harvest or graze lands under CRP contract—in exchange for reduced payments has a number of potential benefits, including:

- Attracting new (particularly full-time conventional) farmers to participate in CRP
- Incentivizing forage and livestock production, which can increase farm diversification and value-added production
- Reducing mid-contract exits by farmers in high commodity price years (increase the stability of the program)
- Reducing the per-acre cost of CRP, allowing for an increase in the total number of acres enrolled without increasing total program costs

The groups and individuals consulted through this project had a number of ideas for how the CRP could be modified to allow for greater flexibility in uses of CRP land. Specific options that were discussed for how working lands could be better incorporated into CRP included:

- Changes to allowed land uses, for example:
    - Allowing harvesting and grazing as a designated use within an existing CRP conservation practice ("CP")
    - Creating a CRP conservation practice specific to harvesting and grazing
    - Creating a new CRP category (like CRP Grasslands but with a higher payment) with particular rules that allow for farmers to use the land for economic gain while maintaining identified environmental benefits
- Changes to contract terms, for example:
    - Inclusion of a grazing or harvesting plan compliant with NRCS conservation plans in order to preserve important environmental co-benefits
    - Allowing shorter contract extensions
    - Allowing mid-contract modifications
    - Allowing for a wide number of markets and uses by not specifying the end use for harvested vegetation
- Changes to payment rates, for example:
    - Reducing payments to recognize the value of harvesting or grazing the land (e.g., Subtracting established haying/grazing rental rates for the county from the full expected CRP payment)
    - Establishing a tiered payment structure based on allowed land uses
    - Reducing penalties for harvesting or grazing outside of emergency management waivers
    - Matching/supplementing CRP Grasslands payments with state payments to help incentivize adoption of CRP Grasslands in Minnesota

Most of these ideas could also be tested in high-priority locations by setting up pilot CRP areas, rather than seeking to change national program rules.

IX. State Programs

The enabling legislation for this project directs BWSR to make "an assessment of how other state programs could complement the program." The State of Minnesota supports a number of programs that could be used to further a Working Lands Program.

The Clean Water, Land, and Legacy Constitutional Amendment has provided significant new financial resources to address Minnesota water quality and wildlife habitat needs. These funds, in addition to those available through the General Fund and Capital Investment funds, have been used to implement many conservation projects and to acquire land for permanent protection.

State programs are often coordinated with federal Farm Bill programs to leverage federal funds. The Conservation Reserve Enhancement Program (CREP) discussed below is a prime example of a successful effort to leverage federal funds that also helps Minnesota meet its environmental and wildlife habitat goals.

Most State programs have environmental protection and restoration as their primary purpose. The programs are designed mainly to either provide cost-share funds for the establishment of conservation practices or to restore and protect land by acquiring permanent easements. Under current law many of these programs are not available for a Working Lands Initiative, because they do not allow landowners to profit from haying, grazing, or harvesting perennial crops. However, the Reinvest in Minnesota – Clean Energy Program originally developed in 2008 is an example of making adjustments to the structure of a protection and restoration program to support biofuel production from perennials. This program has not been funded, but the statutory authority was enacted and remains on the books to this day.

Other existing programs, such as the Clean Water Fund projects listed below, could be modified simply through an increased emphasis on cover and perennial crops.

Table 8 summarizes information on state programs that could be utilized and/or modified to support a Working Lands Program.

Table 8. Related State Programs That Could Support a Working Lands Program

Program /*Agency*	**Current Use in MN**	**Levers/Opportunities**
Reinvest in Minnesota (RIM) Program: Multiple programs that provide permanent land protection primarily for wildlife habitat and water quality including Groundwater (Wellhead) Protection, Wild Rice, Army Compatible Use Area, and Riparian Buffer.	• 271,674 acres	• Limited opportunities: Haying and grazing are allowed as management tools to enhance grassland habitat but are limited to 1/3 of any site in a single year, along with other requirements. See discussion below under Conservation activities.

Program /*Agency*	Current Use in MN	Levers/Opportunities
BWSR		• Groundwater Protection funds can be used for grants to water suppliers to acquire land in fee title, providing opportunities for introducing harvestable perennials and cover crops in vulnerable wellhead protection areas.
RIM - Clean Energy: A permanent land protection program to support perennial biofuels production, enacted in 2008 but not funded to-date. Elements include: • A competitive allocation process for project area selection, targeting acres in proximity to an energy facility. • An easement period of at least 20 years. • A tiered payment system structured to encourage landowners to grow native perennial plants. The payment rate would be based on the estimated market value of the land, with the highest per-acre payments for lands producing the greatest diversity of species. *BWSR*	• Not currently in use; implementation was not funded. See discussion in Sections II and X.	• Opportunity to update the existing legislation to implement a working lands program.
Conservation Reserve Enhancement Program (CREP): To purchase and restore permanent conservation easements to treat and store water on the land for water quality improvement purposes and habitat protection. This program is a combination of the Conservation Reserve Program (CRP) and RIM. *BWSR*	• New CREP was created in Minnesota to protect up to 60,000 acres in 54 counties, with $350 million from USDA and $150 million from the State. • Continuous sign-ups started in May 2017 and will continue up to five years or until acreage goal is reached.	• See above under Federal Programs. • Adaptability of the current CREP to a working lands program is limited due to permanent easement requirements (RIM).

