



# Climate Change Trends and Action Report

Updated December 13, 2016

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## How and why does climate change matter to BWSR and what trends have been observed?

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. With extreme weather patterns and disrupted natural cycles, climate change has the potential to decrease the ability of Minnesota landscapes to sustainably provide important environmental and economic benefits. Therefore, BWSR is working to integrate climate change considerations in programs and practices for conservation on private lands that make up approximately 75% of Minnesota's land area through wetland protection, conservation easements (retirement of marginal agricultural lands), and providing soil and water conservation grants. These programs play an important role in climate change prevention by preventing the release of stored carbon and methane in wetlands, sequestering carbon, decreasing nitrous oxide emissions from fertilizer and methane from manure, providing opportunities for biofuel production, and increasing landscape resiliency. Following is a summary of primary program areas with observed climate related trends for each.

### Wetland Protection (Administration of the Minnesota Wetland Conservation Act )

The primary goal of the Minnesota Wetland Conservation act is to achieve no net loss in the quantity, quality, and biological diversity of Minnesota's 10.6 million acres of existing wetlands. This is accomplished through avoiding direct or indirect impacts from activities that destroy or diminish wetlands and replacing wetland values where avoidance of such activity is not feasible and prudent. With wetlands holding large amounts of carbon and methane, these actions help protect against climate change. It is estimated that one acre of peatland contains, on average, 750 metric tons of carbon. Total emission of the carbon contained in just 1,000 acres of peatland would increase Minnesota carbon dioxide emissions by almost two percent (Anderson et.al. 2008).

#### OBSERVED CLIMATE-RELATED TRENDS:

- Precipitation has been falling more frequently in heavy downpours, leading to increased erosion of fields, ravines, streambanks and bluffs. This has led to increasing amounts of sediment accumulation in some wetlands and damage to water control structures and embankments in restored wetlands.
- Large storms and flooding have stress aquatic systems by causing water level fluctuations that favor invasive plant species and interrupt the life cycles of aquatic organisms.



*Lakeshore restoration in Carver County.*



*Forested bog in northern Minnesota.*



*Wetland degraded from altered hydrology.*

Approximately half of Minnesota's depressional wetlands (such as marshes and ponds) are considered in poor condition by the Minnesota Pollution Control Agency (PCA, 2012).

### Conservation Easements (Reinvest in Minnesota Reserve)

BWSR's RIM program is focused on the acquisition and enhancement of critical habitat in the predominantly agricultural areas of the state by converting marginal crop lands to permanent native vegetative cover. This includes restoring wetlands, establishing riparian buffers, protecting sensitive ground water areas, planting critical winter cover for wildlife, preserving habitat for rare plant and animal species, protecting and restoring native prairie and grasslands, increasing pollinator habitat, and preserving spawning and reproduction areas for fish.

#### OBSERVED CLIMATE-RELATED TRENDS:

- Combinations of extreme storms, flooding, harmful insects and invasive species have been degrading natural wetlands, prairies and forests.
- The composition of northern forests has been shown to be transitioning from coniferous trees to deciduous trees in areas of disturbance (Frelich & Reich 2010). Northern forests are also being invaded by woody species such as common and glossy buckthorn that can change the structure of forests. Green and black ash populations are threatened by emerald ash borer. Black ash swamps cover about one million acres in Minnesota. Flooding in northeast Minnesota has also caused extensive erosion on steep slopes.

#### Soil and Water Conservation Grants

BWSR's soil and water conservation grant programs provide funding to local government units for the implementation of targeted conservation projects and practices in rural and urban landscapes. A wide variety of conservation practices sequester carbon and decrease nitrous oxide emissions from fertilizer, including: tree planting, grass planting, prairie and wetland restoration, windbreaks/shelterbelts, grassed waterways, contour buffer strips, filter strips, riparian buffers, critical area planting, and cover crops. These practices also increase landscape resiliency and often help protect agricultural fields (protecting productivity) from extreme weather events. Grants also fund nutrient management plans and anaerobic manure digesters that decrease nitrous oxide and methane emissions.



