BOARD OF WATER AND SOIL RESOURCES

Climate Change Trends and Action Plan

September 2022

BOARD OF WATER AND SOIL RESOURCES

This updated report was developed by BWSR Senior Ecologist and Vegetation Specialist Dan Shaw and Special Projects Coordinator Suzanne Rhees. In February 2023, minor revisions were made to Appendix A, updating the acres in various conservation practices and the estimated greenhouse gas reduction associated with each practice.

Previous publishing dates/updates:

January 2013

December 2016

September 2019

BWSR is reducing printing and mailing costs by distributing reports and information online to wider audiences. This report is available on BWSR's website under Landscape Resiliency and Climate Change and is available in alternative formats upon request.

Contents

Executive Summary

The Minnesota Board of Water and Soil Resources' (BWSR) mission is to improve and protect Minnesota's water and soil resources by working in partnership with local organizations and private landowners. As climate change increasingly affects Minnesota's communities, landscapes, economy and ecosystems, it affects BWSR's ability to fulfill this mission.

The purposes of this report are:

- to identify the impacts of climate change on Minnesota's water and soil resources and on BWSR's mission and programs;
- to identify the benefits that conservation programs and practices provide, both in mitigating and adapting to climate change; and
- to identify action steps that BWSR can take to increase programs' effectiveness, both in mitigating the effects of climate change and increasing the resilience of Minnesota's landscapes and communities.

Over the past several years, the Walz administration's focus on climate and related state agencies' efforts have increased significantly. This report recognizes the work of the Climate Subcabinet and its member agencies, and how BWSR's efforts fit into this broader context.

Many of the conservation programs BWSR administers, while primarily designed to protect and improve water quality and soil health, also offer many complementary climate-related benefits. These benefits include both *mitigation* of the effects of climate change and *adaptation* to those effects.

Mitigation: A human intervention to reduce emissions or enhance the removal of a greenhouse gas from the atmosphere (e.g., through carbon sequestration in plants).

Adaptation: Taking action to prepare for and adjust to both the current and projected impacts from climate change. For natural systems, humans may intervene to help adjustment.

Resiliency:
The ability of communities and landscapes to adapt to a changing climate, and specifically to extreme weather events and other stressors.

Mitigation: Soil and water conservation programs mitigate the effects of climate change by storing carbon in the soil and in biomass (perennial vegetation) and by reducing the quantities of fertilizers, fuel, and other inputs needed for agriculture.

BWSR's soil and water conservation programs mitigate the effects of climate change by storing carbon in the soil and by reducing the quantities of fertilizers, fuel, and other inputs needed for agriculture. This report estimates the reductions in greenhouse gas emissions that result from conservation practices such as nutrient management, cover crops, reduced tillage, filter strips and riparian buffers.

Adaptation and Resiliency: The same soil and water conservation programs that contribute to mitigation also increase resiliency by reducing runoff and nutrient loss, reducing erosion and flooding, and maintaining agricultural productivity. Programs that promote integrated water resources management, adaptive landscape management, and multipurpose drainage management all increase resiliency.

Table 1. Summary: Climate-related Benefits of BWSR Programs

Program	Climate-related benefits
Grant and Cost-Share Programs	Promote and support agricultural best management practices (BMPs) that enhance carbon sequestration, reduce fuel and fertilizer use and manage extreme precipitation.
Local Water Management Planning / One Watershed One Plan	Watershed management plans increase landscape resilience through strategies that increase soil health, provide water storage, and protect/restore surface and ground water. Most plans include goals and strategies related to climate change.
Conservation Easement Programs (CREP and RIM)	Enhance carbon sequestration and increase the resiliency of plants, animals and landscapes through creation and restoration of natural habitat on marginal cropland, shorelands and woodlands.
Wetland Restoration and Wetland Banking	Avoid wetland losses and maintain wetland functions, with potential reductions in CO_2 emissions from wetland drainage.
Pollinator and Habitat Programs	Enhance carbon sequestration through creation and restoration of natural habitat and renewable energy production; increase the resiliency of landscapes and wildlife populations.

Action steps to guide future direction

BWSR will increase the focus of its conservation programs on mitigating and adapting to the effects of climate change, and may develop new policies and programs where needed. Priority initiatives in 2022-2023 include:

- Incorporate **soil health** as a primary consideration, along with water quality, when monitoring and assessing the benefits of conservation practices.
- Emphasize the benefits of **water storage practices** that protect infrastructure, improve water quality and related public benefits, and mitigate climate change impacts.
- Expand easement offerings to include a range of **working land and floodplain easements** that allow complementary uses such as haying and grazing while incorporating flood resilience and other ecosystem benefits.

- Develop more comprehensive and accurate methods to track the climate impacts of **wetland conservation and wetland replacement** throughout Minnesota.
- Support **pollinators and other beneficial insects** that create the foundation for resilient landscapes and are at risk due to climate change.
- Incorporate climate mitigation and adaptation principles into **forest management and reforestation programs** that serve private landowners and land managers.

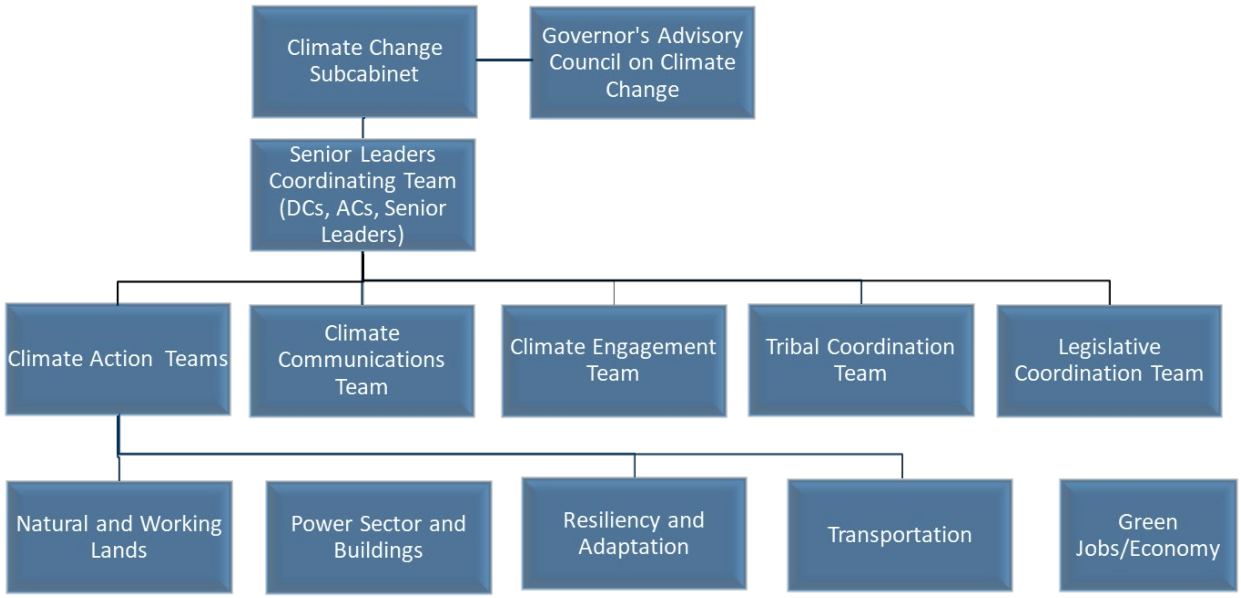
A complete list of action steps is found in Section IV.

I. Context: Minnesota's climate change efforts, 2019 - 2022

As the impacts of climate change are increasingly apparent in Minnesota, the Walz administration and state agencies have responded. On December 2, 2019, Governor Walz signed Executive Order 19-37, directing state agencies to engage communities and identify policies to reduce emissions and build resiliency. The Executive Order emphasized Minnesota's failure to meet the statutory goals of the 2007 Next Generation Energy Act: to reduce GHG emissions by 30% by 2025 and 80% by 2050.

The Executive Order established a Climate Change Subcabinet and a Governor's Advisory Council on Climate Change, with the goal of promoting coordinated climate change mitigation and resilience strategies. The Subcabinet is comprised of executives from 15 state agencies, departments, and boards, and is organized into five action teams. BWSR leadership and staff are directly involved with the **Natural and Working Lands, Climate Communicators**, and **Resiliency and Adaptation** Teams.

The Advisory Council is comprised of up to 15 members appointed by the Governor and includes civic and community leaders with experience in business, agriculture, conservation, environmental protection, and other relevant fields.



The Subcabinet and Advisory Council led the development of Minnesota's Climate Action Framework, released in September 2022. The Framework adopts new climate goals based on the best available science from the Intergovernmental Panel on Climate Change (IPCC). These include reducing our greenhouse gas emissions by 50% by 2030, achieving net-zero emissions by 2050, and prioritizing investments in climate resilience over the next 10 years. Natural and working lands – the farms, forests, and grasslands that stretch across our state – are an important part of Minnesota's climate solutions. Agricultural and forestry practices that improve water quality and soil health can also strengthen rural economies, protect natural environments, and help our farmers and forest landowners.