Program /*Agency*	Current Use in MN	Levers/Opportunities
Clean Water Fund: Projects and Practices: Grants to protect and restore surface water and drinking water; to keep water on the land; to protect, enhance, and restore water quality in lakes, rivers, and streams; and to protect groundwater and drinking water. Projects are most often for the implementation of conservation practices with a 10-year lifespan. *BWSR*	• Funds are awarded via an annual competitive grant process. • Since 2010 $61.0 million has been awarded for 323 projects • Establishment of cover and perennial crops is currently an eligible activity (i.e. nonstructural practices, incentives), but few such projects have been funded.	• Increased emphasis and communication on cover and perennial crops. • Establish policies/standards for harvest and profits derived from crops established with state program funding.
Clean Water Fund: Watershed Based Funding Program: Focuses on local units of government organized for comprehensive watershed management plan implementation at a watershed scale in efforts to maximize the impacts on land and water resources while increasing accountability and administrative efficiencies. Projects are expected to be similar to Projects and Practices described above. *BWSR*	• New local implementation funding program that is being implemented in Fiscal Year 2018 as a pilot. • $8.7 million is available in grants for the FY2018-19 biennium.	• Purpose of the program is to fund implementation of One Watershed One Plan and similar local government water management plans, therefore opportunities will be in ensuring that these local plans address cover and perennial crops.
Clean Water Fund: Water Management Transition (One Watershed One Plan): Accelerate implementation of the State's Watershed Approach through the statewide development of watershed-based local water planning (103B.801) that is synchronized with Watershed Restoration and Protection Strategies (WRAPS) and Groundwater Restoration and Protection Strategies (GRAPS) by providing technical assistance, program oversight, and grants to local governments. *BWSR*	• One Watershed One Plan Program was initiated in 2011 by the Local Government Water Roundtable (Association of Minnesota Counties, Minnesota Association of Watershed Districts, and Minnesota Association of Soil and Water Conservation Districts). • 18 planning projects have been funded to	• Encourage planning groups to identify and prioritize cover and perennial crops as actions to address water management goals.

Program /*Agency*	Current Use in MN	Levers/Opportunities
	date with BWSR Board-approval of four plans.	
Minnesota Buffer Program: Requires a 50'or 16.5' perennially vegetated strip for land adjacent to public waters by November 1, 2017 and public ditches by November 1, 2018. *BWSR*	• The perennial vegetation can be hayed, grazed or otherwise harvested. • State funds have been appropriated to support implementation by local governments and to cost-share the establishment of buffers by landowners. • Landowners can also use CRP and CREP to comply with the Buffer Law.	• Landowners can establish buffers wider than the minimum required by law to provide for an economically harvestable area.
Agricultural Best Management Practices Loan Program (AgBMP): A low interest loan program for farmers and other Minnesota landowners to finance capital expenses incurred when implementing best management practices that reduce or eliminate pollution to surface and ground water. The program has a perpetually revolving principal account of $75 million that has a long term loan capacity of $11 million per year. *MDA*	• Started in 1995 • Loans only – participant must qualify for credit with local lenders. • 3% interest, up to 10 year term, max. $200,000. • Funds are available to all counties in Minnesota • Loans may be used to implement practices on working lands and conservation lands.	• AgBMP loans are considered landowner contributed matching funds for state and federal programs. • The program's broad environmental protection purposes can be coordinated with most conservation initiatives of other agencies and programs. • Most expenses incurred to make a practice fully functional are eligible, including equipment and other items not typically eligible under cost share programs.
Minnesota Agricultural Water Quality Certification Program: A voluntary conservation program for farmers and agricultural landowners to take the lead in implementing conservation practices that protect water. Those who implement and maintain approved farm management practices are certified and in turn obtain regulatory certainty for a ten year period. They are recognized for their efforts and	• Program was established in 2013 as a partnership of MDA, MPCA, DNR, BWSR, soil and water conservation districts, and NRCS. • Any existing form of technical or financial assistance may be used to achieve certification,	• Implements cover crops, perennial crops, wildlife and pollinator habitat plantings, filter strips, grassed waterways and other vegetative practices as conservation practices. • Certification process includes field-scale assessment of physical field characteristics, nutrient

