Are Conservation Programs Effective? Evaluating a Collaborative Approach to Improve Water Quality

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WALTON FAMILY FOUNDATION

Cover: A farm in the Upper Macoupin Creek watershed. Photo credit: American Farmland Trust

Report Authors

Sridhar Vedachalam, Ph.D., Director, Safe Drinking Water Research and Policy Program

Max H. Cassell, Cornell University

Eric A. Heath, Senior Policy Counsel, Mississippi River Basin Program

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About the Institute

The Northeast-Midwest Institute is a Washington, D.C.-based, nonprofit, nonpartisan public policy organization committed to economic vitality, environmental quality, and regional equity for the 18 states of the Northeast and Midwest. As a policy-focused institute with a 40-year track record of producing first-rate research, developing policy options, and building and supporting regional coalitions, the Institute has unique standing in that it was founded in response to calls by the Congressional Northeast-Midwest Coalition for a stable and trusted source of regional data and research as well as policy options and analysis. It is precisely these roots and relationships on Capitol Hill which now position the Northeast-Midwest Institute to chart a future that encompasses an expanded agenda of critical regional issues and to embark on a strategy to achieve increased impact.

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Executive Summary

The Mississippi River Basin is the largest watershed in the United States, draining approximately 40% of the land area in the lower 48 states. Agriculture is the dominant industry in the Basin, impacting land-use and water quality. Heavy use of fertilizers and manure on agricultural fields has substantially contributed to high levels of nitrogen and phosphorus across the Basin, resulting in algal blooms, contaminated drinking water, and "dead zones" in open waters. A focus on addressing the problem at the source has led the federal government to invest significantly in conservation programs through farmer education, outreach, and cost-sharing of practices that aim to improve soil health and water quality. One such conservation program, the Regional Conservation Partnership Program (RCPP) – implemented by the Natural Resources Conservation Service (NRCS) – is designed to bring together upstream farmers and downstream stakeholders such as cities, water and wastewater utilities, and other watershed preservation groups.

This report analyzed the implementation of RCPP in six watersheds in the Upper Mississippi River Basin – Middle Cedar River in Iowa, Upper Macoupin Creek and Otter Lake in Illinois, the State of Minnesota with a special emphasis on Middle Cannon River, and Baraboo River and Oconomowoc River in Wisconsin. An assessment of these six projects confirms the role of federal funding in initiating or strengthening these collaborations across various sectors from state and local governments to educational institutions, agri-businesses, and environmental organizations. Phosphorus was a major concern in three projects, nitrogen was a major concern in one project, and two projects were structured to address both phosphorus and nitrogen. Fish and wildlife, soil health, and flooding were additional issues targeted by the projects.

RCPP projects do not follow any set template and each one is structured differently. The projects studied in this report employed a variety of conservation practices, although a few dominated. Planting cover crops during the off-season was an especially popular practice, even though it is less-effective than other edge-of-field practices such as filter strips and bioreactors. Filter strips, nutrient management, and strip till/no till were other commonly employed conservation practices. Water quality monitoring is an important element of RCPP projects, and one that sets it apart from other historical conservation efforts. The inclusion of downstream stakeholders elevated the role of monitoring as well as its scope. However, a lack of standardized water quality monitoring protocol resulted in instances where sparse monitoring frequency provided no meaningful data.

Nearly every project used computer models and software to identify farms with high nutrient loss and to suggest customized conservation practices tailored to each farm, thus integrating technology in one of the oldest occupations perfected by human civilization. Each RCPP project also contained one or more unique elements that made the project stand apart and marked it for success. Examples of such elements included leveraging RCPP funding with state regulatory programs or local industry support, outreach to non-traditional farmers, comprehensive water monitoring program, and a focus on improving each farm rather than improving the watershed.

Watershed modeling conducted in HAWQS to simulate the impact of climate change suggested significant increases in the water yield, both in the near-term (median increase of 65%) and the long-term (median increase of 68%). The contaminants evaluated in this study – phosphorus, nitrogen, and sediment – were projected to increase consistently in certain watersheds, while others showed an oscillating pattern. The RCPP projects evaluated in this report resulted in statistically significant but low-impact reductions in contaminant pollution across watersheds. RCPP projects, as currently implemented, generally reduced pollution from phosphorus, nitrogen, and sediment by approximately 3-6% across the watershed. A 10-fold expansion of the current conservation adoption in the watersheds will result in a 17-27% reduction, while full implementation of conservation on all available farmland will bring a 55-66% reduction in contaminant loading.

The Farm Bill has been an effective vehicle for undertaking critical conservation efforts by bringing stakeholders with varying interests. However, the funding allocated for conservation is not enough to meet the scale and severity of the water quality challenge facing the Mississippi River Basin and the nation at large. Additional funding for source water protection in the 2018 Farm Bill is an important step toward enhancing conservation efforts, but this study identifies several policy lacunae that need to be addressed at the federal, state, and local levels to ensure productive lands and high quality water in the region that feeds and powers America for many years to come.

Policy implications and recommendations

- Increase conservation funding to expand the scope and scale of conservation programs.
- Incorporate climate change projections in all conservation programs funded by the U.S government.
- State efforts must complement and enhance, not inhibit, federal conservation efforts.
- Provide additional incentives for high-efficiency conservation practices.
- Provide funding specifically for water quality monitoring, so the impacts of conservation are easily identified.
- Conservation projects must consider long-term viability to ensure longevity beyond the 5-year RCPP funding period.
- Enable transfer of funds across the conservation programs to ensure maximum utilization of limited funds.
- Citizen activism must be an integral part of the conservation movement.

Chapter 1: Introduction

The Mississippi River Basin is the largest watershed in the United States, draining approximately 40% of the land area in the lower 48 states. Agriculture is the dominant industry in the Basin, impacting land-use and water quality. Cultivated crops, primarily corn and soybeans, contribute 66 percent of Nitrogen and 43 percent of Phosphorus that is delivered from the Mississippi River Basin to the Gulf of Mexico (USGS, 2018). Heavy use of fertilizers and manure on agricultural fields has substantially contributed to high levels of nitrate across the Basin, resulting in the use of expensive nitrate treatment units in drinking water treatment facilities.

A 2018 Northeast-Midwest Institute study evaluated the cost of nitrate treatment at three water treatment facilities in the Upper Mississippi River Basin and highlighted the role of conservation in improving water quality (Vedachalam et al., 2018; Vedachalam et al., 2019). The study found that a 20 percent reduction in the intake nitrate concentrations would yield a 48-71 percent reduction in daily exceedances above the USEPA's Maximum Contaminant Level of 10 mg/L.

One of the key challenges with measuring the effectiveness of conservation is the lack of data and consistent monitoring of water quality before and after implementation. This stems from the way conservation programs are structured – farmers receive financial support to adopt best management practices, but are not held responsible for the quality of water leaving their farms. The Regional Conservation Partnership Program (RCPP), instituted under the 2014 Farm Bill and reauthorized in the 2018 Farm Bill, overcomes the above-described challenge by requiring partnerships between upstream farmers and downstream stakeholders. The inclusion of a partner that stands to benefit from conservation practices (for instance, a water utility or a lake management association) provides an additional legal and social contract that allows for an evaluation of outcomes such as water quality.

This report utilized publicly available project documents, but relied on relationships developed with project leaders to gather relevant information about RCPP-funded collaborative conservation projects, and analyzed the problem scope, project strategy, monitoring plans, and water quality-related outcomes. In addition, the study simulated various conservation scenarios that modeled the future impacted by climate change, and evaluated the resulting changes in water quality. These scenarios identify the limitations of our current conservation approach, and lay out a path for designing future approaches that account for these external factors.

Chapter 2: Background

There is a global nitrogen crisis—not one of shortage but one of overabundance. The world is using more nitrogen, mainly via fertilizers, than ever before (Pearce, 2018). The fallout is seen in the form of algal blooms, contaminated drinking water, and "dead zones" in open water. The Gulf of Mexico's hypoxic zone has been a perennial cause for concern, but 2017 brought fresh worries as the dead zone expanded to its largest extent ever recorded (Smith, 2017). The proliferation of harmful algal blooms and the occurrence of toxins such as microcystin in Lake Erie in 2014, which caused the shutdown of the drinking water system in Toledo, Ohio, elevated the discussion on the impact of nutrients such as nitrate and phosphorus on freshwater sources (Kozacek, 2015).

Although treatment to remove or reduce the concentration of these nutrients in drinking water is widely practiced, addressing the problem at the source remains a preferred option as it benefits other uses of the surface water, such as recreation, drinking water via groundwater, industries such as food processing plants that rely on water as a primary input, as well as the riparian ecosystems. Furthermore, investing in upstream watershed for source water protection can often be cheaper than treatment downstream at a water treatment facility (Gartner et al., 2013).

Ample evidence exists on the efficacy of conservation strategies in nutrient loss reduction through monitoring conducted on individual plots (Stuart and Gillon, 2013; Zhang et al., 2010). However, the extent of their effectiveness is less clear when measured on a watershed scale, where a variety of land activities contribute to the water quality (Osmond et al., 2012). Furthermore, the success of federal conservation programs is typically measured through outputs such as the number of participating farmers, land enrolled in conservation, or modeled nitrogen or phosphorus removed, but not in terms of outcomes such as improved water quality. Newer programs such as RCPP could upend that old paradigm by placing the focus on water quality improvement. Perez (2017) cataloged success stories that used a targeted approach to achieve water quality through conservation, but did not review any RCPP projects as they were insufficiently mature at the time.

Under the cooperative federalism structure of governance, states have greater autonomy on setting policies such as that relating to non-point source pollution. Since the federal Clean Water Act does not regulate non-point sources, states are a critical line of defense in monitoring and addressing pollution abatement efforts (Secchi and McDonald, 2019). The UMRB states have been particularly notable in their effort to conduct science-based assessments of nutrient loss reduction strategies. Iowa conducted a thorough science assessment, which became a basis for nutrient reduction strategies in Illinois and Missouri. Minnesota also adopted an independent watershed-based approach; Wisconsin relied on the Iowa and Minnesota documents as a guide for developing a Wisconsin-centered plan (Secchi and McDonald, 2019). Despite the above, the federal government's role in conservation is not insignificant.

Chapter 3: Farm Bill and Conservation

Approximately every five years, Congress develops an omnibus piece of legislation known as the Farm Bill. This bill covers a host of agricultural issues, ranging from crop subsidies to the Supplemental Nutrition Assistance Program (SNAP), generally authorizing each program in five year stints. These somewhat disparate issues are addressed collectively in pursuit of a "grand bargain" that garners political support from both urban and rural politicians from both sides of the aisle.

The twelve titles within the Farm Bill cover: (I) commodity programs; (II) conservation; (III) trade; (IV) nutrition; (V) credit; (VI) rural development; (VII) research; (VIII) forestry; (IX) energy; (X) horticulture; (XI) crop insurance; and (XII) miscellaneous issues like livestock production (Johnson and Monke, 2018). These twelve titles shift and adjust from each iteration of the Farm Bill to the next, but the overall structure has remained relatively the same in recent decades. The 2018 Farm Bill authorized $867 billion in federal spending compared to $956 billion for the 2014 Farm Bill and $288 billion for the 2008 Farm Bill.

Starting in 1985, the Farm Bill began to include funding for various conservation programs to address the environmental consequences of certain agricultural practices. This initial entry into conservation policy began with efforts to address soil erosion. In the subsequent Farm Bills, the conservation title has continually expanded to include a host of conservations programs targeted at a number of issues, like soil erosion, water and air quality, and energy efficiency. These programs are run through the Natural Resources Conservation Service (NRCS) and the Farm Service Agency (FSA), both of which are housed within the U.S. Department of Agriculture (USDA). Other USDA programs like the Agricultural Research Service (ARS), the Economic Research Service (ERS), the National Institute of Food and Agriculture (NIFA), and the Forest Service (FS) support these activities in their respective capacities.

One recent addition to the Farm Bill's conservation efforts that holds great promise for improving national conservation is the Regional Conservation Partnership Program (RCPP). Created in the 2014 Farm Bill, RCPP provides technical and financial support for conservation projects that operate at the watershed-scale or across multiple states. These projects are implemented as a partnership that leverages federal funding in conjunction with a larger portion of funding from local partners to address conservation needs in NRCS-defined critical conservation areas (CCA) or in a selected partnership area. The CCA classification is currently applied to a number of areas, including the Mississippi River Basin.[1] RCPP was created by consolidating earlier programs that focused on agricultural water enhancement, and two regional programs related to the Chesapeake Bay and the Great Lakes. Funding for RCPP contracts are often obligated under one of several existing programs, such as Environmental Quality Incentives Program (EQIP), Conservation Stewardship Program (CSP), Agricultural Conservation Easement Program (ACEP), and the Healthy Forest Reserve Program (HFRP) (Stubbs, 2014).

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[1] Natural Resources Conservation Center. Retrieved June 10, 2019, from https://www.nrcs.usda.gov/wps/portal/nrcs/detail/id/home/?cid=stelprdb1254053.

Competitive state and national selections determine which eligible projects receive RCPP funding. In FY2017, a total of 88 projects were selected for a total of $225 million in federal funding and $500 million in partner contributions (Stubbs, 2017). This ultimately resulted in 53 projects at the state level, 17 projects for CCAs, and 18 projects at the national level (Stubbs, 2017). Selected partnerships last for five years with the possibility of a one-year extension.

Chapter 4: Methods

Study Scope

The scope of this study was limited to projects supported by the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS) under the RCPP program. Since 2014, 43 projects have been implemented in four states of the Upper Mississippi River Basin – Illinois, Iowa, Minnesota, and Wisconsin. Excluding duplicates of projects that span across multiple states, 33 separate projects worth $95.1 million have been supported in the last four years. Of these, 22 projects state water quality improvement as one of their primary objectives.

These 22 projects became the master list of projects that were deemed relevant for the purpose of this study. Preliminary data gathering was conducted via two separate tracks:

1. Identifying the key stakeholder contact for each project, and contacting them via phone and email.
2. Working with NRCS to obtain project documents related to this master list of projects. This involved several back-and-forth conversations with NRCS staff at the Washington, DC office, and later with the state offices. Finally, at the request of NRCS, requests for information on projects were filed under the Freedom of Information Act (FOIA).

Both approaches were successful in identifying pieces of information about RCPP-funded projects. Eventually, the authors were successful in establishing contacts with six project leaders who had received RCPP funding. Table 4.1 and Figure 4.1 describe the project attributes and the location of the watersheds.

Table 4.1. Attributes of the assessed RCPP projects.

Project Location	**State**	**Fiscal Year (FY)**	**NRCS Funding ($ million)**	**Project Leader**
Baraboo River	WI	2014-2015	1.3	Sauk County Conservation, Planning, & Zoning Department
Middle Cedar River	IA	2014-2015	2.1	City of Cedar Rapids
Minnesota, *with emphasis on* Middle Cannon River	MN	2014-2015	9.0	Minnesota Department of Agriculture
Oconomowoc River Watershed	WI	2014-2015	0.5	Tall Pines Conservancy; City of Oconomowoc
Upper Macoupin Creek	IL	2017	1.0	American Farmland Trust
Otter Lake	IL	2018	0.8	Otter Lake Water Commission; Illinois Corn Growers Association

Note: The Sauk County Conservation, Planning, & Zoning Department received RCPP funding for a second project within the Baraboo River watershed in FY 2018 (the geographical focus of this project was much narrower than the first project). The second project is not evaluated in this report.

Figure 4.1. Location of RCPP projects assessed in this report.

The six projects chosen for assessment come from all four states in the Upper Mississippi River Basin – two each from Illinois and Wisconsin, and one each from Iowa and Minnesota. Information regarding several other projects were gathered via FOIA requests and online searches, but it was insufficient to conduct a full assessment. One project turned down a request from the authors to participate in the study. Chapters 5-10 describe each RCPP project in detail, capturing highlights from the proposal submitted to NRCS, progress achieved so far, and water quality results from the HAWQS model. At the beginning of each chapter, details regarding size of the watershed, resource concerns targeted under RCPP, number of eligible producers, etc. are provided in graphic form, based on the legend shown in Figure 4.2.

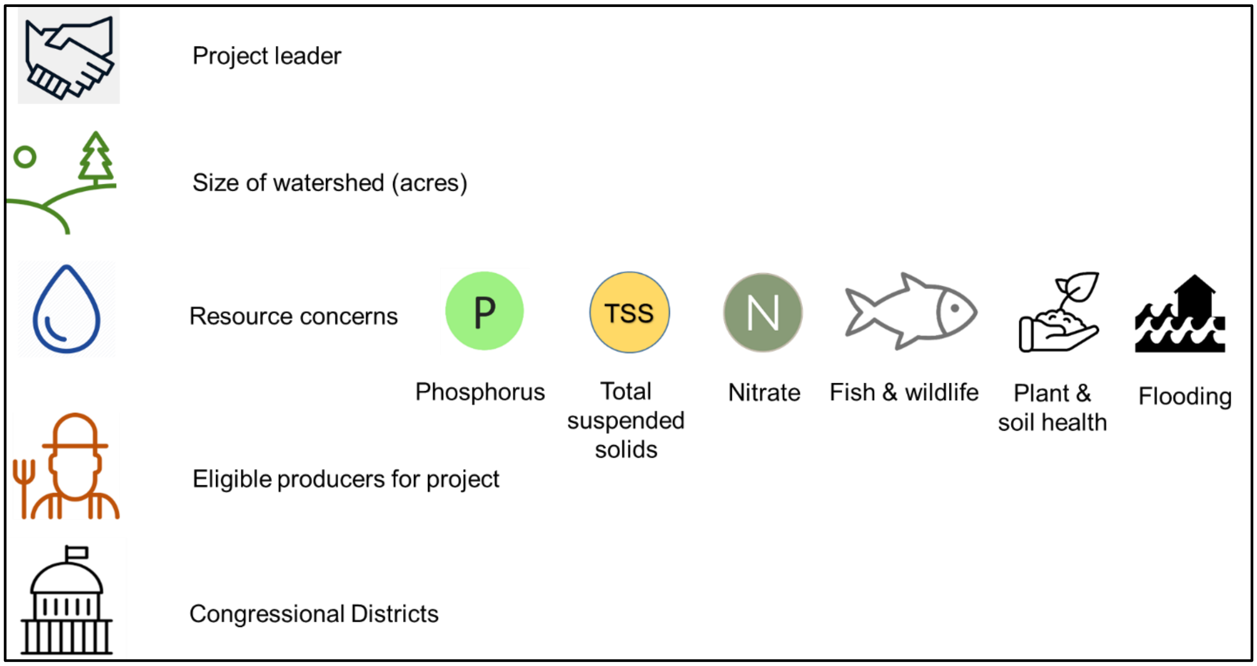


Figure 4.2. Typology for project attributes

Each RCPP project analysis is comprised of two parts. The first part includes a review of the RCPP project – stated objectives in the proposal, sampling protocol, progress made toward achieving the objectives, economic benefits arising from the project, stakeholder relationships developed, and viability to continue the work beyond the 5-year funding period. This assessment is based on the proposal submitted by the project leaders to NRCS, discussions with project leaders, along with documents and data provided to the authors. The second part of the analysis utilizes the Hydrology and Water Quality System (HAWQS) model to simulate various conservation scenarios that model the future impacted by climate change, to quantify the impact of ongoing conservation efforts. The next section describes the HAWQS model in detail.

HAWQS

The Hydrologic and Water Quality System (HAWQS) is a web-based interactive water quantity and water quality modeling system that utilizes the widely used and recognized Soil and Water Assessment Tool (SWAT) as its core modeling engine (USEPA, 2017). SWAT requires vast amounts of data to set its boundary conditions and is computationally intensive. HAWQS, collaboratively developed by the USEPA and Texas A&M University, provides a user-friendly, simplified version of SWAT. HAWQS v1.0 was released in September 2017, and is thus a relatively new tool with enormous potential for water quality assessment.

According to the creators of the tool, “HAWQS is an advanced, total water quantity and quality modeling system with databases, interfaces and models that evaluates the impacts of proposed regulations, water quality management actions and scenarios of climate and land use change on the quality and quantity of the Nation’s streams and rivers” (Fant et al., 2017). HAWQS allows users to select a watershed for analysis at three different spatial resolutions (HUC 8, HUC 10, and HUC 12) and the temporal scale can be set to daily, monthly, or annual. In addition, users can set model parameters at different values instead of using the pre-defined sets.

According to HAWQS, each watershed consists of a number of smaller units called Hydraulic Response Units (HRU). Each HRU represents a specific land use, soil, slope class, and subbasin. The software allows the elimination of minor land uses, soils, and slopes in each subbasin based on user-selected thresholds (percentage or area) to reduce processing time. A threshold of 1% was used in each of the watershed models presented in this report.

Although all watersheds in the continental United States (CONUS) are not calibrated, the HAWQS model matches uncalibrated watersheds with similar-sized calibrated watersheds that share physical and hydrologic characteristics to generate water quality data. For historical data, the timeframe (all dates are expressed in MM/DD/YYYY format) chosen was 1/1/1961 to 12/31/2010, with a five-year warmup period. To model future climate projections, the chosen timeframe was 1/1/2006 until 12/1/2078, with a similar five-year warmup period to ensure continuity across time.

The climate module in HAWQS provides the option to select any one of several climate models. The climate model selected for this study was the Hadley Global Environment Model 2 - Carbon Cycle (HADGem2-CC) developed by the United Kingdom Met Office, as it scores highly on various measures of performance and future forecast (Chhin and Yoden, 2018).

The model provides two options for choosing climate change projections, which are typically presented as Representative Concentration Pathway (RCP) values. These values correspond to the trajectory of greenhouse gases emitted in future years, with higher values suggesting higher emissions (Wayne, 2013). The HAWQS model provides an option of choosing between RCP 4.5 and RCP 8.5.[2] The analysis presented in this report is based on a higher emission scenario represented by RCP 8.5.

The HAWQS model provides a number of water quality outputs (both as loading and concentration) such as organic phosphorus, mineral phosphorus, total phosphorus, organic nitrogen, total nitrogen, sediment, and water quantity, both when entering and leaving the watershed. While the analysis of each contaminant can tell a different story about a certain watershed, this report presents total phosphorus, total nitrogen, and sediment at the outlet of each watershed as water quality indicators. Additionally, monthly averages of water yield (precipitation + snowfall – evapotranspiration loss) from the recent past (1980-2010) are compared with near-term (2010-2040) and long-term (2040-2070) future projections to assess changes in seasonal patterns that could impact water quality.

[2] The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report includes two additional trajectories: RCP 2.5 and RCP 6.0

Modeling Future Scenarios

To assess the effectiveness of conservation programs implemented under the RCPP project, four different scenarios were modeled for each watershed such that they meet state and federal nutrient loss reduction targets. The scenarios are as described below:

1. **Control**

The control scenario is a simple projection of current conditions, without the influence of the RCPP program. We assume no land use changes, and no changes in management practices. This scenario approximates the likely outcomes should no action be taken.

2. **Program continued**

This scenario estimates the water quality outputs on the assumption that the RCPP program continues in its current state but is not scaled up. We assume that the amount of land currently engaged in sponsored BMPs continues to do so, but that no additional land implements BMPs. This scenario approximates the long-term effectiveness of the RCPP program in its current form, with current funding.

3. **Program scaled up**

This scenario increases the implementation of sponsored BMPs, in the ratios currently active in the RCPP program[3], until the program is 10 times its current size. This shows the potential effectiveness of the program given a substantial budget and scope increase.

4. **100% implementation**

This scenario models the watershed with full implementation of all sponsored BMPs. This shows the maximum nutrient reduction that could be accomplished without making large structural changes to the nature of farming and to land use.

Scenario Coding

The implementation of the above mentioned conservation scenarios – *Continued*, *Scaled*, and *Full Implementation* – relies on changes made to HRUs within HAWQS. The most commonly used conservation practices under RCPP include cover crops, nutrient management, streambank cover, bioreactors, and wetland conversion, among many others. Depending on the total acreage of a certain practice such as cover crop, one or multiple HRUs, whose land area is the closest approximation, was chosen.

To implement cover cropping, till operation beginning November 1 was replaced with planting operation for rye, which is a common winter cover crop. A kill (no harvest) operation was added on April 1, before the first operations for summer planting. This mimics traditional cover cropping practice, where cover crops are grown during the winter and are killed and plowed

[3] For example, if an RCPP program is sponsoring 10,000 acres of cover crops and barrier strips on 5% of farmland, a scaled-up program would have 100,000 acres of cover crops and barrier strips on 50% of farmland.

under (without being removed) to provide extra nutrients for cash crop growth (Masiunas et al., 1995). Based on data from one of the study sites, nitrogen nutrient management reduces the application of nutrients by 17%. This proportional reduction was then applied to phosphorus and nitrogenous fertilizer.

Interactions with project leaders suggested that each 10 meter long streamside barrier strip filters 50-80 acres of land. Depending on the number of streamside barriers installed in each watershed, general parameters of HRUs representing an approximate area were modified. Tile drain bioreactors were an uncommon BMP which HAWQS has no explicit term for modeling, however they could be modeled by replacing tile drains with filter strips, which has a relatively similar effect on runoff nutrient concentration. Practices were added on separate HRUs for maximum impact whenever possible, except in the case of Minnesota, where conservation practices are being implemented on the same land for operational reasons.

To model the *Continued* scenario, conservation practices were employed in HRUs that represent corn cultivation because corn mono-cropping uses the largest amount of fertilizer and therefore nutrient reductions attributed to conservation will be maximized. To model the expansion scenario represented by *Scaled*, the area under conservation was increased by a factor of 10 and changes were applied to HRUs representing cultivation of corn, corn/coy rotation, and soy/corn rotation. Furthermore, the impact of nutrient management was doubled to yield a 33% reduction in nutrient input, on top of the expansion of land under management. Under the *Full Implementation* scenario, cover cropping and nutrient management were applied to all HRUs cultivating corn and soy, and streamside barrier strips were applied to all farming HRUs.

Results

The next six sections describe each RCPP project in detail, along with an assessment of the projected changes in water quality based on the HAWQS model.

Chapter 5: Baraboo River Watershed

Sauk County Conservation, Planning, & Zoning

419,731 acres

P TSS

3,771

2nd, 3rd, and 6th

About the Watershed

The Baraboo River watershed covers an area of 419,731 acres located in southwest Wisconsin (see Figure 5.1). The watershed spans several counties and contains the cities of Baraboo and Reedsburg. There are several smaller villages in the watershed.

The Baraboo River is a tributary to the Wisconsin River, the state's longest river and a tributary to the Mississippi River. The topography of the area combined with agricultural uses creates a high potential for water quality impacts from nonpoint source pollution. The Baraboo River watershed has four sub-watersheds, as described below:

Table 5.1. Subwatersheds in the Baraboo River watershed

Subwatershed (HUC 12)	HUC ID	Size (acres)
Seymour Creek	0707000401	105,621
Crossman Creek	0707000402	141,420
Narrows Creek	0707000403	100,751
Lower Baraboo River	0707000404	55,000

The largest land use in the watershed is devoted to cropland (42%); forest (31%) and pasture (16%) are other prominent land uses in the watershed. The main goal for the Baraboo River Watershed Regional Conservation Partnership Program (RCPP) is to reduce phosphorus and sediment levels to improve water quality.

Drinking Water Sources

The Baraboo River is not a drinking water source for any community in the watershed.

Impairments in the Watershed

The Wisconsin Department of Natural Resources (WDNR) found that Baraboo River was the second largest contributor of total phosphorus loading to the Wisconsin River, with an average total phosphorus concentration of 259 µg/l, which is well above the state standard of 100 µg/l (Wisconsin Administrative Code, 2019). There are nineteen stretches of the Baraboo River listed on EPA's 303(d) list of impaired waters and about twenty more are proposed to be listed. Many of the subwatersheds have been selected for the Nonpoint Source Pollution Abatement Project in the past twenty to thirty years. Seymour Creek contains portions that have Class I, II, and III trout streams[4], and Narrows Creek supports a Class II trout stream. Due to the nonpoint source pollution, some areas of the watershed are better suited for trout production than other portions.

[4] The Wisconsin DNR has classifications for different trout streams throughout the state. Class 1 produces high quality trout waters that can naturally sustain populations of wild trout. Class 2 may have some natural reproduction occurring, but not enough to utilize food and space. Class 3 has no natural reproduction of trout occurring. https://dnr.wi.gov/topic/fishing/trout/streamclassification.html

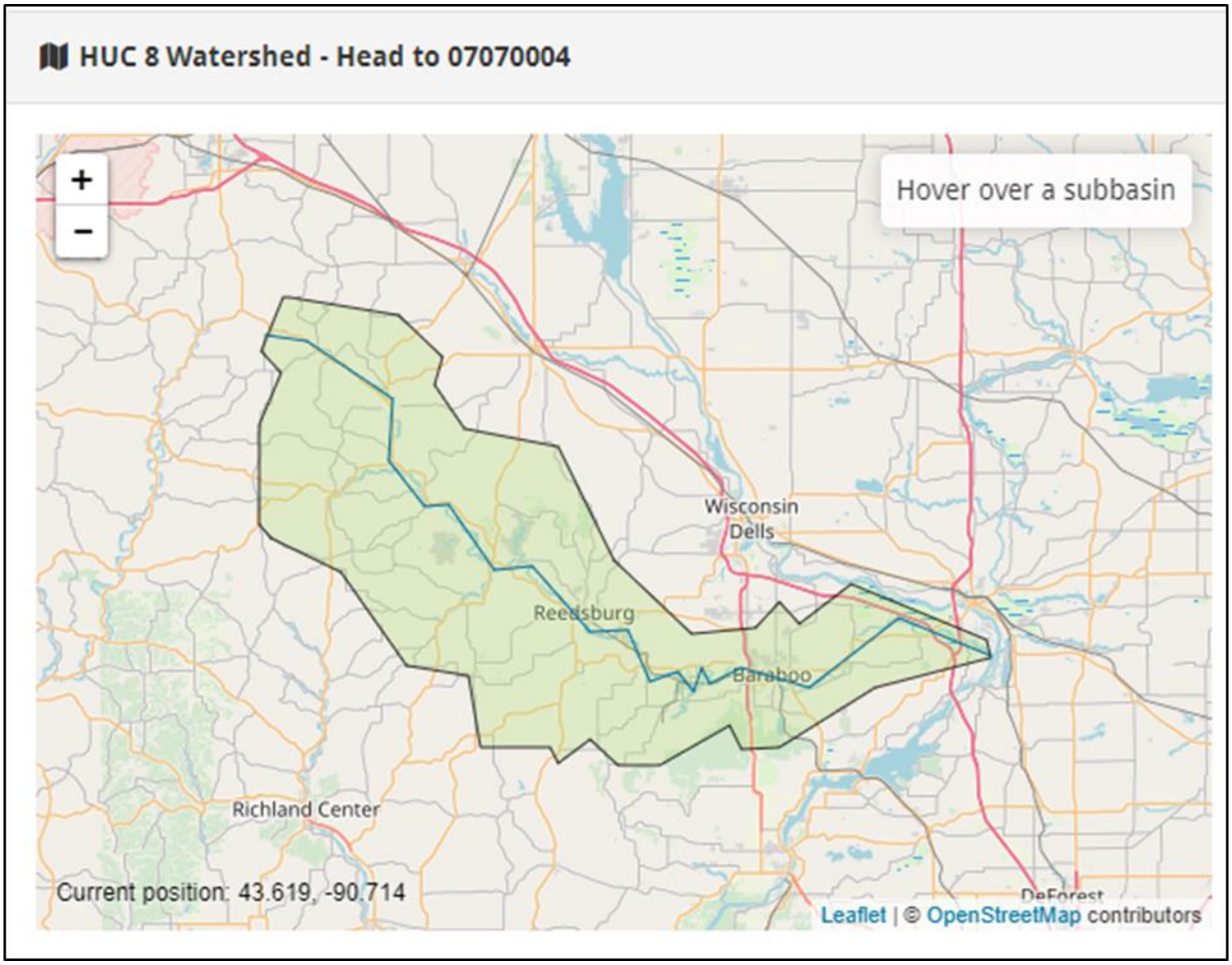


Figure 5.1. The Baraboo River watershed, as visualized in the HAWQS software.

Natural Resource Concerns

There are two principal natural resource concerns:

1. Water quality degradation from high phosphorus and sediment levels in surface waters.
2. Degraded plant condition and the absence of adequate vegetative systems in areas susceptible to soil erosion.

The project has three objectives to address these above concerns:

1. Prevent soil loss on cropland and pastures on 50 percent of "target" farms[5]
2. Reduce agricultural runoff to surface and groundwater on 50 percent of target farms
3. Improve aquatic and wildlife habitats using 10 percent of the financial assistance funds.

[5] Target farms are farms which have been found to contribute the greatest amount of phosphorus to the watershed. In the Baraboo River watershed, 137 farms were identified as target farms.

The project will consist of actions in two stages to meet the above objectives. The first stage includes providing education and outreach to the producers about the resource concerns and conservation practices that can be installed on farms. The second stage includes providing technical assistance in the form of planning, surveying, or designing practices to farmers choosing to implement conservation practices.

Key Project Partners

The project leader is Sauk County Conservation, Planning, & Zoning Department, whose mission is to conserve natural, cultural and community resources by integrating economic, social, and environmental strategies. They are assisted in this RCPP project by a host of other local and regional stakeholders, some of whom are listed in Table 5.2.

Table 5.2. A list of key project partners

Type	Organizations
Municipal / Local government	Columbia County Land & Water Conservation Department, Vernon County Land & Water Conservation Department, Monroe County Land Conservation Department, Juneau County Land Conservation Department, Richland County Land Conservation Department
State agencies	Wisconsin Department of Natural Resources, Wisconsin Department of Agriculture, Trade & Consumer Protection
Educational	University of Wisconsin Extension, Madison Area Technical College-Farm Business Program
Cooperatives	Wisconsin Land and Water Conservation Association Inc
Trade groups	
Industry	
Environmental/ Conservation	Lake Wisconsin Alliance, River Alliance of Wisconsin, The Nature Conservancy, Trout Unlimited

Project Monitoring Plan

The Baraboo River RCPP project plans to do relatively little monitoring. It plans to monitor Total suspended solids (TSS) and total phosphorus (TP) six times at nine sites along the Baraboo River and its tributaries in the fifth year of the RCPP project, and compare the results to the baseline data collected by Wisconsin DNR in 2014. [6] Given the timeline of the end-of-project data collection, there will not be any data from the project while it is in progress.

[6] The proposal lists the monitoring period as occurring during May-October 2019, but since the project started four months later than originally envisioned, the monitoring period is likely to move into early 2020.

The Wisconsin DNR has conducted in-stream water quality monitoring at 50 sites in the Baraboo River watershed, prior to the project inception in 2014. According to Wisconsin DNR, 23 of those 50 sites were classified as "clearly exceed" P limits, 5 were classified as "may exceed", 20 had insufficient data (however, most "insufficient data" readings *were* above limits), and only two sites clearly met standards.

Project Practices

The RCPP engaged in cover cropping, streambank processes, and land use conversion from farmland to rotational grazing.

Producer Outreach and Activities

There are an estimated 3,771 producers in the area, 2,074 (55%) of whom participated in the project. The RCPP has assisted 60 of the 137 priority landowners, whose land was targeted for having large amounts of nutrient runoff relative to other producers in the area. The RCPP held regular educational seminars, which were successful in educating farmers on BMPs, and developed a rainwater runoff simulator, which was an effective tool for showing why BMPs are good for soil health (Figure 5.2). The RCPP used all of its available funding before the completion of the program, due to obligatory spending. The enthusiastic enrollment from producers and reception toward outreach education is an indication that farmers are highly receptive to this RCPP program, and that the Baraboo River RCPP was highly effective in terms of outreach and marketing.

Figure 5.2. An outreach program led by the project leaders in the Baraboo River watershed. Photo credit: Sauk County Conservation, Planning, & Zoning Department.

Accomplishments

The RCPP contracted 3,294 acres of nutrient management, established 7,004 acres of cover cropping, and created 10 streamside barriers. The program startup hit the ground running and used up all federal funding earlier than planned. High numbers of farmers are interested in the BMPs encouraged by the program, and request only technical assistance in changing farmland use patterns. The RCPP also contributed supplies and support for farmers wishing to switch from crops to rotational grazing.

Figure 5.3. A streambank stabilization project. Photo credit: Sauk County Conservation, Planning, & Zoning Department.

Efficiency and Efficacy

The RCPP created cover cropping at an average cost of $56 per acre, established 10 streambank protection projects, and contracted 3,294 acres of nutrient management at a cost of approximately $19 per acre. Approximately 7,500 tons of soil were saved through the program, at an estimated cost of between $20 and $25 per ton. Reduction in phosphorus loading is unclear.

The project made some progress towards the goal of lowering soil runoff. The project had no clear, achievable goals for phosphorus reduction, and it is unclear whether it made substantial progress towards lowering phosphorus loads or reducing the phosphorus concentration in water.

Water Quality Monitoring Results

In 2018, phosphorus levels exceeded state standards at all monitoring points[7]. Median phosphorus concentration in Baraboo River was 168 µg/l, still above state standards but significantly less than 2014 measurements. It is unclear whether this shows a trend, as data for P concentration in the 2016 and 2017 were unavailable[8].

Fish Sampling

Fish and macroinvertebrate index of biotic integrity (IBI) data was collected before and during the project period at more than 40 sites (see Table 5.3).[9]

[7] Source: Baraboo River Watershed RCPP 2018 annual report
[8] Source: Baraboo River Watershed RCPP annual reports, 2016 and 2017
[9] IBI is a composite index – originally designed for fish species and later extended to benthic macroinvertebrates – that reflects the health of the river ecosystem, based on species richness and

Table 5.3. Site conditions before project inception and during project implementation

Condition	Fish IBI		Macroinvertebrate IBI	
	2014	**2018**	**2014**	**2018**
Excellent	7	1	1	
Good	10	2	10	
Fair	1		24	1
Poor	2		11	5
Insufficient data	23		–	
Total	**43**	**3**	**46**	**6**

In 2018, Wisconsin DNR conducted fish monitoring in some of the streams, but did not report extensive IBI data. Three streams were surveyed in the Baraboo River watershed, of which two had Fish IBI ratings of good and one had a Fish IBI rating of excellent. Of the six locations surveyed for Macroinvertebrate IBI, one was rated fair and five were rated poor. The fish and macroinvertebrate sampling data collected by the Wisconsin DNR are inconclusive in determining change in water quality during the past four years.

Economic Benefits

The RCPP succeeded in creating large amounts of cover crops, and farmers noted that this cover cropping reduced the amount they had to spend on both fertilizer and herbicides. Moreover, the program helped farmers transition their land from agriculture to dairy grazing. As a result, the RCPP was able to increase the gross profit per acre. Many farmers didn't require financial assistance to participate in the practices encouraged under RCPP, and needed only technical assistance, which was provided by the project leaders.

Long-term Viability

The RCPP used all of its available funding before the completion of the program, due to obligatory spending. While this is a positive indicator in terms of outreach, it is a sign that given current spending, the program may have difficulty scaling. Many farmers used the RCPP to transition to dairy grazing, and the effects of this should persist until it becomes more profitable for farmers to transition back to crop farming. However, because many of the program practices, such as cover cropping, are contracted for a specific time frame, they will have to be discontinued when funding expires. This also will hinder the expansion of the program; increasing those program elements will require permanent and recurring budget increases. If the program were to be continued, a focus on lower-cost and more efficient projects such as edge-of-field practices (filter strips, wetlands, etc.) might allow for more measured spending.

composition, number and abundance, reproductive behavior, etc. A higher score indicates a vibrant ecosystem and higher water quality.