Legislative Initiatives

The Minnesota Legislature has also responded to climate change trends, with directives and funding for new initiatives to increase community resilience, protect infrastructure, and manage the impacts of extreme precipitation. Recent climate-related funding directed to BWSR includes:

- Funding through both the Clean Water Fund and General Fund for cover crops and soil health practices;
- Funding for a demonstration water storage and treatment program;
- Funding for Phase 2 of the Lawns to Legumes pollinator program and other pollinator protection efforts.

Interagency and Partner Efforts

The Climate Subcabinet teams created several interagency workgroups on specific initiatives and tasks. BWSR staff have participated in workgroups focused on greenhouse gas emissions tracking, water storage, carbon markets and credits, and funding and policy opportunities. These efforts have helped to inform the latest iteration of this plan.

BWSR also works closely with external partners on climate initiatives, including the U.S. Climate Alliance's Natural and Working Lands Working Group, federal agencies such as the U.S. Department of Agriculture, local and regional governments, and non-governmental organizations.

II. Climate Change Trends and Impacts

Many of the effects of climate change are already obvious, while others are less visible but are already affecting Minnesota's natural and working lands. Among the most visible:

- **Warming temperatures.** Temperatures in Minnesota have risen more than 2.5°F since the beginning of the 20th century. Since 1998, Minnesota has experienced eight of its 10 warmest years on record. This warming has been concentrated in the winter and at night, while summers have not warmed as much.
- **Increased precipitation.** Heavy rains are more common and more intense than at any time on record. Spring precipitation is projected to increase by about 15% to 20% by midcentury.
- **Extreme precipitation.** Since 2000, the number of very heavy rains (6 inches or more in a day) has been 2 to 3 times higher than in the 20th century. Extreme precipitation events are

projected to increase in frequency and intensity, resulting in increased flooding and associated impacts, such as increased erosion, infrastructure damage, and agricultural losses.[1]

Since the 2019 update of this plan, much more extensive research is now available regarding Minnesota's climate and how it is changing. Here are several highly informative and up-to-date state-level online sources:

- Minnesota Climate Trends (DNR) includes downloadable data on historical temperature and precipitation trends and an overview of the most significant trends.
- Our Minnesota Climate provides a broad overview of trends, local impacts, state actions and community solutions.

Effects of Climate Change on Soil and Water Resources

Climate change and related extreme weather events are impacting the quality of soil and water resources across Minnesota:

- More frequent, heavier, or longer-duration rainfall events increase **soil erosion and runoff**, thereby degrading water quality through deposition of sediment and contaminants in water bodies.
- Intense rainfall events are impacting Minnesota agriculture, resulting in **increased runoff of fertilizers, pesticides, and sediment**, particularly from agricultural fields that do not have best management practices (such as buffers, grassed waterways, and crop residue left on the fields) in place. Field flooding and crop failure can result. Costs of disaster assistance will likely continue to increase.
- Greater precipitation increases **challenges for applying manure** in an environmentally safe manner to fields. Flooding can also cause **overflow of manure storage basins** which have inadequate storage capacity, leading to contamination of nearby water bodies and death of aquatic organisms.
- Extreme weather events put additional pressure on the state's **drainage infrastructure**. There is a potential for more erosion within older drainage

Flood damage in Scott County (above) and Rock County, (below) 2014

[1] Key messages drawn from Minnesota Climate Trends (DNR) and NOAA 2022 State Climate Summary for Minnesota, https://statesummaries.ncics.org/chapter/mn/

systems that do not have adequate outlets or erosion controls in place.

- Flooding from extreme precipitation can **damage the built environment**, affecting commercial and residential buildings, roads, parks, and stormwater infrastructure. Water-saturated soils can destabilize bluffs, trees, and utility poles. Costs of disaster assistance will likely continue to increase.

- Changes in amount, frequency, and intensity of precipitation can impact **stormwater management,** potentially exceeding the design capacity of stormwater treatment structures or impacting future structure design. Extreme weather also adds to challenges in monitoring water quality.

- Combinations of extreme storms, flooding, harmful insects, and invasive species will further degrade **natural wetlands, prairies and forests**.

- **Northern forests** could significantly change in structure from the spread of the emerald ash borer and woody invasive species such as common and glossy buckthorn and invasive honeysuckles. Some areas are expected to transition from coniferous forest to savanna as the climate warms.

- **Wetland health** has been impacted due to more frequent extreme water fluctuations and prolonged inundation of vegetation that favors invasive species and disrupts the life cycle of aquatic organisms.

Flood damage at Hokah dam, Houston County, 2018

Climate change also affects different regions and populations disproportionately. Lower income communities and communities of color often have limited access to land and natural areas and fewer financial resources to cope with flooding and other climate change impacts. Tribal communities are threatened by decreasing opportunities to hunt, fish, and harvest natural resources from ceded lands and waters under established treaty rights. Farm families and rural communities are also particularly vulnerable to the financial and emotional stresses that result from damages to land and equipment. Finally, both for urban and rural communities, climate change can put community cohesion, relationships, and resiliency at risk.

III. BWSR's Role in Climate Action

Mitigation

Soil and water conservation programs can mitigate the effects of climate change through carbon sequestration and emission reduction.

Soils contain vast quantities of carbon — more than double the amount in the atmosphere. Carbon levels in soil vary depending on climate, soil parent material, vegetation type, landscape position, and human activities. Healthy soil holds the carbon that plants absorb from the air and incorporate into their root systems. Carbon is stored in the soil as roots, root exudates, and decomposed plant matter. Repeated plowing and chemical fertilizer use can reduce soil carbon, as well as soil fertility and water-holding capacity.

The same practices that are known to improve soil health and water quality can also increase carbon sequestration. These include conservation practices that keep soil covered year-round, such as cover crops, reduced tillage, or perennial vegetation, thereby reinvigorating soil biology and increasing carbon sequestration. Conservation practices can also reduce the quantities of fertilizers, fuel, and other inputs needed for agriculture, thus reducing greenhouse gas emissions while reducing costs.

Definitions

Carbon sequestration (biological): The process by which atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in **biomass** (trunks, branches, foliage, and roots) and soils.

Greenhouse gases (GHGs): Gases in the Earth's atmosphere that trap heat. Carbon dioxide is the primary greenhouse gas emitted through human activities such as burning fossil fuels. Nitrous oxide and methane are also important greenhouse gases.

GHG emission reduction: Greenhouse gas emissions can be reduced both through carbon sequestration, which offsets a portion of the emissions, and through reduction in emission-producing activities such as fertilizer use and fossil fuel consumption associated with agricultural production. GHG emission reduction is expressed in this report in metric tons of carbon dioxide equivalent (see Appendix A) for details.

While these benefits can be significant, there are also significant uncertainties and challenges in assessing and verifying them. Carbon sequestration in soils is highly variable, depending on multiple factors such as soil type, weather patterns, root growth and depth, tillage, and fertilization (Gutknecht and Jungers, 2021). Furthermore, carbon stored in soils can quickly dissipate if those soils are later tilled, making duration of soil health practices key in achieving substantial benefits.

While recognizing these uncertainties, BWSR staff have worked with other agencies since 2019 to track and estimate the GHG reductions achieved through the programs that the agency funds, manages, or oversees. To date, we can estimate these results in two program areas:

- **Conservation easement practices:** Since the Reinvest in Minnesota program began in 1987, almost 290,000 acres of land, much of it marginal farmland, have been restored to grasslands, wetlands, or forestland (or CRP conversion to agriculture has been prevented) through easement programs. Conservation easements that establish native vegetation, restore wetlands, plant trees and shrubs or improve forest management can achieve substantial carbon sequestration. Reduction of nitrous oxide and carbon dioxide entering the atmosphere from

fertilization, fertilizer production, and consumption of fossil fuels for farming marginal agricultural fields also contribute to total emission reductions.

Since easements are permanent (although practices and land management may change), there is a higher degree of confidence in the carbon sequestration benefits they provide. While not all easements incorporate conservation practices, and the database of conservation practices is incomplete, practices can be tracked on **204,395 acres as of 2020,** and are estimated to have reduced GHG emission reductions by **about 350,800 metric tons CO_2e per year** (CO_2e is a measure that combines emissions from a "bundle" of GHGs, including carbon dioxide, methane, nitrous oxide and ozone based on their relative global warming potential).

- **Grant and cost-share practices:** Conservation practices are tracked in BWSR's eLINK conservation tracking system. The most widely implemented practices include conversion of cropland to grassland, installation of riparian buffers, field borders and filter strips, reduced tillage, and improved fertilizer management. As discussed above, there is a high degree of uncertainty as to the amount and permanence of carbon sequestration benefits. However, several agencies have used emission-reduction factors developed by MPCA (Ciborowski, 2019) to develop initial estimates of the results of conservation practices funded through state and federal programs. Through 2021, conservation practices funded through BWSR's grant and cost-share programs and documented in eLINK have been implemented across **618,839 acres** and are estimated to reduce greenhouse gas emissions by about **324,000 metric tons CO_2e per year**.