Program /*Agency*	Current Use in MN	Levers/Opportunities
are eligible for specially designated technical and financial assistance to implement conservation practices. *MDA*	along with dedicated federal and state funding pools for MAWQCP applicants. • As of January 2018, over 500 farms and 300,000 acres are certified.	management, tillage management, conservation practices, and related practices.
MDA Bioincentive Program: Program was established in 2015. Provides production payments to attract commercial-scale production of advanced biofuels, renewable chemicals and biomass thermal energy. Eligible facilities must be located in Minnesota and must source raw materials from Minnesota agriculture, forestry or solid waste. *MDA*	• $3.0 million is available for the FY2018-19 biennium. • Two production payments have been made since program inception, one in 2017 and another in 2018; both for renewable chemicals.	• The advanced biofuels portion of the program contains requirements for use of perennials and cover crops for feedstock, creating market opportunities.
Water Quality Trading: A market-based approach to accelerating water quality improvements through transactions among point and nonpoint sources in a watershed. Typically, the point source – an industrial processor or wastewater treatment plant – purchases credits from upstream nonpoint sources in order to offset an increase in the discharge of a pollutant or to avoid the need for an upgrade to its wastewater treatment facility. A trading ratio is established to ensure that equal or greater reductions in the pollutant load are achieved *MPCA, Watershed Districts*	• Water quality trading has been coordinated by the MPCA between point sources and nonpoint sources on a case-by-case basis since 1997. • Trades have included practices such as establishment of cover crops to offset phosphorus discharges. • Several permit programs have expired as wastewater treatment plants have been upgraded.	• While water quality trading is usually viewed as limited and temporary in nature, it has potential to accelerate establishment of perennial and cover crops, along with other BMPs, in watersheds with high levels of pollutant loading. For example, the City of Albert Lea and the Shell Rock River Watershed District are initiating a trading program to address stormwater discharge and phosphorus levels in city lakes. A trading framework of this type could be applied in other watersheds.

Integration of working lands concepts with existing state conservation requirements to benefit wildlife production

The potential effects of biomass production on wildlife habitat, including pollinator habitat, can be positive or negative. Effects can be beneficial when row crops are converted to more diverse crops or crop rotations, but negative effects can occur if biomass harvesting occurs during the nesting season, for example. Sustainable sourcing requirements and production guidelines for biomass crops can be established to avoid such negative impacts.

> "Grassland biomass harvest, like prescribed fire, managed grazing, or well-timed haying, is a management tool that if property planned and managed, can mimic natural disturbance and thus maintain grassland ecosystems."
>
> *Minnesota Prairie Conservation Plan*

North American prairies evolved in an environment that was subject to periodic disturbance, primarily by wildfire and intensive grazing by native herbivores such as bison. Without this disturbance, prairie plant communities and wildlife habitat tend to decline as trees encroach. Burning of prairie vegetation is a common management tool, but managed grazing and haying can also be effective. However, if grasslands are harvested too often or at inappropriate times, wildlife, especially ground-nesting birds, can be negatively impacted. There is also concern about planting monocultures of crops such as switchgrass, and the resulting lack of diversity for wildlife habitat.

Federal funds restrict some management activities in wildlife areas, including lands in the Conservation Reserve Program. Harvesting is allowed only as a management tool. Examples include harvesting in seasonally flooded wetlands or floodplains or during drought emergency conditions. (Minnesota has lost about 686,800 acres of Conservation Reserve Program (CRP) acres statewide since 2007, due to pressure for conversion of these lands to row crop production.)

The DNR has conducted research and pilot projects to evaluate the use of managed haying and grazing as management tools for grassland resources, specifically on Wildlife Management Areas (WMAs).

- In 2007, the DNR's Wildlife Section established agreements for biomass harvest on six WMAs in need of disturbance management. Biomass was baled and evaluated for combustion at the University of Minnesota – Morris power plant, but technical difficulties prevented use of the fuel. Yields ranged from one to three tons per acre.
- A 2009 report to the Minnesota Legislature, *Prairie Vegetation and Energy Production Harvest Plan for WMAs*, details DNR policies on "management of native prairie lands and harvesting of native prairie vegetation for use for energy production in a manner that does not devalue the natural habitat, water quality benefits, or carbon sequestration functions." (Laws 2008, c. 179, s. 7, subd. 14).

RIM policies were also changed during this period to allow haying and grazing on easements in accordance with a conservation plan that identifies the type of desired cover to be maintained on the site. Techniques such as prescribed burning, mechanical haying, or grazing can be used to improve

wildlife habitat and benefit ground nesting birds and pollinators. Typically, these types of activities may occur once every 3-5 years on portions of any given easement and may only affect 1/3 of any given site in one year. For grazing, only temporary fencing and water sources are allowed and must be removed when the activity is complete. Activities must occur outside of the nesting season, from May 15 to August 1.

Haying and grazing on RIM easements, while permissible with a conservation plan, is not common because of logistical challenges: grazing requires temporary or permanent fencing and a water source, while the seasonal restrictions on haying result in lower-quality hay. Lack of haying equipment and distance from markets also hinders these practices.

The policies and best management practices outlined in the 2009 *Prairie Vegetation and Energy Production Harvest Plan for WMAs* remain valid today, and can serve as guidance for any Working Lands activities on existing conservation lands or on private lands with high habitat value.