Project Highlight

The Baraboo River RCPP was particularly effective in its outreach and advertisement. The project attracted more interest among producers in the area than anticipated Furthermore, a number of farmers in the watershed wanted only technical assistance in implementing BMPs, another indication of the quality of education and outreach led by the project leaders. The Baraboo project leaders conduct several educational programs every year, and the results of those programs should persist even if funding for BMP implementation is reduced in the future.

HAWQS Modeling Results

Presented below are results for water quantity and quality in the Baraboo River watershed obtained from the HAWQS model.

Flow and Water Yield

A temporal plot of surface flow (referred to as just 'flow' here) at the outlet of the watershed suggests a steady increase until 2055, after which the flow declines sharply (Figure 5.4). A review of the monthly distribution of water yield (which includes subsurface flow, in addition to the surface flow) reveals additional patterns (Figure 5.5). Water yield is compared across three time periods: 1980-2010 (historical data), 2010-2040 (near-term future), and 2040-2070 (long-term future). Water yield is expected to increase by 12% in the near-term and 25% in the long-term, as compared to historical data. But this increase is not uniformly spread out. A disproportionate increase is expected to occur in the winter (Dec-Feb) and spring (Mar-June) seasons (104% and 26%, respectively, in the near-term and 128% and 38%, respectively, in the long-term).This is consistent with a warming climate which results in higher precipitation (in the form of snow in winter. However, the snow will readily melt as summer approaches and temperatures rise. As a result, water yield will diminish in the subsequent months. This is consistent with a warming climate that results in higher precipitation (in the form of snow in winter), but one that quickly melts leaving a lower amount of snowpack for the summer. This lopsided distribution of water yield across seasons will result in extreme flooding during the spring, not unlike the one being experienced in the region in 2019, and drought during the summer and fall seasons.

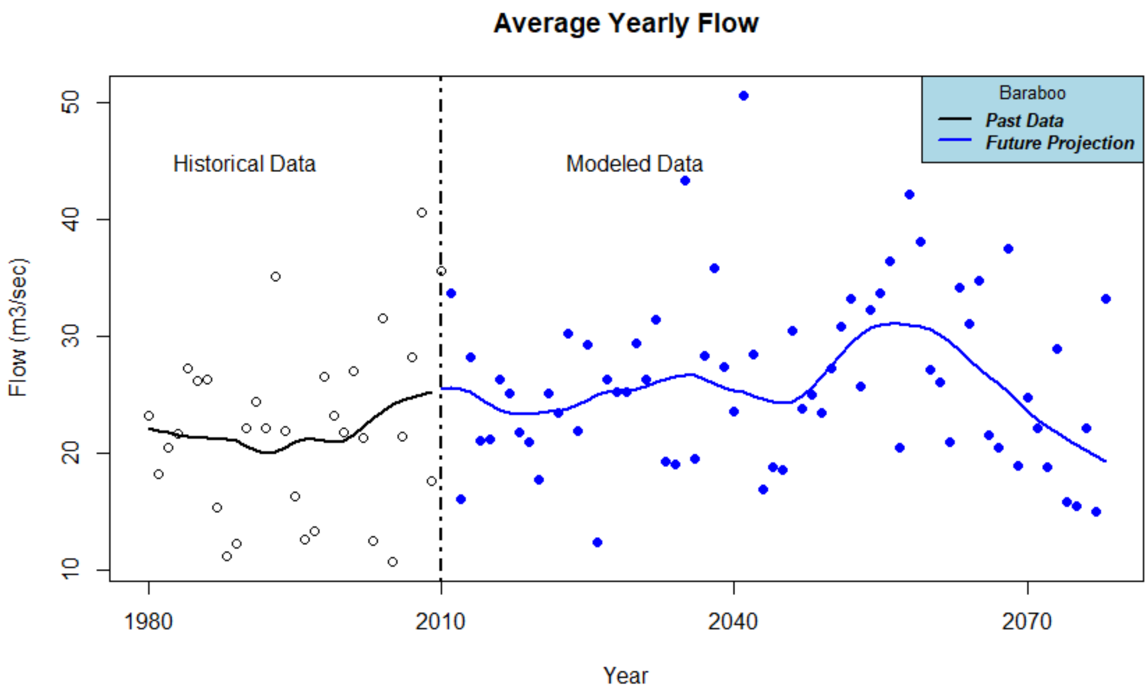


Figure 5.4. Average yearly flow (m³/s) at the outlet of the Baraboo River watershed. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

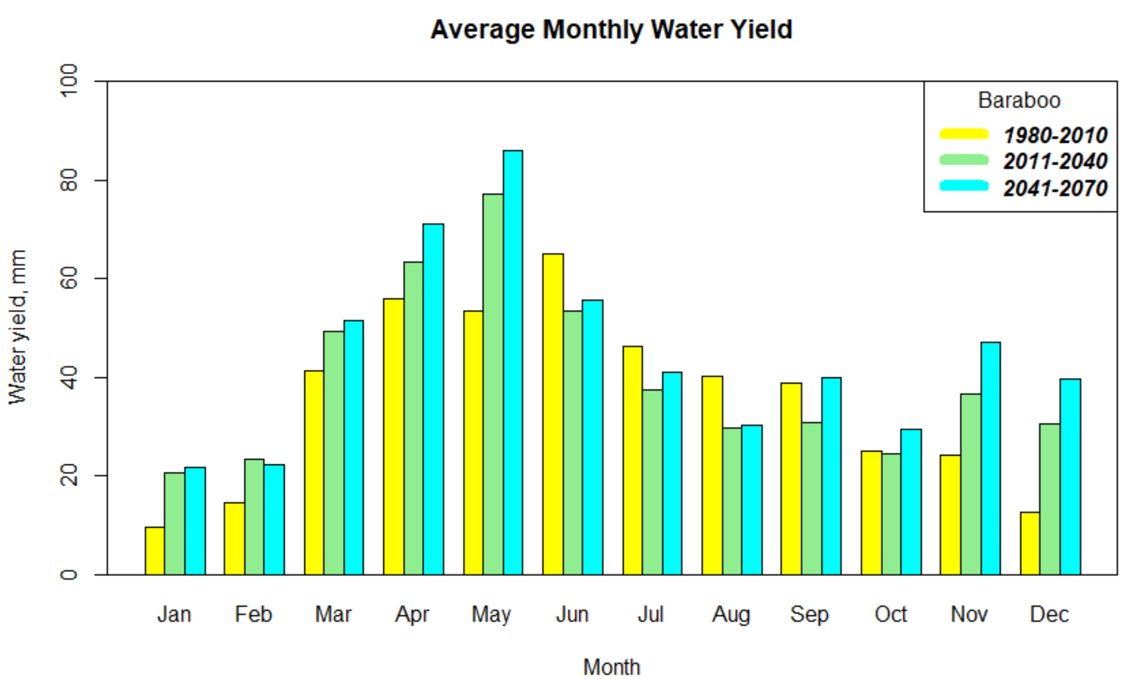
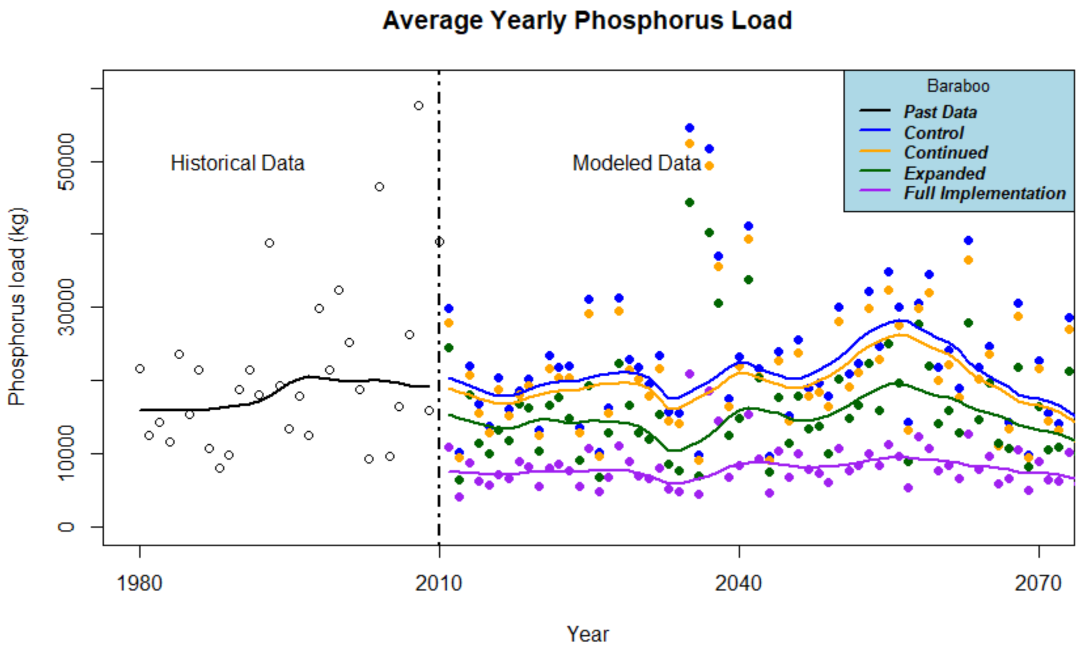


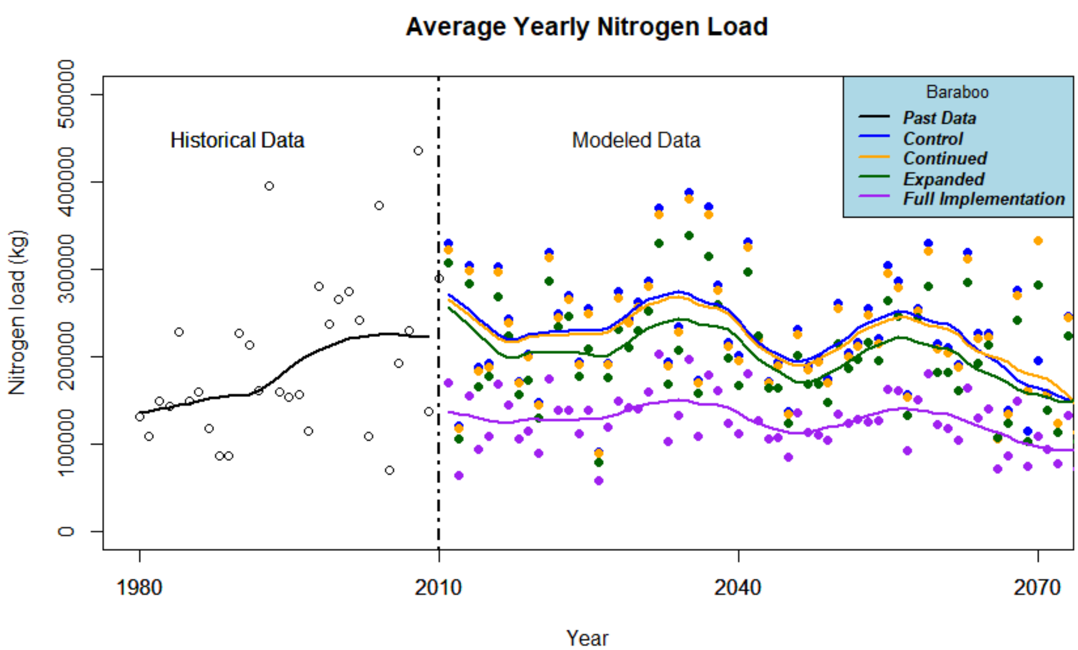
Figure 5.5. Average monthly water yield (mm) at the outlet of the Baraboo River watershed across three time periods.

Contaminant Loading

Figure 5.6 shows the average annual loading for phosphorus (kg), nitrogen (kg), and sediment (metric ton) at the outlet of the Baraboo River watershed under the four scenarios described earlier in the Methods section.



(a)



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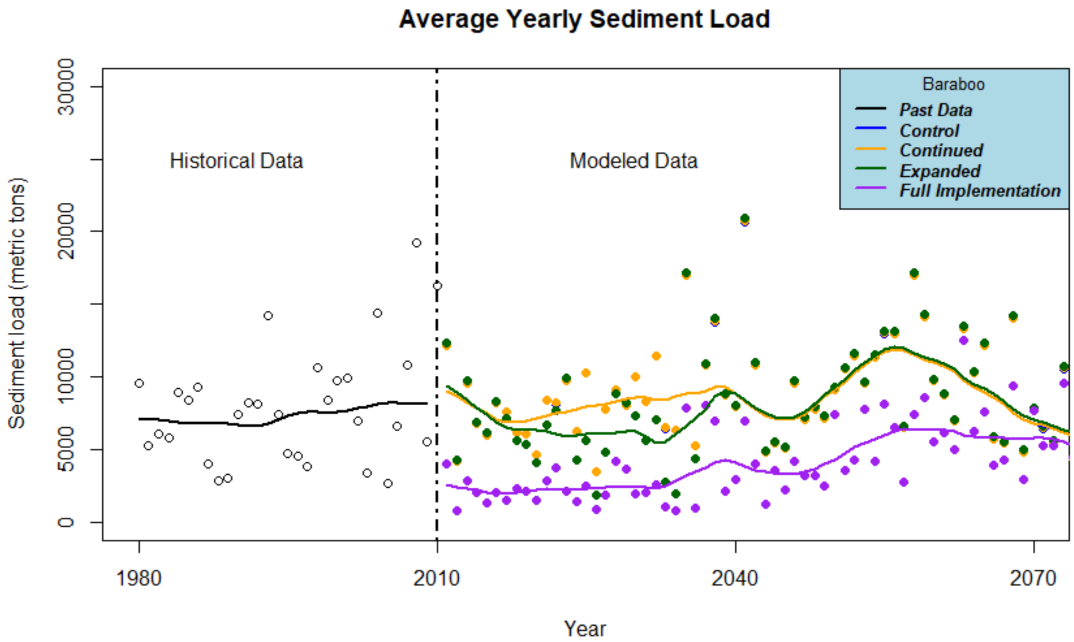


(c)

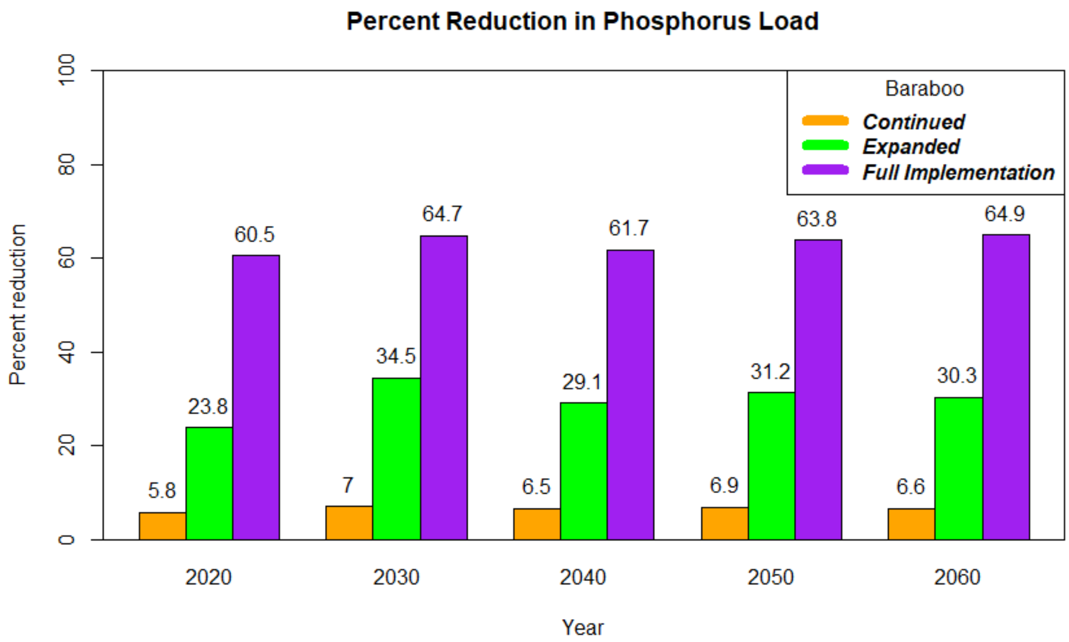
Figure 5.6. Average annual load for (a) phosphorus, (b) nitrogen, and (c) sediment at the outlet of the Baraboo River watershed under four future scenarios. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

Under the *Control* scenario, annual loading for phosphorus and sediment displays wide year-to-year variations, but the smoothing curve identifies a largely increasing trend until 2055, after which the loading declines sharply. Nitrogen loading displays a slightly different pattern, but stays relatively constant over long periods of time. It must be noted that the smoothed water quality data become less precise toward the end of the temporal scale due to overfitting. Therefore, the modeling results beyond 2070 should be treated with caution.

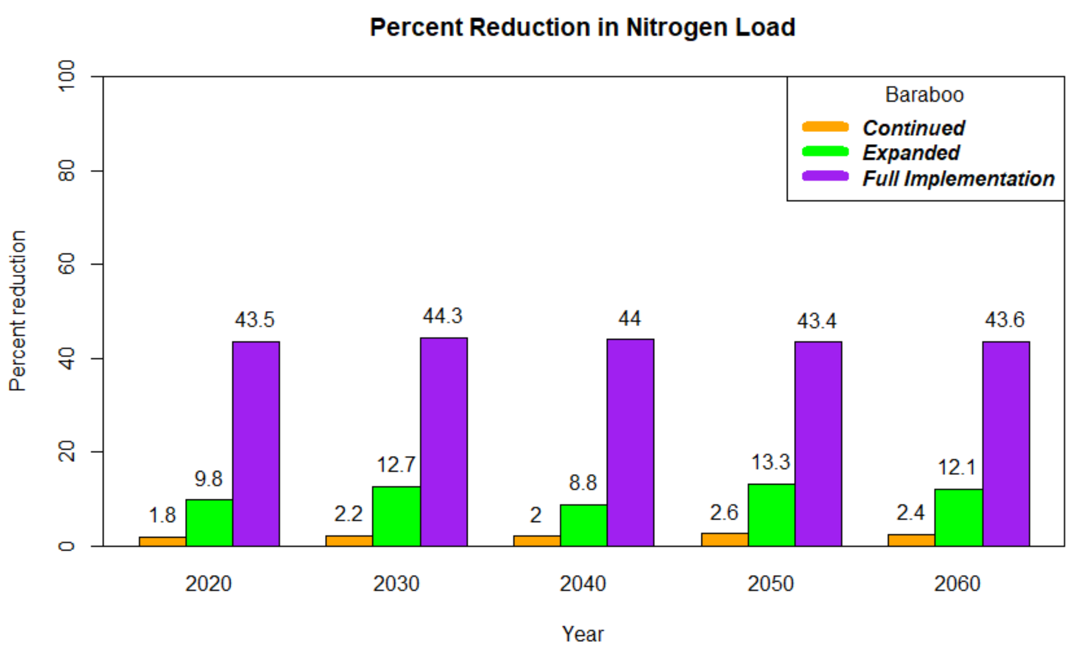
According to the model, during the period 2020-2060, phosphorus loading is expected to increase by 35% (from 19,253 kg to 25,804 kg), while nitrogen and sediment are expected to increase by 9.6% (from 217,827 kg to 241,107 kg) and 10.6% (from 217,827 metric tons to 241,107), respectively.

Phosphorus and nitrogen loading under the *Continued* and *Expanded* scenarios are marginally and significantly lower than the *Control* scenario, respectively, and generally track the same trend as the *Control* scenario. In contrast, the sediment loading under the *Continued* and *Expanded* scenarios are almost identical to the *Control* scenario. In the case of all three contaminants, the *Full Implementation* scenario results in the lowest loading rates. Except in the case of sediment, which experiences a 10% increase, the loading under the *Full Implementation* scenario does not vary much across time.

Figure 5.7 displays the reduction in loading (in percentage) under the three conservation scenarios – *Continued*, *Expanded*, and *Full Implementation*.



(a)



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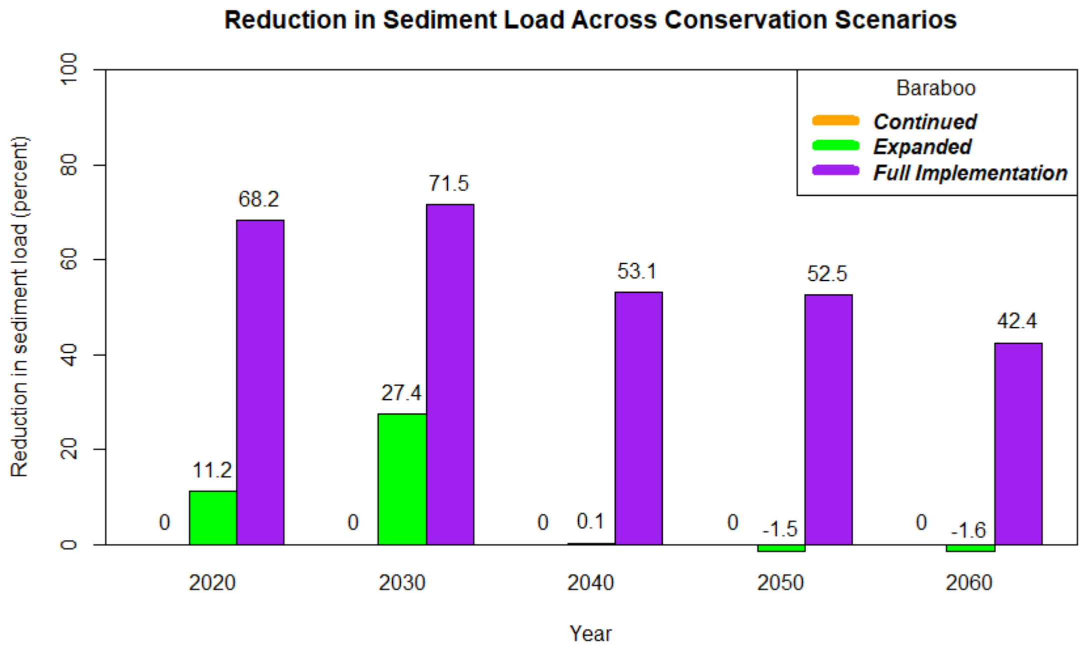


(c)

Figure 5.7. Reduction in (a) phosphorus, (b) nitrogen, and (c) sediment loading under three conservation scenarios as compared to the *Control* scenario.

Taking decadal snapshots at 2020, 2030, 2040, 2050, and 2060, reduction in the phosphorus loading under the *Continued* scenario ranges from 5.8% to 7.0%, while that of nitrogen ranges from 1.8% to 2.6%. Sediment runoff reduction under the *Continued* scenario is approximately zero. This suggests that if the ongoing RCPP conservation program is continued at the same scale, it will result in a relatively minor reduction in key contaminants by 2060.

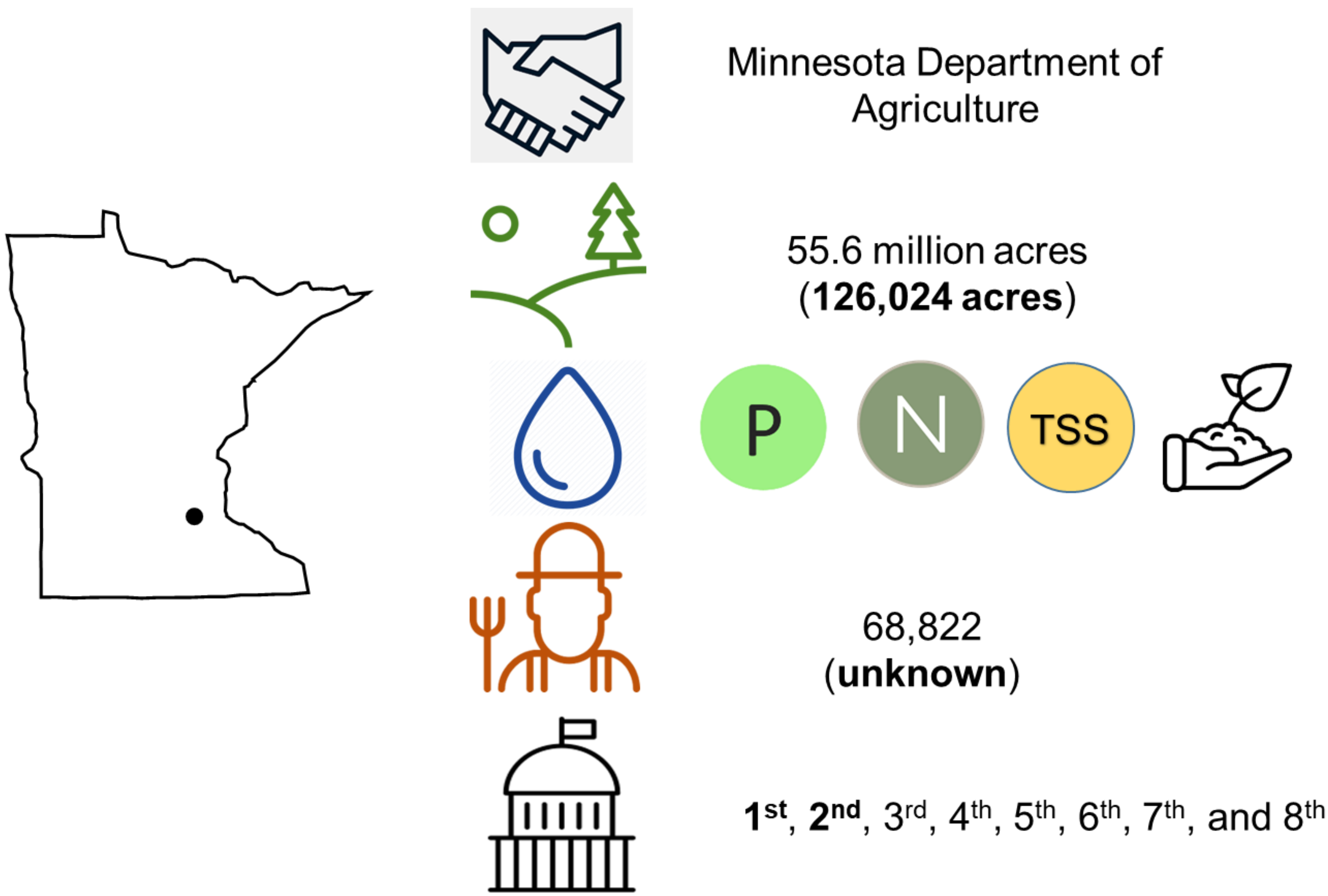
The *Expanded* scenario results in a significantly larger reduction for phosphorus (25.4% to 34.1%) and nitrogen (8.8% to 13.3%). In the case of sediment, the *Expanded* scenario results in a significantly larger reduction in the first two decades, rising from 12.3% in 2020 to 28.3% in 2030. However, this reduction disappears by 2040. It is unclear why this is the case, but it's possible that the changing climate, which will increase heat and precipitation, may result in changes in soil runoff patterns which will reduce the impacts of BMPs.

The *Full Implementation* scenario results in the largest reduction of all scenarios – ranging from 60.5% to 64.9% for phosphorus, 43.4 to 44.3% for nitrogen, and 42.5% to 71.5% for sediment. Large-scale expansion of the RCPP program across the watershed would be needed to significantly reduce the nutrient and sediment loading in the watershed and improve the water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations. However, it must be noted that despite implementing conservation on all farmland in the watershed in the *Full Implementation* scenario, average annual phosphorus concentration in the Baraboo River would fail to meet the Wisconsin standard of 100 μg/l during most of the study period.

Summary

The Baraboo River contains high levels of phosphorus loading, well above the state standard. The RCPP project aims to address water quality issues caused by high phosphorus and sediment in the River. The project identified priority landowners whose farms were responsible for the most nutrient runoff in the watershed. Predominantly, the RCPP project engaged in cover cropping, streambank processes, and land use conversion from farmland to rotational grazing. The project has been successful in averting soil runoff in the watershed. However, the project had no clear, achievable goals for phosphorus reduction, and it is unclear whether substantial progress was made towards lowering phosphorus loads or reducing the phosphorus concentration in water. The project's water quality monitoring plan is noticeably weak and relies on baseline monitoring conducted prior to the project origination and a round of monitoring conducted close to the project completion. However, the project was particularly effective in its outreach and education to the farmers. HAWQS modeling suggests an increase in phosphorus loading in the watershed over the next 40 years, and that the current conservation approach, as executed via the RCPP project, will only lead to modest reductions in the phosphorus loading. Large-scale expansion of the RCPP program across much of the watershed would be needed to significantly reduce the phosphorus loading in the watershed and improve the water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations.

Chapter 6: Minnesota, with Emphasis on the Middle Cannon River Watershed



Note: The numbers in bold in the above graphic refer to the Middle Cannon River watershed

About the Program

The Minnesota Agricultural Water Quality Certification Program (MAWQCP) is a voluntary approach for producers and agricultural landowners to become certified through a whole-farm evaluation that assesses the operation's risk to water quality and management of that risk. Producers that demonstrate superior water quality conservation management receive certification by the State of Minnesota and receive regulatory certainty for the duration of their 10-year certification. The MAWQCP Regional Conservation Partnership Program (RCPP) aims to establish and administer a state-level agricultural water quality certification program for export and adoption by states throughout the country.

Producers and agricultural landowners enter MAWQCP voluntarily and are subject to a risk assessment and approval by a certifying agent accredited by the Minnesota Department of Agriculture. The MAWQCP-RCPP is being conducted to develop and refine a model for operations and administration of a statewide program and to create a successful structure for whole-farm risk assessment and mitigation processes. Although the program is being implemented statewide and its goals differ in significant ways from other RCPP projects evaluated in this report, a HUC 10 watershed was selected to enable a watershed-scale analysis to comport with the structure of the rest of the report. The Middle Cannon River watershed was recommended by the project leaders for analysis as a representative watershed.

About the Watershed

The Middle Cannon River watershed covers an area of 126,024 acres located in southeast Minnesota (see Figure 6.1). The watershed covers Dakota, Rice, and Goodhue counties and contains the cities of Northfield, Faribault, and Cannon Falls. The Cannon River is classified as a State Recreational River in this area.

The Middle Cannon River is a segment of the Cannon River that is created by the Straight River joining the Upper Cannon River. The Middle Cannon eventually becomes the Lower Cannon River that then joins the Mississippi River. The Middle Cannon River watershed has five sub-watersheds, as described below (Table 6.1).

Table 6.1. Subwatersheds in the Middle Cannon River Watershed

Subwatershed (HUC 12)	HUC ID	Size (acres)
Crystal Lake-Cannon River	070400020601	24,074
Wolf Creek	070400020602	27,152
Heath Creek	070400020603	26,083
City of Northfield-Cannon River	070400020604	27,085
Lake Byllesby	070400020605	21,751

The Middle Cannon River watershed is dominated by cultivated crops (57%) and pasture (16%), but also includes a greater urban land use (8%) than some of its neighboring watersheds. The main goals of the MAWQCP RCPP are: 1) successful state-wide implementation of program operations and administration, and 2) successful mitigation and prevention of risks posed by agricultural operations on water quality using a whole farm, parcel-by-parcel basis.

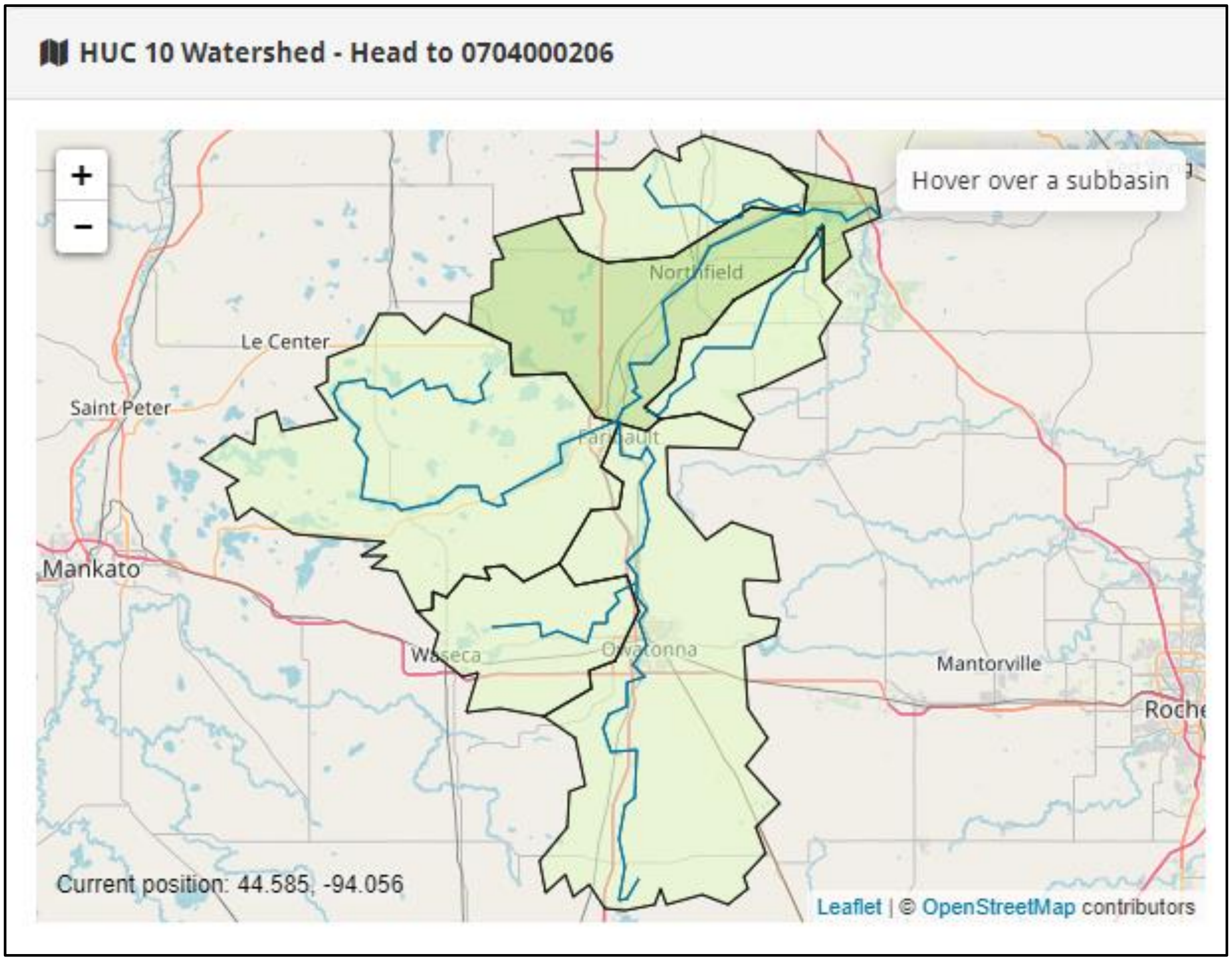


Figure 6.1. The Middle Cannon River watershed (highlighted), as visualized in the HAWQS software.

Drinking Water Sources

As reported by the Minnesota Department of Health Source Water Assessment, all public water supplies in Rice, Goodhue, and Dakota counties appear to be from groundwater.[10] All other drinking water is likely private wells.

Impairments in the State and the Watershed

The Minnesota Pollution Control Agency (MPCA) conducted substantial monitoring activities and found that approximately 40 percent of the surface waters across the state are impaired. They also reported that an estimated 86 percent of the pollution that impairs these waters is a result of nonpoint sources, like agricultural and urban run-off. The Cannon River watershed is particularly affected by high sediment and nutrient loads. Four streams that are also drinking water sources have elevated levels of nitrogen: Pine Creek, Little Cannon River, Spring Brook, and Trout Brook. The Middle Cannon River, along with 18 lakes in the larger Cannon River watershed are impaired due to high levels of mercury in fish. Although many lakes in the Cannon River watershed are nutrient-rich, the watershed includes a few lakes that stand out as high-quality resources for recreation.

[10] See https://swareport.web.health.state.mn.us/SWA_Default.html

Past Efforts

In 2013, the MAWQCP was undertaken as a pilot effort in four HUC-10 watersheds. Based on the success of that pilot program, a statewide initiative with support from NRCS and other partners was launched. Beginning in 2009, the Cannon River Watershed Management Strategy was launched to bring together existing knowledge about the watershed as well as plans and priorities of the local governments and state agencies to create an overarching strategy for the watershed. This was followed by the implementation of a watershed-wide monitoring approach in 2011. These efforts brought together several regional and statewide stakeholders, which would be later leveraged for the MAWQCP program.

Natural Resource Concerns

There are two principal natural resource concerns:

1. Protect water quality from non-point source pollution, including agriculture.
2. Soil health is the secondary concern addressed by the project, as it intrinsically linked to water quality.

The project has the following objectives to address the above concerns:

1. Making certification available on a volunteer basis to all of Minnesota's agricultural operations.
2. Providing technical assistance to producers on a crop-by-crop, field-by-field basis to address water quality issues and facilitate whole farm planning.
3. Prioritizing funding for the installment of on-the-ground conservation practices.
4. Building on infrastructure and administrative systems, and expanding the program statewide.

Key Project Partners

The project leader is the Minnesota Department of Agriculture, whose mission is to protect, enhance, and restore water quality in lakes, rivers and streams; to protect groundwater from degradation; and to protect drinking water sources. The MAWQCP is assisted by both state and federal agency partners, agricultural commodity groups, environmental organizations, and agribusinesses, some of which are listed in Table 6.2.

Table 6.2. A list of key project partners

Type	Organizations
Municipal / Local government	Minnesota's 88 Soil and Water Conservation Districts
State agencies	Minnesota Department of Agriculture, Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, Minnesota Board of Water and Soil Resources
Educational	University of Minnesota – College of Food, Agriculture and Natural Resource Sciences
Cooperatives	Central Farm Service
Trade groups	Minnesota Milk Producers Association, Minnesota Soybean Growers Association, MN Farmers Union, MN Farm Bureau, Minnesota Corn Growers Association
Industry	Land O'Lakes, Hormel Foods, Syngenta Field to Market
Environmental/ Conservation	Environmental Initiative, The McKnight Foundation, The Nature Conservancy, MN Soil Health Coalition, Pheasants Forever

Project Monitoring Plan

The environmental outcomes of this program will be measured by a number of different techniques including:

- Predictive modeling that is based on certification records
- Extrapolation of empirical data and conservation practice installations
- Surveys that gauge social measures like the producer's knowledge, attitudes, and practices

Project Practices

The RCPP has engaged in a number of practices such as cover cropping, grassed waterways, water and sediment control basins, grade stabilization structures, bioreactors, saturated buffers, constructing animal waste facilities, and implementing precision or variable rate application of pesticides and nutrients (Figure 6.2 and 6.3). Funds budgeted for constructing treatment wetlands remain unspent due to an inability to identify suitable land and willing landowners.

Figure 6.2 A water and sediment control basin under construction. Photo courtesy: Minnesota Department of Agriculture.

Producer Outreach and Activities

The MWAQCP's goal is to provide certification services on a voluntary basis to all agricultural operations within the state and demonstrate that the benefits thus obtained can be adapted to other states as well. The MDA has provided technical assistance to producers on a "crop-by-crop, field-by-field" basis to identify and address water quality issues. The MDA utilizes regional staff who work with individual farmers and farm managers to identify and address issues on the land (for instance, manure in close proximity to a waterway) that can potentially affect water quality. To undertake the land assessment, MDA utilizes an online risk assessment tool, developed in-house, to identify all risks to water quality. The tool analyzes nutrient management, tillage management, pest management, irrigation and water drainage management, and existing conservation practices, which guides subsequent on-site inspections, and helps mitigate all risks.