*Restored depressional wetland.*



*Woodland converted to agriculture.*



*Erosion in northern Minnesota from flooding.*



*Restored buffer along an agricultural ditch.*

### OBSERVED CLIMATE-RELATED TRENDS:

- Flooding has caused significant damage to private lands and conservation practice infrastructure in Minnesota. BWSR has provided flood relief funding for floods in southeast, northwest and northeast Minnesota in recent years; \$42.3 million has been distributed for flood relief through local government units between 2000 and 2012.
- Conservation practices such as grassed waterways, filter strips, vegetated buffers, etc. have helped farmers retain topsoil and agricultural productivity during extreme weather events.
- New National Oceanic and Atmospheric Administration rainfall frequency data (NOAA Atlas 14) has shown that the amount of rainfall for given storm frequencies (5-yr., 10-yr. etc.) has risen substantially in many areas of the U.S. in recent decades. The new data indicates that for rainfall events having low probability of occurrence (1-2% chance of occurring in a given year) the amount of predicted rainfall in a 24-hour period has increased by approximately 25%. This rainfall increase could generate approximately one third more runoff volume than estimated using the old data. The previous 100-year 24-hour event that generated approximately six inches of rainfall will now have a probability of occurring two to three times in 100 years (rather than once per 100 years).
- N<sub>2</sub>O emissions are projected to increase by 5% between 2005 and 2020, driven largely by increases in emissions from agricultural activities (U.S. Department of State 2007).



*Grass waterway eroded from flooding.*

## What are potential long-term trends and impacts from climate change?

### Wetland Protection (Administration of the Minnesota Wetland Conservation Act)

#### LONG-TERM TRENDS AND IMPACTS:

- It is likely that wetland health will decline due to more frequent extreme water fluctuations that will favor invasive species and disrupt the life-cycle of aquatic organisms.
- Northern black ash swamps covering about one million acres in Minnesota may significantly change in structure due to emerald ash borer and the loss of black ash trees.



*Restored wetland with altered hydrology.*

### Conservation Easements (Reinvest in Minnesota Reserve)

#### LONG-TERM TRENDS AND IMPACTS:

- State easements with aquatic systems will likely be degraded due to changing hydrology conditions.
- Combinations of extreme storms, flooding, harmful insects, and invasive species will further degrade natural wetlands, prairies and forests.
- With climate change, the National Wildlife Federation concludes that there will be diminished numbers of migratory waterfowl, pheasants, moose, walleyes, northern pike and brook trout, and fish kills will likely become more prevalent (National Wildlife Federation 2013).
- Upland and wetland northern forests could significantly change in structure from the spread of woody invasive species such as common and glossy buckthorn and invasive honeysuckles, invasive insects, and changes in dominant tree species. Some areas may transition from northern coniferous forest to savanna (Frelich & Reich 2010)



*Invasive buckthorn changing the structure of a forest.*



*Invasive species such as wild parsnip have a competitive advantage with climate change.*

### Soil and Water Conservation Grants

#### LONG-TERM TRENDS AND IMPACTS:

- Water quality in streams, rivers, wetlands, and lakes will likely degrade and/or be more challenging to restore, due to runoff from heavy rainfall, particularly in agricultural lands that are prone to erosion.
- Increase in requests for assistance to repair and replace structures installed to manage water and improve habitat.
- Soil productivity and crop yields may decrease due to increased soil erosion and loss of organic content.





*Climate change may lead to the transition from coniferous trees to deciduous trees in northern forests.*

## What has BWSR already done?

Over the years BWSR has played a significant role in decreasing greenhouse gas emissions by protecting wetlands, retiring marginal agricultural land and through soil and water conservation grants. The following information summarizes benefits from BWSR programs.

### Wetland Protection (Administration of the Minnesota Wetland Conservation Act)

The Minnesota Wetland Conservation Act has been in place since 1991 and has significantly reduced the loss of wetland acres. Wetlands contain significant amounts of carbon that can be released to the atmosphere with wetland losses. Approximately 16,000 acres of wetland have been restored to replace wetland losses through wetland banking and on-site mitigation since the start of wetland conservation act, capturing approximately **35,000 – 111,000 metric tons of carbon dioxide** per year (assuming .6-1.9 MT of C sequestered per ac./yr., Anderson et al, 2008).



Wetlands in Washington County.