Cover crops, Jackson County

Other restoration efforts can be more difficult to assess. Restoration of high quality, diverse, and resilient wetlands to replace wetland losses can mitigate the increased emissions that result from conversion of wetlands to agriculture or urban development. Evidence suggests more carbon is sequestered by a richer mix of native species (such mixed forests) and that such communities are more stable over time. It is not currently feasible to quantify these mitigation benefits, because we lack sufficient data on the characteristics of wetlands lost to development compared to the wetlands that replace them. However, typical replacement ratios of 2.5 or 1.5 to 1 (acres of replacement

Wetland restoration in Wright County

wetland to acres of impacted wetland) can result in increased wetland acreage, which would be beneficial to track and quantify.

See **Appendix A** for a detailed analysis of estimated carbon sequestration and GHG reduction benefits from conservation practices through BWSR programs.

Adaptation and Resiliency:

Conservation programs can assist local partners, communities, and individual landowners in adapting to our changing climate. The ability to adapt is a hallmark of a resilient landscape as well as more resilient and durable infrastructure.

- **Agricultural conservation practices.** BWSR promotes conservation practices in agricultural areas that promote soil health and the ability of soils to capture and store rainfall, store carbon and decrease heat absorption from tilled ground. Most "ag BMPs" are designed to improve water quality, but can also minimize impacts from extreme precipitation as well as periods of water scarcity. Such practices include cover crops, field terraces, no-till farming, riparian buffers, retention areas, and restored or constructed wetlands.

Participants in the Increasing Diversity in Environmental Careers (IDEC) mentorship program view soil and seed samples

- **Forestry protection and restoration practices.** BWSR is becoming increasingly active in working with local partners and the DNR in the management of privately-owned forestland, working with SWCDs by offering training, information, and technical assistance on forestry and agroforestry issues. County-level programs are aligned with work being done by the DNR, using easements and other conservation practices to protect wildlife and water quality. Forest management practices such as reforestation, stand thinning, wildlife habitat enhancement and erosion control can increase forest health and resilience. Healthy forests are more resilient to threats such as wildfire, insect and disease outbreaks, invasive species, flooding, and other problems exacerbated by climate change.

- **Watershed planning.** BWSR supports and promotes integrated water resources management at a variety of watershed scales, either developed under the One Watershed, One Plan (1W1P) program or through other planning efforts by watershed districts, watershed management organizations or other basin-wide partnerships, with the primary goal of improving water quality. Plans incorporate multiple complementary goals and strategies to improve soil health, create or restore wetlands, improve forest and grassland habitat, increase water storage for flood control and resource protection, protect drinking water, and improve stormwater management. Climate change is referred to as an "emerging issue" in BWSR's guidance to 1W1P participants. While most comprehensive watershed management plans incorporate

resilience-oriented goals and strategies, less than half include goals and actions explicitly designed to address the topic of climate change (MS-STEP Capstone Paper, 2022).

- **Conservation easements.** By converting marginal agricultural land from row crops or pasture to forest, wetlands, or native grasslands, easement conservation practices build resilience to extreme weather events, including flooding and drought periods, as well as to threats such as wildfire, insect and disease outbreaks, and habitat loss.

- **Wetlands and upland buffers.** The ecosystem services provided by wetlands also protect against intense storm events and periods of drought. Associated upland buffers protect wetland ecosystems and provide landscape connectivity and other functions that promote landscape resiliency. Restoration projects also increase infiltration rates and store water on the landscape. BWSR has developed technical resources to help practitioners restore diverse and resilient landscapes, such as the Minnesota Wetland Restoration Guide, State Seed Mixes and Native Vegetation Establishment and Enhancement Guidelines. Riparian buffers installed under the Buffer Law (Minn. Stats. 103F.48) must include perennial cover, which also help to hold water on the land and can increase wildlife habitat (depending on the vegetation used).

- **Water management and green infrastructure.** Water volumes across Minnesota have been increasing as a result of climate change, in turn increasing flooding, erosion, and infrastructure damage. Clean Water Fund grants administered by BWSR play a key role in planning and implementing water management projects, including urban green infrastructure projects that manage water volumes and improve water quality. BWSR staff also provide technical assistance and resources for green infrastructure projects.

- **Pollinator and habitat enhancement programs.** The decline of wildlife populations, including beneficial insects (pollinators, butterflies, dragonflies, etc.), birds, amphibians and other species, is a significant concern in Minnesota. These species provide a foundation for food production, food webs and native ecosystems. Their loss results from a variety of factors including habitat loss, invasive species, pesticides, climate change, and diseases. BWSR's pollinator and habitat enhancement programs, termed the "Living Landscape Initiative," assist local partners in establishing targeted, high diversity pollinator and beneficial habitat on conservation lands and natural areas.

Table 2 summarizes the ways in which BWSR's primary grant, easement and planning programs contribute to climate mitigation and support climate adaptation/increase resiliency. The primary objective of each program is noted, recognizing that climate benefits, while significant, are usually secondary to that objective.

Table 2. Summary of BWSR Program Relationships to Climate Concerns

Program and Primary Objective	Program Objective	Mitigation	Adaptation and Improved Resiliency
Clean Water Fund Grants: Projects and Practices, including Drinking Water	To protect, enhance, and restore water quality in lakes, rivers, and streams and protect groundwater and drinking water sources from degradation.	Many funded non-structural practices sequester carbon and reduce inputs. Achieving long-term mitigation depends on duration of practices.	Most practices improve adaptation to extreme precipitation; prevent flood damages, erosion and soil loss.
Clean Water Fund Grants: Multipurpose Drainage Management	Targeting critical pollution source areas to reduce erosion and sedimenta-tion, reduce peak flows and flooding, and improve water quality, while protecting drainage system efficiency and reducing maintenance for priority Chapter 103E drainage systems.	Likely not significant, although storage and treatment wetlands may provide some degree of carbon sequestration.	Practices that keep drainage systems functioning efficiently can also increase resiliency to flood damage, erosion and sedimentation.
Erosion Control and Water Management (State Cost-share)	To share the cost of conservation practices for high priority erosion, sedimentation, or water quality problems, or water quantity problems due to altered hydrology.	Many funded nonstructural practices can sequester carbon and reduce emissions of GHGs. Achieving long-term mitigation depends on duration of practices.	Nonstructural practices such as cover crops, residue management, and nutrient management all contribute to resiliency of agricultural operations to extreme precipitation and soil loss.
Local Water Management Planning / One Watershed One Plan	Support a planning process to improve water quality with a focus on prioritized, targeted, and measurable implementation of restoration and protection activities	Varies depending on specific plan strategies	Most plans increase landscape resilience through strategies that keep water on the land, build soil health, and protect or restore key natural resources. Goals and strategies for climate adaptation and resilience are incorporated in a majority of plans.
Conservation Easement Programs (CREP and RIM)	Enhance habitat for wildlife, non-game species and pollinators through conversion of riparian areas and marginal cropland to native grasses, woodland or wetland, improve water quality and reduce nitrate loading in drinking water supplies	Easement permanence supports long-term carbon sequestration	Easement practices increase landscape resilience to flooding, drought, invasive species and other threats.

Program and Primary Objective	Program Objective	Mitigation	Adaptation and Improved Resiliency
Wetland Restoration and Wetland Banking	Achieve no net loss of quantity, quality and diversity of existing wetlands	Bank projects that restore/rewet peatlands can significantly reduce GHG emissions; more research needed to compare replacement wetlands to those lost to development	Wetland restoration and creation
Water Storage Pilot Program	Per legislation, "to provide financial assistance to local units of government to control water volume and rates to protect infrastructure, improve water quality and related public benefits, and mitigate climate change impacts"	Effects on GHG emissions are unknown; more research needed	Water storage will increase resiliency to extreme precipitation and other effects of altered hydrology.
Soil Health Pilot Programs	Clean Water Fund: Improve water quality through targeted soil health practices, focusing on public water supplies. General Fund: Increase carbon sequestration.	Soil health practices can increase carbon sequestration if maintained for sufficient amounts of time.	Improving soil health helps to hold water, improving resiliency to flooding and erosion.
Pollinator and Habitat Programs: • **Lawns to Legumes** • **Habitat Enhancement Landscape Pilot** • **Habitat-Friendly Solar**	To assist local partners in establishing targeted, high diversity pollinator and beneficial habitat on conservation lands and natural areas.	Pollinator habitat that includes deep-rooted native plants is likely to increase carbon sequestration; more research needed.	Restoration of native landscapes increases resilience to flooding, drought, invasive species, habitat fragmentation, pesticides and other threats.

IV. Priority Action Steps

This section summarizes key work categories that BWSR plans to pursue to advance climate adaptation and mitigation benefits. Action steps are classified by program or topic area and identified as "policy" or "program" related.