Figure 6.3. Buffer strip on a farm. Photo courtesy: Minnesota Department of Agriculture.

Accomplishments

As of December 31, 2018, the program has certified 692 farms, representing 450,696 acres of working lands. These farms have implemented 1,328 new BMPs. According to the MAWQCP, this has resulted in an annual reduction of 127 million pounds of soil runoff, keeping 50.2 million pounds of sediment and 30,000 pounds of phosphorous from entering waterbodies across Minnesota.

Figure 6.4. Owners of a certified farm in central Minnesota. Photo courtesy: Minnesota Department of Agriculture.

Efficiency and Efficacy

Since its inception, the MAWQCP has consistently been able to decrease the average cost (per acre) of farm certification, suggesting that the program currently benefits from scale economies and has room for further efficiency even as it expands (Figure 6.5). During the last year of operation, the program cost $28/acre (FY 2018). The program's per acre certification cost is well below other USDA programs in Minnesota such as the Conservation Reserve Program ($107/acre in FY 2017), the Environmental Quality Incentives Program ($204/acre in FY 2017), and the Conservation Reserve Enhancement Program ($8,603/acre in FY 2018).

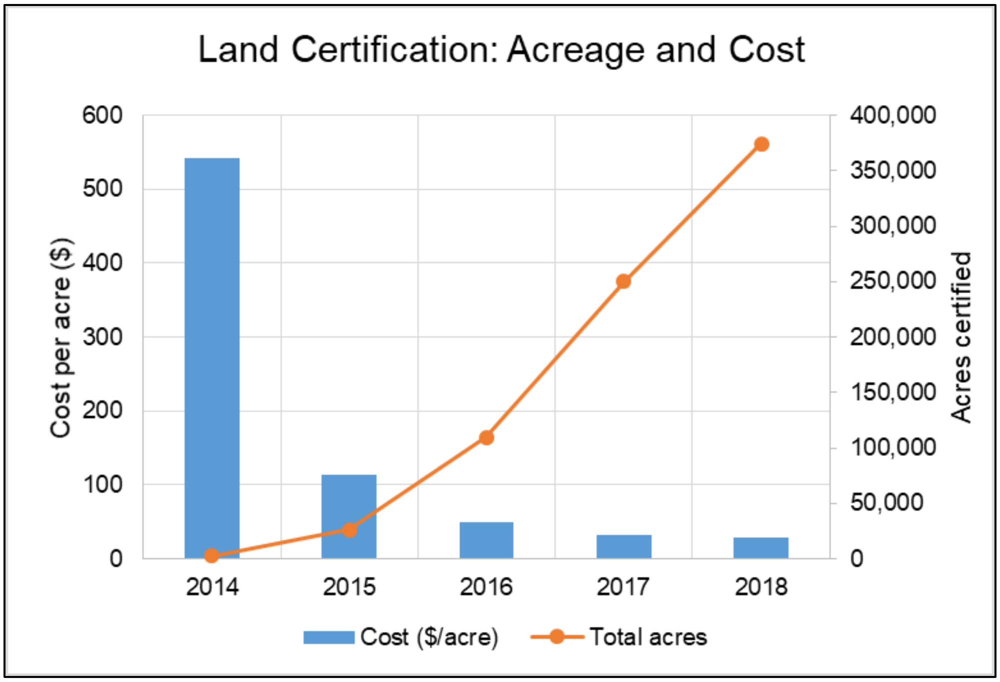


Figure 6.5. Land certified annually under MAWQCP and average cost of certification

Water Quality Monitoring Results

The MAWQCP uses geographic information system (GIS) mapping to record and track every acre assessed and certified, including existing and new conservation practices and management changes. Using established NRCS standards and calculation, each practice and management change is quantified for annual reductions, as seen earlier in the Accomplishments section of this chapter. The RCPP does not conduct any water quality monitoring as part of this project. As noted earlier in this chapter, the state's environmental agency, MPCA, conducts water quality monitoring for the State of Minnesota on a rotating watershed basis. Any benefits of conservation adoption across farms in a particular watershed, including the Middle Cannon River watershed, would likely be captured and quantified, if and when, monitoring is conducted by MPCA. But until such time, no aggregate water quality measurements are available to assess the effectiveness of this RCPP on this particular metric.

Economic Benefits

Minnesota's landscape is dotted with numerous lakes and rivers, and the state famously calls itself, "The Land of 10,000 Lakes." The Cannon River watershed attracts visitors for recreational activities such as camping, fishing, and boating. The River is classified as a State Recreational River in the Middle Cannon River stretch, and as a Minnesota Wild and Scenic River in the Lower Cannon River stretch. Lake Byllesby, an artificial lake that marks the transition from Middle to Lower Cannon is an important bird habitat. Improvements in water quality along the Middle Cannon River will enormously benefit the region as well as the entire state in its ability to continually attract visitors for tourism and recreation.

Long-term Viability

MAWQCP contracts last ten years, so any implemented BMPs are guaranteed to remain in effect for a decade after they are first implemented. Because the MAWQCP provides incentives to implement BMPs other than the RCPP cost-sharing, coverage should increase even if RCPP funding ceases. Based on the current progress of MAWQCP, the program will eventually reach a peak implementation of approximately two million acres of farmland, out of the 25 million acres in the state, assuming no program scale-up occurs. The average cost of certification has consistently gone down, allowing the program to use its resources efficiently. The program is working with the state's Department of Natural Resources to certify their 15,000 acres of cropland. The program offers opportunities to improve the sustainability of agricultural supply chains as the certification adds value to the products grown in certified farms. As of now, state funding is likely to continue until the program reaches its first 10-year mark, even in the absence of NRCS funding.

Project Highlight

This RCPP project is unique as it is not restricted to any particular watershed, but is being implemented statewide, by leveraging NRCS funds with a new state program. However, the key highlight of this project is simply a different viewpoint. While most conservation projects aim to improve water quality in a certain river (using a contaminant level as a reference) and work their way back to individual farms, the MAWQCP's conservation approach begins and ends at the farm. The project's goals is to work on a field by field and crop by crop basis to assess the agricultural processes that place water quality at risk. Although the project doesn't prioritize improvements in water quality indicators (for e.g., nitrate and phosphorus levels in the nearby stream), the project leaders believe that changing farm practices on each individual farm will collectively result in water quality improvements, which will eventually be noticeable on watershed-level indicators.

In doing this, the MAWQCP overcomes two key shortcomings of traditional conservation programs. Typically, conservation programs, including the RCPP, provide limited-duration payments to farmers to adopt one or more practices whose continuity is not guaranteed or expected once the funds run out. These programs also implement conservation practices that are restricted to a portion of the farm. The MAWQCP ensures farmers are provided guidance on all the risks affecting water quality on their farm, but support is only provided if all of the recommended conservation practices are applied wholesale, rather than voluntarily choosing one or some of them. In return, farmers receive a certification, which can be a value addition to the farm's products, as well as a 10-year regulatory certainty that no new regulations will be applicable to that land.

HAWQS Modeling Results

Presented below are results for water quantity and quality in the Middle Cannon River watershed obtained from the HAWQS model.

Flow and Water Yield

A temporal plot of surface flow (referred to as just 'flow' here) at the outlet of the watershed suggests a rapid increase until 2035, after which the flow undergoes an oscillatory pattern (Figure 6.6). A review of the monthly distribution of water yield (which includes subsurface flow, in addition to the surface flow) reveals additional patterns (Figure 6.7). Water yield is compared across three time periods: 1980-2010 (historical data), 2010-2040 (near-term future), and 2040-2070 (long-term future). Water yield is expected to increase by 87% in the near-term and 73% in the long-term, as compared to historical data. But this increase is not uniformly spread out. A disproportionate increase is expected to occur in the winter (Dec-Feb) and spring (Mar-June) seasons (201% and 143%, respectively, in the near-term and 268% and 136%, respectively, in the long-term).[11] This is consistent with a warming climate which results in higher precipitation (in the form of snow in winter). However, the snow will readily melt as summer approaches and temperatures rise. As a result, water yield will diminish in the subsequent months. This lopsided distribution of water yield across seasons will result in extreme flooding during the spring, not unlike the one being experienced in the region in 2019, and drought during the summer and fall seasons.

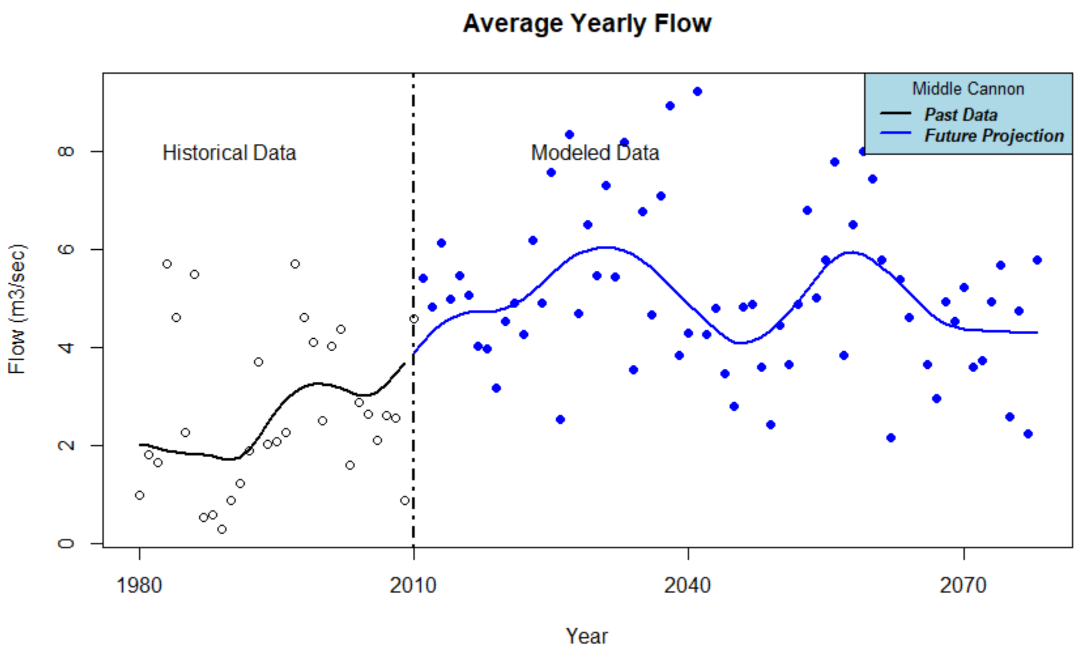


Figure 6.6. Average yearly flow (m^3/s) at the outlet of the Middle Cannon River watershed. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

[11] Since the winter season accounts for only a small proportion of the annual water yield in the Middle Cannon River watershed, not much should be read into the 200+% increase in the near-term and long-term. The impact of the spring water yield is likely to be more substantial.

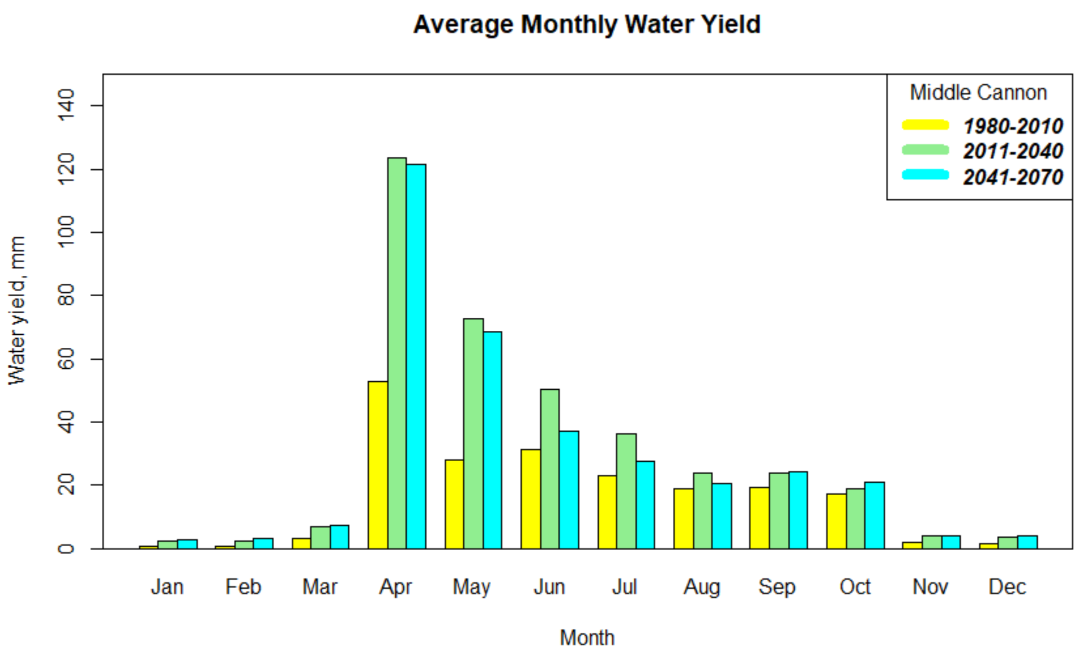
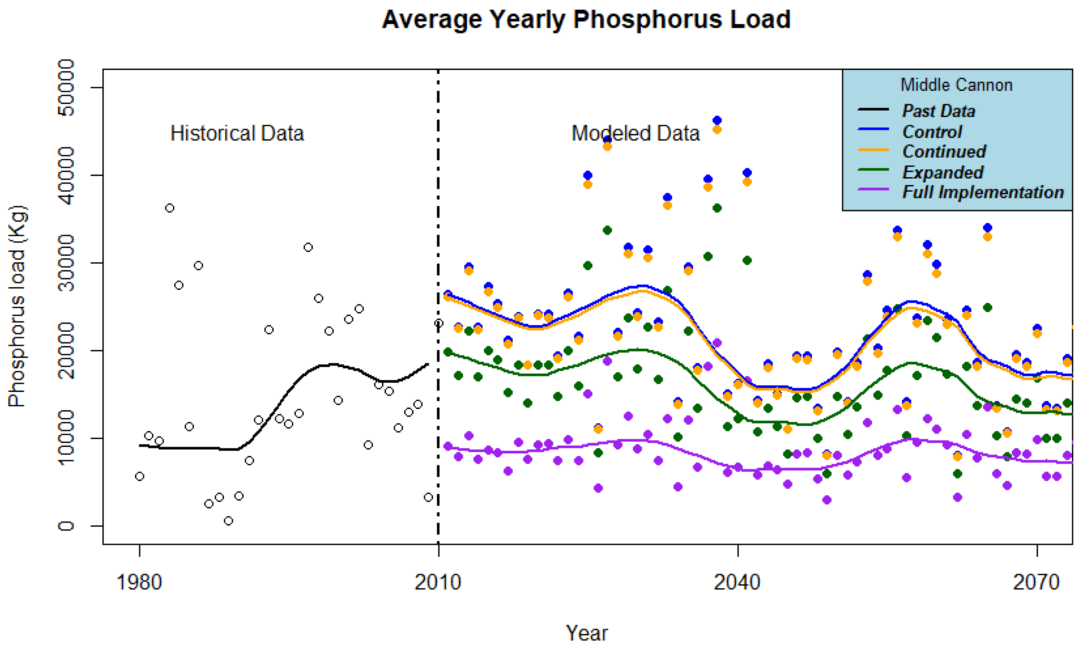


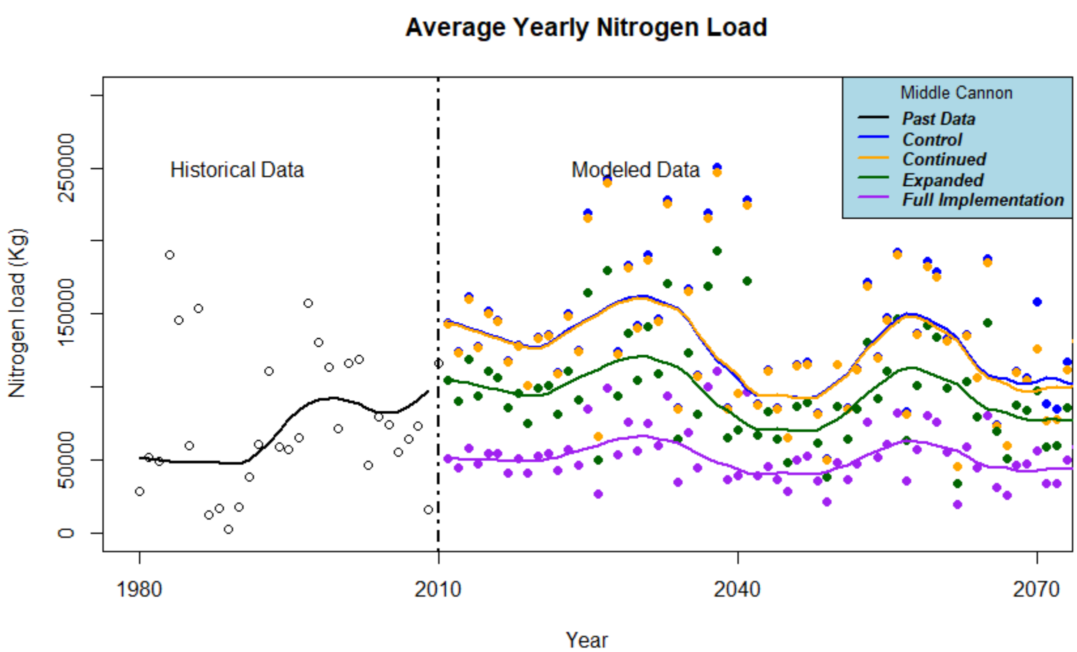
Figure 6.7. Average monthly water yield (mm) at the outlet of the Middle Cannon River watershed across three time periods.

Contaminant Loading

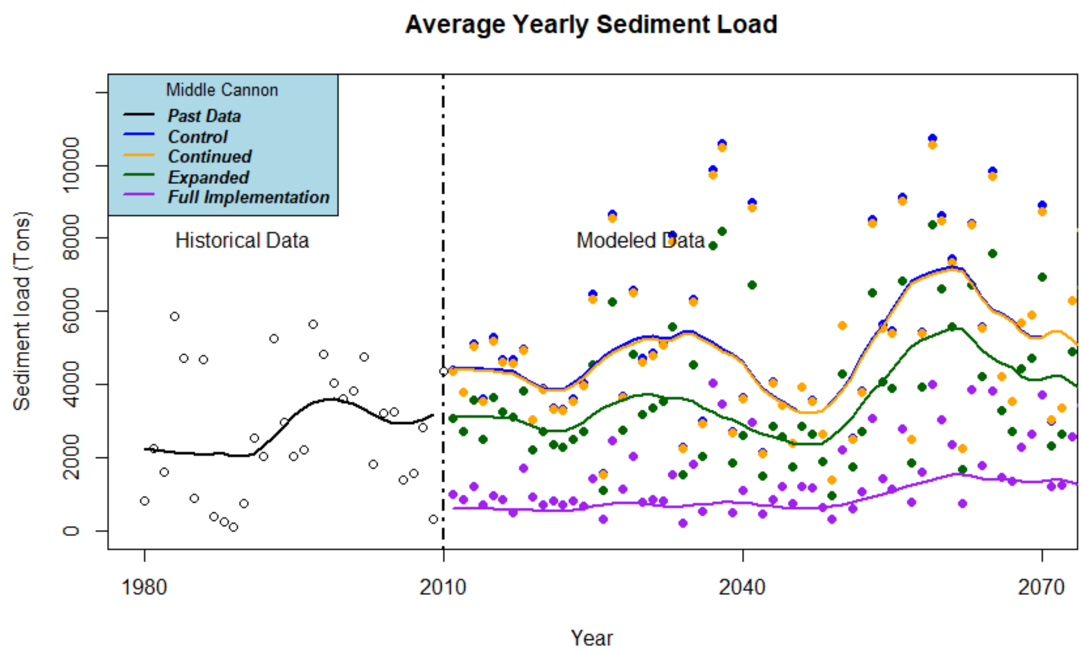
Figure 6.8 shows the average annual loading for phosphorus (kg), nitrogen (kg), and sediment (metric ton) at the outlet of the Middle Cannon River watershed under the four scenarios described earlier in the Methods section.


Average Yearly Phosphorus Load
Historical Data
Modeled Data
Middle Cannon
Past Data
Control
Continued
Expanded
Full Implementation
Phosphorus load (Kg)
0
10000
20000
30000
40000
50000
1980
2010
2040
2070
Year

(a)


Average Yearly Nitrogen Load
Historical Data
Modeled Data
Middle Cannon
Past Data
Control
Continued
Expanded
Full Implementation
Nitrogen load (Kg)
0
50000
150000
250000
1980
2010
2040
2070
Year

(b)



(c)

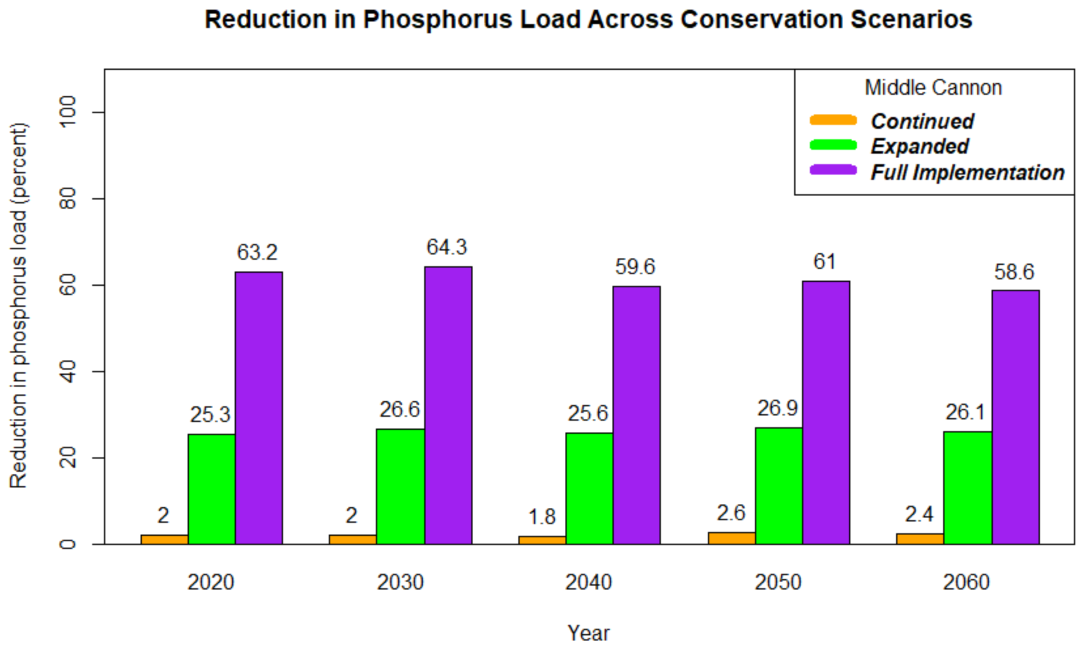
Figure 6.8. Average annual load for (a) phosphorus, (b) nitrogen, and (c) sediment, at the outlet of the Middle Cannon River watershed under four future scenarios. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

Under the *Control* scenario, annual loading for phosphorus, nitrogen, and sediment displays wide year-to-year variations, but the smoothing curve identifies an oscillating pattern. It must be noted that the smoothed water quality data get less precise toward the end of the temporal scale due to overfitting, and hence modeling results beyond 2070 should be treated with caution.

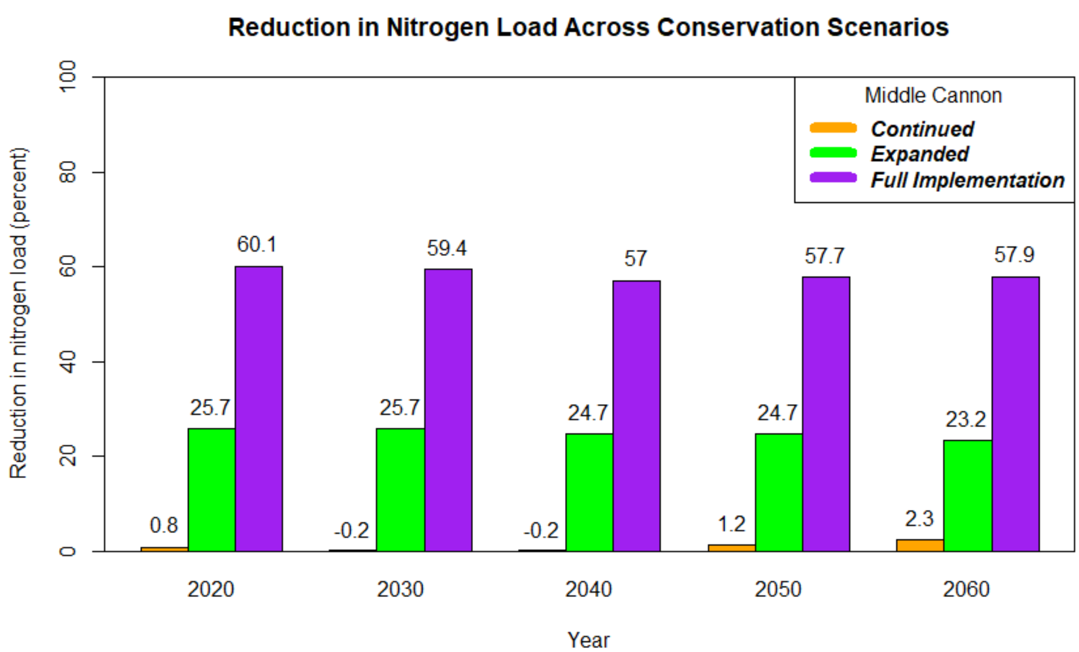
According to the model, during the period 2020-2060, both phosphorus and nitrogen loading are expected to decrease by 20% (from 25,101 kg to 20,134 kg for P and from 146,158 kg to 116,624 kg for N, respectively). Sediment loading, however, is expected to increase by 38% (from 4,522 metric tons to 6,236).

Phosphorus, nitrogen, and sediment loading under the *Continued* scenario are almost identical to the *Control* scenario but are significantly different in the *Expanded* scenario. However, both generally track the same trend as the *Control* scenario. In the case of all three contaminants, the *Full Implementation* scenario results in the lowest loading rates and they do not vary much across time.

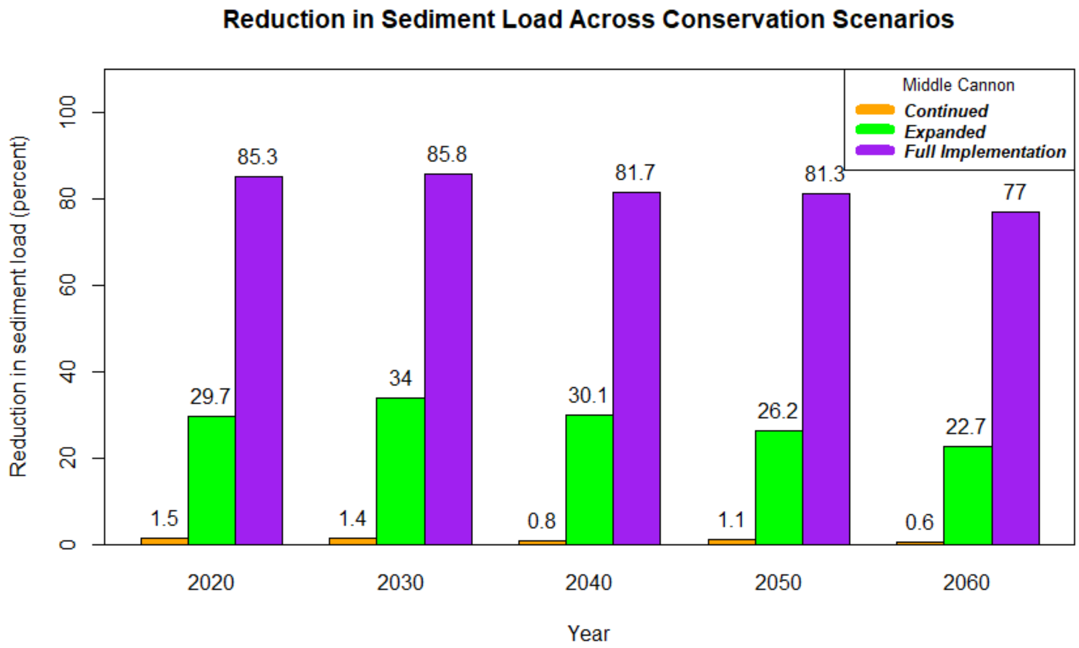
Figure 6.9 displays the reduction in loading (in percentage) under the three conservation scenarios – *Continued*, *Expanded*, and *Full Implementation*.


Reduction in Phosphorus Load Across Conservation Scenarios
Middle Cannon
Continued
Expanded
Full Implementation
Reduction in phosphorus load (percent)
0
20
40
60
80
100
2
25.3
63.2
2
26.6
64.3
1.8
25.6
59.6
2.6
26.9
61
2.4
26.1
58.6
2020
2030
2040
2050
2060
Year

(a)


Reduction in Nitrogen Load Across Conservation Scenarios
Middle Cannon
Continued
Expanded
Full Implementation
Reduction in nitrogen load (percent)
0
20
40
60
80
100
0.8
25.7
60.1
-0.2
25.7
59.4
-0.2
24.7
57
1.2
24.7
57.7
2.3
23.2
57.9
2020
2030
2040
2050
2060
Year

(b)



(c)

Figure 6.9. Reduction in (a) phosphorus, (b) nitrogen, and (c) sediment loading under three conservation scenarios as compared to the *Control* scenario.

Taking decadal snapshots at 2020, 2030, 2040, 2050, and 2060, reduction in the phosphorus loading under the *Continued* scenario ranges from 1.8% to 2.6%, while nitrogen ranges from -0.2% to 2.3%. Sediment runoff reduction under the *Continued* scenario ranges from 0.6% to 1.5%. This suggests that if the ongoing RCPP conservation program is continued at the same scale, it will result in a relatively minor reduction in key contaminants by 2060.

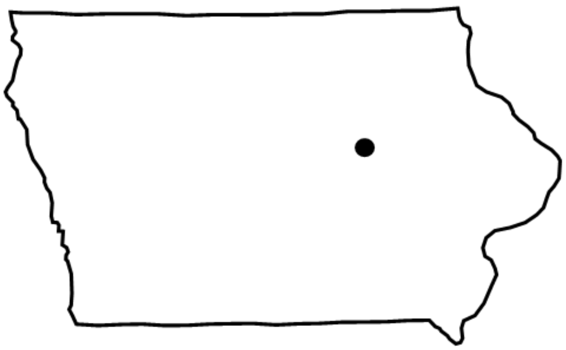
The *Expanded* scenario results in a significantly larger reduction for phosphorus (25.3% to 26.9%), nitrogen (23.2% to 25.7%), and sediment (22.7% to 34%). The *Full Implementation* scenario results in the largest reduction of all scenarios – ranging from 58.6% to 64.3% for phosphorus, 57% to 60.1% for nitrogen, and 77% to 85.8% for sediment. In the case of sediment, across all three scenarios, the reduction is the highest in the first two decades, and then slowly reduces over time. It is unclear why this is the case, but it's possible that the changing climate, which will increase heat and precipitation, may result in changes in soil runoff patterns which will reduce the impacts of BMPs.

Large-scale expansion of the RCPP program across much of the watershed would be needed to significantly reduce the nutrient and sediment loading in the watershed and improve the water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations.

Summary

The Minnesota Agricultural Water Quality Certification Program (MAWQCP) is a voluntary statewide project that assesses producers and agricultural landowners' operation risk and water quality management, and allows those who have superior water quality management to become certified by the state of Minnesota. The main goals of the MAWQCP RCPP are to successfully implement the certification program statewide, and to mitigate and prevent risks posed by agricultural operations on water quality using a whole farm, parcel-by-parcel basis. Any water quality benefits arising from this program are considered vital, but incidental to the project and thus not tracked. The RCPP engaged in a number of practices such as cover cropping, grassed waterways, water and sediment control basins, grade stabilization structures, bioreactors, saturated buffers, constructing animal waste facilities, and implementing precision or variable rate application of pesticides and nutrients. As of December 31, 2018, the program has certified 692 farms, representing 450,696 acres of working lands across the state of Minnesota. This has resulted in an annual reduction of 127 million pounds of soil runoff, keeping 50.2 million pounds of sediment and 30,000 pounds of phosphorous from entering waterbodies across Minnesota. The Middle Cannon River watershed, which is affected by high sediment and nutrient loads, was selected for analysis as a representative watershed. HAWQS modeling suggests a decrease in phosphorus and nitrogen loading but a significant increase in sediment loading in the watershed over the next 40 years, and that the current conservation approach, as executed via the RCPP project, will lead to only modest reductions in the contaminant loading. Large-scale expansion of the RCPP program across much of the watershed would be needed to significantly reduce the contaminant loading in the watershed and improve the water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations.

Chapter 7: Middle Cedar River Watershed



City of Cedar Rapids

135,000 acres

435

1st

About the Watershed

The Middle Cedar watershed covers an area of 1.5 million acres located in east-central Iowa, and is part of the larger Cedar River watershed (Figure 7.1). The largest municipality in this watershed is the city of Cedar Rapids, which relies on the Cedar River as a source of drinking water, among other uses.

The Cedar River joins the Iowa River, which is a tributary to the Mississippi River. The RCPP project is targeted in five HUC 12 watersheds located in Benton, Tama, and Black Hawk counties (Table 7.1).

Table 7.1. Subwatersheds in the Middle Cedar River watershed

Subwatershed (HUC 12)	HUC ID	Size (acres)
Rock Creek-Cedar River	070802051001	24,365
Pratt Creek	070802051101	31,696
Wolf Creek	070802050809	36,220
Miller Creek	070802050905	19,324
Headwaters Miller Creek	070802050904	23,137

Note: The Rock Creek-Cedar River, Pratt Creek, and Wolf Creek subwatersheds are part of the Benton/Tama Nutrient Reduction Demonstration Project, and the Miller Creek and Headwaters Miller Creek sub-watersheds are part of the Miller Creek Water Quality Initiative.

The primary land use in the Middle Cedar watershed is row crop, particularly corn and soybeans. The goal of the RCPP project is to support and expand ongoing implementation of projects in the watershed to reduce nutrient impacts in Iowa's waters.

Drinking Water Sources

The city of Cedar Rapids draws its drinking water from shallow wells along the Cedar River, and 70-75% of that water is distributed to large industrial users such as Cargill, PepsiCo and General Mills. The inability to provide safe and high-quality water to these industries could cause an economic devastation in the region.

Impairments in the Watershed

Relative to its land area and water yield, Iowa contributes a disproportionately large fraction of nutrients to the Mississippi River Basin (Jones et al., 2018). The EPA listed upstream Cedar River as impaired in 2004 on its 303(d) list for nitrate. A TMDL was then established in 2006 to target a 35% nitrate reduction. According to this TMDL, current loading to the impaired section of the Cedar River is estimated at 28,561 tons of nitrate-N/year. The intake water for Cedar Rapids consistently records high levels of nitrate, necessitating blending with low-nitrate water from other sources (Royte, 2017). The Iowa Nutrient Reduction Strategy has also implemented a statewide reduction of total nitrogen and total phosphorus by 45% to comply with the 2008 Gulf Hypoxia Action Plan (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2008).

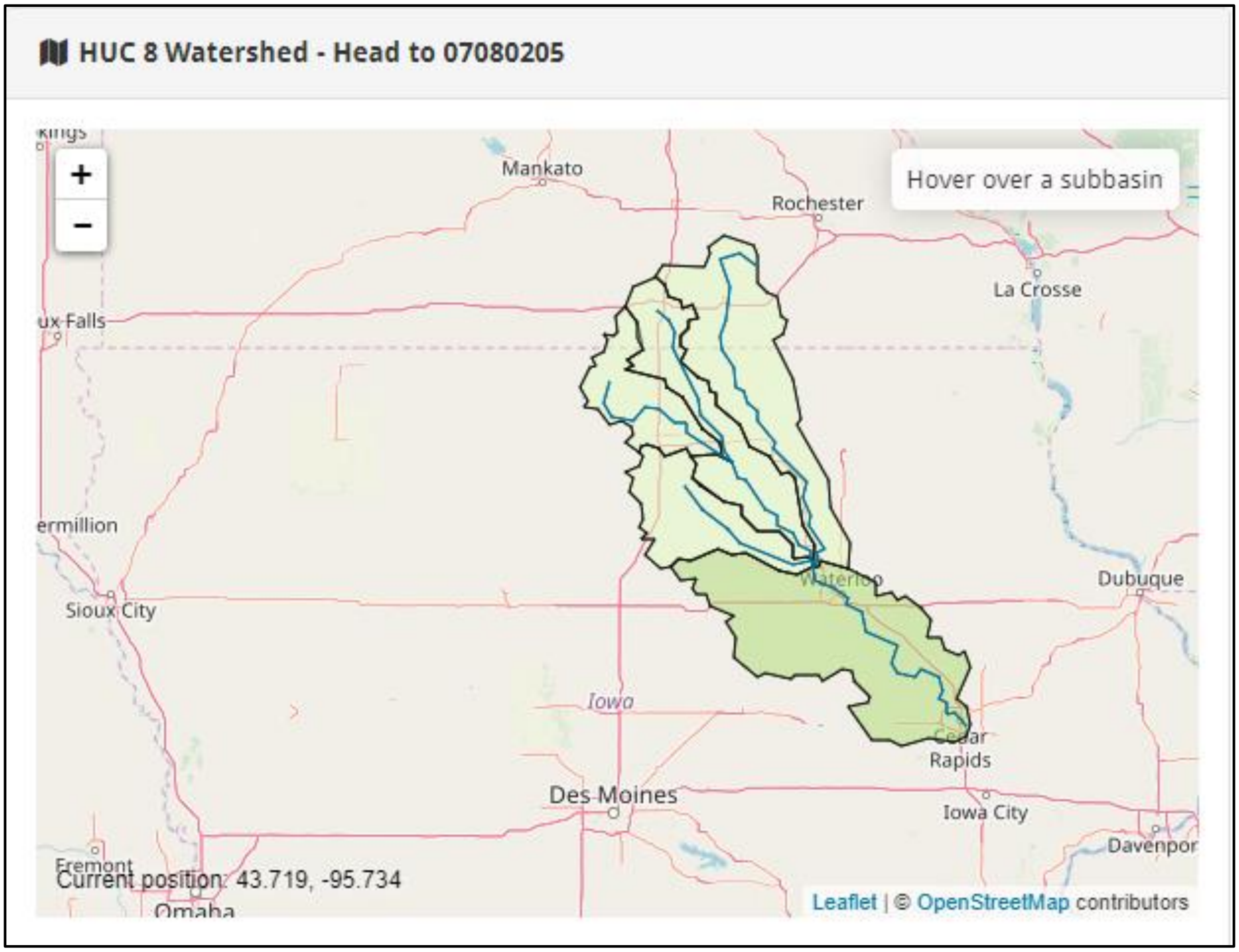


Figure 7.1. The Middle Cedar River watershed (highlighted in green), as visualized in the HAWQS software.

Past Efforts

The Middle Cedar watershed is designated as one of nine priority watersheds by the Iowa Water Resources Coordinating Council (IWRCC) under the Iowa Nutrient Reduction Strategy.[12] Under this framework, $4.1 million was dedicated by the state of Iowa to establish watershed projects across the nine watersheds. Middle Cedar received funding for two projects in 2014 – the Miller Creek Water Quality Initiative and the Benton/Tama Nutrient Reduction Demonstration Project – which are currently underway. The Middle Cedar Partnership Project (MCPP), which brought together various stakeholders in the watershed, led by the City of Cedar Rapids, sought RCPP funding to expand the two extant programs in the five sub-watersheds of the Middle Cedar watershed.