### Conservation Easements (Reinvest in Minnesota)

- 230,000 acres of marginal farm land has been restored (or prevented CRP conversion to agriculture) over the last 26 years, leading to the sequester of approximately **(316,500 – 781,000 metric tons of carbon dioxide per year)** (assuming easements in 75% grassland and 25% non peatland wetlands and sequestering .3-.6 MT C per ac./yr in prairie and .6-1.9 MT C per ac./yr. in wetlands) (Anderson et.al.2008). **Cumulative CO<sup>2</sup> sequestration over 26 years has been approximately 8.2 million MT CO<sup>2</sup>– 20.3 million MT CO<sup>2</sup>.**

The equivalent of approximately **66,790 metric tons of carbon dioxide per year** will be prevented from entering the atmosphere from fertilization and release of nitrous oxide (assuming 44% of agriculture in fertilized corn and the equivalent of .66 mT of CO<sup>2</sup> emitted per ac./yr. for anhydrous ammonia use) (Pearson et.al. 2010). Approximately **14,170 additional metric tons of carbon dioxide per year** will be prevented from entering the atmosphere from fertilizer production for retired lands (assuming 44% of agriculture in fertilized corn and .14 mT of CO<sup>2</sup> to produce fertilizer for one acre, EPA 2013).

- Approximately **9,200 metric tons of carbon dioxide per year** will be prevented from entering the atmosphere from burning of fossil fuels for farming marginal agricultural fields that are restored to native vegetation (assuming .04 mT of CO<sup>2</sup> to cultivate, plant and harvest, EPA 2013).

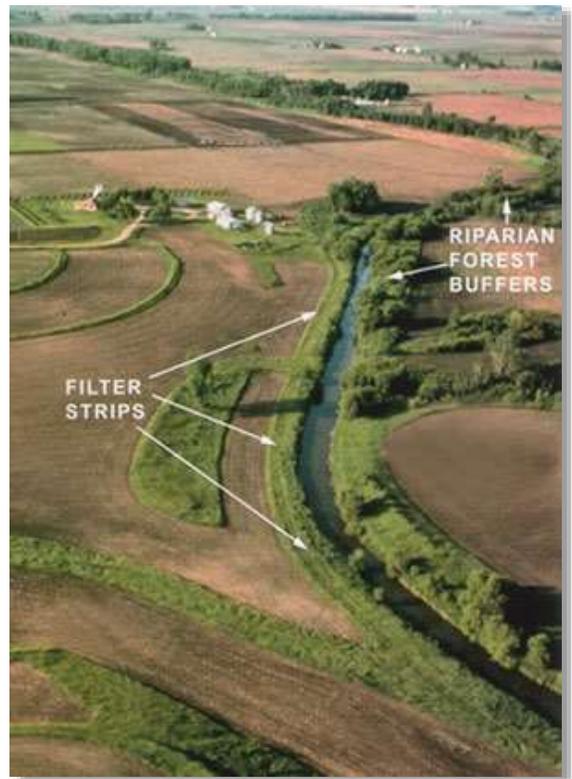


### Soil and Water Conservation Grants

- Approximately **28,000 -56,000 metric tons of carbon dioxide per year** have been sequestered through soil and water conservation grants (assuming 23,265 acres of grassland planted sequestering .6-1.9 MT C per ac./yr., and 6,424 acres of trees and shrubs planted sequestering .1-.2 MT C per ac./yr.) (Anderson et.al.2008).
- The equivalent of approximately **8620 metric tons of carbon dioxide per year** will be prevented from entering the atmosphere from fertilization and release of nitrous oxide (assuming 29,689 acres, 44% of

agriculture in fertilized corn and the equivalent of .66 mT of CO<sup>2</sup> emitted per ac./yr. anhydrous ammonia use)( Pearson et.al. 2010). Approximately **1830 metric tons of additional carbon dioxide per year** will be prevented from entering the atmosphere from fertilizer production (assuming 29,689 acres, 44% of agriculture in fertilized corn and .14 mT of CO<sup>2</sup> to produce fertilizer for one acre)(EPA 2013).

- Approximately **520 metric tons of carbon dioxide per year** will be prevented from entering the atmosphere from burning of fossil fuels for farming land areas in conservation practices (assuming 29,689 acres, .04 mT of CO<sub>2</sub> to cultivate, plant and harvest)( EPA 2013).
- The equivalent of approximately **17,320 metric tons of carbon dioxide per year** will be prevented from entering the atmosphere from nitrous oxide release from lands with nutrient management plans (assuming 180,723 acres, 44% of agriculture in fertilized corn, a 33% reduction in nitrogen fertilizer use with nutrient management plans, and the equivalent of .66 mT of CO<sub>2</sub> emitted per ac./yr.)( Pearson et.al. 2010, EPA 2013).