Best Management Practices for Harvesting Grassland Biomass on State Conservation Lands (WMAs and AMAs)

- No more than one-third of the land should be disturbed in any one growing or breeding season. Manage grassland parcels as shapes that maximize the core interior area.
- Dormant season harvest is preferred – otherwise, include a refuge component for wildlife.
- During harvest, stubble height of at least four inches should be maintained.
- Minimize soil disturbance; avoid rutting from heavy equipment, wet soils
- Storage of biomass should occur off-site.
- Avoid habitat of rare plant and animal species
- Manage invasive species risk

Several other state plans support a working lands approach to prairie and grassland management.

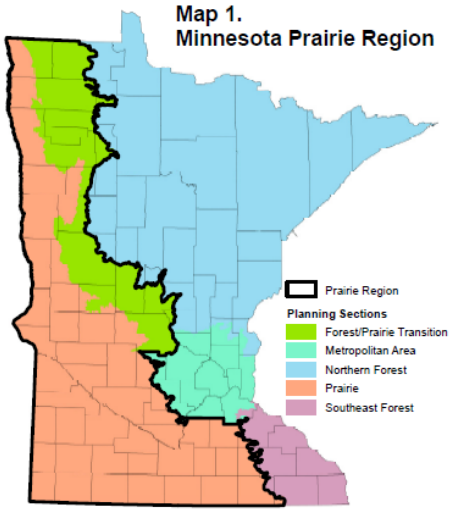
The *Minnesota Prairie Conservation Plan* (2011) lays out a vision for the future of Minnesota's prairie region: "Although conventional agricultural uses will continue to dominate the Prairie Region, protecting remaining native prairie and associated habitats, reconstructing additional grasslands, expanding perennial crops, and increasing the implementation of conservation practices will make these areas more sustainable and more wildlife "friendly." In strategic locations, large areas of prairie, grassland and associated habitats will be protected and restored to create functioning prairie systems that provide major opportunities for sustainable grass-based agriculture such as grazing and haying. These functioning landscapes will also contribute clean water, fish and wildlife habitat complexes, high quality recreational opportunities, and thriving rural communities where Minnesota's citizens will want to live and visit."

The plan calls for a three-part strategy for achieving functional prairie systems: 1) Protect native prairie where it exists; 2) Restore landscapes by connecting and buffering the native prairie and other protected habitats; and 3) Enhance natural disturbance regimes on native and restored prairie, through techniques such as prescribed burns, drawdowns, managed grazing, and biofuel harvest.

The plan identifies three specific areas for conservation activities within a larger Agricultural Matrix:

- **Core Areas:** 36 large landscape areas that retain some features of a functioning prairie landscape and can function as a habitat base. The goal is to achieve 40% grassland and 20% wetland coverage within each area. The uppermost part of the Shakopee Creek watershed falls within a large Minnesota Biological Survey-identified core area, while the Whiskey Creek watershed includes a portion of the Blanketflower Prairie Scientific and Natural Area.

- **Corridors:** Linear stretches of habitat six miles wide that connect Core Areas, allowing for wildlife movement and exchange of genetics. The goal is that 10% of each square mile is protected grassland and wetland habitat.



The Prairie and Forest-Prairie Transition Planning Regions, from the Minnesota Prairie Plan

- **Corridor Complexes:** "Stepping stones" of protected land that allow for movement of many bird and animal species between suitable patches of habitat. The goal for these complexes would be to reach 40% grassland, 20% wetland, and 40% other land uses, with half of the grasslands permanently protected. The Whiskey Creek watershed is part of the Agassiz Beach Ridges Corridor, in close proximity to the Rothsay Prairie (a core area) and the Barnesville WMA. The watershed also contains several Waterfowl Production Areas, managed by USFWS.

- **The Agricultural Matrix:** the remaining area of the prairie region forms the heart of Minnesota's agricultural economy. The plan proposes to improve water quality and habitat through a broad distribution of small conservation projects such as grassland buffers, grass waterways, and small restored wetlands. The goal is that at least 10% of each Land Type Association (land units defined by the U.S. Forest Service and the DNR) be set aside for soil, water, and wildlife conservation purposes.

The 2015 *Minnesota Pheasant Summit Action Plan*, a joint effort of the DNR, BWSR, and MDA, identifies similar issues in habitat management on private lands, pointing to management to simulate natural disturbances as well as improving pheasant habitat with food plots and winter cover. Because pheasants are dependent upon grassland habitat, they serve as an indicator species for grassland conservation. The plan calls for integrating agricultural practices such as prescribed grazing and haying into management of selected public and private lands. Strategies include increasing the acreage and improving the management of land in private conservation programs. The loss of acres in the Conservation Reserve Program is one factor that threatens pheasant habitat, but the new CREP offers an opportunity to increase conservation acreage.