[12] See Iowa Nutrient Reduction Strategy Annual Progress Report, 2014 at http://www.nutrientstrategy.iastate.edu/sites/default/files/documents/1408draftpr.pdf

Natural Resource Concerns

The key resource concerns in the Middle Cedar watershed are:

- Poor water quality, particularly from high nitrate loads. Cedar Rapids relies on the Cedar River as a source for drinking water, making water quality a high priority issue in the watershed.
- Address flood risk. Middle Cedar watershed includes multiple communities that have experienced substantial flood damage and economic devastation in the recent past. Of particular note, Cedar Rapids sustained $5 billion in damages from a flood event in 2008.
- Deteriorating soil health. This is critical to sustain high levels of agricultural productivity.

In order to address these resource concerns, the project has three objectives and actions to achieve success.

1. Develop watershed plans to include monitoring and evaluation to optimize the deployment of effective best management practices.
2. Implement BMPs through financial and technical assistance to reduce nitrate loads to the Cedar River. The project's goal is to reduce nitrate by 55 tons per year, or about 3% of the nitrate loads from the project watersheds. Leveraged projects and practices would reduce another 65 tons per year, allowing total reduction to be about 6% in the project area.
3. Conduct outreach activities with landowners/producers in the five HUC 12 watersheds and conduct project administration and reporting to properly manage overall project objectives. Outreach such as field days, webinars, or mailings are important to engage landowners/producers in the area.

The RCPP will ensure that all producers and landowners are contacted a minimum of five times during the project period. This is anticipated to increase the adoption of conservation practices throughout the Middle Cedar watershed.

Key Project Partners

The project leader is the City of Cedar Rapids Utilities Department – Water Division. Prior to the RCPP, the city has a history of collaboration with upstream stakeholders to improve soil health and water quality. They are assisted in this RCPP project by a host of other local and regional stakeholders, some of whom are listed in Table 7.2.

Table 7.2. A list of key project partners

Type	Organizations
Municipal / Local government	
State agencies	Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources
Educational	Iowa State University Extension Service, Coe College
Cooperatives	Benton Soil and Water Conservation District, Tama Soil and Water Conservation District, Black Hawk Soil and Water Conservation District
Trade Groups	Iowa Soybean Association, Iowa Pork Producers Association, Iowa Corn Growers Association
Industry	DuPont Pioneer
Environmental/ Conservation	Sand County Foundation, The Nature Conservancy

Project Monitoring Plan

Since 1999, the Iowa Department of Natural Resources (IDNR) has run a statewide Ambient Stream Monitoring (ASM) program that conducts monthly water quality testing for nitrogen, phosphorus, and other indicators. In the Middle Cedar watershed where RCPP project is under implementation, there are three sites that are part of the ASM program (Beaver Creek near Cedar Falls, Wolf Creek at La Porte City, and Black Hawk Creek at Waterloo). The Benton/Tama Nutrient Reduction Demonstration Project monitors water quality weekly from tile outlets and other tributaries of the Middle Cedar River. The Miller Creek Water Quality Initiative monitors water quality conditions from conservation practices and tile outlets.

Partners tracked implementation of BMPs and used models to estimate cumulative environmental benefits annually. Tile outlet monitoring was conducted at ten locations to track field-scale outcomes of practice implementation. Additionally, six tributary locations throughout the watershed were baseline monitored. Finally, landowners will be surveyed to gauge the changes in attitudes and knowledge regarding conservation practices during the project period.

Project Practices

To address the issue of water quality and soil health in the watershed, nutrient reduction practices were implemented in the chosen HUC 12 watersheds. The primary activity under the RCPP was sponsoring cover cropping, of which 17,382 acres were contracted as of the end of 2018 (Figure 7.2). Other conservation activities included implementing bioreactors, saturated buffers, wetland reserve easement, and nutrient management.

Figure 7.2. Cover crops on a farm. Photo credit: Iowa Soybean Association.

Producer Outreach and Activities

There are an estimated 435 producers and landowners in the project area, 100% of which were eligible for the RCPP. The conservation work prior to the RCPP in the Miller Creek and Benton/Tama County projects experienced high interest and participation. If RCPP were to expand to additional watersheds, it is likely there will be a similar eagerness and participation from farmers/landowners., The RCPP planned to retain the current participants of these projects, along with enticing additional landowners and producers.

According to the project leaders, rural landowners in Iowa include a large segment of women that may be interested in leasing or renting their property for production. Accordingly, the RCPP project incorporated targeted educational and outreach efforts with this landowner group in mind. Additionally, the project also targeted land areas within the watershed with the following characteristics:

- Highly erodible soil types
- Silage or seed corn production
- Hydric soil types, which may indicate pattern tiled or higher percent of tiled areas
- Fall tilled
- Fall applied nitrogen

Accomplishments

The RCPP has contracted 17,382 acres of cover crops by December 2018, almost doubling the amount of cover crops from the previous year's total of 9,958 acres. Additionally, the RCPP developed five barrier strips, covering an area of 50 acres each, and two bioreactors, which filter water runoff from between 40 and 70 acres (see Figures 7.3 and 7.4). Partner projects have also sponsored several thousand acres of cover cropping, and some farmers have even begun voluntarily cover cropping without compensation, a positive sign for future sustainability of the conservation program in the watershed. The project is in the process of designing a wetland that is located outside the RCPP project area, but within the Middle Cedar watershed.

Figure 7.3. Saturated buffer. Photo credit: Iowa Soybean Association.

Efficiency and Efficacy

The RCPP project engaged in large amounts of cover cropping, which cost $46.72 to $72.47 per acre per year. The Middle Cedar RCPP estimates that this cover cropping reduces pollution at an estimated cost of between $1,640 and $26,800 per ton of nitrate-nitrite removed per year.[13] Fields treated with cover crops showed small (~8%) improvements in runoff nitrogen content. Estimated program costs for the 2018 year were $1,032,170. Based on the nitrogen reduction thus far, it appears that the program is on track to meet its goal of 55 tons of nitrogen reduced per year by 2020.

Figure 7.4. The construction of a bioreactor. Photo credit: Iowa Soybean Association.

[13] This large variation is due to uncertainty on the part of the Middle Cedar RCPP in the effectiveness of cover cropping. Source: Middle Cedar RCPP proposal

The biggest successes of the program were in edge-of-field practices, such as barrier strips and, in particular, bioreactors, as they accomplished greater water quality improvements. Bioreactors decreased nitrogen content in the runoff by approximately 41%, a much larger improvement than that offered by cover crops (Figure 7.5). Additionally, bioreactors are far more cost-effective than cover cropping – despite larger startup costs, bioreactors require little maintenance and have an estimated 20-year lifespan, meaning annualized costs per acre are substantially lower than cover cropping. An expansion of the RCPP with a focus on edge-of-field practices will likely be more effective than one focused heavily on cover cropping, as most conservation programs typically do.

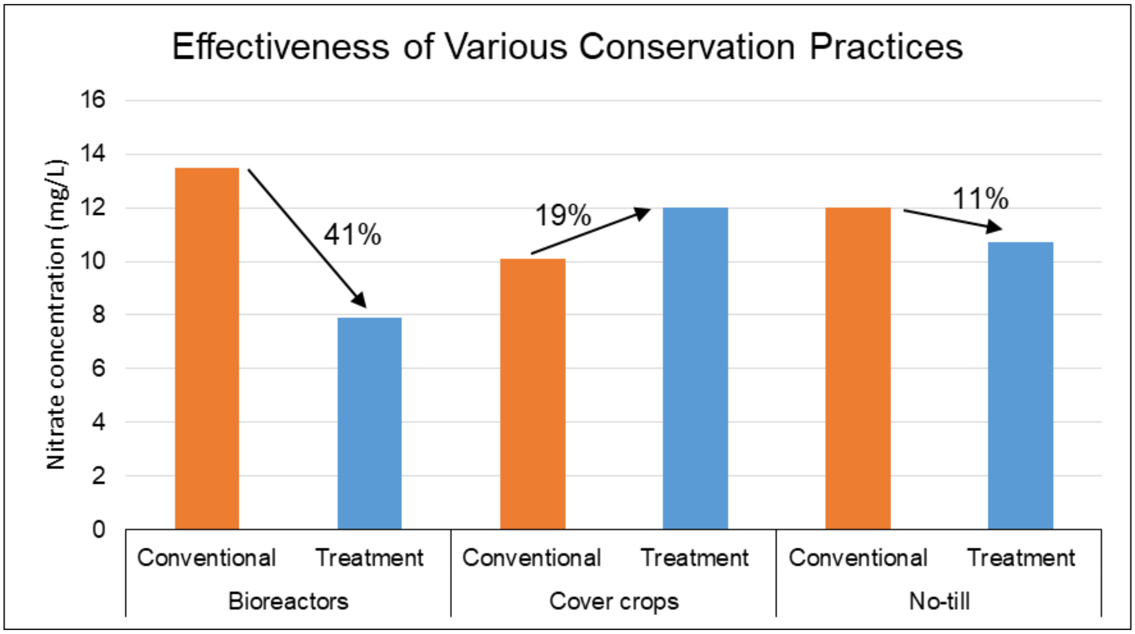


Figure 7.5 Changes in runoff nitrate concentration from different practices, with bioreactors showing the largest reduction. Adapted by the authors using source image provided in the Benton/Tama 2018 Water Monitoring Report.[14]

Water Quality Monitoring Results

The Iowa DNR's Ambient Stream Monitoring (ASM) program monitors several indicators; the most relevant for the Middle Cedar watershed was inorganic nitrogen, which includes both nitrate and nitrite (Iowa DNR, 2019). Presented below are ASM program data for inorganic nitrogen over a nine-year period (January 2010 to December 2018) from three monitoring sites in the Middle Cedar watershed (Figure 7.6). The data at the three sites track one another very closely. There is no singular trend across the nine-year period, but a few things stand out. The Spring of 2013 recorded extremely high values of nitrogen. Although the next few years recorded levels lower than that observed in 2013, the average concentrations steadily increased until 2016, when they started decreasing. It is unclear if this decreasing trend since 2016 is entirely attributable to the precipitation pattern or is impacted by the conservation efforts in the watershed.

[14] The Benton/Tama Nutrient Reduction Project collected 284 samples in 2018 to assess runoff from specific farms

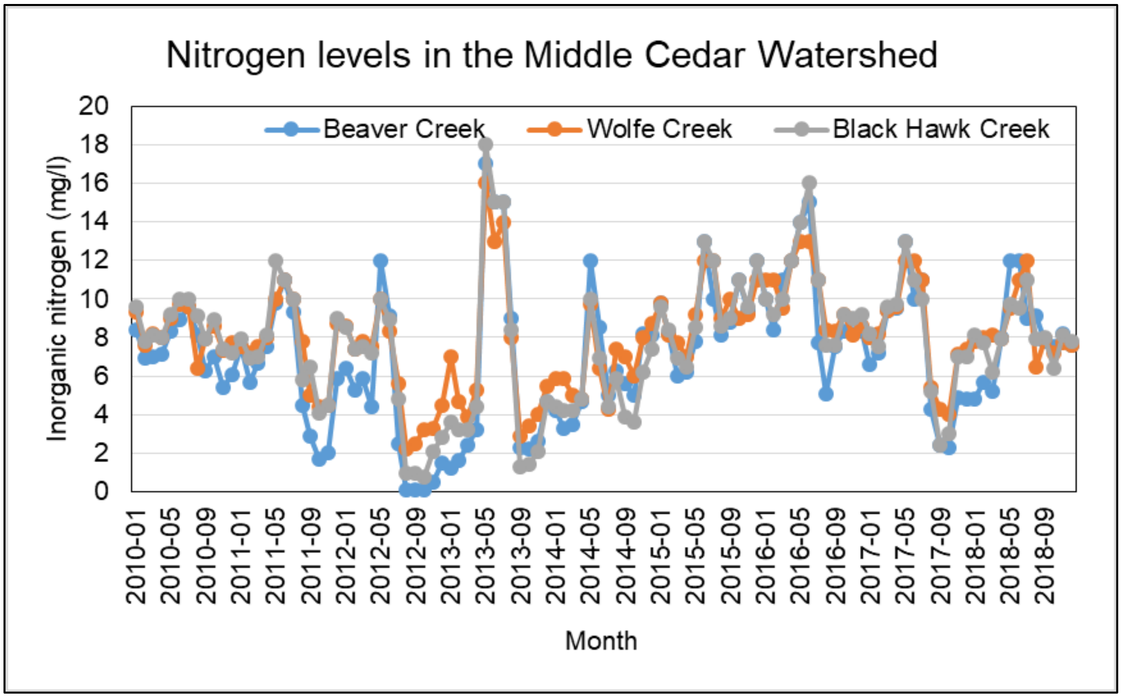


Figure 7.6. Monthly average nitrogen levels at three sites in the Middle Cedar River watershed for the period covering January 2010 to December 2018. Source: Iowa DNR's Ambient Stream Monitoring (ASM) program[15]

Monitoring conducted by the project partners suggest that nitrate levels have dropped over the course of the project, and several sub-watersheds transitioned from being above the 10 mg/L threshold to below it (Figure 7.7). Notably, the edge-of-field monitoring results from drained tiles show consistent and significant year-to-year declines, suggesting effectiveness of bioreactors and buffer strips.

[15] See https://www.iowadnr.gov/Environmental-Protection/Water-Quality/Water-Monitoring/Streams

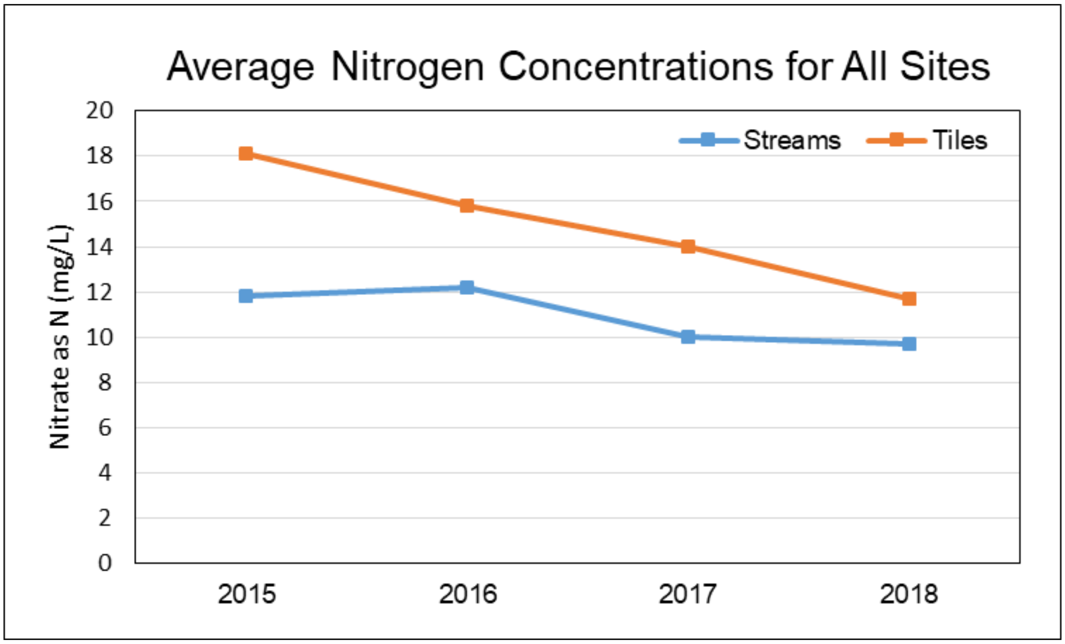


Figure 7.7. Average nitrogen concentrations for all Cedar River sites surveyed by year show consistent declines over the project period. Adapted by the authors using source image provided in the Benton/Tama 2018 Water Monitoring Report.[16]

Economic Benefits

Anecdotal evidence from some farmers suggests that the use of cover crops not only holds nutrients, but it also reduces the need for commercial fertilizers and weed control due to the mulching effect from cover crop residue.[17] Moreover, it improves water retention in soils during wet conditions. Project leaders believe that this ability to retain water would prove beneficial in flood mitigation in a region that experiences frequent flooding. Tiled drains remove excess water from the soils by short-circuiting the natural residence time of water, resulting in excess nitrate and high peak flows in downstream rivers. By implementing long-term solutions like bioreactors, the project is also mitigating the pernicious water quality impacts of tiled drains.

Long-term Viability

Contracting cover crop was the primary program activity. Cover crop contracts require periodic renewal and they will have to be discontinued when funding expires, and therefore are difficult to scale up in the long term. The program's educational and technical assistance are likely to have long-term benefits. The use of bioreactors and barrier strips produces benefits which persist for several decades, and therefore are better suited for scaling up and achieving long-term results.

In 2018, the Iowa legislature created a Water Service Excise Tax (WET) through a new law, SF 512, effective July 1, 2018 (https://tax.iowa.gov/WET). Under the previous system, sale of water in Iowa was subject to a 6% state sales tax. Under the new law, sale of water is exempt from the

[16] The Benton/Tama nutrient reduction project collected water quality samples from 23 sites to assess changes in nutrient concentration over several years
[17] See www.ipm.uconn.edu/documents/view.php?id=23

state sales tax, but it is subject to a 6% excise tax. Because the new excise tax is identical to the earlier sales tax, water use patterns shouldn't change. The money from this new tax goes to two funds – the Water Quality Infrastructure Fund and the Water Quality Assistance Fund – which, in turn, will provide money to the Department of Agriculture and Land Stewardship (IDALS) and the Iowa Finance Authority. These funds will be specifically used to improve water quality in Iowa, presumably supporting projects such as this one.

Project partners are currently exploring the feasibility of a pay-for-success model, which would create a "framework for cities and farmers, along with private investors, to work together to solve water quality and flood-related problems through outcome-based financial incentives" (Cedar Rapids, 2019). A feasibility study is underway and will identify mechanisms supporting upstream water quality improvements that are cheaper than infrastructure improvements at water treatment plants.

Project Highlight

The Middle Cedar RCPP has a very strong data collection plan, and the information collected enables the stakeholders to clearly track trends in the watershed. Data collection is extensive, with over fifty sites sampled every year. In addition, the project monitors several different measures of water quality including nitrate, phosphorus, sediment, and bacteria. That, coupled with a history of engagement with farmers and industries in the region, makes for a strong collaborative project. Cedar Rapids is a somewhat unique water utility with a large base of industrial customers, in addition to serving more than 125,000 residents in the city. The city has engaged farmers by emphasizing the connections between the water they use and food they grow with the international agri-business market in the Cedar Rapids area.

HAWQS Modeling Results

Presented below are results for water quantity and quality in the Middle Cedar River watershed obtained from the HAWQS model.

Flow and Water Yield

A temporal plot of surface flow (referred to as just 'flow' here) at the outlet of the watershed suggests a nearly constant flow with minor variations (Figure 7.8). A review of the monthly distribution of water yield (which includes subsurface flow, in addition to the surface flow) reveals additional patterns (Figure 7.9). Water yield is compared across three time periods: 1980-2010 (historical data), 2010-2040 (near-term future), and 2040-2070 (long-term future). Water yield is expected to increase by 3% in the near-term and 18% in the long-term, as compared to historical data. But this increase is not uniformly spread out. A disproportionate increase is expected to occur in the winter (Dec-Feb) and spring (Mar-June) seasons (32% and 25%, respectively, in the near-term and 27% and 44%, respectively, in the long-term). This is consistent with a warming climate which results in higher precipitation (in the form of snow in winter). However, the snow will readily melt as summer approaches and temperatures rise. As a result, water yield will diminish in the subsequent months. This lopsided distribution of water yield across seasons will result in extreme flooding during the spring, not unlike the one being experienced in the region in 2019, and drought during the summer and fall seasons.

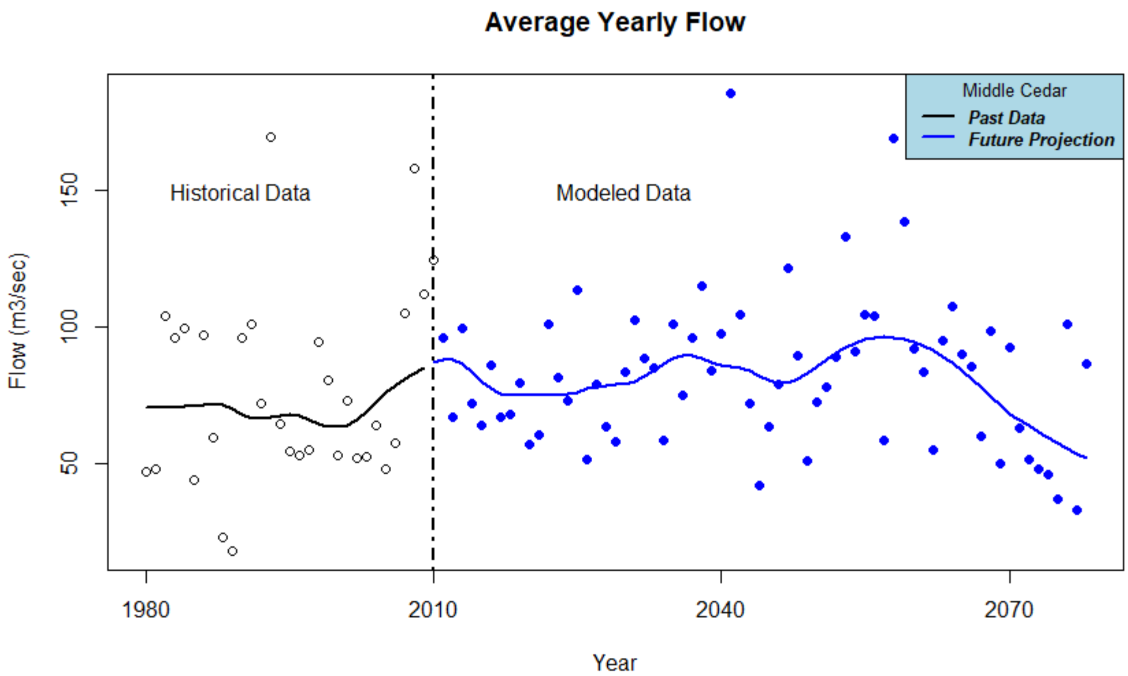


Figure 7.8. Average yearly flow (m^3/s) at the outlet of the Middle Cedar River watershed. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

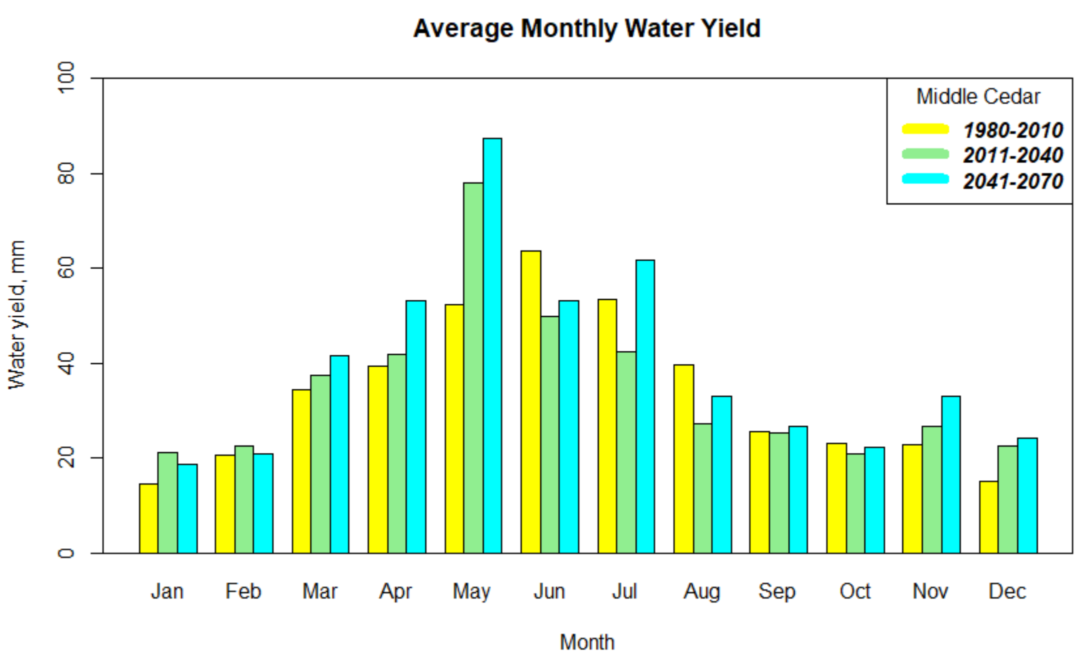
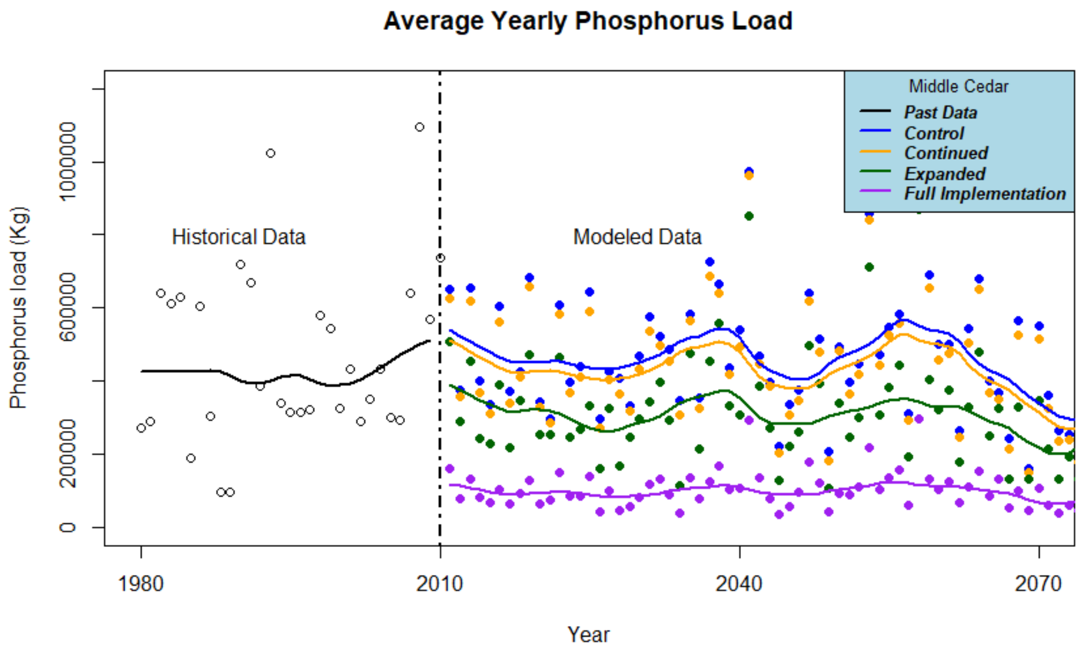


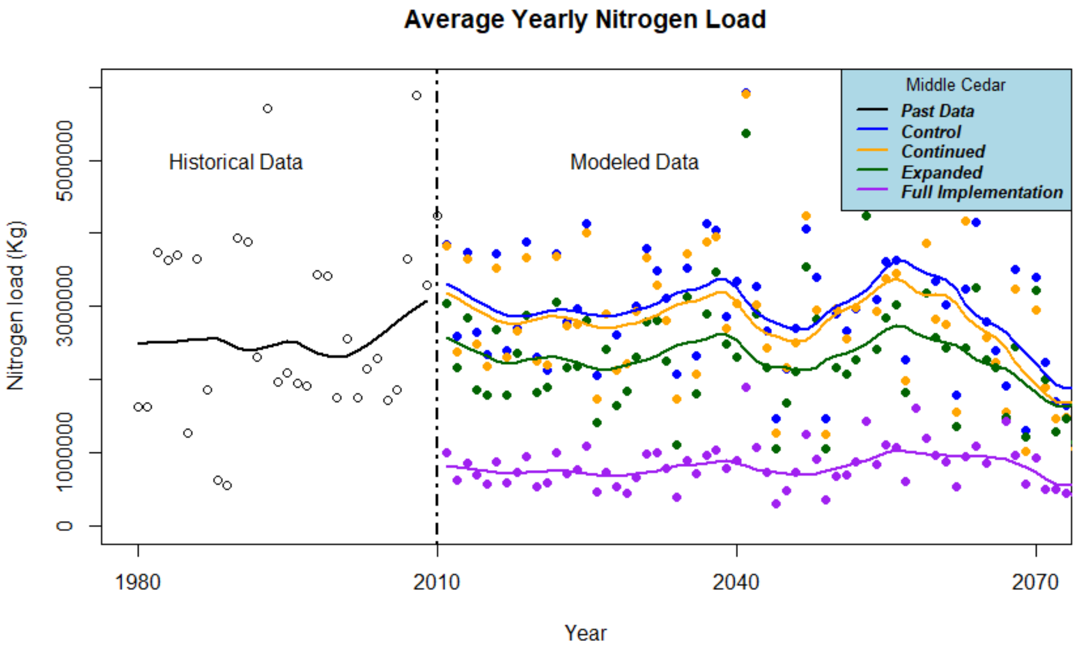
Figure 7.9. Average monthly water yield (mm) at the outlet of the Middle Cedar River watershed across three time periods.

Contaminant Loading

Figure 7.10 shows the average annual loading for phosphorus (kg), nitrogen (kg), and sediment (metric ton) at the outlet of the Middle Cedar River watershed under the four scenarios described earlier in the Methods section.



(a)



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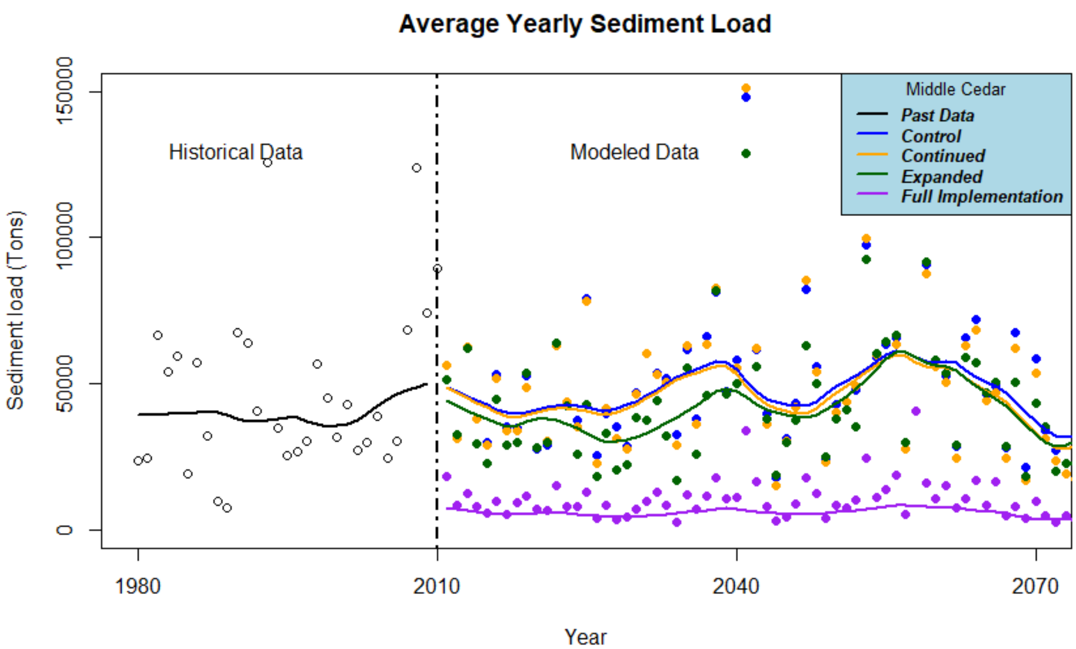


(c)

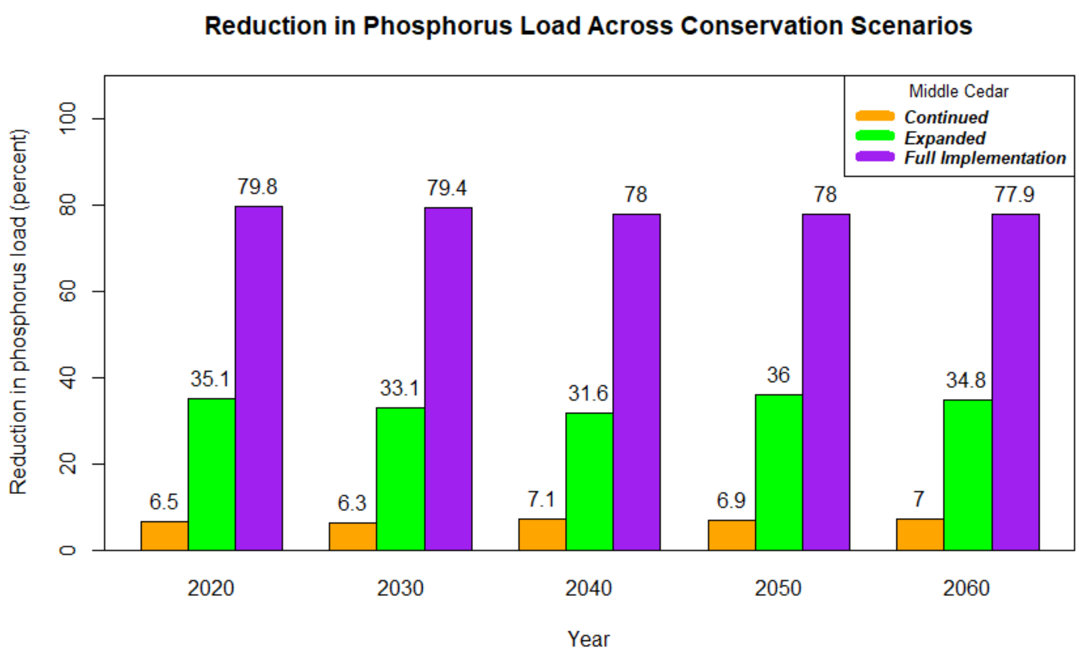
Figure 7.10. Average annual load for (a) phosphorus, (b) nitrogen, and (c) sediment, at the outlet of the Middle Cedar River watershed under four future scenarios. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

Under the *Control* scenario, annual loading for phosphorus, nitrogen, and sediment displays wide year-to-year variations, but the smoothing curve identifies an oscillating pattern, in which the highest loading levels occur in 2055. It must be noted that the smoothed water quality data is less precise toward the end of the temporal scale due to overfitting. Thus, the modeling results beyond 2070 should be treated with caution.

According to the model, during the period 2020-2060, phosphorus and nitrogen loading are expected to undergo a modest *decrease* by 1% (from 444,507 kg to 440,204 kg) and 2.8% (2,915,318 kg to 2,835,011 kg), respectively. Sediment loading, on the other hand, is expected to increase by 18.2% (from 42,147 metric tons to 49,812 metric tons). Due to the oscillating pattern, however, the choice of interval informs the change in contaminant loading. If the period of analysis is considered to be 2020-2050, phosphorus and nitrogen loading increases by 18% and 15%, respectively, while sediment loading increases by 34%.

Phosphorus and nitrogen loading under the *Continued* and *Expanded* scenarios are marginally and significantly lower than the *Control* scenario, respectively, and generally track the same trend as the *Control* scenario. In contrast, the sediment loading under the *Continued* and *Expanded* scenarios are almost identical to the *Control* scenario. In the case of all three contaminants, the *Full Implementation* scenario results in the lowest loading rates. Contaminant loading under the *Full Implementation* scenario does not vary much across time.

Figure 7.11 displays the reduction in loading (in percentage) under the three conservation scenarios – *Continued*, *Expanded*, and *Full Implementation*.



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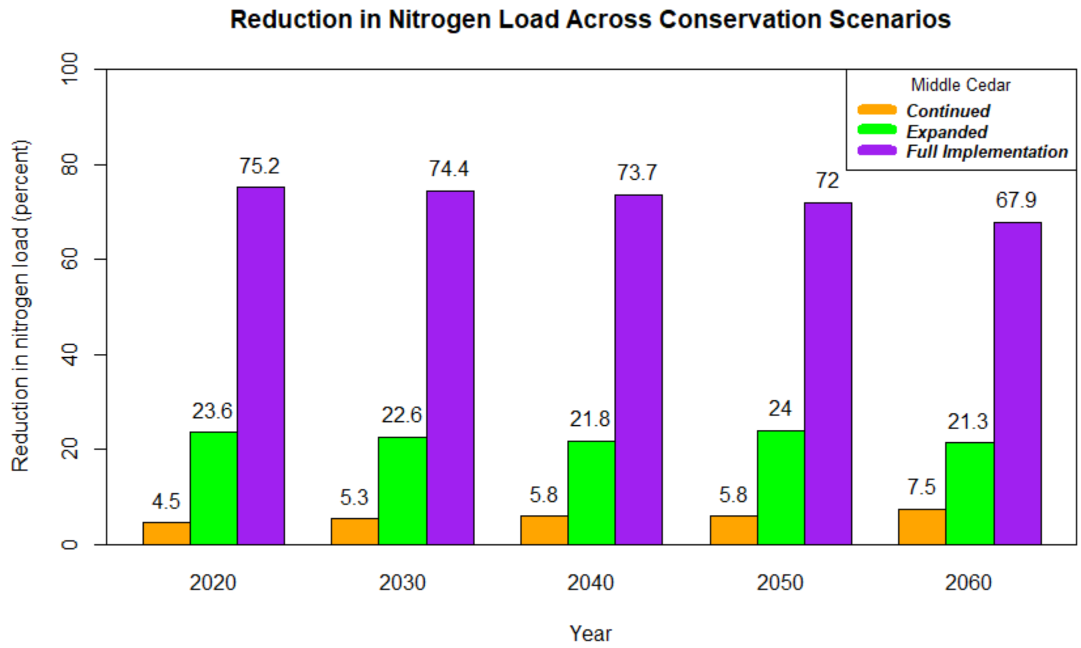

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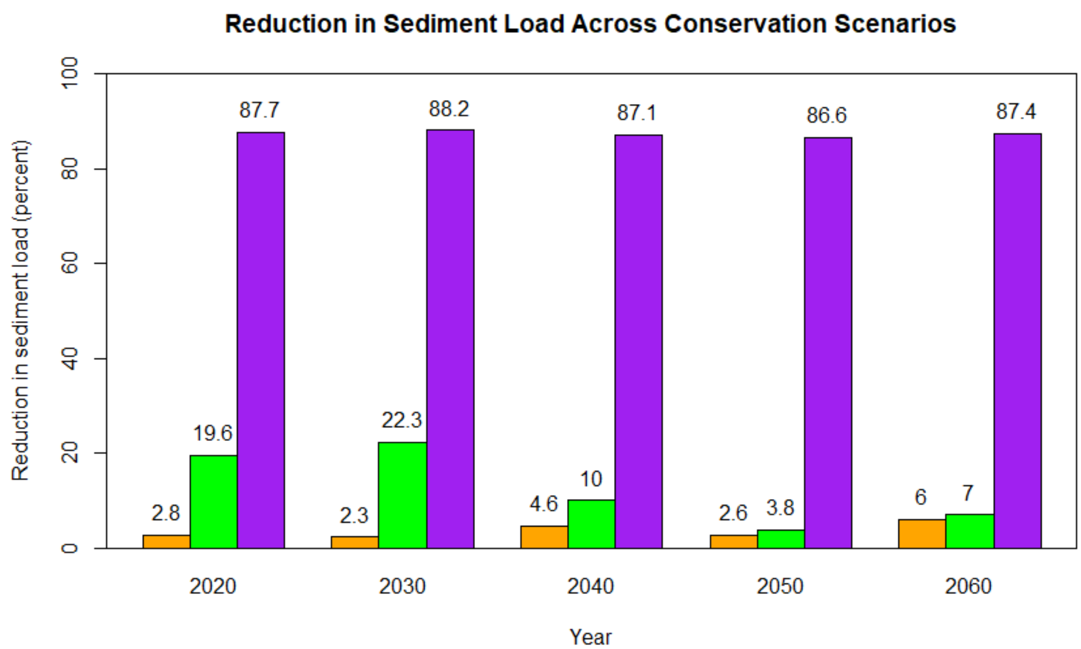


(c)

Figure 7.11. Reduction in (a) phosphorus, (b) nitrogen, and (c) sediment loading under three conservation scenarios as compared to the *Control* scenario.