Grant and Cost-Share Programs

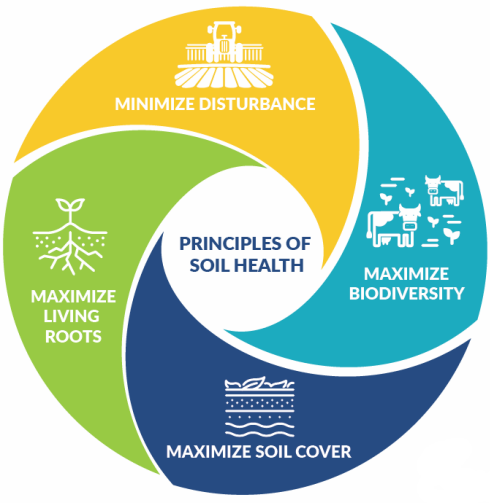
Policy Actions

Establish standards under which **harvestable perennial and cover crops** such as alfalfa, Kernza and winter camelina may be eligible for grants and cost-share funding. These crops are generally non-native and potentially marketable, but can also play key roles in improving soil health and protecting public and private drinking water supplies. This effort is part of the update of BWSR's *Native Vegetation Management and Enhancement Guidelines*.

Incorporate a greater focus on **non-forest tree-planting efforts**, including shelterbelts, buffers and windbreaks, under **cost-share program standards**. These practices were discouraged under previous statutes, but those limitations have since been lifted (Minn. Statutes §103C.501, subd. 6(b)) and there is renewed interest in planting trees in agricultural regions for both energy conservation and carbon sequestration. Encourage diverse tree species that are adaptable to future conditions.

Link **multipurpose drainage** programs and policies to emerging water storage initiatives (discussed below). Altered hydrology, including higher peak flows, add stresses to public drainage systems. BWSR will continue to develop and refine standards for drainage management practices that foster climate adaptation and improve resilience to flooding, erosion, and habitat loss. Addition of water storage within drainage systems can reduce the need for system expansion or repair.

Incorporate **soil health** as a consideration when monitoring and assessing the benefits of conservation practices. "Soil health" is shorthand for a systematic approach to managing soil based on specific principles (see sidebar). BWSR is working with the Minnesota Office for Soil Health (MOSH), a collaborative partnership of BWSR and the University of Minnesota, on a strategic planning effort to **scale up adoption of soil health management practices** that mitigate the impacts of climate change and increase landscape resiliency. This initiative, along with the new programs noted below, will improve our ability to promote and assess soil health, similar to the "prioritize, target and measure" approach to watershed health.



Principles of soil health, NRCS graphic

New Programs

In 2021, BWSR received new appropriations and authorities to partner with local government and landowners to implement additional actions to sequester carbon and adapt to our changing climate. These new initiatives are directed at accelerating the adoption of cover crops, soil health practices and water storage and treatment projects. BWSR staff will assess the results of

these pilot programs and the impacts of proposed projects on climate mitigation and landscape resilience.

- The **Water Quality and Storage Pilot Program** was initiated in 2022 to provide financial assistance to local governments to control water rates and/or volumes to protect infrastructure, improve water quality and related public benefits, and mitigate climate change impacts. This program has been established as a pilot that will fund design and construction of storage projects and practices, with priority given to applicants in the Minnesota River Basin or Lower Mississippi River Basin. Three grants were awarded in 2022 for projects in Lyon and Le Sueur counties. Program expansion may be feasible if additional funding becomes available, and both local governments and watershed planning partners need better information on water storage options.

- Several **Soil Health Pilot Grant Programs** are available in 2022, using funds received in the 2021 legislative session. BWSR received funding to implement two soil health initiatives, one through the Clean Water Fund to enhance adoption of cover crops and other soil health practices in areas where there are direct benefits to public water supplies and a second (noncompetitive) cost-share program through the General Fund with a focus on practices that promote carbon sequestration.

Easement Programs

Policy Actions

Incorporate **climate mitigation and adaptation benefits** as criteria when evaluating and prioritizing potential easements.

Program Actions

Implement and monitor progress of **working lands and floodplain easement programs** that incorporate haying/grazing, silviculture, and similar practices to increase landscape resilience while allowing economic use. Staff will assess continued development and successful implementation of programs and discuss how economic uses influence payment structures.

New Programs

The purpose of the **Working Lands RIM Easement** pilot program is to protect and promote perennial vegetation land cover for the benefit of surface and groundwater through "working lands" easements, defined as lands that are used for haying or grazing. This program is focused on the Pine, Crow Wing and Redeye River watersheds, all priority source water protection areas in Minnesota. Tracking the implementation of this program will help us account for the role of perennial haying and grazing lands in carbon sequestration as well as source water protection.

Rattlesnake master and other native plants on RIM parcel, Rice County

Other innovative easement offerings are under discussion. **RIM Floodplain Easements** are being developed as of 2022. These easements are designed to set aside sensitive land in river riparian corridors to address water quality concerns and meet climate adaptation and mitigation goals. Participating landowners will have options to establish flood-hardy understory, establish trees, haying/grazing, silviculture, silvopasture and agroforestry, with payment structures based on the proposed uses.

RIM Wetland Restoration Easements in the Prairie Pothole Region are also in the planning stages, funded through the Outdoor Heritage Fund. As discussed under "Peatlands Initiatives," carbon sequestration and climate mitigation factors should be considered when reviewing and ranking easement applications for wetland restoration.

Forestry Initiatives and Programs

Forestry initiatives cut across several other program sectors, including Grants, Watershed Planning, and Easement programs, but are highlighted separately because of their increasing importance for both mitigation and adaptation.

Policy Actions

Incorporate climate mitigation and adaptation into forest management programs and policies. Focus on supporting private forest management practices (including forest stand improvement, timber harvesting, forest health, invasive species, wildfire suppression and fuel load management, tourism and recreation activities, etc.) that improve carbon sequestration and assist with adaptation to climate change.

Program Actions

Further incorporate climate mitigation and adaptation into **Landscape Stewardship Plans (LSP).** Landscape stewardship is an "all lands" approach to forest management, created by the US Forest Service and based on five working principles: 1) Invest in priority areas, 2) Build a collaborative network of service providers that effectively work together to serve more landowners, 3) Appeal to interests of both landowner and service providers, 4) Manage for results, and 5) Encourage flexibility at all levels to be more adaptive and cooperative in serving customers. LSPs have been developed for five watersheds as of 2021.

To date, LSPs have prioritized water quality protection and improvement, using the percentage of forest cover in each subwatershed as an indicator of watershed health (75% forest cover is generally considered a benchmark for a healthy forested watershed). As LSPs are developed for additional watersheds, they could be enhanced by identifying the importance of forest cover for carbon sequestration, and examining the mix of tree species from an adaptation perspective. The "Climate Change Field Guide for Northern Minnesota Forests," from the USDA, UMN and Northern Forests Climate Hub should be used for site-level adaptation considerations. Another helpful resource is the East Central Landscape Plan (2021) from the Minnesota Forest Resources Council.

Support a **large-scale reforestation initiative** focused on planting 1 million acres of trees over 20 years, focusing on previously forested regions of Minnesota. The Nature Conservancy (TNC) has led this "Minnesota Million" effort, working with multiple stakeholders. TNC has identified about three million

acres with reforestation potential, largely in the Midwest Broadleaf Forest province and adjacent areas to the north. This effort will include supporting partner efforts to accelerate production of tree seedlings. Incorporating reforestation opportunities into watershed plans and enlisting SWCDs and watershed districts will be critical in advancing this initiative.

Practice/Implementation Actions

- Encourage local governments to use Watershed-Based Implementation Funding program dollars and other funding sources to increase local capacity to implement LSP goals in comprehensive watershed management plans, working with local forestry technical teams.
- Increase cost-share funding for reforestation, complementing LSP/DNR efforts and adding SWCD capacity where it's lacking.
- Promote forest management practices such as lengthened rotations, forest thinning, prescribed burning and sustainable harvest practices that can increase the landscape's ability to store carbon. More research is needed on the effects of specific practices on carbon sequestration.

Watershed and Water Planning Programs

Policy and Program Actions

One Watershed One Plan (1W1P): Expand and strengthen the climate-related technical and policy guidance provided to 1W1P participants developing comprehensive watershed management plans (CWMPs) and other plans for which BWSR provides oversight. A comprehensive analysis prepared by a Humphrey School of Public Affairs graduate student team (MS-STEP Capstone Paper, 2022) makes several recommendations for improving the 1W1P program's technical resources, and public engagement to foster climate resilient CWMPs, including:

- Promotion of watershed-specific predictive modeling to complement the NOAA Atlas 14 (the current design standard for infrastructure engineering) (see Noe et al, 2019)
- Identification of best practices for climate resilience and funding directed specifically toward resilience measures
- Improved consultant and public engagement around climate issues, while recognizing that the term "climate change" remains polarizing and divisive in many areas

BWSR's Water Planning Team will review these and other recommendations over the coming months and determine how to develop specific guidance on climate change issues and responses for watershed planning participants (e.g., add a climate change/resilience chapter to the 1W1P guidebook; update planning guidance in BWSR's Climate Resilience Toolbox).