What role could existing conservation lands play in supporting a perennial-based biomass production system? While the focus of this initiative is on conversion of privately-owned lands from row crops to perennials and cover crops, there is great potential for linkages between public and private conservation

lands and working lands. For example, grazing of livestock on a WMA could benefit plant diversity as well as aiding local ranchers by giving them an opportunity to rest their own lands. Private companies that are interested in prescribed haying could also benefit from such partnerships. Biomass crops could replace or supplement row crops grown on WMAs. Habitat for pollinators could be enhanced through strategically timed haying and grazing, as well as introduction of early-flowering winter camelina as a cover crop on WMAs, regardless of whether it is harvested.

X. Findings and Recommendations

Challenges and Changing Attitudes

Participants in this project recognize the significant challenges of shifting the crop mix away from the well-established row crops to alternative crops and livestock operations. The biofuel market presents particular challenges at present. That market is focused on a search for the cheapest feedstock, which is typically a waste product or residue of another crop or process – for example, corn stover, distillers' grains, used cooking oil, or wood waste. Crops grown specifically for biofuel have not been able to compete against these cheaper and widely available feedstocks.

Many of the most promising crops still need significant research and development in agronomic, plant breeding, food science, and environmental impacts. Some crops have generated great market interest, but are still at least two or three years from being fully scalable. BWSR and project stakeholders are keenly aware of the "chicken or the egg" problem: large-scale processors of biomass crops will not invest in Minnesota facilities without a guaranteed supply chain, while farmers are unlikely to grow biomass crops for which a guaranteed market does not yet exist.

It is important to recognize that establishing and maintaining perennial cover on sensitive lands is part of a suite of best management practices, ranging from riparian buffers to no-till or strip till cultivation, to controlled drainage and stream restoration. The effects of these practices can't be viewed in isolation.

In spite of these caveats, we see increasing interest in more sustainable agricultural practices that benefit soil, water, and wildlife. Interest in and awareness of cover crops is high, as indicated in the landowner survey. Awareness of newer crops being developed by the University of Minnesota's Forever Green Initiative, such as Kernza and oilseeds, is still limited, but will increase as new highly productive varieties are developed and as market opportunities are identified. Keeping the agronomic, marketing, and outreach efforts moving forward in a coordinated way will be challenging but necessary.

This section identifies the most promising implementation strategies for initiating a working lands program, as well as some of the challenges that a program would need to address.

Landowner Incentive Payments

The central objective of the Working Lands Watershed Restoration Program is to define the parameters of a contract program that will, as specified in the enabling legislation, create incentives for the establishment and maintenance of perennial and cover crops to improve water quality, while protecting landowners' income and managing risk.

How could a working lands program lead to more widespread adoption of alternative crops that improve water quality and soil health, but currently lack dependable markets? Essentially, the program needs to subsidize the alternative crops while working to create or improve their markets, with the goal of achieving a fully market-based program where subsidies are unnecessary.

According to the landowner survey results and stakeholder input, the following factors are likely to encourage participation in a working lands program:

- **Profitability:** Landowners want a reasonable return from alternative crops.
- **Flexibility:** Landowners want to be able to choose which crops to plant and where to plant them; choices that may change from year to year.
- **Simplicity:** "Red tape" is minimized.

In response to these expressed preferences and research findings, the following program elements are offered for consideration:

Different contract terms for different "classes" of crops: The program would establish different contract terms for 1) perennials (where the primary crop is replaced), 2) cover crops (where the primary crop remains) and 3) cash cover crops (where the primary crop remains but its yields may be reduced).

Livestock enterprises, such as grass-fed beef, cow-calf enterprises, or grazing dairy, could fall into one or more of these categories, depending on the mix of forage and feed crops. These enterprises could be categorized based on the crop mix or on other factors to be determined.

Flexibility on What to Plant: Landowners should have the ability to choose which alternative crops to plant in any growing season, so long as living cover is maintained – that is, soil is not left bare during critical spring and fall periods, and is protected as much as possible against extreme rainfall events.

Flexibility on End Uses of Crops: An important factor in developing markets for alternative crops is freedom for producers to experiment and pursue a variety of market opportunities with those crops, provided the program's goal of continuous living cover is maintained. For example, a producer might choose to pursue Kernza in a wide riparian buffer or mixed perennials and cover crops for a grazing enterprise without needing to renegotiate the terms of a contract.

Watershed or "Supplyshed" Focus: To be able to model and monitor water quality improvements, a continued focus on specific watersheds is preferred. The watersheds analyzed and surveyed throughout this project offer a starting point for a pilot program, although other watersheds with landowner interest and organizational capacities could also be considered.

At the same time, a new working lands program should be flexible enough to respond to new opportunities. If a potential biomass processing facility sought producers in order to establish a reliable supply chain, a "supplyshed" spanning multiple watersheds could be considered, potentially taking advantage of market opportunities created by the MDA Bioincentive Program (see State Programs, Section IX).