Taking decadal snapshots at 2020, 2030, 2040, 2050, and 2060, reduction in the contaminant loading under the *Continued* scenario ranges from 6.5% to 7.1% for phosphorus, 4.5% to 7.5% for nitrogen, and 2.3% to 6% for sediment. This suggests that if the ongoing RCPP conservation program is continued at the same scale, it will result in a relatively minor reduction in key contaminants by 2060.

The *Expanded* scenario results in a slightly larger reduction for phosphorus (31.6% to 36%) and nitrogen (21.3% to 24%). The average annual nitrogen concentration in the Middle Cedar River during the study period is 8.8 mg/L, which is just below the maximum contaminant limit (MCL) of 10 mg/L set by USEPA for drinking water.[18] In the case of sediment, the *Expanded* scenario results in a significantly larger reduction in the first two decades (around 20%), but this reduction decreases to 10% in 2040 and then reduces even further in the subsequent years. It is unclear why this is the case, but it's possible that the changing climate, which will increase heat and precipitation, may result in changes in soil runoff patterns which will reduce the impacts of BMPs.

The *Full Implementation* scenario results in the largest reduction of all scenarios – ranging from 77.9% to 79.8% for phosphorus, 67.9% to 75.2% for nitrogen, and 86.6% to 88.2% for sediment. Large-scale expansion of the RCPP program across the watershed would be needed to significantly reduce the nutrient and sediment loading in the watershed and improve the water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations.

Summary

The Cedar River is impaired for nitrate, and past efforts have focused on addressing this issue in certain subwatersheds in the Middle Cedar watershed. The RCPP project aims to address the high nitrate levels in the river and flood risk. A history of engagement with watershed farmers allowed the RCPP project to build on prior success and expand the scope of their conservation efforts. The RCPP project primarily engaged in cover cropping, but also supported installation of bioreactors, saturated buffers, wetland reserve easement, and nutrient management. The project has been successful in its efforts to reduce nitrogen so far, and it remains on track to meet its goal of 55 tons of nitrogen reduced per year by 2020. The Middle Cedar RCPP has a very strong data collection plan, and the information collected enables the stakeholders to clearly track trends in the watershed. Water quality data collected in the watershed suggests a decline in the nitrate levels, although more confirmation is needed to separate the impact of the project from variations attributed to precipitation and temperature. HAWQS modeling suggests an increase in phosphorus, nitrogen, and sediment loading in the watershed over the next 30 years, and that the current conservation approach, as executed via the RCPP project, will only lead to modest reductions in contaminant loading. Large-scale expansion of the RCPP program across much of the watershed would be needed to significantly reduce the nitrogen loading in the watershed and improve the water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations.

[18] Water utilities, however, begin taking action (blending the nitrate-rich water with other sources, or undertake treatment) at a lower influent concentration such as 8.5 mg/L (Vedachalam et al., 2019).

Chapter 8: Oconomowoc River Watershed

City of Oconomowoc & Tall Pines Conservancy

82,000 acres

P

TSS

440

5th

About the Watershed

The Oconomowoc River watershed covers an area of 82,000 acres located in southeast Wisconsin spanning multiple counties, including Washington, Dodge, Waukesha, and Jefferson, and contains a number of municipalities (see Figure 8.1). The Oconomowoc River is a subwatershed of the Rock River, which joins the Mississippi River after traveling south into Illinois. It consists of four subwatersheds, listed below (Table 8.1).

Table 8.1. Subwatersheds in the Oconomowoc River watershed

Subwatershed (HUC 12)	**HUC ID**	**Size (acres)**
Little Oconomowoc River	070900010501	36,003
Okauchee Lake	070900010502	19,059
Lac La Belle	070900010503	11,953
Oconomowoc River	070900010504	16,735

Over 45 percent of the land use is agriculture, primarily focused on dairy operations, along with corn, soybean, and wheat production. The Oconomowoc River Watershed is considered a high ground water recharge area by the Southeastern Wisconsin Regional Planning Commission (SEWRPC). The goal of the Oconomowoc River Watershed Water Quality and Soil Loss Improvements project is to improve water quality within and downstream of the watershed.

Drinking Water Sources

The Oconomowoc River is not a drinking water source for the watershed. The main water source in the region is groundwater.

Impairments in the Watershed

The Oconomowoc River is a tributary of the Rock River which is impaired and identified on the EPA 303(d) list for total suspended solids (TSS) and total phosphorus (TP). There is currently an EPA-approved Total Maximum Daily Load (TMDL) rule in place to improve water quality in the Rock River based upon the state standard of 100 µg/l (Wisconsin Administrative Code, 2019). The Oconomowoc River watershed has several surface waters that are impaired. Three lakes in the watershed – North Lake, Friess Lake, and Okauchee Lake – are also on the Wisconsin Department of Natural Resource's proposed list of impaired waterbodies to the EPA. The WDNR considers 41% of rivers and streams for fish and aquatic life to be in poor condition. The watershed also contains two Class 1 trout streams – Mason Creek and Rosenow Creek.[19]

[19] The Wisconsin DNR has classifications for different trout streams throughout the state. Class 1 produces high quality trout waters that can naturally sustain populations of wild trout. Class 2 may have some natural reproduction occurring, but not enough to utilize food and space. Class 3 has no natural reproduction of trout occurring. https://dnr.wi.gov/topic/fishing/trout/streamclassification.html

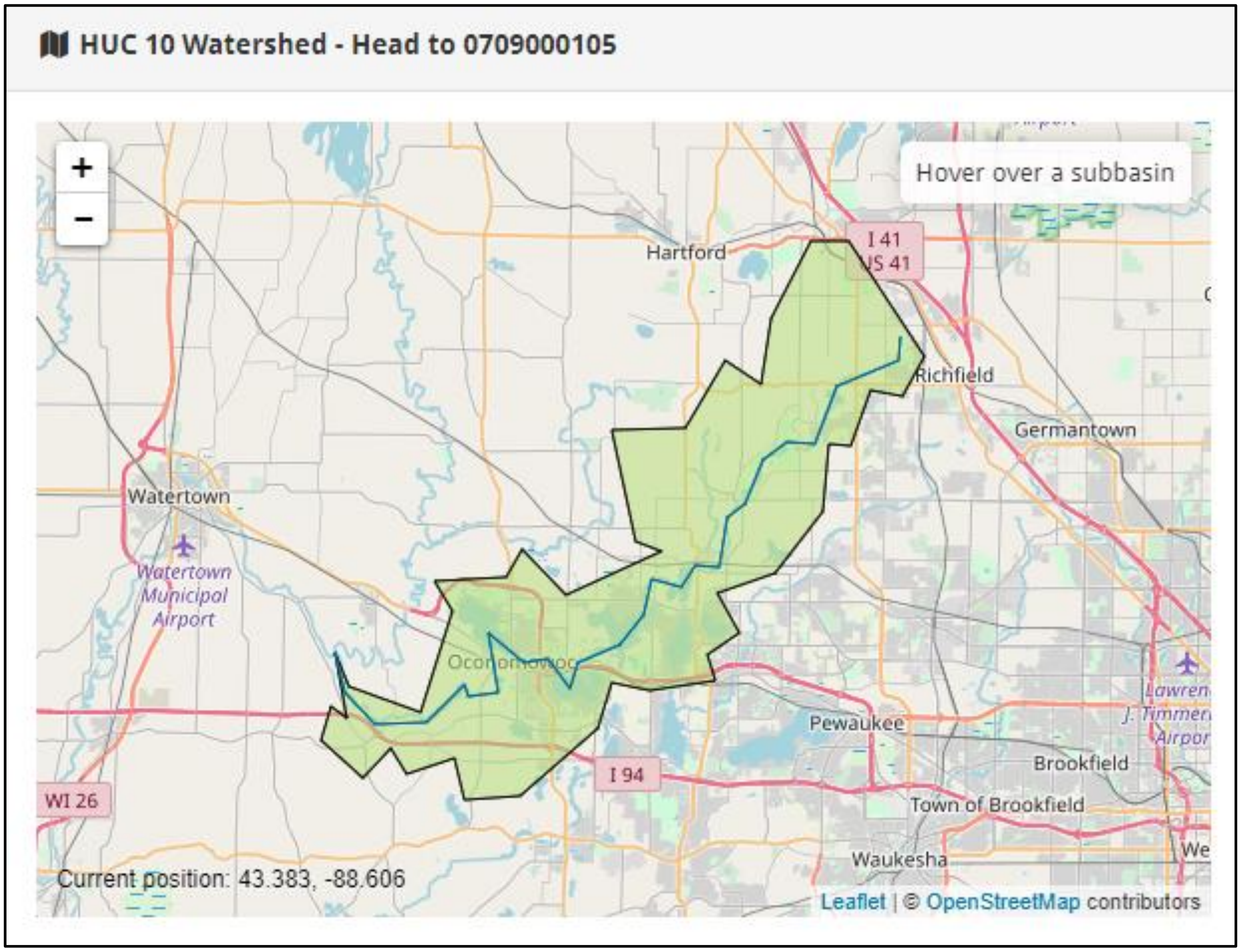


Figure 8.1. The Oconomowoc River watershed, as visualized in the HAWQS software.

Natural Resource Concerns

The project has two major natural resource concerns and a supplemental energy concern:

1. Water quality degradation, resulting from excessive sediment in surface waters and excess nutrients in surface and ground water.
2. Degraded fish and wildlife habitat.
3. High fertilizer use and energy consumption.

To address these resource concerns, the project has three goals:

1. Improve water quality by reducing total phosphorus (TP), to meet or exceed the WDNR's guideline of 0.075mg/L for TP by the end of the project. Additionally, reduce the amount of total suspended solids (TSS) to meet any proposed TMDL limits.
2. Improve degraded fish and wildlife habitats by restoring wetlands.

3. Save energy through the application of municipal biosolids from the city's wastewater treatment plant on agricultural land.

One of the key innovations of this project is the leveraging of the federal NRCS funds with a critical state regulatory mechanism. The Wisconsin DNR created an Adaptive Management Program for point source pollutant discharges (such as wastewater treatment plants) to reduce phosphorus, whereby the point source polluters can work with agricultural producers to reduce the total amount of phosphorus in the watershed at a lower cost.

Figure 8.2. A degraded pasture. Photo credit: American Farmland Trust

Key Project Partners

The project leader at the time of the proposal was the City of Oconomowoc, with a local conservation group, Tall Pines Conservancy, providing support to the city. The roles have shifted over time, and Tall Pines Conservancy – which seeks to protect farmland, water resources, and open areas in Wisconsin's Waukesha County – provides most of the leadership on this project now. [20] They are assisted in this RCPP project by a host of other local and regional stakeholders as described in Table 8.2.

[20] The key official in the City leading the project, Tom Steinbach, joined Tall Pines Conservancy after retiring from the City, thus shifting the role of the agencies in the project execution.

Table 8.2. A list of key project partners

Type	Organizations
Municipal / Local government	Washington County, Jefferson County, Waukesha County, Town of Oconomowoc, Town of Merton, Village of Merton, Village of Summit, Village of Oconomowoc Lake
State agencies	Wisconsin DNR, Wisconsin Department of Agriculture, Trade and Consumer Protection
Educational	University of Wisconsin – Extension,
Cooperatives	Friess Lake Advancement Association, Silver Lake Management Group
Trade groups	
Industry	Ruekert & Mielke, Inc., SHE Consulting Engineers
Environmental/ Conservation	Tall Pines Conservancy, Clean Wisconsin, Rock River Coalition, American Farmland Trust

Project Monitoring Plan

The main method for evaluating project outcomes will be a reduction of TSS and TP at key points in the watershed. In addition to the confluence of the Oconomowoc River and the Rock River being a key monitoring location, points upstream and downstream of runoff reduction project areas were also monitored to assess success of specific activities. The project had 19 monitoring locations at the beginning, which were then expanded to 40. Although TP was the primary parameter that was measured at these locations, other parameters such as dissolved oxygen and TSS were later added to provide a better understanding of the watershed health. The project plans to create a model to approximate flow using depth of the stream channel, and then use the modeled flow data, along with monitoring of phosphorus concentration, to approximate phosphorus runoff.

Wisconsin's Consolidated Assessment and Listing Methodology (WisCALM) will be used to reduce, model, and monitor the levels of TSS due to soil erosion as well as monitor water quality. WisCALM, issued by the Wisconsin DNR, provides guidance on assessment of water quality data against surface water quality standards and for Clean Water Act reporting on surface water quality status.

Project Practices

The RCPP implemented BMPs such as filter strips, agricultural sediment basins, grassed waterways, cover crops, pasture management, barnyard runoff, timed harvesting, and manure storage facilities. In addition, the project aimed to improve degraded habitats through wetland restoration, and reduce energy usage through land application of biosolids as fertilizer. A small number of non-traditional producers also implemented pollinator cover crops to attract bees.

Figure 8.3. Cereal rye planted into corn stalks. Photo credit: American Farmland Trust.

Producer Outreach and Activities

There are an estimated 440 eligible producers in the project area, of which 167 (38%) participated in the project. Outreach included Jefferson, Waukesha, and Washington County staff that will educate landowners about the various conservation programs available as well as the specifics of the RCPP project. The staff of these counties have had a history of success working with producers through NRCS programs. Partners worked to identify beginning farmers, veteran farmers, and limited resource/socially disadvantaged farmers to include in the program.

The watershed includes an area designated as an Agricultural Enterprise Area (AEA). The AEA is a voluntary program run by the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) that is open to producers who implement and maintain good land use practices. Producers receive assurance that their surrounding land will be protected from development. Producers received partner and NRCS funding to implement project activities in their area of the watershed, helping them maintain compliance throughout the 5-year RCPP program.

Accomplishments

The project created 2169 acres of cover crop to reduce phosphorus runoff, and has addressed five of the eight “problem spots” identified at the beginning of the program. Additionally, the OWPP has held five educational seminars. The project has also developed an innovative water quality monitoring program called the “mud chasers” program, in which local residents collected water quality data from several sites immediately following large weather events, to get accurate information on water quality and soil runoff.[21]

Program Efficacy and Efficiency

2,169 acres were cover cropped through the program, at a cost of $25/acre. The total cost of the program was $92/acre, resulting in a total annual reduction of 1.2 tons of phosphorus in 2018. The cost per ton of phosphorus per year reduced would therefore be $166,200/ton/yr. According to the Wisconsin DNR (2017), the Oconomowoc program will reduce phosphorus runoff by 2.25 tons when "fully operational". According to the OWPP, a 2.25 ton reduction will bring water TP down below the 0.075 mg/l target.

Water Quality Monitoring Results

The project leaders set up water quality monitoring points along main trunk of the Oconomowoc River and at main road crossings. The authors were provided data collected monthly spanning two years at one key location – at the confluence of the Oconomowoc and Rock Rivers (see Figure 8.4).

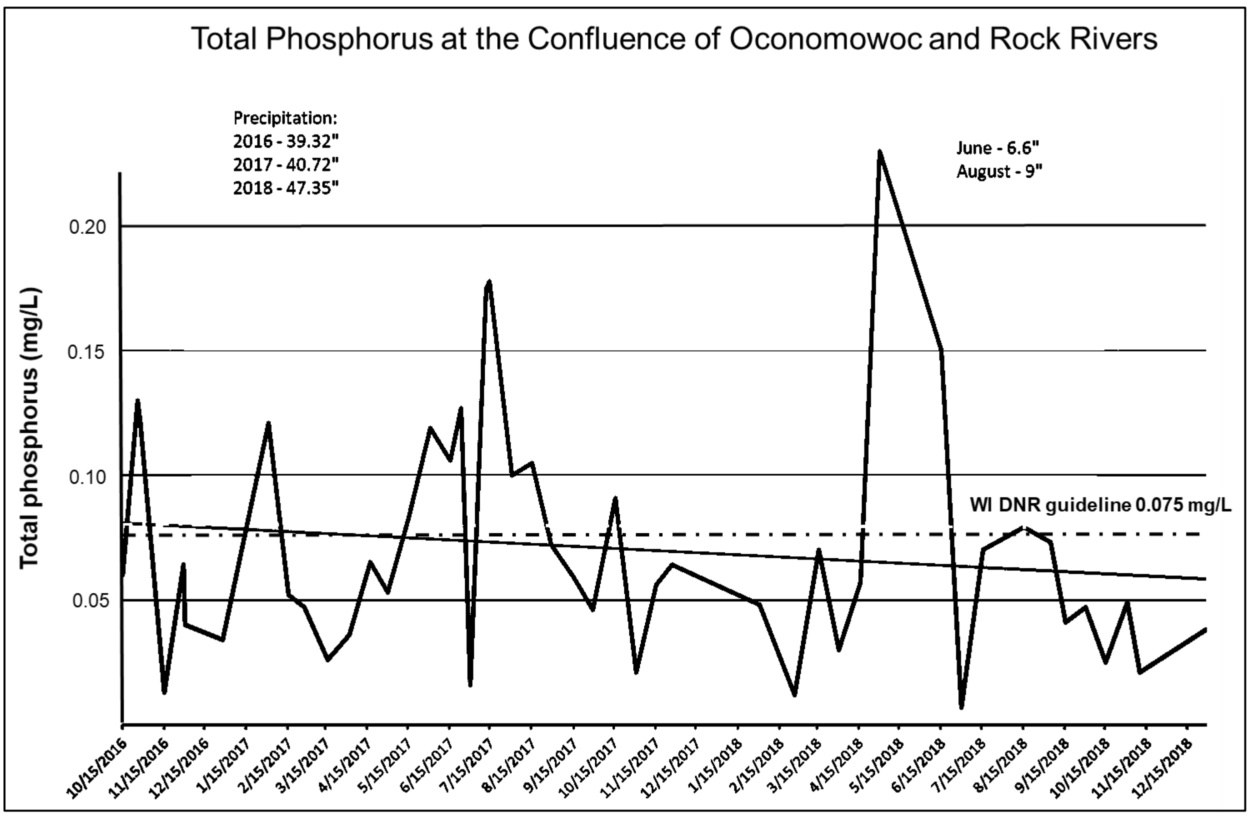


Figure 8.4. Water quality monitoring data at one location in the Oconomowoc River watershed. Adapted by the authors using source image provided by Tom Steinbach of the Tall Pines Conservancy.

[21] The term "mud chasers" is a riff on "storm chasers" who go to locations experiencing severe weather such as tornadoes to photo/video record them as a hobby.

The highest levels of total phosphorus were observed in May and June – during the spring season when snowmelt and rain causes significant soil erosion. The project leaders believe that despite above-annual precipitation in the past few years, including record precipitation in 2018, the Oconomowoc River is experiencing a downward trend in phosphorus concentration, giving them optimism about the efforts undertaken so far. Since the state does not conduct any monitoring in the watershed, this finding cannot be independently corroborated. Furthermore, it is also likely that increased precipitation resulted in increased phosphorus loading, but the dilution resulted in a decrease in the concentration. It may be a few more years before the true impact of the conservation project is isolated.

Economic Benefits

Although the project adopted the traditional approach of paying a producer to incorporate specific conservation practices, it also planned to offer a newer pay-for-performance option. Under this approach, factors such as soil type, crop, climate, and drainage patterns would be modeled for each producer to identify the most cost-effective conservation practice for their land, producing optimal results and economic benefits for the producers. However, this approach could not be implemented in time for this project.

The funding from RCPP has prioritized the implementation of critical projects in the area, including the approval of additional projects, and has thus helped the larger watershed. This has resulted in "smarter" projects that target headwater streams and critical locations (highly erodible lands, those in proximity to waterbodies, etc.). The Oconomowoc watershed contains a chain of lakes (17 total, of which five are considered major) which are highly regarded for their recreational use. The recreation and tourism opportunities created by the lakes and their surrounding areas significantly drive the economy of this region. The project leaders believe that as conservation efforts improve water quality in the upper half of watershed, those efforts will eventually translate to water quality improvements in the chain of lakes, resulting in economic benefits in the long-term.

Long-Term Viability

The RCPP is regarded as highly successful, not just by the project leaders, but by the producers participating in it as well. Although the project leaders have not identified a clear strategy for long-term viability, this is clearly an issue they remain deeply interested in. The project leaders are in discussions with key stakeholders to identify strategies and funding options to continue the program, such that it is maintained at the current level, if not expanded. Currently, the primary funding for the conservation activities comes from the City of Oconomowoc and communities in the lower half of watershed, which the project leaders believe will continue beyond the federally funded RCPP. The combination of federal funding with the state regulatory mechanism (described below) presents a robust opportunity to address critical water quality issues in the watershed at low costs, and makes this project attractive to the state government, local governments in the watershed, and private philanthropies for support.

Project Highlight

One of the key innovations of this project is the leveraging of the federal NRCS funds with a critical state regulatory mechanism. The Wisconsin DNR created an Adaptive Management Program (AMP) for point source pollutant discharges (such as wastewater treatment plants) to reduce phosphorus, whereby the point source polluters can work with agricultural producers to reduce the total amount of phosphorus in the watershed at a lower cost. In effect, the AMP, in conjunction with the TMDL, works as a nutrient cap-and-trade program that sets a cap on the phosphorus discharge from point source polluters and forces them to trade pollution permits with non-point source polluters, thereby lowering the overall nutrient discharge in the watershed. Such a program is also cost-effective for the entire region/state.

HAWQS Modeling Results

Presented below are results for water quantity and quality in the Oconomowoc River watershed obtained from the HAWQS model.

Flow and Water Yield

A temporal plot of surface flow (referred to as just 'flow' here) at the outlet of the watershed shows a steady increase until 2055, after which the flow declines sharply (Figure 8.5). A review of the monthly distribution of water yield (which includes subsurface flow, in addition to the surface flow) reveals additional patterns (Figure 8.6). Water yield is compared across three time periods: 1980-2010 (historical data), 2010-2040 (near-term future), and 2040-2070 (long-term future). Annual water yield is expected to increase by 42% in the near-term and 62% in the long-term, as compared to historical data. But this increase is not uniformly spread out. A disproportionate increase is expected to occur in the winter (Dec-Feb) and spring (Mar-June) seasons (188% and 25%, respectively, in the near-term and 264% and 32%, respectively, in the long-term).[22] This is consistent with a warming climate which results in higher precipitation (in the form of snow in winter). However, the snow will readily melt as summer approaches and temperatures rise. As a result, water yield will diminish in the subsequent months. This lopsided distribution of water yield across seasons will result in increases in flooding during the spring, not unlike the one being experienced in the region in 2019, and drought during the summer and fall seasons.

[22] Although water yield increase in spring in the near-term and long-term future is lower than the average annual increase, spring is the wettest season for the watershed, so moderate increases can still disturb the human and natural systems designed for historical averages.

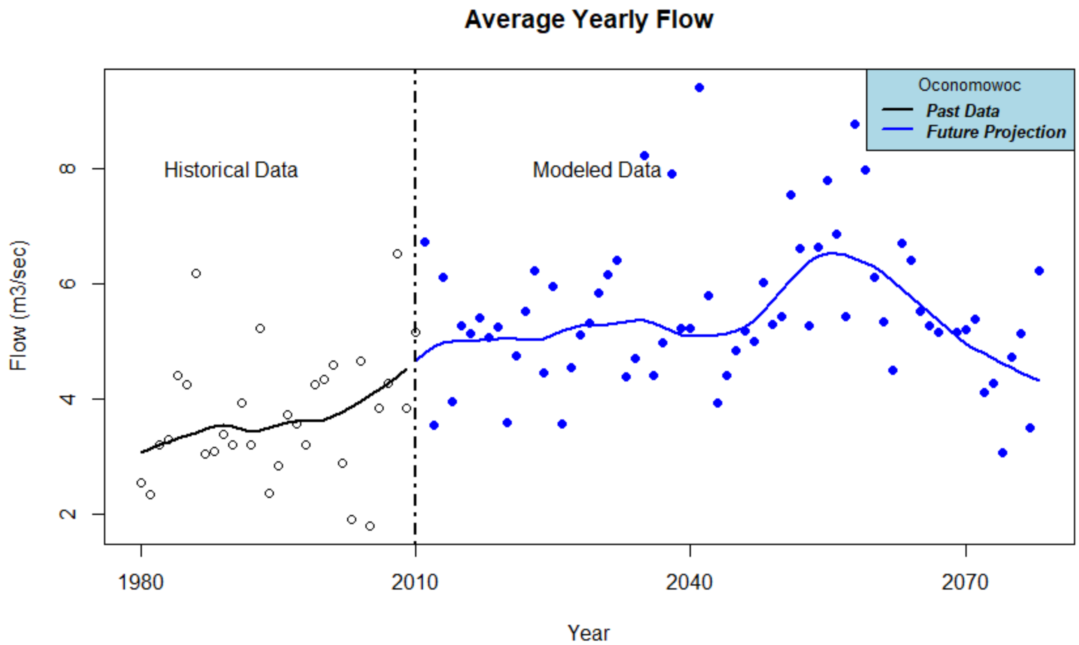


Figure 8.5. Average yearly flow (m^3/s) at the outlet of the Oconomowoc River watershed. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

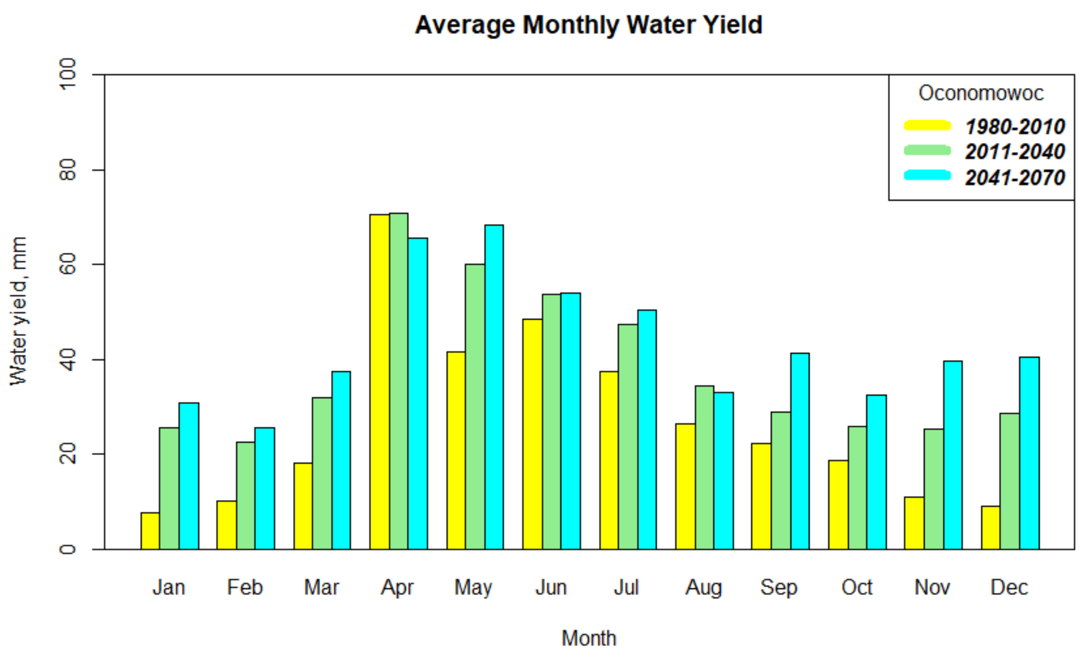
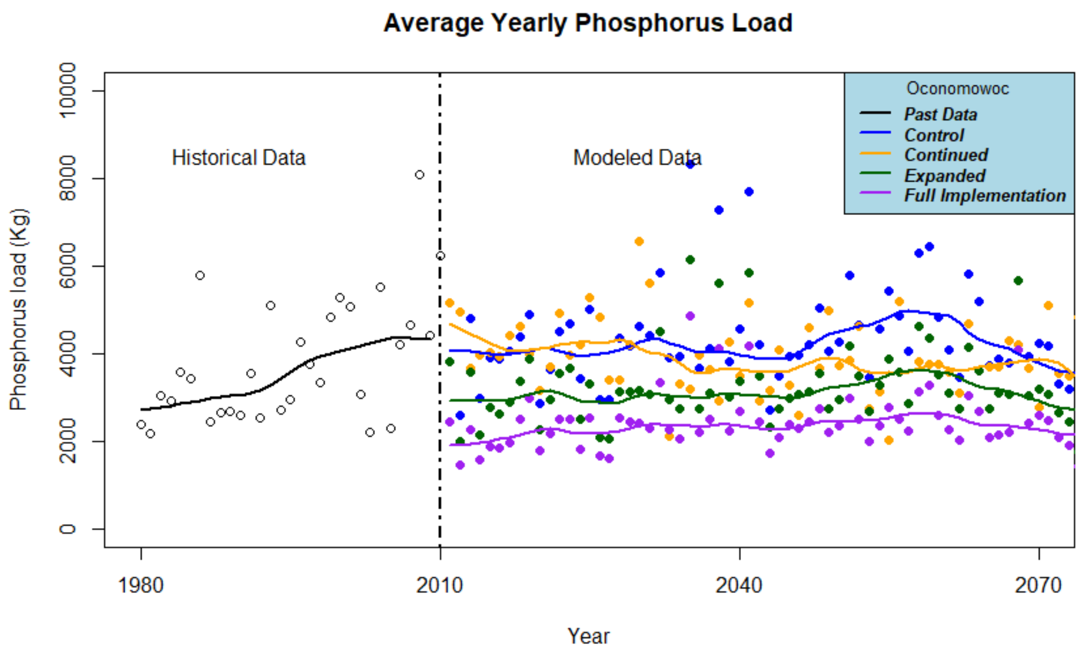


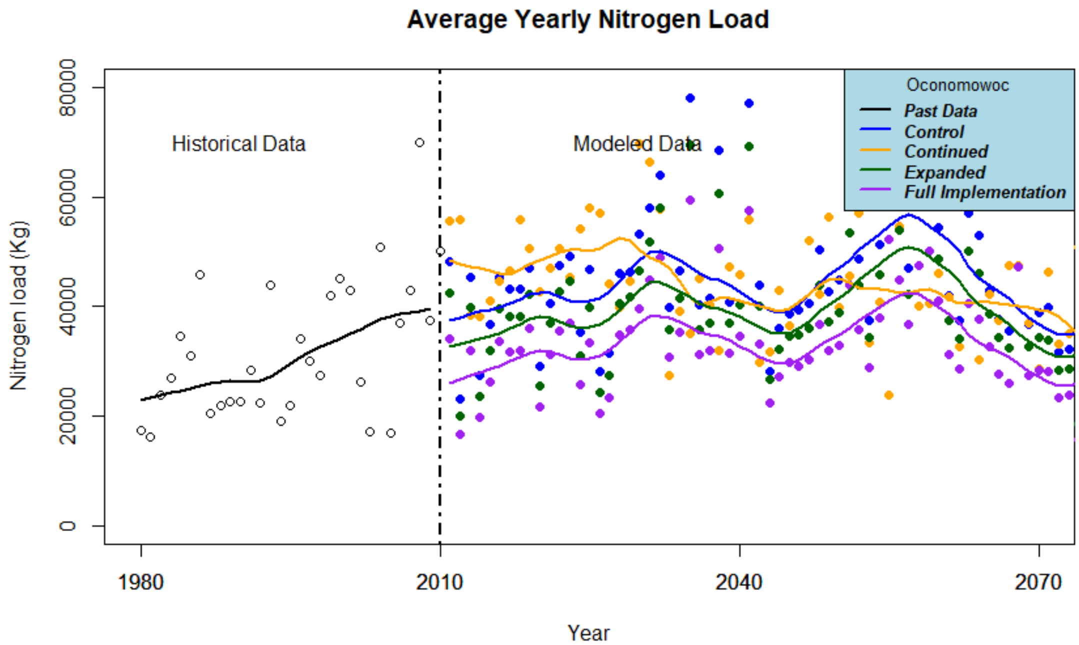
Figure 8.6. Average monthly water yield (mm) at the outlet of the Oconomowoc River watershed across three time periods.

Contaminant Loading

Figure 8.7 shows the average annual loading for phosphorus (kg), nitrogen (kg), and sediment (metric ton) at the outlet of the Oconomowoc River watershed under the four scenarios described earlier.



(a)



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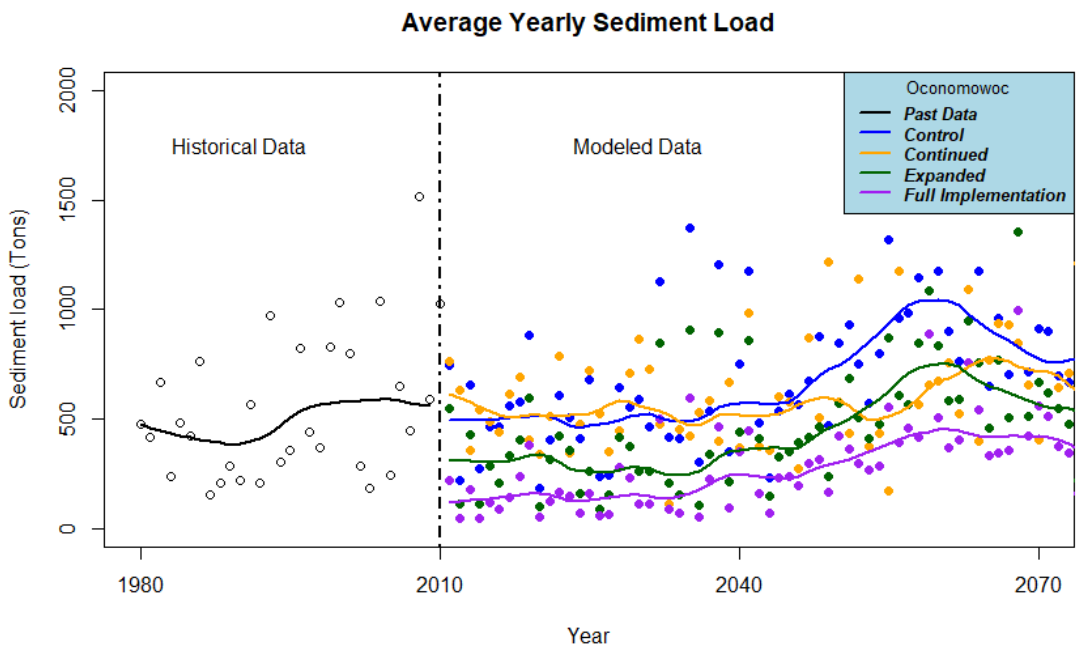


(c)

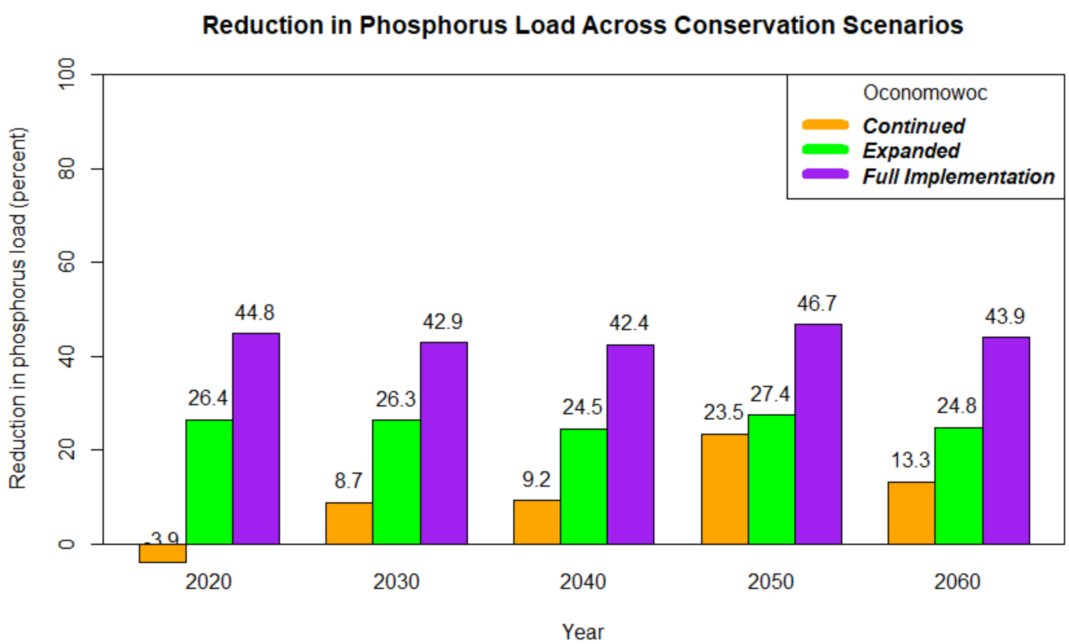
Figure 8.7. Average annual load for (a) phosphorus, (b) nitrogen, and (c) sediment, at the outlet of the Oconomowoc River watershed under four future scenarios. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

Under the *Control* scenario, annual loading for phosphorus and sediment displays wide year-to-year variations, but the smoothing curve identifies increasing levels of P, N, and sediment until 2055, after which the loading declines steadily. It must be noted that the smoothed water quality data get less precise toward the end of the temporal scale due to overfitting, and hence modeling results beyond 2065 should be treated with caution.

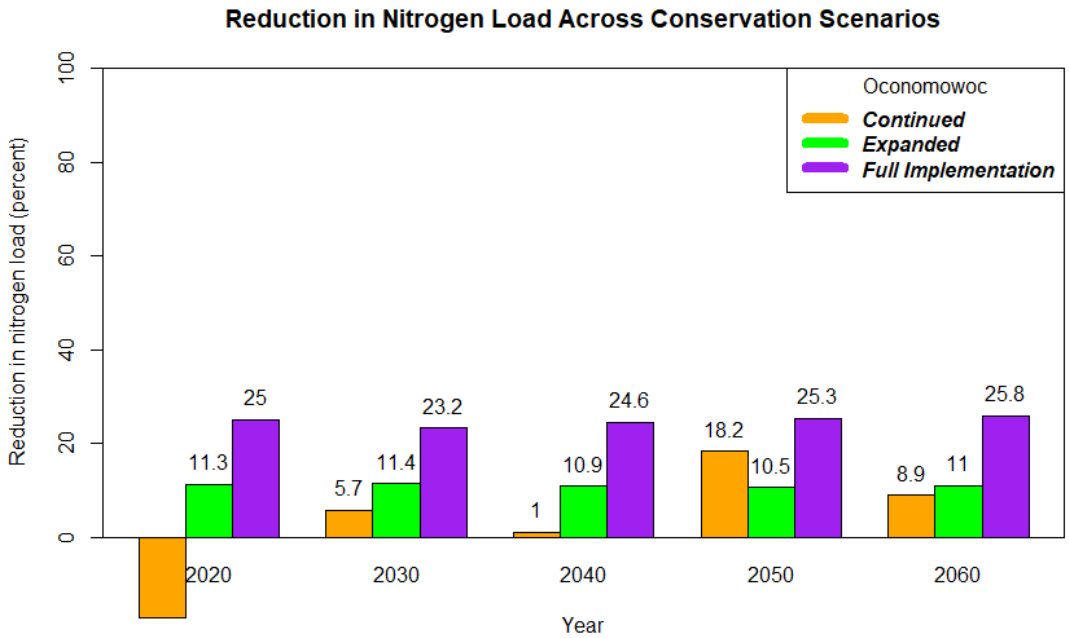
According to the model, during the period 2020-2060, nitrogen and phosphorus loading is expected to increase by about 3.5% (from 43,060 kg to 44,578 kg) and 6% (from 4,066 kg to 4,315 kg), respectively, whereas sediment loading is expected to increase by about 85% (from 494 metric tons to 916 metric tons), respectively.