An additional challenge is that climate-related initiatives in plans may appear to be less measurable than reductions in pollutants such as phosphorus. The MPCA has developed metrics to identify the greenhouse gas reductions achievable through soil health and forest management practices, though additional discussion is needed about how to effectively measure the outcomes of climate adaptation and resiliency efforts. BWSR staff will share available metrics with local partners and will explore the potential to integrate these metrics into the next generation eLINK system.

Landscape Ecology, Restoration and Resiliency Programs

Policy and Program Actions

Update BWSR's *Native Vegetation Establishment and Enhancement Guidelines* regarding plant selection, establishment and management considerations to maximize climate adaptation and mitigation and to address the impacts of increased invasive species pressure and extreme precipitation. The Guidelines were updated in 2022 to a web-based format with factsheets providing guidance on a broad range of project types. Factsheets will be updated periodically to incorporate new information on landscape resiliency and habitat enhancement.

Though BWSR's **Living Landscapes Initiative**, increase focus on maximizing benefits to all wildlife and native plant populations through all BWSR conservation programs. The decline of wildlife populations, including beneficial insects (pollinators, butterflies, dragonflies, etc.), birds, amphibians and other species, is a significant concern, as these species provide a foundation for food production, food webs and the resiliency of native ecosystems. Their loss results from a variety of factors including habitat loss, invasive species, pesticides, climate change, and diseases. BWSR's Habitat Friendly Solar, Lawns to Legumes, Habitat Enhancement Pilot and Cooperative Weed Management Area programs play key roles in accomplishing the goals of this initiative. Key technical resources such as state seed mixes, BWSR Pollinator and Biodiversity Toolbox and What's Working for Conservation webpages are also being updated.

Adaptive management strategies play an important role in maintaining landscapes in a way that will increase landscape resiliency with the increasing threats posed by invasive species. Strategies include:

- Long-term monitoring and adaptive management of restored plant communities to control invasive species and promote plant diversity and the resiliency of forests, grasslands and wetlands.
- Promoting Cooperative Weed Management Areas (CWMAs), local organizations that provide a mechanism for sharing invasive species management expertise and resources across jurisdictional boundaries to achieve widespread invasive species prevention and control in a broader geographic region
- Increasing focus on emerging weed threats that benefit from a warming climate, such as woody invasive species that are starting to invade northern forests.

Programs

- **Lawns to Legumes**: with funding from the Environmental and Natural Resources Trust Fund (ENRTF), BWSR and nonprofit partners offer incentives and technical assistance to plant residential lawns with native vegetation and pollinator friendly forbs and legumes. Phase I of the program awarded around 850 individual grants and 12 demonstration neighborhood grants, resulting in establishment of pollinator habitat on around 1,000 projects. Phase II is increasing the number of awards to meet high demand while expanding eligibility to community and educational spaces. Additional research and tracking of planted acreage would help BWSR staff to assess the carbon sequestration benefits of pollinator habitat (likely similar to the benefits of native grassland), as we are able to do with agricultural practices.

- The **Habitat Friendly Solar Program** promotes the plantings of diverse native vegetation on solar projects. State legislation allows solar developers to claim that they are "Habitat Friendly" if they meet standards defined in BWSR's Assessment forms. These projects add habitat value as well as increased carbon sequestration on solar installations. It is estimated that about 1,000 acres of solar sites are being developed annually in Minnesota and around 50 projects currently meet standards. However, the lack of dedicated funding for this program limits the amount of time BWSR staff can devote to it. BWSR will seek funding to support habitat friendly plantings for solar installations and other utility infrastructure, such as wind energy and transmission corridors.

- The **Habitat Enhancement Landscape Pilot (HELP) Program** is a new grant program designed to improve habitat on public lands or private lands with a public investment, including existing RIM easements, CRP, city parks, county parks, and protected natural areas. Projects focus on: 1) Establishing new floral rich plots or riparian plantings 0.5 to 5 acres in size and/or 2) Enhancing prairie, savanna, wetland, and shoreline communities that provide high value habitat. Projects are being planned to benefit a variety of beneficial insects in need of habitat improvements, including at-risk species (e.g., Rusty-patched bumblebee), and other declining insect guilds (e.g., dragonflies, native bees, butterflies).

Bluff prairie restoration, Winona County

Wetland Protection and Restoration Programs

Policy and Program Actions

Develop more **comprehensive and accurate methods to track the climate impacts of wetland conservation and wetland replacement** throughout Minnesota. Wetlands, especially those with peat soils, can store large quantities of carbon, but can also emit methane and release methyl mercury into watercourses. Currently, outcomes under the Wetland Conservation Act are reported by local governments, but without any information on the quality and type of wetlands that are converted or replaced, making it impossible to assess the climate impacts of these actions. Wetlands staff are planning an online permit application and tracking system associated with the state's potential assumption of the 404 federal regulatory program. The system could be developed to track specific types or characteristics of wetland losses and gains that correlate to net GHG emission reductions or increases.

Restorable Peatland Assessments: BWSR staff, working with other agencies, the Climate Subcabinet Natural and Working Lands Team, The Nature Conservancy, and university researchers, will conduct an analysis of acres and restoration potential of restorable drained, farmed or pastured peatland soils (histosols), classified as bogs, fens, and related wetland types. These soils, rich in organic matter, emit about 11 million metric tons of carbon dioxide and nitrous oxide per year, making them the single largest source of emissions in Minnesota's "Agriculture, Forestry and Land Use" sector (MPCA GHG inventory). However, peatland soils can be restored and rewetted to again act as carbon sinks.

Minnesota has the largest acreage of peatlands in the continental U.S. As shown in Figure 1, an estimated 600,000 acres of peatland soils have been partially drained but not currently farmed, while another 300,000 – 400,000 acres are currently farmed or grazed.

BWSR has developed and is testing an interactive mapping application, drawing from soils and vegetation map layers developed by The Nature Conservancy, the Natural Resources Research Institute and other researchers, to allow users to enter an address, legal description or zoom into a project location. Information will be shown for 1) intact natural peatlands; 2) drained natural (not farmed or pastured) peatlands, and 3) drained and farmed or pastured peatlands. BWSR will also continue to work with partner agencies and organizations on policies and programs affecting peatlands, and on strategies for their preservation.

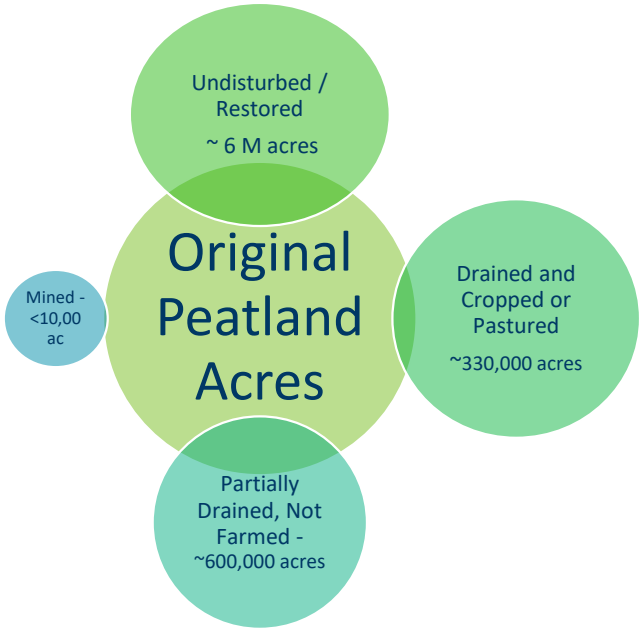


Figure 1: Estimated peatland acreage in Minnesota. Data source: The Nature Conservancy

Programs

Pitcher plants and sphagnum moss, Big Bog State Recreation Area

- **Wetland Banking**: Climate impacts of wetland banking programs could also be further recognized and prioritized among other wetland functions such as flood mitigation and habitat enhancement. Some of the largest wetland banks, such as the Lake Superior Mitigation Bank in St. Louis County, have restored thousands of acres of drained open and forested bog, enhancing important bird habitat (notably the 24,000-acre Sax-Zim Bog) while mitigating GHG emissions from these peatlands. Because wetland banks are compensatory – that is, they compensate for wetland losses through development elsewhere – it is difficult to "count" their benefits, but it is important to recognize them.
- The ongoing **Wetland Functional Assessment pilot** (a partnership of Minnesota and Wisconsin) will provide an opportunity to include GHG emission reductions as one of the "functions" being assessed for existing wetlands and help guide decision making for new wetland restoration projects.

General and Interagency Action Steps

Program Action – Explore how best to connect existing conservation programs to emerging **carbon trading markets, water quality trading markets, and other ecosystem service markets**.

Carbon markets are still in the early stages of formation, with many questions around how they are managed, their effectiveness in reducing emissions, and the verifiability and durability of the practices they support. Topics like additionality (how much improvement is being made compared to a baseline), lookback provisions (offering credit for existing practices rather than only new ones), and verification of practice implementation still require further study. Guidance for landowners, local governments, and state agencies will be needed to ensure that new carbon markets are verifiable and transparent.