Prioritize environmentally-sensitive lands and multiple benefits: Many questions about program priorities have been discussed. Should the program be structured similar to CRP, with rates based on cropland productivity? Or should it be designed to prioritize water quality and other ecosystem benefits? Project stakeholders and advisors strongly recommend assigning the highest rates to those lands that contribute the highest loads of pollutants to waterways. Lands that offer multiple benefits in addition to water quality, such as wildlife and pollinator habitat, should also be prioritized.

The Soil Map Unit spreadsheet developed for the Shakopee Creek watershed provides some indications of how these benefits could be determined. The spreadsheet assigns values to each soil map unit based on erodibility, slope, drainage class, nitrogen loading, and other elements of the Universal Soil Loss Equation. In reality, each soil map unit typically makes up only a part of a field, and is frequently too small an area to convert to an alternative crop while continuing to cultivate the rest of the field. However, new precision agriculture software could be applied at the field scale to determine the water quality and ecosystem benefits that conversion of a particular tract of land would yield. The Minnesota Agricultural Water Quality Certification Program's Technical Guide uses a field-scale method to calculate soil physical characteristics, including susceptibility to runoff and erosion.

Risk management: A contract should provide assurance of a base level of payment for a defined period (e.g., 5 or 10 years to protect the landowner's income and investments in new crops and methods). Because perennials and cover crops take several years to establish, a five-year contract is likely the minimum that would be effective. In addition to providing a guaranteed payment for the length of a contract, future eligibility for the federal crop insurance program should be maintained if feasible. (See the related recommendations below regarding the federal crop insurance program.)

It will take time and a source of funding to establish a pilot program based on contracts with landowners. Strategies other than a contract program, both short-term and long-term, should also be considered, as discussed below.

Federal Farm Bill Opportunities

As discussed in Section VIII above, there are two primary opportunities to leverage federal Farm Bill programs that emerged from discussions with agricultural and conservation organizations.

Use Crop Insurance to Provide Incentives for and Gather Data on Conservation Practices: Work with the RMA and state agencies to develop a program similar to the Iowa Cover Crop – Crop Insurance Demonstration Project, under which participating farmers will receive a $5.00 discount on their crop insurance premiums for "new" acres on which they establish cover crops. A Minnesota program could incentivize a wider range of conservation practices and could make aggregated data available to crop insurance providers to develop new insurance policy products or risk pools that reward conservation practices. Iowa's discount program is funded by the state at $21.7 million for an initial three-year demonstration period. A Minnesota program would also require a state funding source.

Improving Opportunities and Incentives for Working Lands in CRP Contracts: Allow greater flexibility in the use of Conservation Reserve Program (CRP) land—specifically increased ability to harvest or graze lands under CRP contract—in exchange for reduced payment. CRP could be modified in several ways:

- Changes to allowed land uses – for example, allowing harvesting and grazing as a designated use within an existing CRP conservation practice or creating a new conservation practice specific to grazing and harvesting.
- Changes to contract terms – for example, allowing a wide number of markets and uses by not specifying the end use for harvested vegetation.

- Changes to payment rates – for example, reducing penalties for harvesting or grazing so that the rates more accurately reflect the value of these practices.

Establishing pilot areas for testing these approaches would likely be more feasible than seeking to change national program rules.

See Section VIII for a more detailed description of these opportunities.

State Program Opportunities

Revise the RIM-Clean Energy Program legislation as a basis for a working lands RIM program. The RIM-CE statute (§103F.518) establishes priorities for selection of land as "bioenergy crop production, water quality, soil health, reduction of chemical inputs, soil carbon storage, biodiversity, and wildlife habitat." It limits agricultural crop production and harvest to "native, perennial bioenergy crops." The statute could be revised to encompass the full range of perennial and cover crops discussed in this report, as well as other crops still under development, and to establish the other parameters of a "RIM-Working Lands" program.

Integrate working lands concepts into existing water quality programs. Evaluate and modify existing water quality programs where feasible, to ensure that perennial and cover crops are eligible for cost-share and other incentives. This evaluation should identify the need for and benefits of additional state support, along with the criteria under which perennial and cover crops can be established, maintenance and harvest requirements, duration of practices, and disposition of any revenue earned from harvest.

Integrate working lands concepts into soil health initiatives. Work to ensure that the development of the Soil Health Action Plan, to be developed by the new State Office for Soil Health, includes priorities and actions to increase the establishment of perennial and cover crops to improve soil health and resilience, and protect water quality. Among the components of soil health are runoff volume control, water holding capacity, organic matter, and crop productivity.

Create linkages between public conservation lands and working lands. Grazing of livestock on public lands such as wildlife management areas, establishment of perennial crops on conservation lands currently in row crop agriculture, or requiring the use of cover crops on leased WMA lands are all strategies that could enhance wildlife and pollinator habitat while increasing public awareness of perennial and cover crops.