Phosphorus, nitrogen, and sediment loading under the *Expanded* scenario is significantly lower than the *Control* scenario, and generally tracks the same trend as the *Control* scenario. In contrast, the contaminant loading under the *Continued* scenario displays wide variation, with minimal to negative impact until about 2030, and a reduction in contaminant levels afterward. In the case of all three contaminants, the *Full Implementation* scenario results in the lowest loading rates. Under this last scenario, each of the three contaminants displays a different trend across time. Phosphorus loading does not vary much across time, sediment loading increases gradually, while nitrogen loading displays an oscillating curve, tracking the *Control* scenario.

Figure 8.8 displays the reduction in loading (in percentage) under the three conservation scenarios – *Continued*, *Expanded*, and *Full Implementation*.



(a)



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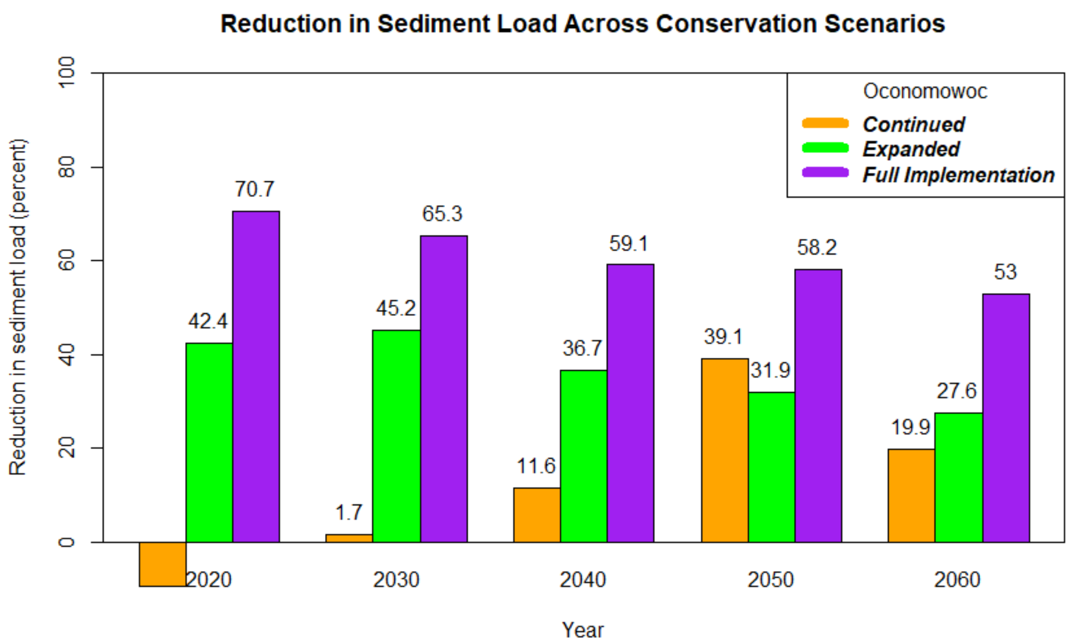

(c)

Figure 8.8. Reduction in (a) phosphorus, (b) nitrogen, and (c) sediment loading at the outlet of the Oconomowoc River watershed under three conservation scenarios as compared to the *Control* scenario.

Taking decadal snapshots at 2020, 2030, 2040, 2050, and 2060, reductions in phosphorus loading under the *Continued* scenario ranges from negative to 23.5%, while that of nitrogen ranges from negative to 18.2%, with high variation. Sediment runoff reduction under the *Continued* scenario is between zero and 39.1%, again with high year-to-year variation. It is unclear what causes the reduction in contaminant levels to be negative in the early part of the modeled data, before it flips back into positive territory in the later years. Overall, this suggests that if the ongoing RCPP conservation program is continued at the same scale, it will result in a relatively minor reduction in key contaminants by 2060.

The *Expanded* scenario results in a significantly larger reduction for phosphorus (24.5% to 27.4%), nitrogen (10.5% to 11.4%), and sediment (27.6% to 45.2%). The *Full Implementation* scenario results in the largest reduction of all scenarios – ranging from 24.4 to 46.7% for phosphorus, 23.2 to 25.8% for nitrogen, and 53% to 70.7% for sediment.

Large-scale expansion of the RCPP program across much of the watershed would be needed to significantly reduce the nutrient and sediment loading in the watershed and improve the water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations. However, it must be noted that despite implementing conservation on all farmland in the watershed in the *Full Implementation* scenario, average annual phosphorus concentration in the Oconomowoc River would fail to meet the Wisconsin standard of 100 μg/l during most of the study period.

Summary

The Oconomowoc River is a tributary to the Rock River, which contains high levels of sediment and phosphorus loading, well above the state standard. The RCPP project aims to address water quality issues caused by high phosphorus and sediment in the River. The RCPP implemented BMPs such as filter strips, agricultural sediment basins, grassed waterways, cover crops, pasture management, barnyard runoff, timed harvesting, and manure storage facilities. In addition, the project aimed to improve degraded habitats through wetland restoration, and reduce energy usage through land application of biosolids as fertilizer. At the conclusion of the project, 2.25 tons of phosphorus will be prevented from being discharged into the river. The project developed a unique water quality monitoring program called the "mud chasers" program, in which local residents collected water quality data from several sites immediately following large weather events, to get accurate information on water quality and soil runoff. One of the key innovations of this project is the leveraging of the federal NRCS funds with a critical state regulatory mechanism. The Wisconsin DNR created an Adaptive Management Program for point source pollutant discharges (such as wastewater treatment plants) to reduce phosphorus, by trading some of the pollutant discharges with agricultural producers to reduce the total amount of phosphorus in the watershed in a cost-effective manner. HAWQS modeling suggests a moderate increase in phosphorus and nitrogen loading and a significant increase in sediment loading in the watershed over the next 40 years, and that the current conservation approach, as executed via the RCPP project, will lead to only modest reductions in the contaminant loading. Large-scale expansion of the RCPP program across much of the watershed would be needed to significantly reduce the contaminant loading in the watershed and improve water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations.

Chapter 9: Upper Macoupin Creek Watershed

American Farmland Trust

137,694 acres

1,128

13th and 18th

About the Watershed

The Upper Macoupin Creek (UMC) watershed covers an area of 137,694 acres located in southwestern Illinois in Macoupin County (Figure 9.1). The UMC is part of the larger 99.7 mile Macoupin Creek that joins the Illinois River, which is a tributary to the Mississippi River. Some of the municipalities in this watershed are the cities of Carlinville, Gillespie, Royal Lakes, and Shipman. The UMC watershed consists of six smaller watersheds that all lead to Macoupin Creek: Dry Fork, Spanish Needle, Honey Creek, Hurricane Creek, Coop Branch, and Bullard Lake (see Table 9.1).

Table 9.1. Subwatersheds in the Upper Macoupin Creek watershed

Subwatershed (HUC 12)	HUC ID	Size (acres)
Dry Fork	071300120108	19,445
Spanish Needle	071300120109	32,717
Honey Creek	071300120106	15,680
Hurricane Creek	071300120107	19,315
Coop Branch	071300120101	35,017
Bullard Lake	071300120102	15,520

The UMC watershed is comprised of rolling grounds, of which about 62% is agricultural land and 20% is forested. The natural resource concerns, coupled with the presence of two local water supply lakes and strong interest from local partners resulted in conservation efforts in the watershed. The main goal of the Upper Macoupin Creek watershed project is to significantly reduce the loss of phosphorus and curb soil erosion across the Macoupin Creek watershed.

Drinking Water Sources

The Macoupin Creek (Figure 9.2) is not a direct source for drinking water in the project area. The subwatersheds of Honey Creek and Dry Fork are connected to Lake Carlinville and New Gillespie Lake, respectively. These lakes are drinking water sources for the cities of Carlinville (population: 7,428) and Gillespie (population: 3,900), so it is important to protect their water quality (Illinois EPA, 2019).

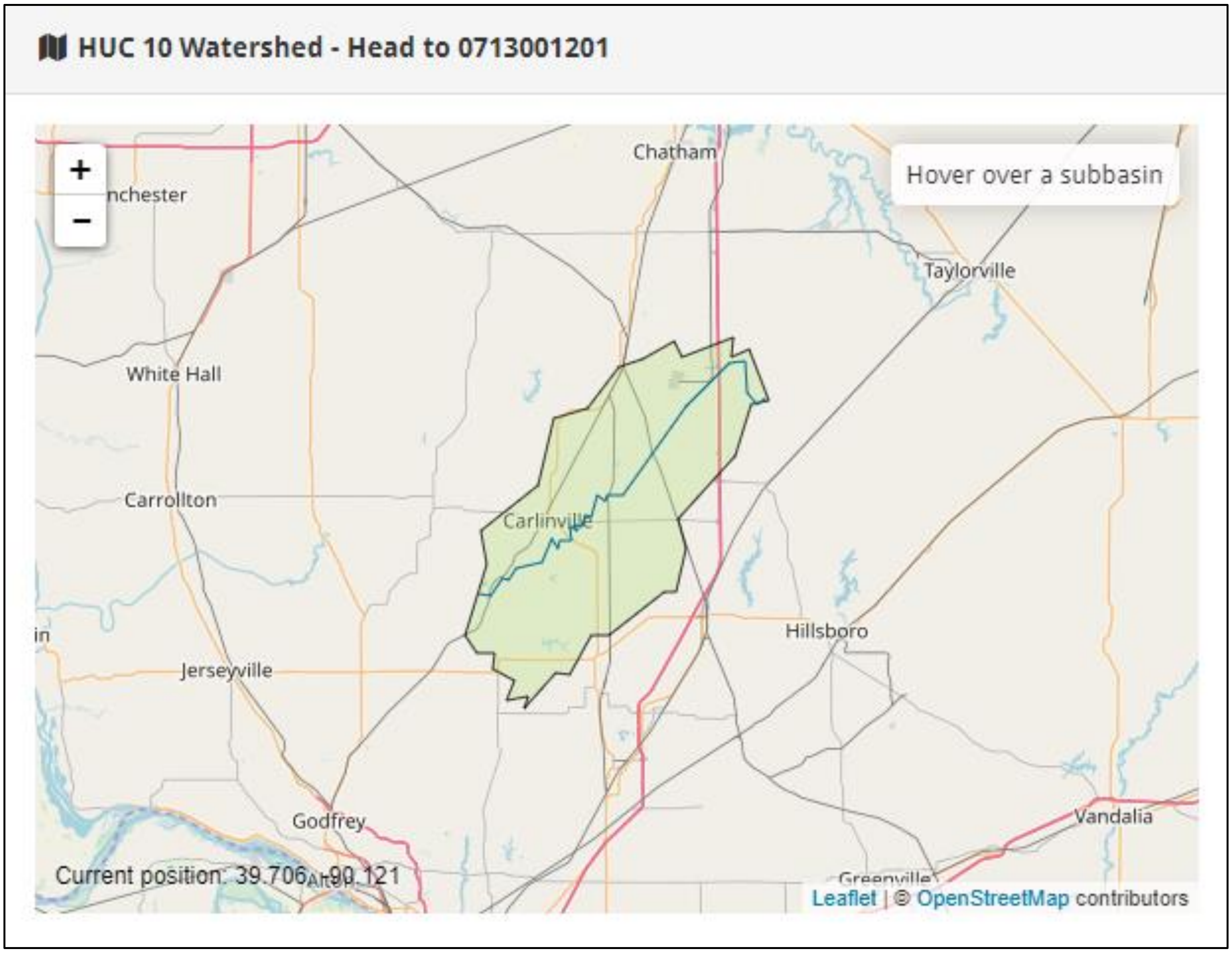

Figure 9.1. The Upper Macoupin Creek watershed, as visualized in the HAWQS software.

Impairments in the Watershed

A 2014 Science Assessment of Illinois' Nutrient Loss Reduction Strategy (NLRS) found that 80% of all nitrogen and 48% of all phosphorus lost from Illinois watersheds comes from rural non-point sources. The Macoupin Creek was identified to be one of the top three phosphorus-yielding watersheds in Illinois.

The Illinois Environmental Protection Agency (IEPA), listed three lakes in the UMC watershed on the IL Section 303(d) Impaired Waters in 2006 for not meeting designated uses. Standards for phosphorus and a Total Maximum Daily Load (TMDL) were identified and indicated that phosphorus loads needed to be reduced by 48-74%. In 2014, IEPA stream assessments found that Briar Creek and Coop Branch were not meeting standards for designated use of aquatic life due to the total suspended solids from Macoupin Creek.

Figure 9.2. Macoupin Creek near Beaver Dam. Photo credit: American Farmland Trust.

Past Efforts

In 2015, the Upper Macoupin Creek watershed was designated as a priority area under the Mississippi River Basin Healthy Watershed Initiative (MRBI) led by USDA-NRCS, with the subwatersheds of Dry Fork, Spanish Needle, and Honey Creek as focus areas. This initiative resulted in producer-led conservation efforts to reduce the phosphorus loss and soil erosion throughout the UMC. While efforts in those subwatersheds continue, the three remaining subwatersheds of Hurricane Creek, Coop Branch, and Bullard Lake are being added to address water quality issues and to better serve producers in the area.

Figure 9.3. Streambank erosion. Photo credit: American Farmland Trust.

Natural Resource Concerns

The key resource concerns in the Upper Macoupin Creek watershed are:

- Water quality degradation as a result of the nutrient and sediment runoff
- Soil health is a secondary concern as its overall improvement can reduce nutrient and sediment runoff which will improve water quality and habitat for fish and wildlife.

To address these resource concerns, the primary objective of the project is to reduce the loss of phosphorus and sediment from the watershed.

Key Project Partners

The project leader is American Farmland Trust, a non-profit organization that works to protect and conserve farmland. They are assisted in this RCPP project by a host of other local and regional stakeholders as described in Table 9.2.

Table 9.2. A list of key project partners

Type	Organizations
Municipal / Local government	City of Carlinville, City of Gillespie
State agencies	Illinois Department of Agriculture, Illinois Environmental Protection Agency
Educational	Blackburn College
Cooperatives	CHS Shipman, Macoupin County Farm Bureau
Trade Groups	Illinois Corn Growers Association, Macoupin County Pork Producers
Industry	Environmental Tillage Systems
Environmental/ Conservation	Illinois Stewardship Alliance, Macoupin County Soil & Water Conservation District

Project Monitoring Plan

Water quality will be monitored in the watershed by expanding upon the already existing monitoring from three subwatersheds to five. Data generated monthly from instream sampling of the existing (started October 2015) and new subwatersheds (started Spring 2017), are anticipated to show improvement in total suspended solids, total phosphorus, and volatile suspended solids over time. Moreover, the project leaders are pursuing a new upstream-downstream monitoring program that measures improvements across all six subwatersheds. Turbidity sensors and flow data would be used to determine TP levels in the water. Since the watershed is large, seeing improvements in five years might be difficult and may take a longer amount of time.

To monitor soil health in the watershed, the project team will explore in-field diagnostic tests that have been successfully implemented in other watershed projects. This could be in the form of soil grid sampling and edge-of-field water quality monitoring using USDA's Water Quality Index for Runoff from Agricultural Fields (WQIag) (USDA, 2013).

The project team will also mail surveys to producers in the project area to track awareness and behavior changes. This will help measure trends in BMP adoption of conservation systems in place throughout the watershed.

Project Practices

To address the natural resource concerns, project leaders have promoted the use of Conservation Cropping Systems (CCS). The CCS is a managed system of conservation practices consisting of conservation cropping rotation, no-till/strip-till, cover crops, nutrient management and other supporting practices as needed. Each practice complements or enhances one another to improve the health and function of the soil. Apart from the above-mentioned practices, the

RCPP also covers additional practices such as water and sediment control basins for producers, grade stabilization structures, and grassed waterways. Partners will provide education and technical assistance to producers to determine the best method to meet project objectives in the watershed.

Figure 9.4. A farm practicing no-till. Photo credit: American Farmland Trust.

Producer Outreach and Actions

There are an estimated 1,128 eligible producers in the watershed broken down into 504 farm operators and 624 non-operator farmland owners. The goal is to have 126 (25%) of farm operators to enroll to address issues in the watershed. Macoupin County producers and landowners have consistently shown interest in financial and technical assistance programs, specifically in regards to interest in conservation programs. Outreach and education will be available to any producer in the watershed, but some workshops and information will have specific targets.

Women landowners are a target group for this project because the project leaders have identified this group as one that cares about healthy land issues, but is often unaware of programs best suited for their interest. The project is also designed in such a way to give priority to landowners if their land has a likelihood to achieve significant phosphorus reductions, and to rank their applications higher if they agree to implement at least three priority BMPs.

Accomplishments

In 2018, Upper Macoupin Creek RCPP contracted 7,503 acres of cover crop and 3,673 acres of conservation tilling. Of these, over 6,000 acres were enrolled under the long-term Conservation Stewardship Program. Additionally, the program paid for 5,000 acres of soil testing for nutrient management, and created water and sediment control basins (WASCOBs) and grassed waterways covering 1,546 acres of land.[23] The program has only been active for one year, and a large majority of the budget for 2018 was successfully spent. The RCPP also conducted several classes on soil health, cover cropping, and nutrient management.

Figure 9.5. A farm practicing strip-till with cover crops. Photo credit: American Farmland Trust.

Program Efficacy and Efficiency

The RCPP contracted cover crops and conservation tillage at a cost of $36 an acre in 2018. Overall, the program impacted 17,849 acres of farmland at an average cost of $22.66 per acre. The average cost of the program was brought down due to the low cost ($2 per acre) of soil phosphorus concentration testing on 5,000 acres. The RCPP estimates that 10,740 kg of nitrogen and 1,795 kg of phosphorus were removed because of these BMPs, based on the assumption that cover cropping reduces nitrogen pollution by 30% and phosphorus pollution by 50%.

Water Quality Monitoring Results

The Upper Macoupin Creek RCPP has just completed the construction of a Soil and Water Integrated Model (SWIM), which will be used to model the UMC watershed. Through this, the project leaders expect to target specific farms with high runoff, resulting in higher reduction efficiency as the program continues. Since the program started in 2018, there is no long-term data showing the impact of the program.

Economic Benefits

The project's short duration has meant that no immediate economic benefits are known at this point. However, there are several potential benefits of the adopted conservation activities in the

[23] Source: American Farmland Trust BMP database

watershed. The USGS identified aquifers in the Macoupin Creek watershed that were particularly sensitive to nitrate and pesticide leaching (USGS, 2008). Two of the areas, located in the Dry Fork and Spanish Needle subwatersheds, were identified as particularly sensitive. Reductions in nutrient loss as well as a decline in fertilizer and pesticide application would have a disproportionate impact on the local aquifers, given their increased sensitivity.

Long-Term Viability

A large majority of the RCPP practices are short- and mid-term contracts for cover cropping, strip tillage, and nutrient management. As a result, should funding cease, these practices are likely to end. However, the project leaders are confident that several farmers will continue to practice conservation without the financial incentive. In the absence of external funding, the project leaders plan to provide technical assistance and education to local producers. The UMC RCPP's heavy reliance on long-term conservation funding (as provided under the CSP program) did not meet the expectations of local farmers, who preferred short-term conservation funding (as provided under the EQIP program).[24] The project leaders believe that conservation programs are more likely to be successful if the funding framework matches the needs and interests of the farmers.

Project Highlight

The Upper Macoupin Creek RCPP has a special emphasis on non-operating landowners, many of whom are women.[25] The project leaders believe that this underserved group is critical to the widespread adoption of environmentally sound farming practices. In 2019, American Farmland Trust published its report, "Testing the Women Landowner Conservation Learning Circle Model," that supports previous research on the importance of women landowners in conservation, and the role of women-only learning circles for expanding conservation actions (Fairchild et al., 2019). In collaboration with the Women, Food and Agriculture Network (WFAN), AFT has initiated several learning circles in Indiana and Illinois, and recently expanded to other Midwestern states as well as California. The project leaders believe outreach to this underserved group through intimate learning circles is more effective than larger community events.

Additionally, the project has a strong emphasis on watershed-scale impact and conservation customized to each land. The project has hired staff to take information obtained from the watershed model and go door-to-door to offer technical assistance and education to each individual farmer, such that they receive one-on-one tailored assistance. Based on the watershed model, certain specific farms are being prioritized, where adoption of conservation will yield maximum reduction in nutrient loss.

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[24] CSP funding requires farmers to incorporate conservation practices across their entire land, while EQIP allows farmers to choose certain conservation practices to be adopted on parts of their land.
[25] Non-operating landowners are those that own the land but do not farm themselves. Such farmlands comprise about 30% of the total farmland in the U.S. However, Iowa and Illinois have particularly high rates of NOL, approximating 50% of the states' farmland (Petrzelka and Sorensen, 2019).

HAWQS Modeling Results

Presented below are results for water quantity and quality in the Upper Macoupin Creek watershed obtained from the HAWQS model.

Flow and Water Yield

A temporal plot of surface flow (referred to as just 'flow' here) at the outlet of the watershed shows a rapid increase between 2005 and 2015, after which the flow remains steady until 2065 when the flow declines sharply again (Figure 9.6). A review of the monthly distribution of water yield (which includes subsurface flow, in addition to the surface flow) reveals additional patterns (Figure 9.7). Water yield is compared across three time periods: 1980-2010 (historical data), 2010-2040 (near-term future), and 2040-2070 (long-term future). Annual water yield is expected to increase 104% in the near-term and 108% in the long-term, as compared to historical data. In contrast to a majority of the watersheds analyzed in this report, the increase is pretty uniformly spread out across the seasons. The winter (Dec-Feb) and spring (Mar-June) seasons, which receive a majority of the precipitation, will experience an increase of 97% and 103%, respectively, in the near-term and 84% and 108%, respectively, in the long-term. This is consistent with a warming climate which results in higher precipitation (in the form of snow in winter). However, the snow will readily melt as summer approaches and temperatures rise. As a result, water yield will diminish in the subsequent months. This lopsided distribution of water yield across seasons will result in extreme flooding during the spring, not unlike the one being experienced in the region in 2019, and drought during the summer and fall seasons.

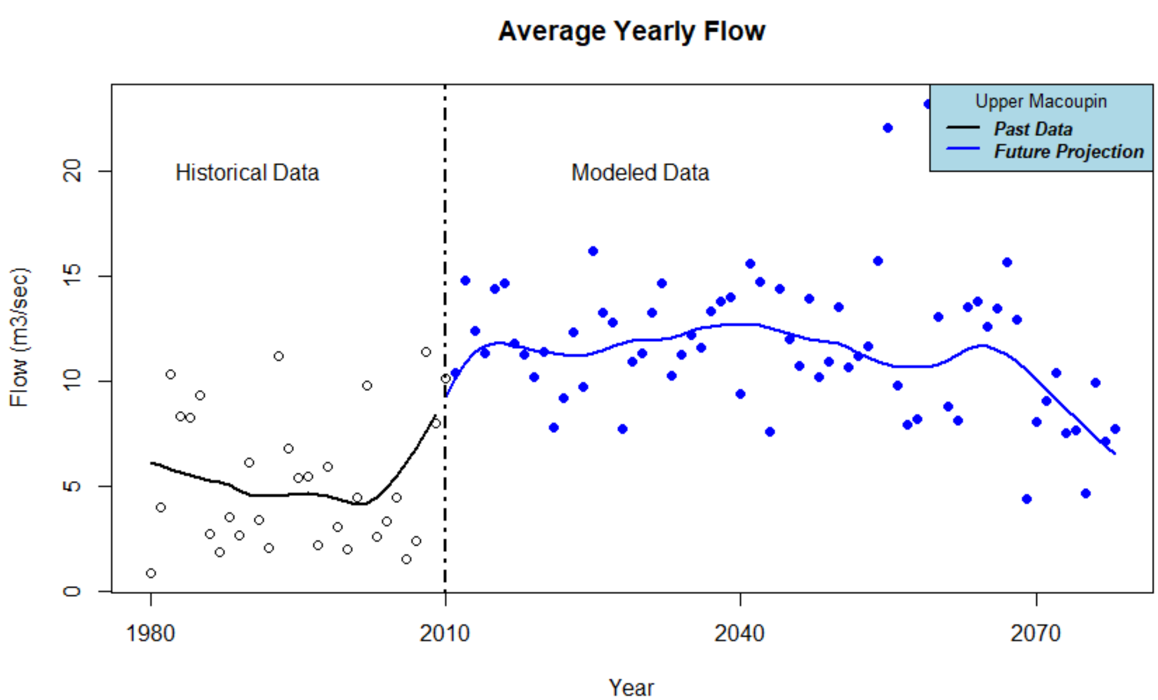


Figure 9.6. Average yearly flow (m^3/s) at the outlet of the Upper Macoupin Creek watershed. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

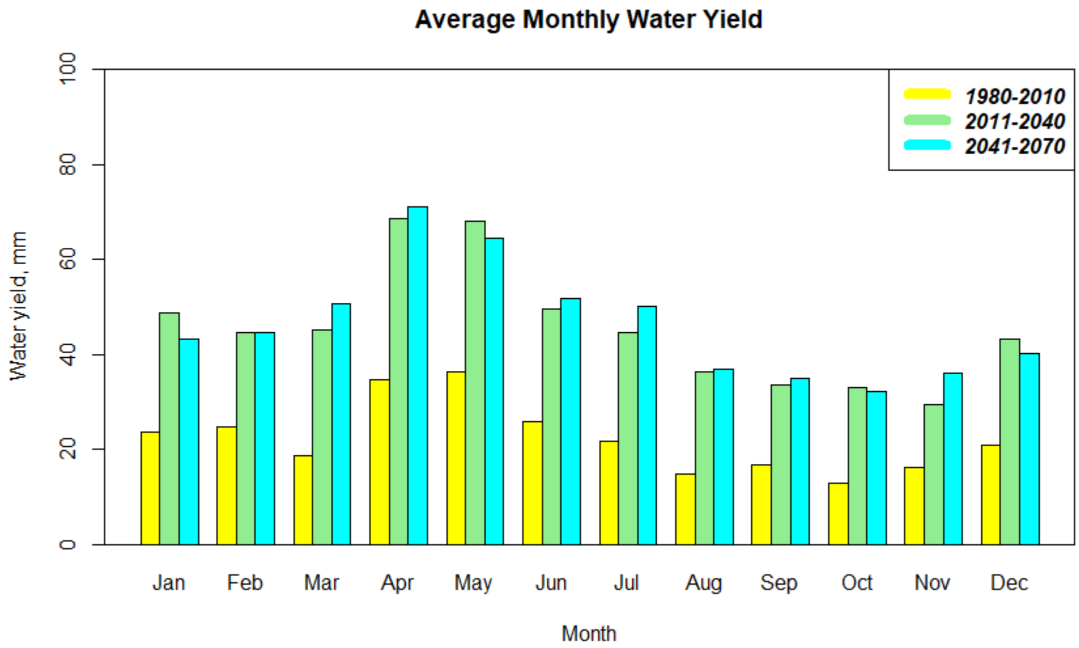
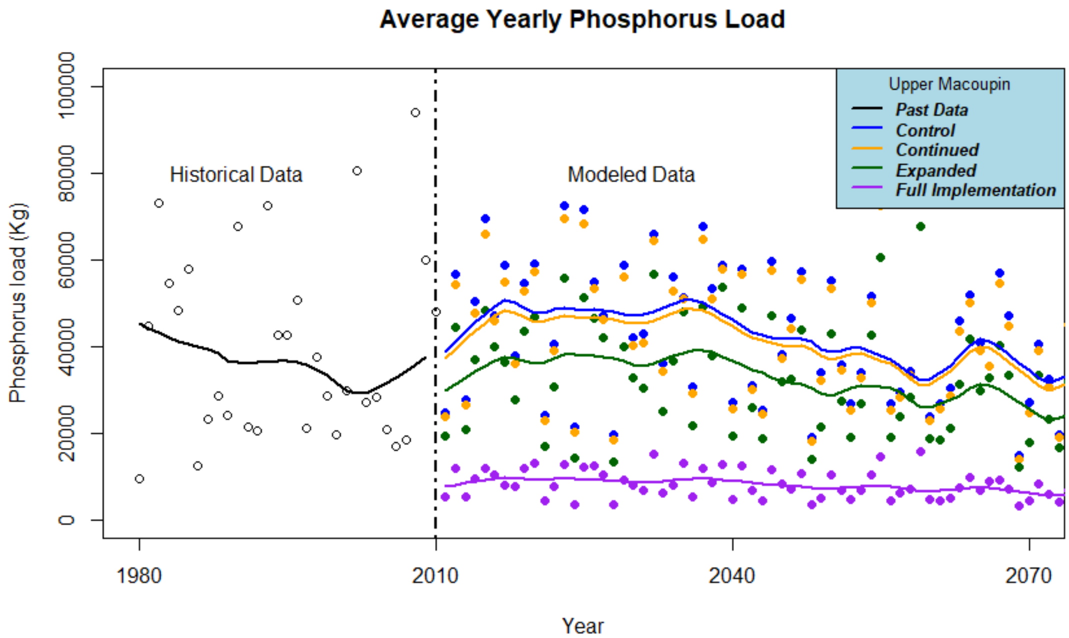


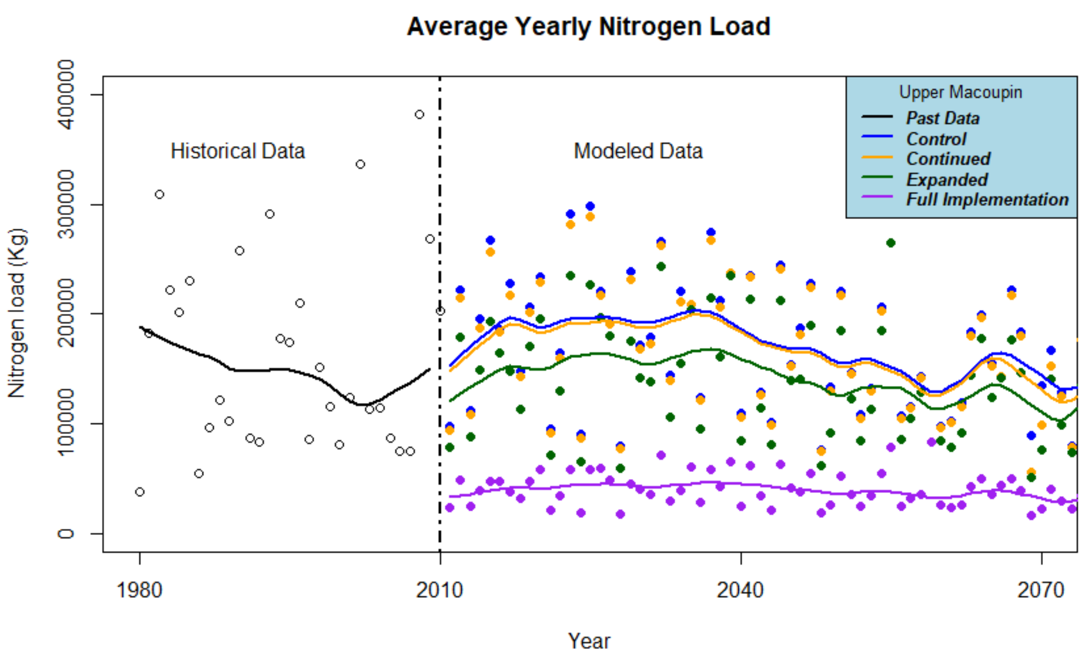
Figure 9.7. Average monthly water yield (mm) at the outlet of the Upper Macoupin Creek watershed across three time periods.

Contaminant Loading

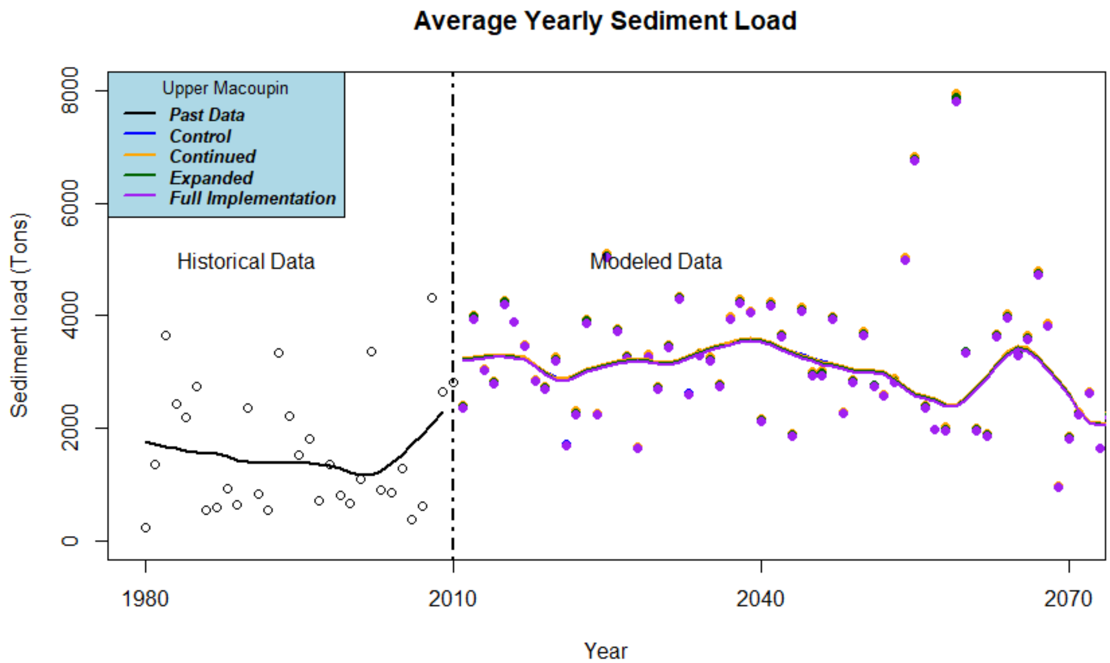
Figure 9.8 shows the average annual loading for Phosphorus (kg), Nitrogen (kg), and sediment (metric ton) at the outlet of the Upper Macoupin Creek watershed under the four scenarios described earlier.


Average Yearly Phosphorus Load
Phosphorus load (Kg)
0
20000
40000
60000
80000
100000
Historical Data
Modeled Data
Upper Macoupin
Past Data
Control
Continued
Expanded
Full Implementation
1980
2010
2040
2070
Year

(a)


Average Yearly Nitrogen Load
Nitrogen load (Kg)
0
100000
200000
300000
400000
Historical Data
Modeled Data
Upper Macoupin
Past Data
Control
Continued
Expanded
Full Implementation
1980
2010
2040
2070
Year

(b)



(c)

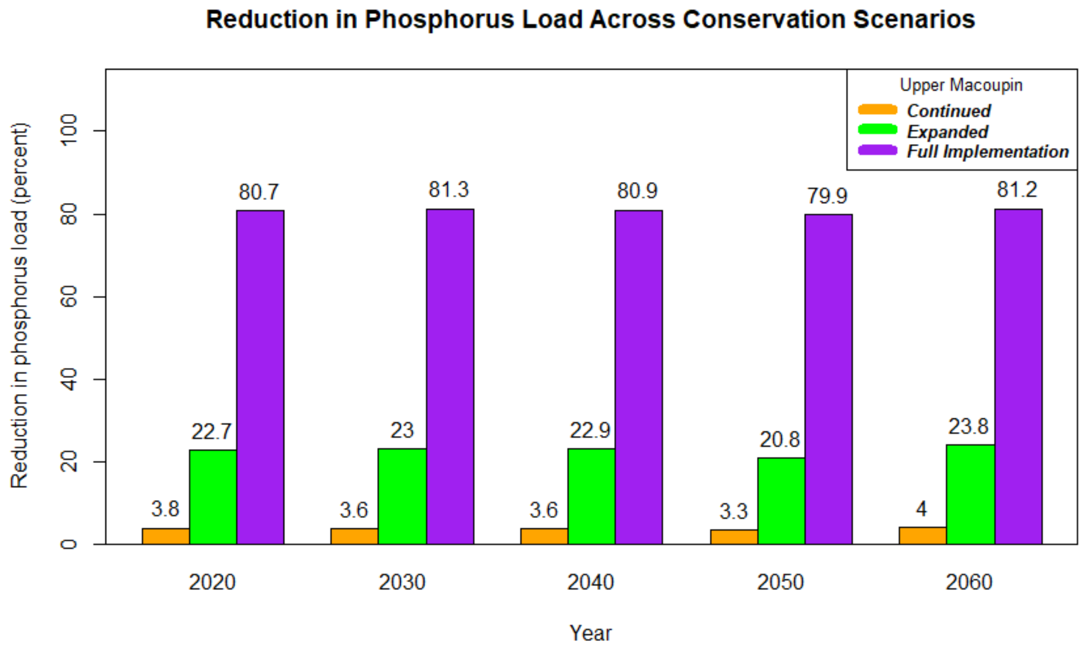
Figure 9.8. Average annual load for (a) phosphorus, (b) nitrogen, and (c) sediment, at the outlet of the Upper Macoupin Creek watershed under four future scenarios. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

Under the *Control* scenario, annual loading for phosphorus and sediment displays wide year-to-year variations, but the smoothing curve suggests elevated levels of P, N, and sediment until 2035, after which the loading declines steadily. It must be noted that the smoothed water quality data get less precise toward the end of the temporal scale due to overfitting, and hence modeling results beyond 2065 should be treated with caution.

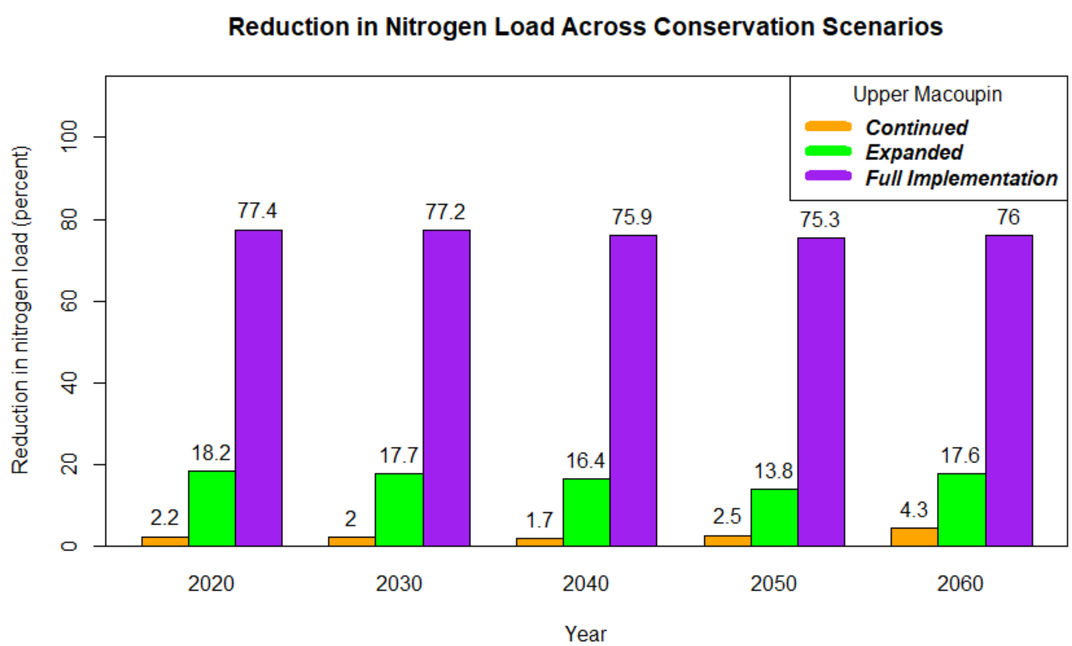
According to the model, during the period 2020-2060, phosphorus and nitrogen loading is expected to decrease by about 31% (from 47,757 kg to 32,506 kg) and 30% (from 187,910 kg to 129,481 kg), respectively, whereas sediment loading is expected to decrease by about 15% (from 2,900 metric tons to 2,550), respectively.