Water quality trading (WQT) has been applied in Minnesota to meet water quality discharge permit requirements, managed by the MPCA. A recent pilot effort in the North Fork Crow River watershed indicated substantial interest among both buyers of water quality credits (mainly wastewater and water treatment plants) and potential credit generators (farmers and landowners). BWSR will encourage the use of WQT in connection with stormwater permitting and as a strategy in watershed plans.

Practice/Implementation Action – Explore potential collaboration with SWCDs to collect soil samples to measure soil carbon. BWSR staff will explore costs of sampling, discuss with Extension staff, and seek resources to support this effort.

Action Steps for Further Discussion

The following practice/implementation action steps are in the formative stages and will require further discussion and clarification before outcomes and timeframes are determined. New or expanded funding sources may be needed to develop some of these steps.

- **Assess the potential to track and measure the climate adaptation benefits of BWSR programs.** Many conservation practices designed to improve water quality or reduce flooding also benefit soil health and increase resilience to more extreme precipitation. However, these adaptation/resilience benefits are difficult to quantify without specific metrics. The U.S. Climate Alliance is working with states and advisors to develop resilience metrics and standards; BWSR staff will monitor this emerging topic.

- **Improve emission tracking tools for established conservation practices and emerging practices**, including establishment of perennial crops, winter annual cover crops, use of biochar, and wetland enhancement. These efforts are continuing among state agencies under the leadership of the Climate Subcabinet.

- **Assess ways to benefit at-risk and underserved populations through conservation programs**. "At-risk" populations in urban and rural communities are those with greater vulnerability to heat, flooding, disruption of water supplies, and other climate-related impacts, due to their location, lack of resources, or historical inequities. To provide equitable access to conservation program benefits, additional outreach and engagement with cities, tribal governments, and environmental justice-focused organizations will be needed.

- **Seek opportunities to recognize and incentivize climate mitigation and adaptation efforts that residents and land managers are doing on their own**, such as tree planting, pollinator plantings, rain gardens, reduced tillage, etc. (A funding source would likely be needed to develop this concept.)

- **Collaborate with partners to increase the testing of soil carbon and organic content before and after conservation projects are installed,** as well as long-term testing to increase our understanding of carbon sequestration benefits of different conservation practices.

- **Assess life-cycle costs of conservation practices** such as water storage, habitat enhancement, wetland creation, etc., and ways to reduce these costs.

References

Adamus, Paul. 2008. Mitigating Global Climate Change: Which Kinds of Wetlands Help, Hurt, or Have Minimal Effect? Presented at the Association of State Wetland Managers Annual Conference, September 2008.

American Farmland Trust. 2020. Combatting Climate Change on US Cropland: Affirming the Technical Capacity of Cover Cropping and No-Till to Sequester Carbon and Reduce Greenhouse Gas Emissions. https://s30428.pcdn.co/wp-content/uploads/2020/12/AFT_Carbon-WP-2020_FNL-web.pdf

Anderson, Jim, et al. 2008. The potential for terrestrial carbon sequestration in Minnesota. A report to the Department of Natural Resources from the Minnesota Terrestrial Carbon Sequestration Initiative. St. Paul: University of Minnesota.

Bjorhus, Jennifer. 2022. A climate conundrum beneath our feet: Minnesota's farmed peat soil releases greenhouse gases. Star Tribune, Feb. 12, 2022. https://www.startribune.com/a-climate-conundrum-beneath-our-feet-minnesotas-farmed-peat-soil-releases-greenhouse-gases/600146107/

Ciborowski, P. 2019 and 2022. Greenhouse gas reduction potential of agricultural best management practices. Minnesota Pollution Control Agency. https://www.pca.state.mn.us/air/agriculture-and-climate-change-minnesota

Fargione, J.E., et. al. 2018. Natural climate solutions for the United States. *Science Advances* 2018; 4. https://advances.sciencemag.org/content/4/11/eaat1869

Friesen, H. et. al. 2020. Climate Change and Minnesota's Forests. A report prepared for the Minnesota Forest Resources Council by the Research Advisory Committee. https://mn.gov/frc/assets/Climate_Change_and_Minnesota%27s_Forests_2020_tcm1162-471265.pdf

Griscom, B.W., et al. 2017. Natural climate solutions. *PNAS* October 31, 2017 114 (44) 11645-11650. https://doi.org/10.1073/pnas.1710465114

Gutknecht, J. and J. Jungers. 2021. Regenerative agriculture can provide many environmental benefits, but is not a "silver bullet" for climate change mitigation. Global Change Biology, in preparation for summer 2022 submission.

Interagency Climate Adaptation Team (ICAT). 2017. Adapting to Climate Change in Minnesota. Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/p-gen4-07c.pdf

Janowiak, M., et al. 2017. Considering Forest and Grassland Carbon in Land Management. United States Department of Agriculture, U.S. Forest Service. https://www.fs.usda.gov/treesearch/pubs/54316

Johnson, W. Carter, et al. 2010. "Prairie Wetland Complexes as Landscape Functional Units in a Changing Climate." *BioScience*, vol. 60, no. 2, 2010, pp. 128–40, https://doi.org/10.1525/bio.2010.60.2.7.

Kolka, R., C. Trettin et. al. 2018. Chapter 13: Terrestrial wetlands. In *Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report*. U.S. Global Change Research Program, Washington, DC. https://www.globalchange.gov/content/about-soccr-2

Lennon, Megan and E.A. Nater. 2006. Biophysical aspects of terrestrial carbon sequestration in Minnesota. St. Paul: University of Minnesota.

Minnesota Forest Resources Council. 2021. East Central Landscape Forest Resources Plan. https://mn.gov/frc/landscape/ec/

Minnesota Forest Resources Council. 2017. North Central Landscape Management Plan. https://mn.gov/frc/landscape/nc/

Minnesota Pollution Control Agency. 2021. Greenhouse gas emissions inventory, 2004-2018. Biennial report to the legislature. St. Paul: MPCA. https://www.pca.state.mn.us/sites/default/files/lraq-1sy21.pdf

Minnesota Pollution Control Agency. 2023. Greenhouse gass emissions in Minnesota, 2005-2020. Report to the legislature. St. Paul: MPCA. https://www.pca.state.mn.us/sites/default/files/lraq-2sy23.pdf

MS-STEP Capstone Paper. 2022. Exploring policy recommendations for promoting climate resilient watersheds. University of Minnesota, Humphrey School of Public Affairs. https://bwsr.state.mn.us/sites/default/files/Exploring_Policy_Recommendations_for_Promoting_Climate_Resilient_Watersheds.pdf

National Wildlife Federation, Wildlife in a Warming World, January, 2013. https://www.nwf.org/~/media/PDFs/Global-Warming/Reports/NWF_Wildlife-Warming-World_Report_web.pdf

Noe, R., Keeler B., Twine T., Brauman K., Mayer T., Rogers M. 2019. Climate change projections for improved management of infrastructure, industry, and water resources in Minnesota. https://hdl.handle.net/11299/209130.

Ogle, S.M., et al. 2014. Chapter 3. Quantifying greenhouse gas sources and sinks in cropland and grazing land systems. In *Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory*. Technical Bulletin 1939. Office of the Chief Economist, USDA.

Paustian, K., et al. 2017. Quantifying soil carbon measurement for agricultural soils management: A consensus view from science. https://jahnresearchgroup.webhosting.cals.wisc.edu/wp-content/uploads/sites/223/2017/08/1.-Quantifying_soil_carbon_measurement_for_agricultural_soils_management_17.09.05.pdf

Paustian K., et. al. 2019. Quantifying carbon for agricultural soil management: from the current status toward a global soil information system, Carbon Management, 10:6, 567-587, DOI: 10.1080/17583004.2019.1633231

Pearson, T., Grimland, S., Brown, S. 2010. A spatial analysis of greenhouse gas emissions from agricultural fertilizer usage in the U.S., Winrock Institute.

Polasky, Stephen, and Y. Liu. 2006. The supply of terrestrial carbon sequestration in Minnesota. St.Paul: University of Minnesota. Report to Minnesota Legislature on Carbon Sequestration Capacities in Minnesota.

Swan, A. et al. 2020. *COMET-Planner: Carbon and Greenhouse Gas Evaluation for NRCS Conservation Practice Planning.* See http://comet-planner.com/

United States Department of Agriculture, National Agricultural Statistics Service. 2019. 2017 Census of Agriculture.

https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_State_Level/Minnesota/

United States Environmental Protection Agency. 2013. *Climate Change, Overview of Greenhouse Gases*. www.epa.gov/climatechange/ghgemissions/gases/n2o.html

United States Environmental Protection Agency. 2018. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2016.* https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2016

Appendix A. Greenhouse Gas Reduction Estimation Methodology

Since 2009, BWSR has been estimating carbon storage from a variety of conservation practices, ranging from wetland restoration to establishment of cover crops and field windbreaks, documented in the eLINK reporting system and through the RIM easement program. Those estimates, based on a 2008 study (Anderson, et. al.), were updated in 2019 and have been further refined in this edition. A primary source for the analysis is the MPCA report "Greenhouse Gas Reduction Potential of Agricultural Best Management Practices," referred to below as the "MPCA GHG Reduction Study," updated in 2022. The report provides a comprehensive synthesis of the methodologies used to estimate greenhouse gas emissions reduction potential from 27 practices related to changing land use, changes in cropping practices, nutrient reduction, and restoration of wetlands and grasslands. It addresses emissions of the major greenhouse gases (GHGs): carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4).