Coordinate with existing and planned water quality trading programs. Water quality trading has been coordinated by the MPCA between point sources and nonpoint sources on a case-by-case basis since 1997, and many trading programs have operated effectively for more than 15 years. Typically, the point source – an industrial processor or wastewater treatment plant – purchases credits from upstream nonpoint sources in order to offset an increase in the discharge of a pollutant or to avoid the need for an upgrade to its wastewater treatment facility. While water quality trading has been viewed as limited and temporary in nature, it has potential to accelerate establishment of perennial and cover crops, along with other BMPs, in watersheds with high levels of pollutant loading.

Focus on vulnerable Drinking Water Supply Management Areas (DWSMAs) as pilots for a working lands program. There is increasing interest in protecting DWSMAs in areas with high risks for nitrate contamination of groundwater. The Minnesota Department of Health has delineated 360,000 acres of land across the state at high risk of pollution. Of these acres, 115,000 are planted in row crops, both within and beyond city limits. The six pilot watersheds surveyed for this project include a number of vulnerable DWSMAs and communities managing high nitrate levels in their water supplies. Other source water protection areas, including surface water sources for cities such as St. Cloud, are also vulnerable to pollution from surface runoff.

RIM Reserve easements are available in DWSMAs but relatively few have been acquired, because producers are reluctant to take highly productive cropland out of production. However, several rural water systems, community water suppliers, and the Minnesota Rural Water Association are actively exploring the potential for planting Kernza, other harvestable perennials, and cash cover crops in vulnerable DWSMAs. These areas offer significant opportunities for piloting a working lands program at a focused and measurable scale.

Local Partner Opportunities

Explore options for sharing equipment for interseeding of cover crops and cultivation and harvesting of hay and other perennial crops. Since haying for on-farm consumption has become less common, many farmers now lack the necessary equipment. Interseeding equipment, likewise, is a costly investment, although interseeding can increase the success rate of cover crops. Private or public entities such as farmers' co-ops and SWCDs could lease or loan out equipment or contract for its use, creating new economic opportunities. Some local partners are already operating such programs. Local partners will also continue to serve as essential conduits for information on conservation practices and as trusted advisors to the farm community.

XI. Program Implementation

This Working Lands study has attempted to provide proof of concept: that perennial crops and cover crops can contribute to improved water quality, that markets for these crops can be found, and that farmers and landowners will respond to incentives encouraging them to plant those crops. Findings of this study indicate that:

- A number of promising perennial and winter annual crops, including Kernza, camelina, and pennycress, are drawing increased attention, but still need several years of plant breeding and agronomic research to be ready for widespread adoption.
- The market feasibility of other crops, including switchgrass and miscanthus, remains uncertain since they are currently not competitive either with conventional fuels or other cheaper sources of biomass such as corn stover.
- Alfalfa remains an important forage crop, although the market for hay is volatile, and there are opportunities to establish partnerships with large dairy operations for purchase locally-grown hay. Incentives such as equipment rental or contract operations may also appeal to producers.
- Livestock enterprises also show some volatility, especially organic dairy, but there is increasing interest in managed or rotational grazing, using paddocks or existing conservation lands, and these practices appeal to consumers looking for sustainably produced meat and dairy products.

Given these findings, how should a working lands incentive program be structured? The recommendations in the previous section establish some basic parameters for such a program, including establishing different rates for different classes of crops, flexibility on what crops to plant each year, and a focus on the most environmentally sensitive lands. However, the specifics of an incentive program remain to be determined.

Implementation of a program is, of course, dependent on funding from new or existing state, federal or private sources. However, it is possible to lay out the general outlines of an implementation strategy in three phases.

Phase 1: Concept Refinement and Program Development – Year 1

This initial phase would include establishment of program guidelines and procedures, including:

- Outreach to watersheds, SWCDs and other local partners;
- Coordination with watershed-scale planning efforts;
- Establishment of criteria for participation in a program – for example, would local entities be asked to respond to a request for proposals?;
- Development of standardized payment rates and mechanisms – for example, would producers submit bids, would flat rates be offered based on type of crop or contract length, would precision conservation tools be applied at a field scale?;
- Development of cost-share contract documents, sustainable harvest standards, and monitoring procedures;

- Support the development of markets through solicitation of support or participation from biomass processors and/or food and agriculture companies;
- Continued exploration of federal farm program opportunities;
- Ongoing collaboration with plant breeding and agronomy researchers as the most promising crops continue to be improved.

Costs for this initial phase are estimated at approximately $250,000.

Phase 2: Pilot Program in Selected Watersheds and/or Vulnerable Water Supply Areas – Years 2-3

This phase would involve establishing a pilot program that could focus on a few watersheds with a high level of interest and local capacity, and that meet the criteria established under Phase 1. A pilot program could also be designed to focus on vulnerable wellhead and other source water protection areas that are currently planted in corn and soybeans. As mentioned in the previous section, there is increasing interest in protecting DWSMAs in areas with high risks for nitrate contamination of groundwater by planting perennials such as Kernza and alfalfa. Depending on the level of available funding, a pilot program could focus on either or both of these areas.

Costs for this phase would likely be in the range of $1.5 to $2 million.