Phosphorus and nitrogen loading under the *Continued* and *Expanded* scenarios are marginally and significantly lower than the *Control* scenario, respectively, and generally track the same trend as the *Control* scenario. In contrast, the sediment loading under the *Continued* and *Expanded* scenarios are almost identical to that under the *Control* scenario. In the case of all three contaminants, the *Full Implementation* scenario results in the lowest loading rates. Except in the case of sediment, which experiences a 4.7% increase, the loading under the *Full Implementation* scenario does not vary much across time.

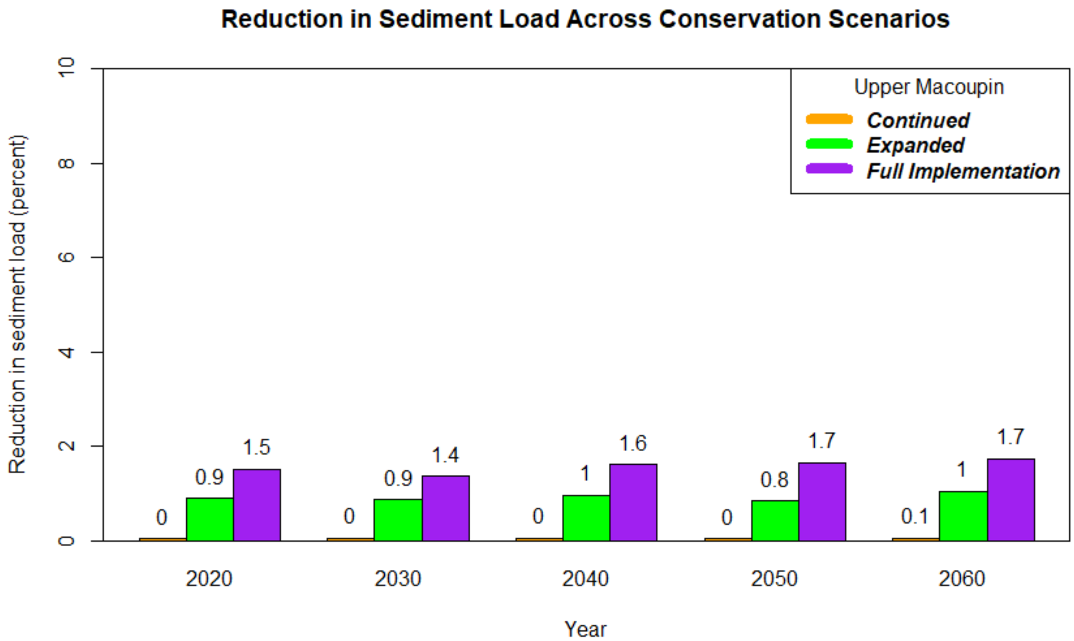
Figure 9.9 displays the reduction in loading (in percentage) under the three conservation scenarios – *Continued*, *Expanded*, and *Full Implementation*.


Reduction in Phosphorus Load Across Conservation Scenarios
Reduction in phosphorus load (percent)
Year
Upper Macoupin
Continued
Expanded
Full Implementation
0
20
40
60
80
100
2020
2030
2040
2050
2060
3.8
22.7
80.7
3.6
23
81.3
3.6
22.9
80.9
3.3
20.8
79.9
4
23.8
81.2

(a)


Reduction in Nitrogen Load Across Conservation Scenarios
Reduction in nitrogen load (percent)
Year
Upper Macoupin
Continued
Expanded
Full Implementation
0
20
40
60
80
100
2020
2030
2040
2050
2060
2.2
18.2
77.4
2
17.7
77.2
1.7
16.4
75.9
2.5
13.8
75.3
4.3
17.6
76

(b)



(c)

Figure 9.9. Reduction in (a) phosphorus, (b) nitrogen, and (c) sediment loading under three conservation scenarios as compared to the *Control* scenario.

Taking decadal snapshots at 2020, 2030, 2040, 2050, and 2060, reduction in the phosphorus loading under the *Continued* scenario ranges from 3.6% to 4%, while that of nitrogen ranges from 1.7% to 4.3%. Sediment runoff reduction under the *Continued* scenario is approximately zero. This suggests that if the ongoing RCPP conservation program is continued at the same scale, it will result in a relatively minor reduction in key contaminants by 2060.

The *Expanded* scenario results in a significantly larger reduction for phosphorus (20.5% to 25.6%) and nitrogen (12.7% to 20.9%). In the case of sediment, the *Expanded* scenario results in a relatively insignificant reduction that ranges from 0.8% to 1.1%. The *Full Implementation* scenario results in the largest reduction of all scenarios – ranging from 79.7% to 81.6% for phosphorus, 74.8 to 78.1% for nitrogen, and 1.3% to 1.6% for sediment. It is unclear why reductions in sediment loading across all three scenarios are insignificant as compared to reductions in P and N loading, but it is possible that the changing climate, which will increase heat and precipitation, may result in changes in soil runoff patterns which will reduce the impacts of BMPs.

Large-scale expansion of the RCPP program across much of the watershed would be needed to significantly reduce the nutrient and sediment loading in the watershed and improve the water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations. However, it must be noted that despite implementing conservation on all farmland in the watershed in the *Full Implementation* scenario, average annual phosphorus concentration in the Upper Macoupin

Creek would remain above 50 µg/l (which is the Illinois standard for total phosphorus in lakes) during the entire study period (Illinois Environmental Council, 2019).

Summary

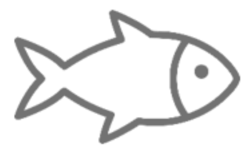
The Macoupin Creek was identified to be one of the top three phosphorus-yielding watersheds in Illinois. The main goal of the Upper Macoupin Creek RCPP project is to significantly reduce the loss of phosphorus and curb soil erosion across the Macoupin Creek. The Upper Macoupin Creek watershed was designated as a priority area under an earlier USDA-NRCS program, and conservation programs were implemented in three subwatersheds. The current RCPP strengthens that effort and extends it to the remaining three subwatersheds. The RCPP project heavily promotes cover crops, no-till, strip-till, and nutrient management. The project has been in operation for only one year, which precludes a wholesome assessment of the conservation efforts. The project has a special emphasis on non-operating landowners, many of whom are women. The project leaders have organized several women-led learning circles across multiple states, finding them to be more effective than larger community events. Additionally, the project has a strong emphasis on watershed-scale impact and conservation customized to each land. HAWQS modeling suggests a doubling of the annual water yield, which will present water management challenges in the watershed. The model also suggests a moderate increase in phosphorus, nitrogen, and sediment loading over the next 40 years, and that the current conservation approach, as executed via the RCPP project, will lead to only modest reductions in contaminant loading. Large-scale expansion of the RCPP program across much of the watershed would be needed to significantly reduce the contaminant loading in the watershed and improve the water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations.

Chapter 10: Otter Lake Watershed

Otter Lake Water Commission & Illinois Corn Growers Association

13,000 acres

P N



76

13th and 18th

About the Watershed

The Otter Lake watershed covers an area of 13,000 acres located in central Illinois, 20 miles southwest of Springfield, in Macoupin County (see Figure 10.1). The lake is 765 acres in size, with an average depth of 19.7 feet. Otter Lake discharges to Otter Creek, which eventually joins the Macoupin Creek and then the Illinois River, a principal tributary to the Mississippi River. The Otter Lake watershed is a HUC 12 scale watershed (HUC # 071300120202), and has no internal subwatersheds. The watershed includes the towns of Auburn, Divernon, Girard, Pawnee, Thayer, Virden, and the villages of Nilwood Tovey, along with other rural residencies. Inflow to the lake is primarily from the West Fork Otter Creek and smaller tributaries.

Approximately 77% of the watershed land use is agriculture, primarily corn and soybeans with lesser amounts of winter wheat, small grains, and hay. Otter Lake is used for recreational activities such as camping, fishing, and boating. Excessive levels of sedimentation and nutrient loading from upstream and in-lake nutrient release have exceeded the state's phosphorus standard of 50 µg/l (Illinois Environmental Council, 2019). Harmful algae blooms have also impacted the recreational use and drinking water use in the watershed. The underlying goals of the Otter Lake Regional Conservation Partnership Program (RCPP) are to provide communities with safe drinking water while keeping water treatment costs low, increase local farm incomes and make food more available to address environmental justice and persistent poverty.

Drinking Water Sources

Otter Lake is a direct drinking water source for Auburn, Divernon, Girard, Pawnee, Thayer, Tovey, Virden, and Nilwood along with additional rural residents. Approximately 19,000 residents rely on the lake for their drinking water. Macoupin County is home to a high percentage of residents living under conditions of persistent poverty, making the area more vulnerable to poor drinking water quality along with other issues of malnutrition and food deserts.

Impairments in the Watershed

Otter Lake has been recognized for water quality issues in the past. In 1996 and 2002, the lake was listed as "impaired", and in 2004 it was officially classified as such on the Illinois EPA 303(d) list, receiving a high priority ranking. This classification is a result of impairments related to sedimentation in erosion. The Otter Lake Watershed Management Plan (OLWMP) estimates that 8,000 tons of sediment is delivered to the lake annually from agricultural land via sheet and rill erosion.

The lake has been cited by the Illinois Nutrient Loss Reduction Strategy for nutrient impairment. A Total Maximum Daily Load (TMDL) was developed in 2005 for Hodges Creek/Otter Lake. The issues in the watershed have been worked on for 25 years, accomplishing significant amounts of work.

Currently the annual contaminant load delivered to the lake from the watershed via surface runoff and internal release is as follows:

- 13,801 lbs/year of phosphorus
- 151,591 lbs/year of nitrogen
- 13,801 tons/year of sediment

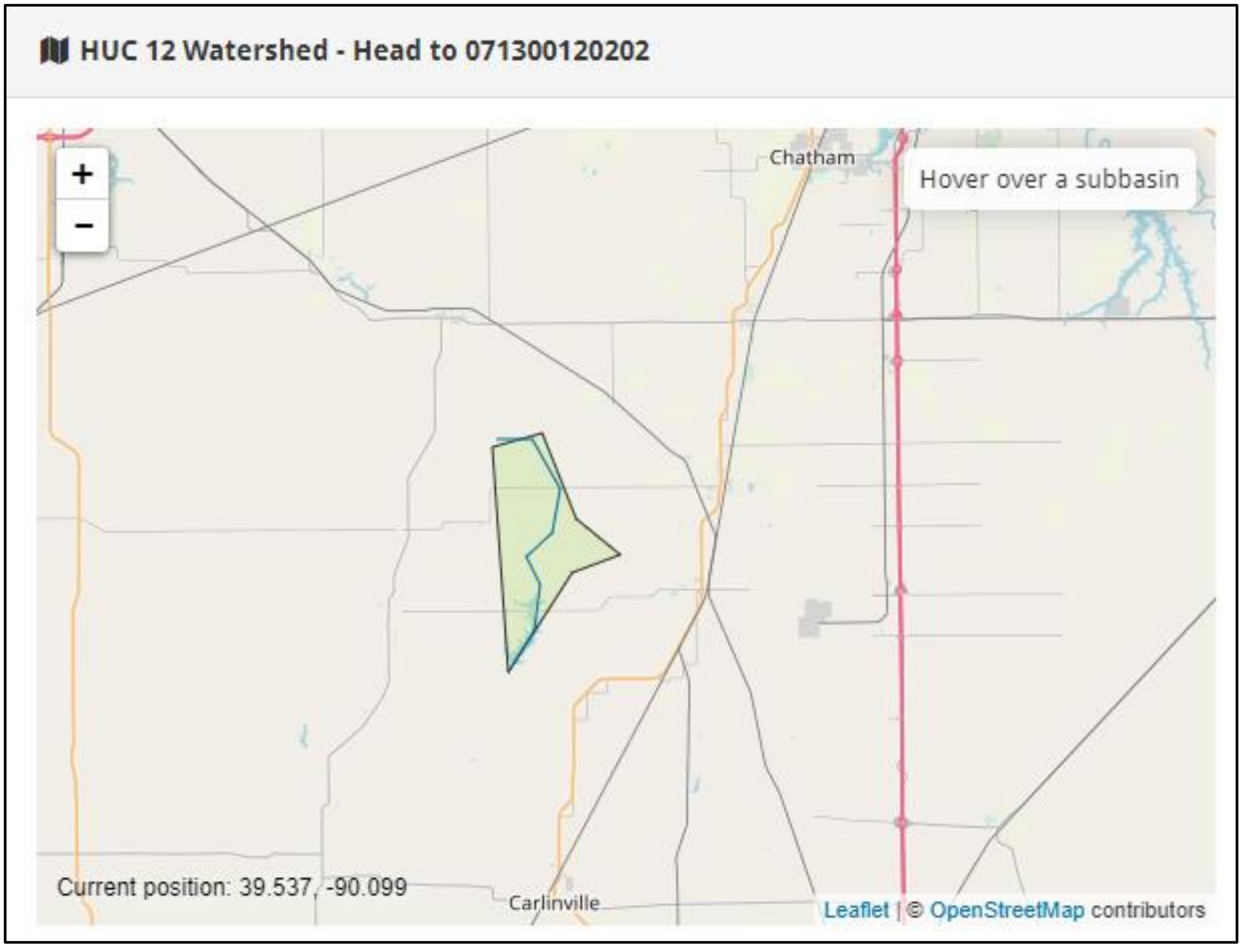


Figure 10.1. The Otter Lake watershed, as visualized in the HAWQS software.

Past Efforts

In the past, the Otter Lake Water Commission received two Section 319 grants from the USEPA, which targeted non-point source pollution. The grants led to the removal of Manganese and aquatic algae impairments in Otter Lake, and the lake achieving a full use designation for public and food processing water supplies. In 2018, a new Otter Lake Watershed Management Plan was completed, which identified and quantified the causes and sources of nutrient and sediment pollution. The plan also identified location-specific practices to address the nutrient and sediment. The plan lays out a roadmap to focus conservation efforts and identifies the most effective treatment practices. The RCPP project will rely heavily on the Watershed Management Plan to identify cost-effective practices and locations at which they are implemented.

Natural Resource Concerns

There are two principal natural resource concerns:

1. Water quality degradation due to high nitrogen and phosphorus loss from upstream lands.

2. Inadequate wildlife habitats in the watershed. Invasive plants, such as bush honeysuckle, have replaced native plants, depleting food and shelter for wildlife

The project has two objectives to address the concerns above:

1. Protect source water and improve water quality, while identifying best management practices that are tailored for each land and producer.

2. Increase and improve wildlife habitat by reducing lake bed sedimentation, establishing corridors, controlling invasive species, and rearing and stocking bass in the lake.

The project features three key innovations to meet the objectives above. First, the project will be guided by the OLWMP and will prioritize those sites where conservation work can achieve the greatest sediment and nutrient reductions. Second, the project will provide producers with cutting-edge tools that combine publicly available data on soils and climate with customized precision agricultural data, such as seeding rate and fertilizer application, to identify crop performance efficiency. Third, the partners will augment USDA-NRCS funding with other sources (federal and non-federal) to implement various conservation practices.

Key Project Partners

The project is jointly led by the Otter Lake Water Commission, an independent public utility that provides water supply to over 19,000 residents, and the Illinois Corn Growers Association, a not-for-profit membership organization, whose members are primarily local producers involved in nutrient loss reduction strategies in Illinois. They are assisted in this RCPP project by a host of other local and regional stakeholders, some of whom are listed in Table 10.1.

Table 10.1. A list of key project partners

Type	Organizations
Municipal / Local government	City of Auburn, City of Girard, City of Virden, Village of Divernon, Village of Nilwood, Village of Pawnee
State agencies	Illinois Environmental Protection Agency- Bureau of Water
Educational	Blackburn College, University of Illinois Extension
Cooperatives	Illinois Lake Management Association, Sunset Lake Homeowners Association, Macoupin County Soil & Water Conservation, Macoupin County Farm Bureau
Trade groups	
Industry	AgSolver, Ecosystem Services Exchange, AgriDrain Corp
Environmental/ Conservation	American Farmland Trust, Otter Lake Quail Forever

Project Monitoring Plan

To evaluate project outcomes, local water quality monitoring results will be compared with the estimates from the Otter Creek Watershed Management Plan. Direct water quality monitoring will include: total nitrogen, total and dissolved phosphorus, and total suspended solids. The monitoring results will be coupled with the load model to quantify effectiveness of the implemented agricultural practices on a watershed scale.

Although the RCPP project was approved in 2017, NRCS funding has not yet been made available to the project leaders and the project has not formally begun. Therefore, there are no monitoring data to assess the effectiveness of the project practices. To enable modeling using HAWQS later in this chapter, the report relied on planned estimates of activities listed in the RCPP proposal.

Project Practices

Activities planned for implementation to address water quality degradation include: filter strips, field borders, grade control structures, grassed waterways, water and sediment control basins, constructed wetlands, nutrient management plans, cover crops, and no till/strip-tills (Figure 10.3). To address inadequate wildlife habitats, the project will establish corridors (grasslands), and control invasive species along with rearing and stocking bass in the lake. The project leaders also believe that the in-field conservation practices will reduce the sediment loss from farmlands, thereby creating a favorable environment for native fish who prefer deep cool waters. Using non-federal funds, the project partners will implement lake shore stabilization, low-flow in-lake dams, stream riffles, and streambank stabilization practices (Figure 10.4).

Figure 10.3. A water and sediment control basin. Photo courtesy: Otter Lake Water Commission.

Producer Outreach and Activities

There are approximately 76 individuals/entities that operate farms in the watershed. Based on previous participation rates, an estimated 19 producers (25%) are likely to engage in the project. Outreach and engagement will be provided by the Precision Conservation Management (PCM) program to address water quality issues by working directly with farmers to help them understand their sustainability levels and how to adopt new conservation practices. Social media, traditional media, and direct contact will be implemented to ensure that producers are informed of the project and its benefits. The project plans to reach out to historically underserved producers including socially disadvantaged, beginning, or limited resource producers.

Figure 10.4. Shoreline stabilization of a local pond. Photo courtesy: Otter Lake Water Commission.

Accomplishments

Since the RCPP project has not yet formally begun, there are no accomplishments as of date to report.

Efficiency and Efficacy

As the RCPP project has not yet formally begun, there is no data for cost and effectiveness of implemented BMPs.

Water Quality Monitoring Results

The project has just begun setting up monitoring stations in the watershed. Level loggers have been placed in all three main tributaries (one in each), which will allow the collection of grab samples – at least once monthly, plus during storm events. The samples will be analyzed for all forms of nitrogen, total phosphorus, dissolved phosphorus, dissolved oxygen, and several other parameters.

Figure 10.5. Partial view of Otter Lake. Photo courtesy: Otter Lake Water Commission.

Economic Benefits

Otter Lake is a direct drinking water source for 19,000 residents across several municipalities. In addition, the lake attracts visitors for recreational activities such as camping, fishing, and boating. All of these uses will be in jeopardy if the lake continues to experience impairment due to sediment and nutrient contamination. The Otter Lake Watershed Management Plan and the RCPP project are targeted toward preserving the water quality in the lake for drinking as well as recreation. The farmers in the watershed are likely to experience economic benefits due to lower usage of farm inputs such as fertilizers and see higher yields. Moreover, the larger benefits will accrue to the entire region from higher quality water in the lake and its tributaries.

Long-term Viability

Since the project has barely begun due to a delay in release of funds from NRCS, project leaders haven't paid much attention to financing approaches to keep the conservation efforts going beyond the 5-year funding period. However, they were confident that some of the watershed efforts will continue even in the absence of RCPP funding. The OLWC has received section 319 grants from the USEPA for non-point source pollution control, which were matched by local partners for maximum leverage. Project leaders expect to apply to such funding again the future.

Additionally, since approximately 25-30% of the nutrient load comes from the lake itself, the leaders will continue to practice in-lake mitigation efforts such as shoreline erosion control, limited dredging of the in-lake basin, aeration to limit nutrient release, etc.

Project Highlight

The Otter Lake project is unique in that it uses an extraordinarily detailed watershed model to pinpoint where interventions will be most effective. This model is similar to the HAWQS model in that it simulates the watershed based on land use, but the Otter Lake model is much more detailed, incorporating the specific geography of the watershed into the model. Based on this, the Otter Lake RCPP plan has chosen to focus on implementing highly impactful BMPs in locations with the most runoff, rather than applying lower impact BMPs such as cover cropping to large areas of farmland. This should allow the Otter Lake RCPP to achieve large reductions in nutrient pollution more efficiently, and at a lower cost.

HAWQS Modeling Results

Presented below are results for water quantity and quality in the Otter Lake watershed obtained from the HAWQS model.

Complications with Modeling

The Otter Lake watershed is small, accounting for a HUC 12 size. The HAWQS model is unable to present future climate projections as well as contaminant loading for a watershed of this size.[26] As a result, the flow and water yield projections are based on data for the HUC 10 watershed that encompasses the Otter Lake watershed, which are then appropriately scaled down to the HUC 12 size. In addition, the Otter Lake watershed RCPP has barely begun implementation, so there are no measures of progress that can be used as benchmarks. Therefore, instead of modeling the future contaminant loading based on various levels of conservation implementation, the results presented below show contaminant loading in the past based on various levels of conservation implementation using historical data.

Flow and Water Yield

A temporal plot of surface flow (referred to as just 'flow' here) at the outlet of the watershed suggests a moderate increase in flow compared to past data, which stays relatively constant until 2070 (Figure 10.6). A review of the monthly distribution of water yield (which includes subsurface and surface flow) reveals additional patterns (Figure 10.7). Water yield is compared across three time periods: 1980-2010 (historical data), 2010-2040 (near-term future), and 2040-2070 (long-term future). Water yield is expected to increase by 106% in the near-term and 108% in the long-term, as compared to historical data. In contrast to a majority of the watersheds analyzed in this report, the increase is pretty uniformly spread out across the seasons. The maximum increase occurs in the spring (Mar-June) season (112% and 118% in the near-term and long-term, respectively). This is consistent with a warming climate which results in higher precipitation (in the form of snow in winter). However, the snow will readily melt as summer approaches and temperatures rise. As a result, water yield will diminish in the subsequent months. Since spring is also the season with the highest water yield, this lopsided distribution of water yield will result in extreme flooding during the spring, not unlike the one being experienced in the region in 2019, and drought during the summer and fall seasons.

[26] HAWQS allows future climate projections for HUC 8 and HUC 10 scale watersheds.

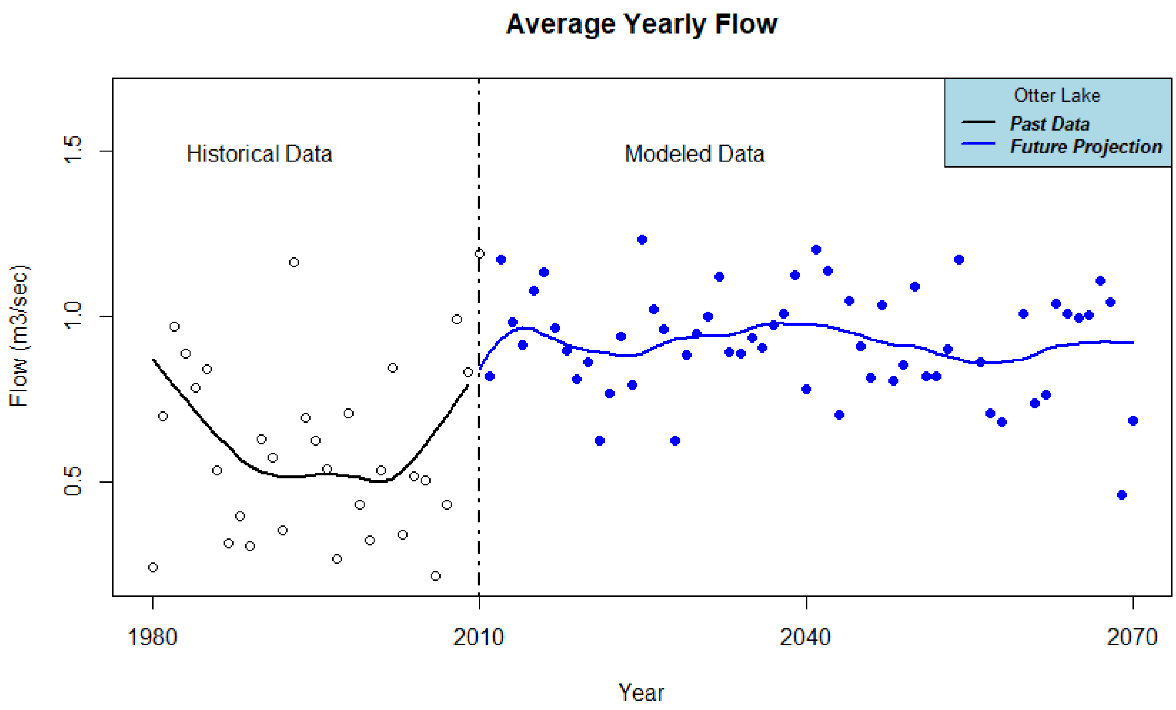


Figure 10.6. Average yearly flow (m^3/s) at the outlet of the Otter Lake watershed. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

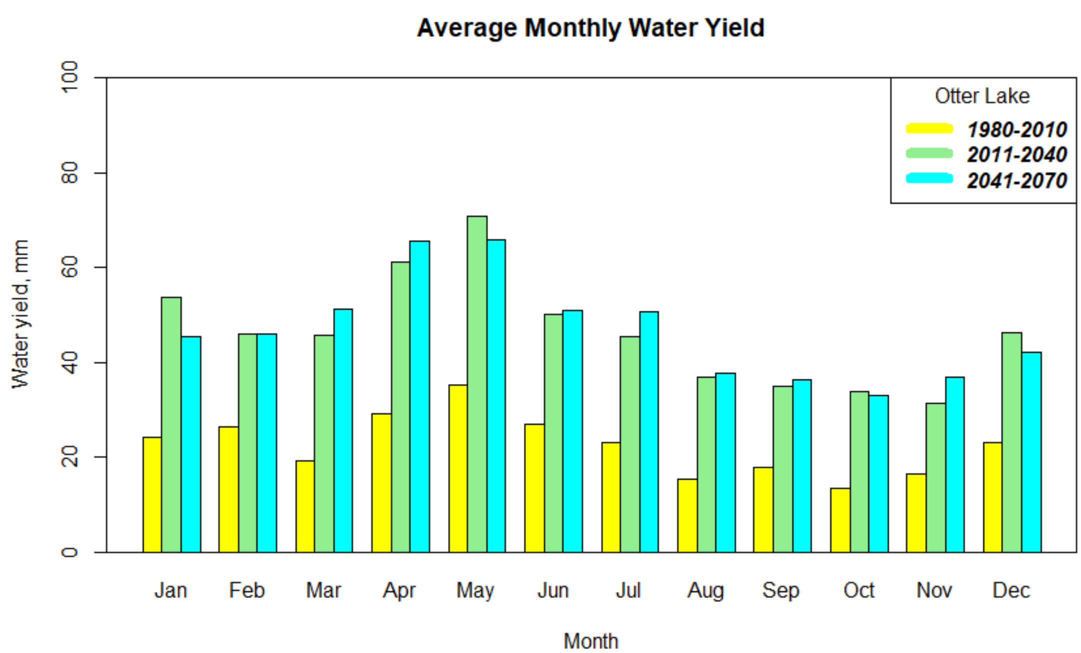
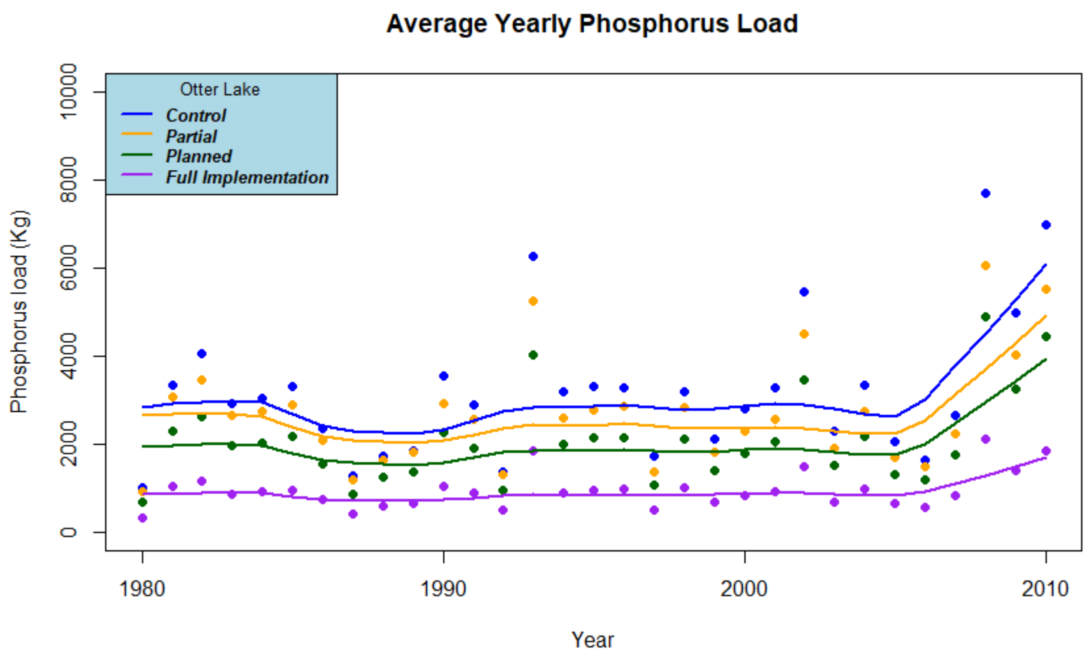


Figure 10.7. Average monthly water yield (mm) at the outlet of the Otter Lake watershed across three time periods.

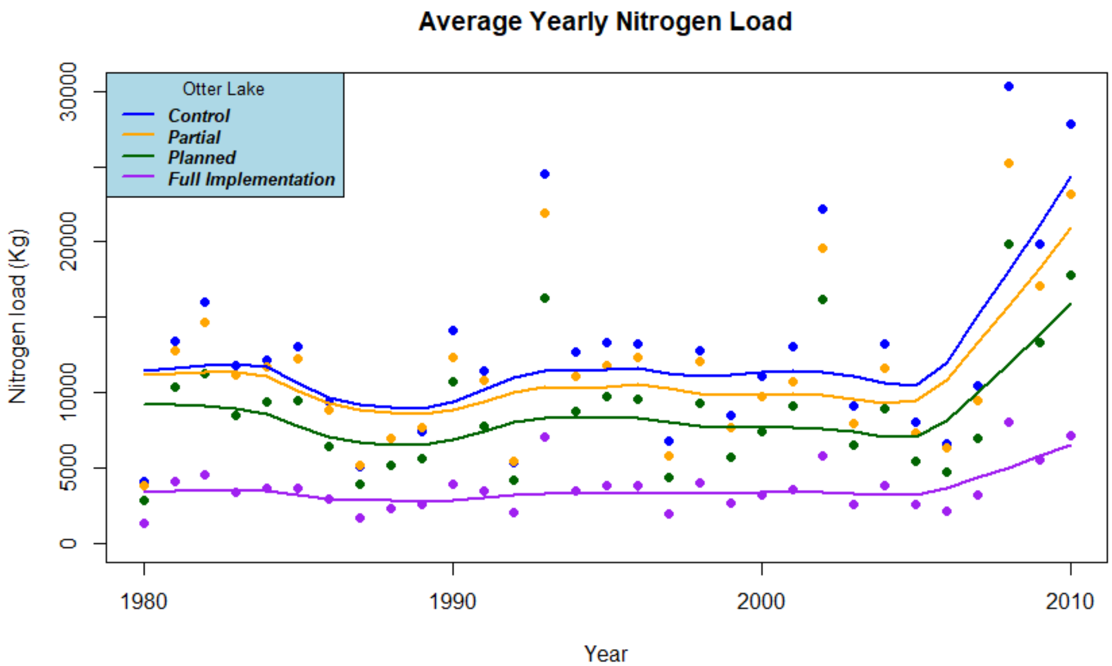
Contaminant Loading

Figure 10.8 shows the average annual loading for phosphorus (kg) and nitrogen (kg) at the outlet of Otter Lake under four scenarios. As described earlier, the Otter Lake watershed scenarios are retrospective, as they imagine a world in which conservation measures were being implemented at various levels since 1980, rather than being prospective. Apart from the HAWQS limitation on future modeling in HUC 12 watersheds, the size of the Otter Lake watershed presented challenges in other ways too as it became impossible to scale up the RCPP efforts without running out of land to model the expansion in conservation practice. As a result, four modified scenarios were generated for the Otter Lake watershed: *Control*, *Partial*, *Planned*, and *Full Implementation*. *Controlled* and *Full Implementation* scenarios retain the same meaning as that in the other case studies. *Partial* refers to 50% implementation of the proposed RCPP activities, whereas *Planned* refers to the complete implementation of the activities described in the RCPP proposal.[27]



(a)

[27] Since most projects rarely achieve 100% of its objectives, an implementation rate of 50% can be taken as a lower-bound estimate of conservation activities carried out under this RCPP project.



(b)

Figure 10.8. Average annual load for (a) phosphorus and (b) nitrogen, at the outlet of the Otter watershed for historical data under four scenarios. Annual average values are smoothed using a local polynomial regression to limit the influence of year-to-year rapid fluctuations.

Under the *Control* scenario, annual loading for phosphorus and nitrogen displays wide year-to-year variations, but track relatively closely with flow. A regression analysis of the data shows that average loading stayed constant over time, but increased in the period from 2005 to 2010, mirroring recent increases in watershed flow.

Phosphorus and nitrogen loading under the *Partial* and *Planned* scenarios are marginally and significantly lower than the *Control* scenario, respectively, and generally track the same trend as the *Control* scenario. For both contaminants, the *Full Implementation* scenario results in the lowest loading rates.

Figure 10.9 displays the reduction in loading (in percentage) under the three conservation scenarios – *Partial*, *Planned*, and *Full Implementation*.

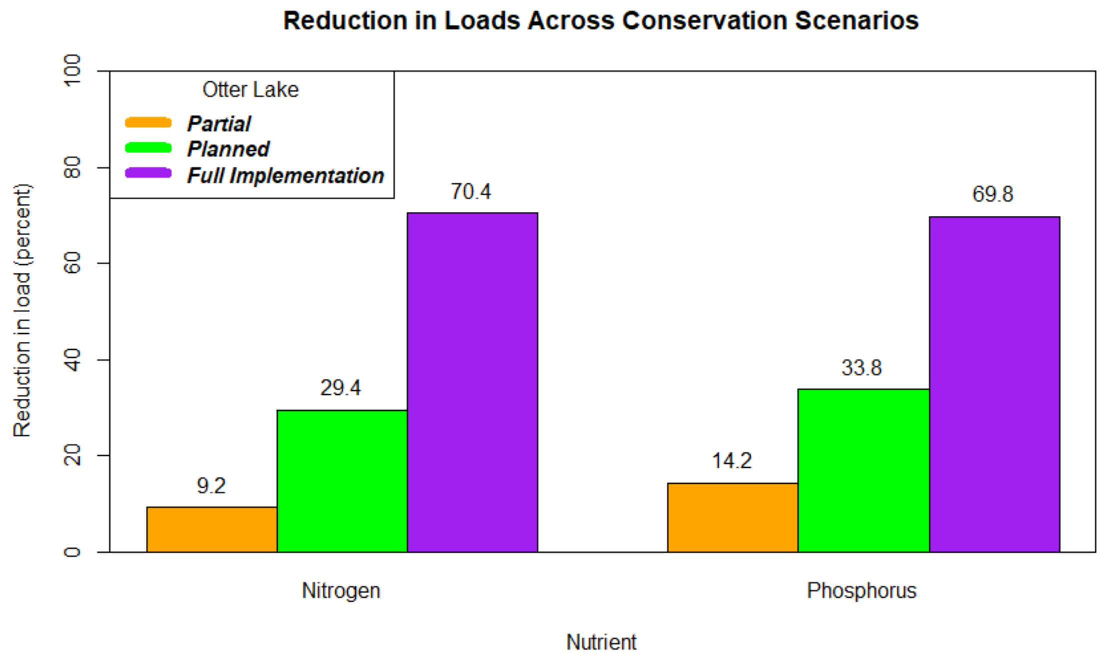


Figure 10.9. Reduction in phosphorus and nitrogen loading under three conservation scenarios as compared to the *Control* scenario.

Under the *Partial* scenario where about half the planned interventions were implemented, phosphorus and nitrogen loading would decrease by 14.2% and 9.2%, respectively, as compared to the *Control* scenario. Additionally, if the Otter Lake RCPP plan had been fully implemented (under the *Planned* scenario), phosphorus and nitrogen loads would have been reduced by 33.8% and 29.4%, respectively. The reductions under the *Planned* scenario are more than twice that achieved under the *Partial* scenario, showing how multiple BMPs used in conjunction can have a much greater impact than each BMP implemented alone. Under the *Full Implementation* scenario, where all applicable BMPs are implemented across the entire watershed, phosphorus and nitrogen loads are predicted to be 69.8% and 70.4% lower, respectively. Reductions in nutrient loading under the *Partial* scenario closely mirror the reductions predicted by the project leaders in the Otter Lake RCPP proposal, suggesting that the project leaders considered the challenges of program implementation while arriving at realistic estimates of program efficacy.

Although the model for the Otter Lake watershed does not provide data for the future, it nevertheless provides a window into the future based on historical data and leads us conclusions similar to those in other locations. Large-scale expansion of the RCPP program across much of the watershed would be needed to significantly reduce the nutrient loading in the watershed and improve the water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations. However, it must be noted that despite implementing conservation on all farmland in the watershed in the *Full Implementation* scenario, average annual phosphorus concentration in Otter Lake remained well above 50 µg/l (which is the Illinois standard for total phosphorus in lakes) during the entire study period (Illinois Environmental Council, 2019).[28]

Summary

Otter Lake has historically suffered from high nutrient levels, and was listed as impaired by Illinois EPA. Excessive levels of sedimentation and nutrient loading from upstream and in-lake nutrient release have exceeded the state's phosphorus standard of 50 µg/l. The main goal of the Otter Lake RCPP project is to significantly reduce the loss of phosphorus and curb soil erosion across the Macoupin Creek. The RCPP project will be guided by the Otter Lake Watershed Management Plan designed in 2018 that identifies locations within the watershed where conservation work can achieve the greatest sediment and nutrient reductions. Although the project was approved in 2018, funds are yet be released and the project has not effectively begun, which precludes any assessment of the conservation efforts. The RCPP project relies on an extraordinarily detailed watershed model to pinpoint where interventions should be applied, such that they achieve large reductions in nutrient pollution more efficiently and at a lower cost. HAWQS modeling suggests a doubling of the annual water yield in the future, which will present water management challenges in the watershed. Unlike other case studies in this report, the HAWQS model was applied retrospectively to phosphorus and nitrogen loading over the last 30 years. The current conservation approach, as executed via the RCPP project, was found to show only modest reductions in historical contaminant loading, suggesting a similar result if the model were to be applied prospectively to the future. Additionally, there needs to be a long-term strategy to remove legacy sediment in the lake bed to prevent impacts downstream. Large-scale expansion of the RCPP program across much of the watershed would be needed to significantly reduce the contaminant loading in the watershed and improve the water quality called for in the Gulf of Mexico Hypoxia Task Force recommendations.