The COMET-Planner tool developed by USDA was used to estimate GHG reductions from prescribed grazing, which was not addressed in the MPCA report.

How are emissions estimated?

Different GHGs can have different effects on the Earth's warming. These gases differ from each other in their ability to absorb energy (their "radiative efficiency"), and how long they stay in the atmosphere (also known as their "lifetime").

The Global Warming Potential (GWP) metric was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO_2). The larger the GWP, the more that a given gas warms the Earth compared to CO_2 over that time period. The time period usually used for GWPs is 100 years. GWPs provide a common unit of measure, which allows analysts to add up emissions estimates of different gases (e.g., to compile a national GHG

inventory), and allows policymakers to compare emissions reduction opportunities across sectors and gases.[2]

The MPCA prepares a report to the Minnesota Legislature every two years on state greenhouse gas emissions. The most recent report (January 2023), Greenhouse Gas Emissions in Minnesota: 2005-2020, identifies emissions by sector – transportation, electricity generation, agriculture/forestry/land use, residential, commercial, and waste. The 2023 report identified a slight decline in emissions from the agriculture and forestry sector compared to 2005, but also a high degree of variability. Emissions of nitrous oxide and methane have both increased since 2005. Carbon sequestered in forest regrowth is a significant offset in this sector, as forests can act as carbon sinks or storage. Reductions in other sectors, particularly the electricity generation and transportation sectors, have left the agriculture/forestry/land use sector as Minnesota's second-largest emitter of GHGs, and also the largest sink of GHGs.

The MPCA's GHG Reduction Study addresses GHG emissions from soils (N_2O, CH_4 and CO_2), surface waters (N_2O), fuel use in field machinery in crop production (CO_2, N_2O), and mostly out-of-state manufacture of agricultural chemicals and fuels (mostly CO_2 and CH_4). The MPCA study also addresses terrestrial carbon sequestration, during which atmospheric CO_2 is withdrawn from the atmosphere and stored in terrestrial soil and biomass. To the degree that CO_2 is withdrawn from the atmosphere through photosynthesis, terrestrial carbon sequestration acts to lower atmospheric CO_2 levels, offsetting surface emissions of GHGs to the atmosphere.

The amount of offset from terrestrial carbon sequestration depends on how long the CO_2 that has been removed from the atmosphere is stored in terrestrial carbon pools before re-release to the atmosphere. To fully offset 1 ton of CO_2 emitted from the combustion of fossil fuels like coal, one ton of CO_2 removed from the atmosphere would need to be retained in soils and standing biomass for roughly 50 years. To offset about one-half of a ton of emitted CO_2, carbon removed from the atmosphere would need to remain stored in soils and biomass for about 25 years.

The GHG Reduction Study assumes that CO_2, once removed from the atmosphere, will remain in storage for 20 years, offsetting about 0.4 tons of emitted GHGs for each ton sequestered. In the language of climate science, this is equivalent to a GWP of 0.4.

The MPCA uses a 20-year time period for reasonably certain future storage of sequestered carbon for several reasons:

- 20 years is considered a reasonable assumption for the duration of agricultural and forestry practices. Some practices, such as cover crops and conservation tillage, can have relatively short durations, based on changes in land ownership, program funding, or other economic considerations. Others, such as conservation cover planted through an easement program, are theoretically permanent. Therefore, the 20-year timeframe provides a common denominator across practices and programs.

- Climate change itself can affect the feasibility and effectiveness of many conservation practices, e.g., increasing wildfires changing the composition and health of forests, flooding affecting

[2] https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

perennial crops, drought affecting wetlands, etc. Looking beyond a 20-year horizon would increase the uncertainty on practice effectiveness.

For internal consistency, the MPCA applied the GWP value of 0.4 to all types of carbon sequestration from all practices. However, it is important to note that most of BWSR's easement programs provide permanent protection, which can increase the effectiveness of carbon sequestration over as much as 40 or 50 years, or substantially longer than the 20 years assumed in the MPCA study.

Conservation practices tracked in eLINK

We assessed the conservation practices tracked in eLINK and selected those that are directly comparable to the practices assessed in the MPCA GHG Reduction Study, or to grazing practices identified in COMET-Planner. Table A-1 is a compilation of acreage in each practice as of November 2022 and the estimated metric tons per acre of GHG reduction, in CO_2 equivalents. Some notes and assumptions that go into this process:

- Where dimensions of a practice are recorded in linear feet – windbreaks, for example – we used an estimate of average width to derive acres – generally 30 to 50 feet, depending on the practice.
- In a few instances where practices are simply counted, such as water and sediment control basins, we estimated an acreage likely to be vegetated – for example, one acre of perennial vegetation was assigned for each basin.
- For the relatively small acreage of wetlands that have been created rather than restored, we made several assumptions, based on discussions with MPCA staff and related research:
    - Methane emissions are highest in wetlands that are permanently or frequently inundated, while seasonally inundated wetland types such as wet meadows seem to sequester more GHGs than they emit.
    - About two-thirds of restored or created wetlands appear to consist of wet meadows and other areas that are seasonally inundated. These wetland types seem to act more like riparian buffers. The remaining one-third are permanently inundated, making them net sources of methane.
- Using this ratio, we estimated net GHG emissions from all restored and created wetlands. Combining these estimates, net carbon sequestration is greater than methane emissions. Additional research and geospatial analysis of wetland types and their respective emissions profiles would help refine these and other estimates.

Another major assumption is that practices, once installed, remain in place. Grant requirements generally require that structural practices remain in place for at least 10 years, while non-structural practices vary in duration. Land management practices such as cover crops are required to remain in place for three years under current grant policies. While we can't verify the current status of installed practices, the assumed 20-year duration built into the MPCA emission reduction estimates provides a common standard for both temporary and permanent practices.

Conservation practices tracked on RIM easements

RIM easements are managed through development of a conservation plan that identifies the acreage on each easement property to be protected or restored through a variety of conservation practices. We tracked the following conservation practices applied to RIM easements:

- Conservation Cover
- Diversion
- Windbreak/Shelterbelt Establishment
- Grassed Waterway
- Tree/Shrub Establishment
- Water and Sediment Control Basin
- Restoration and Management of Declining Habitats
- Wetland Restoration
- Wetland Creation

As with the eLINK data, practices were equated to the MPCA-identified conservation practices and the same estimates of GHG emission reductions were used.

Several easement categories were not included in the estimates. Army Compatible Use Buffers (ACUB) easements, used to limit development around Camp Ripley, were not included since most do not require conservation practices. Wetland bank easements were not included because they are used to compensate for wetland removals elsewhere (see below).

Due to changes in the database and recording practices, easements recorded between 1987 and 2003 show discrepancies between total acreage and the acreage in the conservation plan, leading to substantial overcounting. Parcels with minimal discrepancies – 2.5 acres or less – are included in the acreage totals. Parcels with larger discrepancies are excluded; these comprise about 75,000 acres, or about one-third of the pre-2004 easement acres.

Easements including already established practices are also included in the analysis, since most "established" acres were converted from cropland under previous programs, generally CRP, before they were placed under easement. The results of this analysis are shown in Table A-2.

Wetland banking practices not included: The 2019 edition of this report included estimates of GHG reductions on about 11,000 acres of wetland banks where actual restoration occurred (other wetland bank areas preserved existing wetlands). For this update we determined that because wetland banks are created to allow purchase of credits compensating for wetland removals elsewhere, estimates of "net" GHG reductions are too difficult to assess without further research.

Conclusions: impacts of BWSR programs on the agricultural sector

The combined total GHG reductions of BWSR's programs in 2022 were approximately **675,000 CO_2-equivalent metric tons**, or **744,000 US CO_2 e-tons per year**. The estimated emissions of the agriculture, forestry and land use sector in 2020 were estimated by the MPCA at about **28.7 million CO_2 US tons**, of which **26.4 million tons** were emitted from cropland. Using the estimates outlined above, the combined impacts of BWSR's conservation and easement programs on the emissions of the agricultural-forestry-

land use sector are clearly quite small – **2.6 percent of total emissions, or 2.8 percent of cropland emissions**. Note, however, that this assessment does not include the impacts of related state and federal programs and of voluntary practices:

- **NRCS programs** such as EQIP and CSP are used to support conservation practices on thousands of acres in Minnesota, including the same practices that BWSR supports and tracks in eLINK. The water quality benefits of those practices are tracked by the MPCA in its Healthy Watersheds database. Quantifying the extent and GHG mitigation benefits of those federally-supported acres would be an important next step.