Phase 3: Scaling Up to Multiple Watersheds or Supplysheds – Years 3-5

Depending on the results of a pilot program and available funding, a working lands program could be scaled up to operate across multiple watersheds or supplysheds centered on a production facility. Another opportunity that could be pursued at this stage is working to recruit processors of biomass for end uses such as bio-based packaging or bio-jet fuel, in tandem with improvements to the oilseeds and other suitable crops. Funding could be allocated competitively based on the presence of a production facility.

Costs for this phase could be $5 million or more, depending on scale. However, it is important to recognize that as the markets for perennials and cash cover crops mature, the need for subsidies is expected to decrease.

Estimation of Costs for Crop Subsidies

As noted in Section IV, the prices for many of the alternative crops – specifically the perennial grasses and oilseeds – are hypothetical, based on prices for similar forage crops or soybeans. At the hypothetical prices, camelina and pennycress look highly profitable, as shown in Table __. However, until those crops are improved through additional plant breeding and testing, and until markets are established, a subsidy would be required. Subsidies will be needed for all crops, at least initially, to help producers accept the risks that come with a new enterprise, whether they are changing the crop mix, the crop rotation, or the type of livestock enterprise.

Table 9 estimates the initial subsidies that would be needed for a pilot working lands contract program for the crops identified in each of the six study watersheds, based on current prices for annual crops and assuming that prices for switchgrass, camelina, and pennycress at zero. Note that these crops were selected in response to conditions in each watershed and to achieve a balanced distribution, not to pick winners and losers. The full range of crops and livestock enterprises could be assessed in each watershed using the Six Watershed Comparison Spreadsheet.

Several assumptions are made in the table:

- "Cumulative subsidy" is drawn from the spreadsheet and assumes that 30% of all cropland in the watershed is converted to the selected crop. Prices are based on a cut-off established using the Crop Productivity Index, to ensure that the less productive land is included first.
- "Subsidy for the selected acres" uses the medium-term scenario used in water quality modeling:
  - 30% of marginal lands converted to perennials (including Kernza, switchgrass, alfalfa, livestock)
  - 40% of non-marginal lands planted in cover crops, including camelina and pennycress in various rotations.

  The price per acre established in the spreadsheet is multiplied by 30% or 40% of the acreage, depending on the crop.

This approach simplifies a complex set of calculations. We assume that the same price would be offered for all land, since all landowners and operators are assuming a similar risk and need a similar incentive. However, the per-acre prices in the spreadsheet are based upon actual data on crop productivity and yields in each watershed. In an actual program, prices per acre might differ based on a number of factors, such as length of contract, erodibility or other sensitivity of land, or crop selection. The average CRP rates for each of the counties where the watersheds are primarily located are provided as a comparison. Note, however, that in the current CRP different soils are paid at different rental rates. See Appendix 2 for further details and direct access to the Six Watershed Comparison Spreadsheet.

Table 9. Required Subsidies for Alternative Crops/Livestock Based on Six Watershed Comparison Spreadsheet, using Current Prices

	Freeborn Lk/ Cobb R	Shakopee Creek	Getchell Cr/Co. Ditch 9	Rogers Creek	Watson Creek	Whiskey Cr, part
Selected crop	Covercrop Corn Soy	Kernza	Switchgrass	Camelina Corn-Soy	Covercrop Corn Soy	Kernza
Cost per acre	$39	$86	$176	$63	$39	$36
Cumulative subsidy - 30% of all cropland (prices based on CPI)	$246,419	$331,807	$162,617	$164,780	$48,980	$14,718
Subsidy for selected acres (30% / 40%)	$366,023	$161,044	$231,264	$307,087	$97,500	$109,199
Selected crop	Pennycress	Camelina Corn-Soy	Alfalfa hay for sale	Alfalfa hay for sale	Grazing dairy (organic)	Grass-fed beef
Cost per acre	$53	$67	$119	$114	$228	$39
Cumulative subsidy - 30% of all cropland (prices based on CPI)	$294,264	$365,711	$155,254	$284,371	$127,430	$7,949
Subsidy for selected acres (30% / 40%)	$497,416	$684,231	$156,366	$32,627	$293,573	$118,299
CPI cutoff - non-marginal land	90	80	70	86	71	65
CPI cutoff - marginal land	77	63	31	55	68	50
Acreage - Total Cropland	29,972	31,773	22,212	13,140	10,542	21,965
LCC3+ acreage (marginal)	6,509	6,242	4,380	954	4,292	10,111
Non-LCC3+ Cropland (non-marginal)	23,463	25,531	17,832	12,186	6,250	11,854
30% of marginal cropland	1,953	1,873	1,314	286	1,288	3,033
40% of non-marginal cropland acres	9,385	10,212	7,133	4,874	2,500	4,742
	Freeborn	Kandiyohi	Stearns	Nicollet	Fillmore	Clay
CRP Rates for surrounding counties	$183	$183	$130	$177	$190	$117

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