[28] The state standard is 0.05 mg/l, which is presented in µg/l in this report for consistency with other states such as Wisconsin.

Chapter 11: Discussion & Lessons Learned

Agricultural activities have been identified as the primary contributor of nitrogen and phosphorus across the Mississippi River Basin (Robertson et al., 2014) and other watersheds such as western Lake Erie (Betanzo et al., 2016; Robertson & Saad, 2011). Thus, much of the efforts to address nutrient pollution in lakes and rivers have been focused on reducing the loss of nitrogen and phosphorus from agricultural fields.

Agricultural conservation has long been championed by agronomists, extension educators, and even the federal government. But it has historically relied on voluntary actions by the farmers with little to no feedback from other stakeholders in the region, especially those living downstream of these farms. The current iteration of conservation programs, especially highlighted by RCPP, relies on multi-stakeholder collaborations that focus on holistic improvements to the watershed, and not just to the farms in question.

A review of six ongoing RCPP projects in the Upper Mississippi River basin confirms the role of federal funding from NRCS in initiating or strengthening these collaborations across various sectors from state and local governments to educational institutions, agri-businesses, and environmental organizations. The diversity of institutions was not just reflected in the list of collaborators, but even among project leaders, which included local governments (The City of Cedar Rapids and the City of Oconomowoc), state agencies (Minnesota Department of Agriculture), environmental organizations (Tall Pines Conservancy and American Farmland Trust) and trade associations (Iowa Corn Growers Association). There is no set template for an RCPP project; each one is structured differently. This fact was repeatedly stated by multiple NRCS officials in conversations with the authors.

In nearly all locations, the RCPP project was in response to significant water quality and nutrient loss issues, which manifested in the form of repeated violations of state standards or the establishment of total maximum daily loads (TMDLs). The RCPP projects were however not the first steps taken by the community to address these challenges. In most cases, they were the outgrowth of previous efforts that began in pilot subwatersheds or conducted at a smaller scale. The Gulf of Mexico Hypoxia Taskforce and the various state nutrient loss reduction strategies were major drivers of these efforts as these documents set targets for reduction in various contaminants, highlighted particular watersheds or regions for immediate action, and prescribed a set of practices to be implemented. Across the six projects, phosphorus was a major concern in three projects, nitrogen was a major concern in one project, and two projects were structured to address both phosphorus and nitrogen. Fish and wildlife, soil health, and flooding were additional issues targeted by the RCPP projects.

The RCPP projects studied in this report employed a variety of conservation practices, although a few of them dominated. Planting cover crops during the off-season was an especially popular practice, since not only does it improve soil retention, it also provides a mulching effect, resulting in lesser application of fertilizers when planting corn and soy crops. It is, however, a resource-intensive practice that requires constant financial support, thus limiting its scalability. In terms of effectiveness, cover crop planting is less-effective than other edge-of-field practices such as filter strips and bioreactors[29], but yet ultimately favored by farmers as it can be implemented without any loss of productive land (as would happen in the case of edge-of-field practices). Cover crops are also viewed by project leaders as an easy way to introduce farmers to conservation without radical changes to their land or way of cropping. Filter strips, nutrient management, and strip till/no till were other commonly employed conservation practices.

Outreach and engagement with producers was one of consistent highlights across all the projects. Project leaders have led outreach in a variety of ways, including workshops, booths in local community events, and field trips to demonstrate conservation implementation. Outreach to underserved communities, including women and black farmers, beginning farmers, and non-operating landowners, was a particular focus in several RCPP projects. Providing regulatory relief to participating farmers, as done in Minnesota and Wisconsin, was an added incentive to increase participation in the program. The effectiveness of project outreach caused the RCPP projects to be fully subscribed, with many farmers being waitlisted.

Water quality monitoring is an important element of RCPP projects, and one that sets it apart from other historical conservation efforts. The inclusion of downstream stakeholders elevated the role of monitoring as well as its scope. However, there was no standardized protocol for water quality monitoring across the different projects, and each project designed the scope and frequency of monitoring according to its capabilities and needs. Although this flexibility resulted in collaborations with volunteer groups and local educational institutions providing hands-on training for students, it also led to instances where monitoring frequency was so sparse that it would not result in any meaningful data. One explanation for the lack of a standardized protocol on monitoring could be traced to the fact that the RCPP program does not provide financial support for implementing water quality monitoring as it is not considered a core part of the conservation activity.

All water quality improvements yield benefits to the local waterways, ecosystems, residents, and businesses. However, only some of these can be easily quantified. Bringing region-wide economic benefits is currently not a focus of RCPP and none of the projects quantified economic benefits arising out of conservation implementation as part of the overall project strategy. This might be attributed, at least in part, to the core mission of RCPP – which is to improve water quality and soil health without impacting yield – despite the fact that USDA, the parent agency administering the program, prioritizes economic development as part of its vision.[30] Nevertheless, some of the project leaders were aware of the impact of conservation and improved water quality on the local economy. Particularly, the Oconomowoc River watershed, Otter Lake, and the Middle Cannon River watershed are known for their high-quality water and recreational opportunities. Additionally, anecdotal evidence from farmers suggested that cover crops provided economic value by way of requiring less fertilizer and weedicides, thus improving profitability.

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[29] Bioreactors are effective in treating only nitrogen, but not phosphorus

[30] See https://www.usda.gov/our-agency/about-usda

Even as conservation programs are financially supported by state agencies, charitable foundations, local governments, businesses, and other stakeholders, funding from the federal government remains a critical driver of the widespread adoption of conservation practices. Given the scale of the effort needed to improve soil health and water quality, investments in conservation and related institutions, including identifying community leaders to champion the cause of conservation, need to be expanded both in scope and over time. Any expansion in federal support may be offset by the growing need for conservation funding in other equally deserving watersheds. This means communities need to envision limited federal support, such as those from RCPP, as seed funding to attract non-federal sponsors to retain and expand the producers engaged in conservation. Two out of the four projects approaching maturity are notable in this regard. The Minnesota Agricultural Water Quality Certification Program (MAWQCP) leverages federal funding with a state program expressly designed to incorporate conservation into everyday decision-making. The 10-year window for the certification outlasts the 5-year RCPP funding, and should the state program continue, enrollment in the program should continue to increase with limited drop-offs. The Middle Cedar RCPP is leveraging the presence of several multinational companies that rely on clean water by investigating alternative ways to finance conservation using a "pay for success" model implemented in the social and environmental sector.[31]

Despite shortcomings in an area or two, each RCPP project assessed in this report had one or more unique elements that made the project stand apart and marked it for success. In nearly every project, the use of computer models and software to identify farms with high nutrient loss and to suggest customized conservation practices tailored to each farm integrated technology in one of the oldest occupations perfected by human civilization. The Oconomowoc River RCPP and the MAWQCP in Minnesota utilized state programs in conjunction with federal funds to ensure water quality improvements were achieved at the lowest cost possible. Targeting non-operating landowners, primarily women, through learning circles in the Upper Macoupin Creek RCPP aimed to bring farmers that are not targeted in traditional conservation outreach programs. Projects such as the Middle Cedar RCPP and the MAWQCP have created synergies between local farmers and large agri-businesses to better appreciate water quality and the local supply chain systems. Finally, all of the projects assessed in this report validated the RCPP's principal approach of bringing together upstream and downstream partners, along with a range of stakeholders, to effect change on working lands and ensure better water quality.

The RCPP's structure allows project leaders to craft innovative approaches in implementing conservation practices. There is no template that projects follow, which makes it hard to compare projects across any particular attribute. The first five-year cycle of RCPP comes to an end in 2019. The program was authorized again in the 2019 Farm Bill, giving it another five years. Changes to some elements such as transferability of funds across the different programs (EQIP, ACEP, CSP, and HFRP) are forthcoming, which will be beneficial to project participants.

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[31] See https://www.payforsuccess.org/learn/basics/#what-is-pay-for-success for an explanation of the concept

Watershed modeling conducted in HAWQS to simulate the impact of climate change indicated that the average yearly flow was expected to increase significantly in the future, bringing sediment and nutrients along with it. Significant increases in the water yield are also expected, both in the near-term and the long-term (Figure 11.1). [32] The increase in the annual water yield ranges from 3% to 106% (median 65%) in the near-term, and from 18% to 108% (median 68%) in the long-term, suggesting that much of the increase and its associated impacts are expected to occur in the near-term. Middle Cannon River was the only watershed where the water yield increase in the long-term was less than that expected in the near-term.

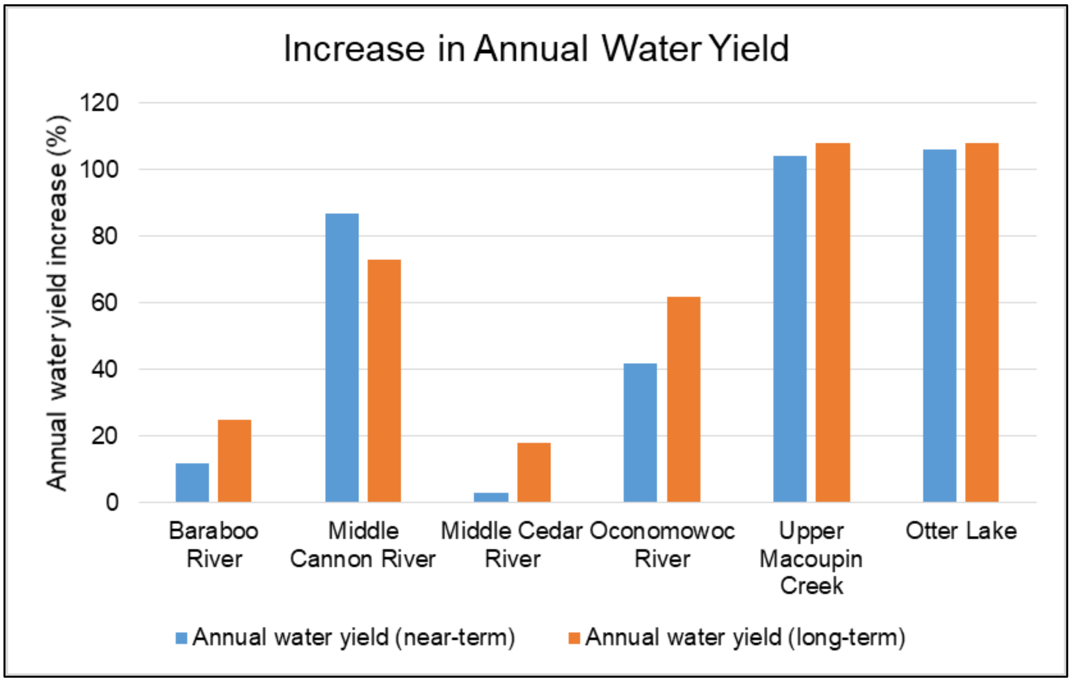

Figure 11.1. Change in annual water yield in the near-term (2010-2040) and the long-term (2040-2070) as compared to the baseline (1980-2010).

There was no consistent pattern in the predicted contaminant loading. The contaminants – phosphorus, nitrogen, and sediment – were projected to increase consistently in certain watersheds, while others showed an oscillating pattern with the loading in 2060 even lower than that in 2020. There was, however, remarkable consistency with regard to how the different scenarios played out. In the five watersheds where future scenarios were analyzed (Otter Lake was analyzed in a slightly different method, and is thus excluded from this analysis), the *Continued* scenario showed the least reduction in contaminant loading, followed by the *Expanded* scenario. The *Full Implementation* was the best performing scenario.

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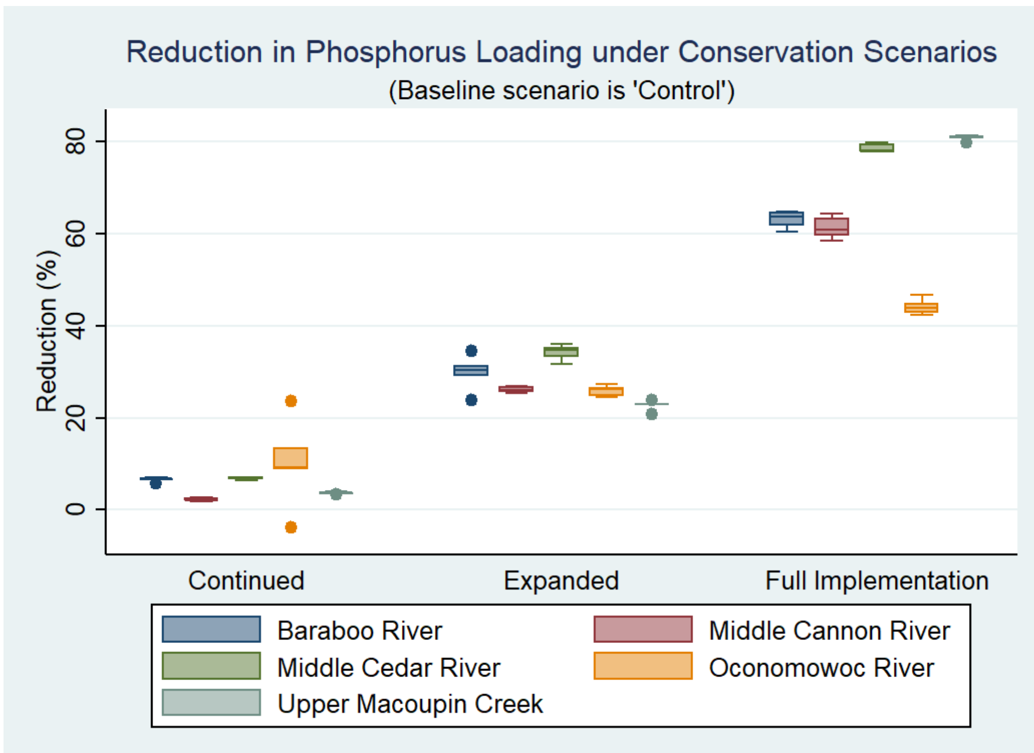
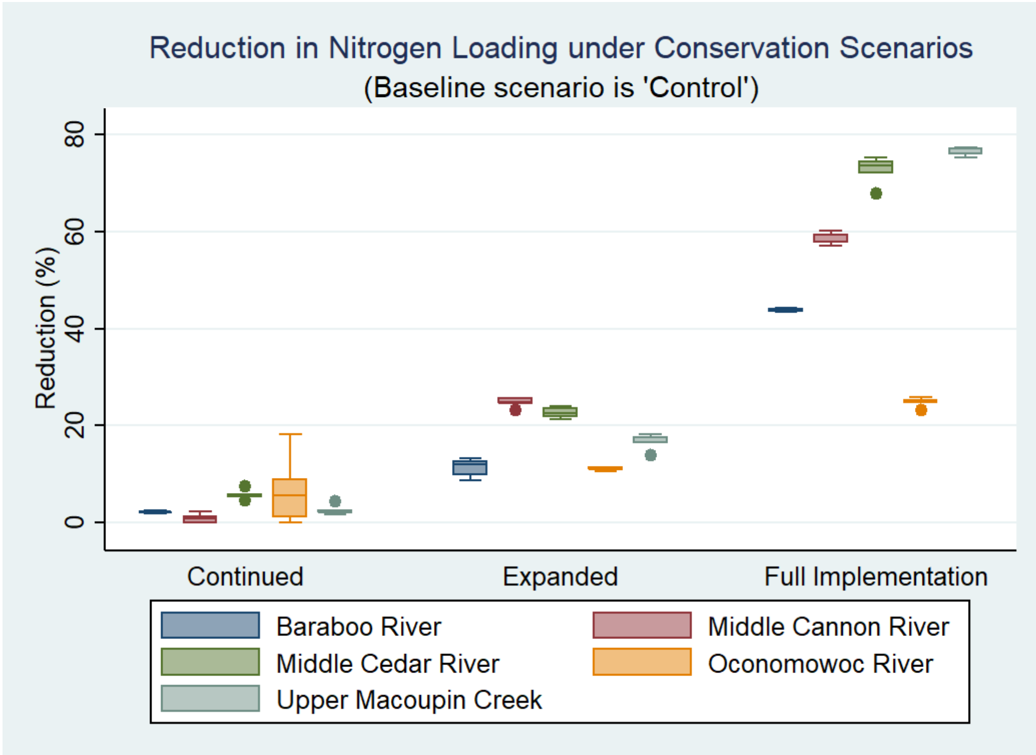
32 This is consistent with findings that rainstorms have gotten bigger and more frequent across the Midwest in the last 100 years. See an article published in FiveThirtyEight (Koeze, 2018): https://fivethirtyeight.com/features/the-midwest-is-getting-drenched-and-its-causing-big-problems/

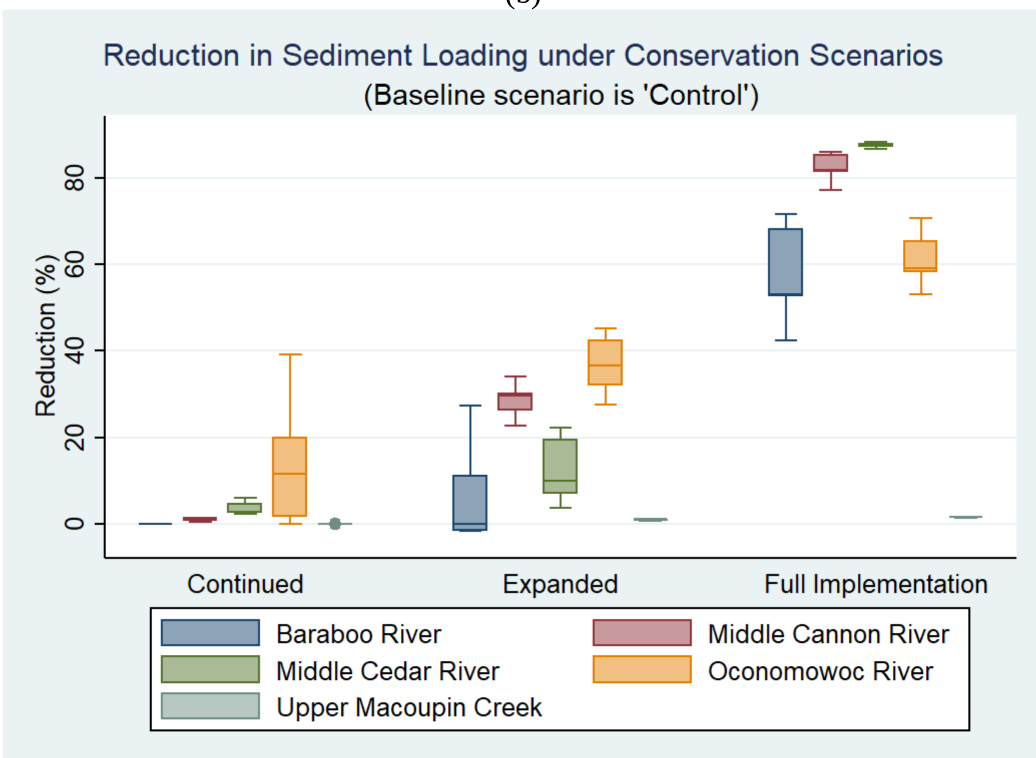
Figure 11.2 shows the reduction in contaminant loading across three conservation scenarios for five project locations. In the case of phosphorus, the *Continued* scenario results in an average reduction of 5.9% (with range from -3.9% to 23.5%), the *Expanded* scenario results in an average reduction of 27.7% (with range from 20% to 36%), and the *Full Implementation* scenario results in an average reduction of 65.5% (with range from 42.4% to 81.3%). While nearly all watersheds exhibited contaminant reductions in a tight range, the Oconomowoc River watershed exhibited a wide range in the *Continued* scenario, and the lowest reduction in the *Full Implementation* scenario.



(a)



(b)



(c)

Figure 11.2. Reduction in contaminant loading under various conservation scenarios for (a) phosphorus, (b) nitrogen, and (c) sediment. Results presented as boxplots, where the bottom and top of the box represent the 25^{th} and 75^{th} percentile and the band inside the box is the 50^{th} percentile (or the median). The circles represent extreme values or outliers.

In the case of nitrogen, the *Continued* scenario results in an average reduction of 3.6% (with range from -0.2% to 18.2%), the *Expanded* scenario results in an average reduction of 17.3% (with range from 8.8% to 25.7%), and the *Full Implementation* scenario results in an average reduction of 55.2% (with range from 23.2% to 77.4%). The Oconomowoc River watershed exhibited similar patterns to those observed in case of phosphorus. Additionally, reductions in nitrogen across the three scenarios were consistently lower than that obtained in the case of phosphorus. This may be attributed to the presence of more projects that targeted phosphorus than nitrogen in our analysis.

In the case of sediment, the *Continued* scenario results in an average reduction of 3.8% (with range from 0% to 39.1%), the *Expanded* scenario results in an average reduction of 17.2% (with range from -1.6% to 45.2%), and the *Full Implementation* scenario results in an average reduction of 58% (with range from 1.4% to 88.2%). The modeling results for sediment reduction were most unlike the ones obtained for phosphorus and nitrogen, with larger ranges for each watershed.

Overall, RCPP projects generally resulted in statistically significant but low-impact reductions in nutrient pollution across watersheds. Programs, as currently implemented, generally reduce pollution from phosphorus, nitrogen, and sediment by approximately 3-6% across the watershed. Project leaders have generally set targets within realistic ranges for the RCPP project, suggesting that project leaders and stakeholders are aware of their organizational capacity and have set targets accordingly. Significant expansion of the conservation adoption in the watersheds will result in a 17-27% reduction, while full implementation will bring a 55-66% reduction in contaminant loading. However, as observed in a few cases, watersheds did not meet the state standards for particular contaminants even after conservation was expanded to the entire watershed. That, however, could be addressed by targeting high nutrient loss lands, which the HAWQS models is not designed to do.

Chapter 12: Policy Implications and Recommendations

This study gives rise to a number of policy implications, applicable from the federal to the state and local levels. This section will explore the policy implications of this study and the resulting recommendations.

Expand conservation funding

Our analysis of five RCPP projects found that if the current scale of conservation was continued, we expect to achieve a reduction of 3-6% in the future contaminant loading, as compared to the baseline scenario. This reduction is statistically significant, but not remarkable. A 10-fold expansion of the current conservation program will result in a more meaningful reduction of 17-27%, which may still not be sufficient to meet the overall challenge. While conservation effectiveness can be enhanced in many ways, some of which are outlined in this section, the primary way to increase adoption of conservation is to increase its scale by supporting more projects and at a greater magnitude. That will allow projects to support more producers over a larger area, increasing the overall impact.

Recommendation

The allocation of 10% of the overall conservation funds toward source water protection in the 2018 Farm Bill is an important step toward increasing the scale of conservation support, but Congress should go above and beyond that to appropriate greater support for conservation. As a pilot measure, NRCS could increase existing RCPP support to a select number of current awardees by 5-10 times and measure the resulting impact on the number of participating producers and water quality results. Results of this pilot can inform the scale of future federal funding for conservation programs.

Incorporating climate change projections

One of the most serious limitations of our current conservation paradigm is the absence of the role of climate change. Discussions with project leaders indicated that they were acutely aware of the impact of climate change on precipitation, soil health, and water quality. However, the current conservation approaches, including but not limited to RCPP, do not require an explicit accounting of the future impact of climate change and the resulting remedial actions necessitated in the respective watersheds. Modeling conducted as part of this study identified varying impacts of climate change on contaminants such as phosphorus and nitrogen over the long-term, but in nearly all the cases, contaminant loading was expected to increase in the near-term. Failure to incorporate the expected increase in contaminant loading can nullify water quality improvements achieved through conservation.

Recommendation

Congress must require NRCS to incorporate the role of climate change in all conservation programs run by the agency. While Congress or NRCS would have no authority over conservation activities supported by non-federal and private sources, the federal government's outsize role in conservation and its agenda-setting power has the potential to transform the agricultural sector and its response to the changing climate.

State efforts to complement federal conservation support

States, especially in the Upper Mississippi River Basin, have been proactive on limiting nutrient and sediment loss. All four states – Iowa, Illinois, Minnesota, and Wisconsin – have some version of a nutrient loss reduction strategy to identify reduction targets that match or mirror those set by the Gulf of Mexico Hypoxia Taskforce. States have also created flexible programs such as the Adaptive Management program in Wisconsin and the land certification program in Minnesota that can be combined with federal programs like RCPP to achieve the maximum possible contaminant reduction. Another example from outside the region is Maryland, where the Nutrient Management Program categorizes farms based on soil nutrient levels and accordingly sets limits on fertilizer usage.[33] State laws can also inhibit conservation, as is the case with a recent legislation in Iowa, approved in May 2019. Iowa's Senate File 548 prevents private entities such as land preservation trusts from purchasing farmland for the purpose of a future sale to a government entity (local, state, or federal) for conservation.[34]

Recommendation

State and local governments should adopt flexible programs that can complement federal efforts toward conservation. To encourage such an approach, federal funding for conservation, including RCPP, must include additional incentives for project awardees if they can leverage state or local laws and regulations to expand the impact of the federal funds and accelerate the pace of conservation. This will force conservation advocates to lobby their respective state and local governments to adopt such laws preemptively, thereby increasing their chances of receiving the federal funding. States may also experiment with mandatory conservation in certain critical watersheds and assess compliance, stakeholder relationship, and water quality results, before any statewide mandatory programs are instituted.

Prioritizing high-efficiency practices

Typical conservation projects, though not limited to RCPP, focus on short-term cover cropping and nutrient management, which are easy for farmers to implement and can result in a profit. However, these in-field practices produce lower reductions than edge-of-field practices such as

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33 See Maryland Department of Agriculture: https://mda.maryland.gov/resource_conservation/pages/nutrient_management.aspx

34 Although the law provides an exception for installing edge-of-field practices such as saturated buffers and wetlands, critics of the law fear the exception is too narrow and that the law is a detriment to the overall cause of conservation. See the text of the law here: https://www.legis.iowa.gov/legislation/BillBook?ga=88&ba=SF%20548

barrier strips, wetlands, and bioreactors, at a higher cost. Edge-of-field installations have a longer lifespan, are more permanent fixtures, and thus easier to verify and measure. Cover crop installation, however, is a "gateway" practice to introduce farmers to the world of conservation. Despite the lower efficiency, cover crops are an essential tool in the complex system of conservation.

Recommendation

While Congress and NRCS should continue to fund cover crops in the Farm Bill, additional incentives must be built in to promote the use of edge-of-field practices such as barrier strips, bioreactors, and constructed wetlands. Section 2503 of the 2018 Farm Bill authorizes an increase in the cost-share and incentives for practices with significant water quality or quantity benefits, including edge-of-field practices.

Monitoring standards

Based on the review of six RCPP projects, it appeared that there were no uniform standards for what contaminants should be monitored, and how they should be measured. It is inherently challenging to separate the impact of nutrient loss reduction efforts from natural cycles of flow and nutrient release. While most projects set up a monitoring program with multiple sampling locations, only a few were capable of assessing the impact of programs, or determining if programs had a significant and meaningful impact. This may be partly attributed to the lack of any financial support for monitoring activities within the RCPP.

Recommendation

Recognizing the importance of monitoring, Congress and NRCS should provide financial support for water quality monitoring through an appropriate cost-share formula and insist on a robust implementation of a monitoring program. In instances where monitoring is not feasible or not part of the core mission of the RCPP project (such as that observed in the case of MAWQCP), NRCS and the project awardee must ensure water quality data collected by state agencies includes the project watershed and are made available for post-hoc analysis.

Long-term viability

Limited financial support for conservation, especially at the federal level, means that conservation projects have to not only optimize their resources and achieve greater benefits, but become sustainable over the long-term. The current RCPP structure provides funding for five years, with an option to provide an additional year of funding. The 2018 Farm Bill also allows a limited number of RCPP awardees to apply for another round of five-year funding. Limited funds and the growing need for conservation across the country, however, will necessitate most RCPP awardees to identify alternative means of financing conservation, or cease their activities after current funding expires. The current RCPP program does not require project awardees to become sustainable after the five-year funding cycle, and as a result, only a few projects have even explored the question of long-term viability, let alone identify a financing mechanism to pay for the conservation activities.

Recommendation

NRCS should prioritize long-term viability when evaluating potential applicants for RCPP. This may include introducing a score for financial viability in the application process, allocating a small portion of the RCPP funding to projects explore and develop alternative financing mechanism, or providing supplemental funding to those projects that are on track to become financially sustainable without the federal support. Achieving financial sustainability may also cause projects to transition faster from financially expensive cover crops in the early stages of the RCPP to more sustainable edge-of-field practices in the later years.

Limiting restrictions on transfer of funds

Project leaders in at least a few projects indicated issues with the distribution of financial support across the various pools of conservation practices. At the time of application, each RCPP recipient indicates the amount of funding requested under each category – EQIP, CSP, ACEP, and HFRP. The 2014 Farm Bill, which provides the framework for all RCPP grants awarded until the publication of this report, does not allow transferability of funds across the various categories. Conversations with project leaders suggested that NRCS officials may have given an impression that transferability may be possible at a later time, but later clarified that it was strictly barred under the current rules. This led to situations where project leaders are unable to meet the demand for enrollment under EQIP, while failing to identify landowners who can participate in other programs such as ACEP (siting constructed wetlands is an especially challenging task) and thus foregoing federal funds marked for that activity.

Recommendation

NRCS should allow limited transferability of funds across the various conservation categories to allow maximum use of limited financial support. The 2018 Farm Bill has revised the structure of RCPP, which is likely to make this issue moot. However, the currently supported RCPP projects are still subject to this transferability rule. The transferability can be limited to ensure all or most of the funds dedicated to ACEP, CSP, or HFRP (which are long-term conservation measures and thus score highly on an application) are not then spent on EQIP (which is short-term and hence easy to allocate).

Citizen activism to achieve compliance and progress

In 2015, the Des Moines Water Works in Iowa filed a lawsuit against three upstream county drainage districts, citing them responsible for high nitrate levels in their intake water supply. The lawsuit was ultimately dismissed in federal court, but the legal fight over who is responsible for the nutrient pollution is just getting started. Earlier this year, an Iowa community organization and the environmental group, Food and Water Watch, filed a lawsuit against the state of Iowa and several state agencies for the poor water quality and recreation in the Raccoon River watershed (E&E News, 2019). In February 2019, the residents of Toledo, Ohio passed a ballot referendum that provides Lake Erie with personhood rights, meaning the city residents can sue on behalf of the lake whenever major environmental harm is caused to the lake.

Recommendations

To achieve compliance with the existing laws and to compel legislative bodies to craft new and progressive laws that protect the environment, citizens and community groups are increasingly turning to the courts and the ballot box. Environmental progress in the U.S. is littered with examples of such successful legal action to bring powerful players, including the government, to the negotiating table and come to an agreement. In the absence of robust and quick progress through institutional means, lawsuits from ordinary citizens and community groups asserting property rights, personhood, and material harm are much more likely in the near future.

Chapter 13: The 2018 Farm Bill

The 2018 Farm Bill reauthorized RCPP, but made some notable modifications to the Conservation Title in the process. In terms of overall funding, the Congressional Budget Office (CBO) projects that the 2018 Farm Bill increased funding for conservation by $555 million in the near future (FY2019-FY2023) while reducing it by $6 million over a longer period (FY2019-FY2028) (McMinimy et al., 2019).

The 2018 Farm Bill also modified its two largest working lands programs, the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP). CSP provides financial and technical assistance to farmers to help improve existing conservation practices and enhance comprehensive conservation efforts. EQIP provides similar assistance, but with a less comprehensive approach, focusing more on ad hoc structural, vegetative, and land management practices. Total funding for both programs was cut, with EQIP expanding (funding increases in increments from $1.75 billion in FY2019 to $2.025 billion in FY2023) while CSP's future enrollment was capped ($700 million in FY2019 rising to $1 billion in FY2023) to pay for the increase and the rest of the overall reduction in spending (McMinimy et al., 2019).

Land retirement and easement programs, including the Conservation Reserve Program (CRP) and Agriculture Conservation Easement Program (ACEP), were both reauthorized under the 2018 Farm Bill. CRP pays out annual rent payments to farmers for replacing crops in erosion-sensitive areas with more sustainable, resource-conserving plantings. In the 2018 Farm Bill, CRP was expanded with annual authorized CRP enrollment increased incrementally from 24 million acres in FY2019 to 27 million by FY2023 (McMinimy et al., 2019). ACEP provides financial and technical assistance through agricultural land and wetland reserve easements. The program was amended in the 2018 Farm Bill to provide flexibility for ACEP-eligible entities and increase overall funding from $250 million in FY2018 to $450 million annually for FY2019-FY2023.

The RCPP program was reauthorized and amended under the 2018 Farm Bill. There were a number of changes in the 2018 version of the program that differentiate it from the original 2014 version. First, RCPP is now moving away from enrolling land by way of existing conservation programs to acting as more of a standalone conservation program with its own distinct contracts. Partners will continue to define the scope and location of the RCPP project while providing a portion of the costs and working to enroll eligible farmers into the program. Second, the scope of RCPP-eligible activities has also expanded with the new Farm Bill, now covering "activities that may be carried out under additional covered programs." These additional programs include the CRP, EQIP, and Watershed Protection and Flood Prevention Act, among others (McMinimy et al., 2019). Third, funding for RCPP was also increased to $300 million a year for FY2019-FY2023, a $200 million-per-year increase from the previous Farm Bill. Fourth, the 2018 Farm Bill also added various flexibility measures to RCPP application, renewal, contribution, and reporting requirements (McMinimy et al., 2019). These changes were made with the intent of streamlining the process and making participation in the program easier for interested partners. Fifth, the 2018 Farm Bill added a requirement that the USDA update legislators on the progress made towards achieving the targeted conservation benefits of the program in the agency's biennial report it makes to Congress. Sixth, the 2018 Farm Bill changed the funding breakdown for RCPP from its previous allocation of 25% for a state competition, 40% for a national competition, and 35% for CCAs. The new funding breakdown is 50% for state and multistate competitions and 50% for CCAs. Finally, there were also a number of more technical and definition-related modifications to program in the 2018 Farm Bill. These changes have been comprehensively detailed by the Congressional Research Service in its report, "The 2018 Farm Bill (P.L. 115-334): Summary and Side-by-Side Comparison (McMinimy et al., 2019)."

The Farm Bill also included other provisions outside of the RCPP program that will still impact it, like a new requirement that 10% of conservation funding set aside for source water protection. This change also came with new incentives for farmers to implement practices that bolster source water protection and the authorization for community water systems to work in conjunction with state agriculture programs to identify top priorities for source water protection at a local level.[35]

[35] American Water Works Association, (2018, December 19). Retrieved June 10, 2019, from https://www.awwa.org/AWWA-Articles/2018-farm-bill-passage-expands-funding-for-drinking-water-protection.

Chapter 14: Limitations

This report uses a case-study approach to exhaustively analyze the various components of an RCPP project implementation. Such an approach, although suited to obtain a high level of detail regarding a particular project, suffers from certain limitations. Efforts were made to contact as many of the 22 short-listed projects as possible through multiple emails, phone calls and third-party contacts, but the authors were able to only talk to about half of the project leaders. The authors are unable to determine if the selected projects differ in significant ways from the overall pool of water-quality focused RCPP projects. However, the diversity of projects chosen (in terms of its leadership, composition, objectives, location, etc.) ensure that any participation bias is kept to a minimum.

A lack of public information related to the RCPP projects meant that the authors relied heavily on information provided by the project leaders. On certain issues, an independent verification of the claims made by project leaders may have been extremely helpful. Water quality data was one such issue.

While the HAWQS modeling system works well for predicting and comparing the effects of different programs on watersheds, it is not perfect. The HAWQS model uses federal land use data to build a model of a watershed, but does not incorporate internal geography of watersheds. This was not a significant issue in the watersheds modeled for this project, because the chosen watersheds were all relatively flat and relatively uniform, but modeling would likely be less accurate on watersheds with internal geography which significantly affect runoff patterns. This also means the HAWQS model is better suited for comparing plans between watersheds than for designing watershed-level plans, for which a SWIM model is more suited. Additionally, the HAWQS model is most accurate when working with large watersheds, at the HUC 8 level. On extremely small watersheds, at the HUC 12 level, the HAWQS model cannot model future climate. While some BMPs are easily modeled with HAWQS, others, especially bioreactors, are more difficult to model. And finally, due to the fact that changes can only be made to entire HRUs, it is difficult to model partial implementation of BMPs, and often impossible to model implementation on a specific number of acres of farmland.

Chapter 15: Conclusions

The 2019 flooding in the Mississippi River Basin brought renewed focus on the might of the Mississippi, the large number of people living and growing the lands in its watershed, and the impact of climate change-fueled flooding on the communities living along the waters. Agriculture's predominant role in the Mississippi River Basin means that the solutions to address the region's growing nutrient and sediment loss challenge have to be focused on the lands themselves, rather than on point-source solutions such as new and improved treatment plants.

A review of six collaborative conservation projects funded by the federal government under the Regional Conservation Partnership Program (RCPP) shows great promise toward achieving that goal. Upstream farmers, downstream water utilities, and a range of other stakeholders came together to achieve a common objective of nutrient loss reduction and water quality improvement. The RCPP projects differ from each other in significant ways, reflecting local priorities and needs, and build on prior efforts undertaken in the watershed.

The RCPP projects have made significant advancements in engaging various stakeholders, getting local farmers interested in conservation, and conducting extension and outreach programs in the watershed. Overall, the RCPP projects assessed in this study resulted in statistically significant but low-impact reductions in nutrient pollution across watersheds. Hydrologic and climate modeling for the future suggested a significant variation in the long-term trends for contamination loads, but a majority of the analyzed watersheds showed an increase in phosphorus and nitrogen loading in the near-term future. RCPP projects, as currently implemented, resulted in a 3-6% reduction in phosphorus, nitrogen, and sediment contamination across the watershed. Significant expansion of the conservation adoption in the watersheds will likely result in a 17-27% reduction, while full implementation will bring a 55-66% reduction in contaminant loading.

The Farm Bill has been an effective vehicle for undertaking critical conservation efforts by bringing stakeholders with varying interests. However, the funding allocated for conservation is not enough to meet the scale and severity of the water quality challenge facing the Mississippi River Basin and the nation at large. Additional funding for source water protection in the 2018 Farm Bill is an important step toward enhancing conservation efforts, but this study identifies several policy lacunae that need to be addressed at the federal, state, and local levels to ensure productive lands and high quality water in the region that feeds and powers America for many years to come.

Abbreviations

Abbreviations frequently used in the report

ACEP	Agricultural Conservation Easement Program
BMP	Best Managment Practice
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
EQIP	Environmental Quality Incentives Program
HAWQS	Hydrologic and Water Quality System
HFRP	Healthy Forest Reserve Program
HRU	Hydraulic Response Unit
HUC	Hydrologic Unit Code
NRCS	Natural Resources Conservation Service
RCP	Representative Concentration Pathway
RCPP	Regional Conservation Partnership Program
SWAT	Soil and Water Assessment Tool
TMDL	Total Maximum Daily Load
USDA	U.S. Department of Agriculture
USEPA	United States Environmental Protection Agency

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