- Likewise, the benefits provided by the roughly 1 million acres in the **Conservation Reserve Program** in 2022 have not been quantified. While CRP acreage has declined in the past decade, the 2018 farm bill increased the nationwide cap on CRP acreage from 24 million to 27 million acres, and included practices such as grassed waterways, filter strips, riparian buffers, and wetland restoration.

- The **Minnesota Agricultural Water Quality Certification Program**, a voluntary program administered by the Minnesota Department of Agriculture, tracks the GHG mitigation benefits of practices adopted by participating producers – currently over 1,270 producers on over 900,000 acres participate, with estimated GHG reductions of over 50,000 CO_2-e tons per year.

- **Minnesota's Buffer Law**, enacted in 2015, requires a continuous riparian buffer of perennial vegetation along public waters (a 50-foot average width and 30-foot minimum width) and public drainage ditches (16.5-foot minimum). It is estimated that over 100,000 acres of new buffers have been installed to comply with the law, with related GHG reduction benefits.

- In addition, many farmers and landowners adopt conservation practices independent of any federal or state program. The **2017 Census of Agriculture** shows increases in the acreage in many GHG-reducing conservation practices:

    - Acreage in no-till practices increased from 818,754 in 2012 to 1,091,337 in 2017, or about 33%

    - Acreage in other conservation tillage practices increased from 6.1 million in 2012 to 8.2 million in 2017, or about 34%

    - Cover crop acreage increased from 408,190 to 579,147, or 41%

By continuing to assess and quantify the benefits of these programs, we can gain a clearer picture of the contributions of the agricultural sector to climate change mitigation and the potential for increasing those efforts.

Table A-1. Ag Practices Reported in eLINK	NRCS CODE	TOTAL ACRES	TOTAL FEET	TOTAL POINTS	CORRECT FEATURE TYPE	TOTAL # PRACTICES	MPCA Practice or Equivalent	Metric Tons/ac/yr	Total MT/yr
155M - Storm Water Retention Basins	155M	385	2,020	385	Point	430	Grassland Riparian Buffers	0.70	270
327 - Conservation Cover	327	5,261.41	1,500	4	Polygon	2,481	Cropland to native grassland	1.44	7,589
327M - Conservation Easement	327M	5,772.03			Polygon	450	Cropland to native grassland	1.44	8,326
328 - Conservation Crop Rotation	328	1,027.59		42	Polygon	51	Perennial added to annual	0.37	382
329B - Conservation Tillage - Reduced Tillage	329B	30,378.33			Polygon	332	Reduced Tillage	0.06	1,929
332 - Contour Buffer Strips	332	729.08			Polygon	41	Field Borders, Filter Strips, etc.	1.43	1,045
340 - Cover Crop	340	129,685.37		4	Polygon	8,206	Winter cover crop/Catch crop	0.24	31,765
342 - Critical Area Planting	342	8,036.32	31,982	11	Polygon	14,350	Cropland to native grassland	1.44	11,592
350 - Sediment Basin	350	294		290	Point	285	Grassland Riparian Buffers	0.70	206
362 - Diversion	362	143	124,591	0	Line	1,473	Field Borders, Filter Strips, etc.	1.43	205
380 - Windbreak/Shelterbelt Establishment	380	4,225	6,135,249	1,657	Line	6,753	Shelterbelts, Hedgerows (trees)	2.70	11,423
390 - Riparian Herbaceous Cover	390	420	40		Polygon	98	Grassland Riparian Buffers	0.70	295
391 - Riparian Forest Buffer	391	4,437			Polygon	1,014	Forested and Multispecies Riparian Buffers	2.00	8,876
393 - Filter Strip	393	65,600	4,870	21	Polygon	8,215	Field Borders, Filter Strips, etc.	1.43	94,028
412 - Grassed Waterway and Swales	412	14,648	68,913	5	Polygon	16,626	Field Borders, Filter Strips, etc.	1.43	20,996
512 - Forage and Biomass Planting	512	1,764			Polygon	169	Cropland to pasture	1.10	1,936
528 - Prescribed Grazing	528	8,458		1	Polygon	134	Prescribed Grazing (COMET)	0.26	2,198
543 - Land Reclamation, Abandoned Mined Land	543	2			Polygon	1	Cropland to native grassland	1.44	3
580 - Streambank and Shoreline Protection	580	587	852,807	9	Line	17,526	Grassland Riparian Buffers	0.70	412
585 - Stripcropping	585	1,281			Polygon	32	No-till Tillage	0.13	166
590 - Nutrient Management	590	203,237		2	Polygon	1,551	15% Fertilizer Use Reduction	0.05	9,597
600 - Terrace	600	13,938	6,748	0	Polygon	882	Field Borders, Filter Strips	1.43	19,979
612 - Tree/Shrub Establishment	612	14,387	13,625	2,576	Polygon	4,643	Cropland Idling: Afforestation	2.32	33,412
638 - Water and Sediment Control Basin	638	8,220	10,531	8220	Point	41,929	Grassland Riparian Buffers	0.70	5,742
643 - Restoration and Management of Declining Habitats	643	14,420			Polygon	1,564	Cropland to native grassland	1.44	20,800
644 - Wetland Wildlife Habitat Management	644	153			Polygon	7	Wetland	2.12	325
645 - Upland Wildlife Habitat Management	645	10,236			Polygon	270	Cropland to native grassland	1.44	14,765
650 - Windbreak/Shelterbelt Renovation	650	108	156,112		Line	146	Shelterbelts, Hedgerows	2.70	291
657 - Wetland Restoration	657	7,641		13	Polygon	386	Wetland Restoration	2.01	15,363
658 - Wetland Creation	658	51			Polygon	19	Wetland Creation	see notes	13
712M - Bioretention Basin	712M	122	390	1,216	Point	1,186	Grassland Riparian Buffers	0.70	85
810M - Storage and Treatment Wetland Restoration	810M	10			Polygon	3	Wetland Creation	see notes	3
		618,839						**TOTAL**	**324,016**

Mitigation - accepted practices
Potential Mitigation - more research needed
Acres used except as noted:
X,XXX - acres derived from linear feet * width or points (i.e., basins)

Table A-2. Conservation Practices on RIM Easements

RIM PRACTICE	NRCS CODE	PRACTICE DESCRIPTION	MPCA EQUIVALENT	2021 PRACTICE ACRES	US Tons/Acre	MT/Acre/yr	TOTAL MT/yr
RR2 - Native Grasses	327	Conservation Cover	Cropland Idling: Grassland Restoration	48,658	1.59	1.44	70,187
RRFB - Native Grasses with Forbs	327	Conservation Cover	Cropland Idling: Grassland Restoration	32,448	1.59	1.44	46,804
RR1 - Introduced Grasses and Legumes	327	Conservation Cover	Cropland Idling: Grassland Restoration	7,588	1.59	1.44	10,946
RR9 - Vegetative Cover Already Established	327AE	Conservation Cover Already Established	Cropland Idling: Grassland Restoration	29,953	1.59	1.44	43,206
RR5 - Diversion	362	Diversion	Field Borders, Filter Strips, etc.	3.4	1.58	1.43	5
RR4 - Field Windbreak	380	Windbreak/Shelterbelt Establishment	Shelterbelts, Hedgerows	96.5	2.98	2.70	261
RR11 - Highway Windbreak (Living Snowfence)	380	Windbreak/Shelterbelt Establishment	Shelterbelts, Hedgerows	33.6	2.98	2.70	91
RR14 - Existing Watercourse/drainage ditch	390AE	Riparian Herbaceous Cover Already Established	Grassland Riparian Buffers	1,142	0.77	0.70	798
RR7 - Grass Waterway	412	Grassed Waterway	Field Borders, Filter Strips, etc.	1.2	1.58	1.43	2
RR3 - Tree and/or Shrub Planting	612	Tree/Shrub Establishment	Cropland Idling: Afforestation	9,287	2.56	2.32	21,569
RR10 - Trees and/or Shrubs- Already Established	612AE	Tree/Shrub Already Established	Cropland Idling: Afforestation	19,433	2.56	2.32	45,131
RR6 - Erosion Control Structure	638	Water and Sediment Control Basin	Grassland Riparian Buffers	3.2	0.77	0.70	2
RR2PP - Pollinator Planting	643	Restoration and Management of Declining Habitats	Cropland Idling: Grassland Restoration	293.2	1.59	1.44	423
RR8 - Wetland Restoration	657	Wetland Restoration	Restored Wetlands	43,846.2	2.22	2.01	88,161
RR13 - Existing Wetland/Waterbody	657AE	Wetland Restoration Already Established	Restored Wetlands	11,565	2.22	2.01	23,253
RR12 - Wetland Creation	658	Wetland Creation	Constructed Wetlands	43.7		see notes*	11
			TOTAL	**204,395**			**350,846**

* wetlands: 1/3 open water @ -0.6, 2/3 wet meadow @ 0.7