*Examples of soil and water conservation projects.*

## How have BWSR's actions benefited Minnesotans and created jobs?

These conservation programs have many benefits to Minnesotans. In addition to mitigating climate change through carbon sequestration and decreased petroleum and fertilizer use, important environmental services such as hunting, fishing, bird watching, boating and swimming are provided. Conservation projects also support jobs to those involved in restoration planning and design, native seed production, construction, native seeding, vegetation management and regulatory and conservation program administration. In addition, the United States Fish and Wildlife Service's "National Survey of Fishing, Hunting and Wildlife Associated Recreation" finds that hunters, fishers, and wildlife watchers spent over \$3.9 billion (2006) on their activities in Minnesota.



## What is BWSR doing now to mitigate further climate change?

### Wetland Protection (Wetland Conservation Act)

- Continued protection of Minnesota Wetlands through administration of the Wetland Conservation Act, preventing the release of stored carbon through organic matter decomposition following drainage.
- Restoration of high quality, diverse, and resilient wetlands to replace wetland losses. Evidence suggests more carbon is sequestered by a richer mix of native species (such as mixed forests) and communities are more stable over time. BWSR has developed technical resources to help practitioners restore diverse and resilient landscapes.
- Restoration of forested wetlands (particularly white cedar and tamarack swamps) through planting and hydrology restoration in northern Minnesota.

### Conservation Easements (Reinvest in Minnesota)

- BWSR is securing easements on approximately 5,000 - 8,000 acres per year.
- Re-enrollment of CRP into conservation programs preventing loss of landscapes where carbon sequestration has been occurring for many years.
- Sequestering and protecting stored carbon by promoting restoration of high functioning and sustainable conservation prairies and wetlands in key corridors and complexes informed by the Minnesota Prairie Conservation Plan and other key plans.
- Protecting stored carbon by preserving natural shoreline forest lands around shallow wild rice production lakes via permanent riparian easements in northern Minnesota forest region.
- Sequestering carbon by converting floodplain lands from crop production to permanent native flood plain forest



*Lakeshore buffer in Washington County.*

cover in areas that have been frequently flooded.

## Soil and Water Conservation Grants

- Protecting soil carbon and decreasing nitrous oxide emissions from fertilizer by promoting cover crops and conservation tillage through a soil health initiative.

### Grant/Information Links:

**Wetland Protection** (Administration of the Minnesota Wetland Conservation Act):

<http://www.bwsr.state.mn.us/cs/index.html>

**Conservation Easements** (Reinvest in Minnesota): <http://www.bwsr.state.mn.us/easements/index.html>;

[http://www.bwsr.state.mn.us/grants/RIM\\_services.html](http://www.bwsr.state.mn.us/grants/RIM_services.html)

**Soil and Water Conservation Grants:** <http://www.bwsr.state.mn.us/cleanwaterfund/index.html>;

<http://www.bwsr.state.mn.us/cs/index.html>; <http://www.bwsr.state.mn.us/cs/index.html>;

<http://www.bwsr.state.mn.us/cs/index.html>

**Disaster Recovery Assistance:** <http://www.bwsr.state.mn.us/grants/DRAP.html>

## What is BWSR doing now to adapt to climate change?

### Local Water Management Planning

BWSR supports and promotes integrated water resources management that uses a watershed approach to solve soil and water resource issues and considers the potential for more extreme weather events and their implications for the water and land resources. This includes the use of design standards for stormwater and conservation projects that address larger precipitation events.



*Restored wetland with diverse wet meadow planting.*

### Wetland Protection and Restoration

Wetland and upland buffer restoration and protection conducted through the Reinvest in Minnesota (RIM) Reserve Program and federal partnerships, Wetlands Conservation Act implementation, and Clean Water Fund projects, help to restore and maintain water retention, runoff reduction, wildlife habitat, and water quality in Minnesota. This, in turn, enhances adaptation to climate change. 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 carbon sequestration that can increase infiltration rates and store water on the landscape.



### Agricultural Conservation Practices

BWSR promotes a variety of 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. Examples of conservation practices that minimize impacts from larger storms include cover crops, field terraces, no-till farming, buffer strips, retention areas, and constructed wetlands.



*Cover crops play an important role in improving water quality*

### Multipurpose Drainage Management

BWSR promotes and supports implementation of traditional and new conservation practices for multiple purposes, including conservation drainage and drainage water management practices. These practices help reduce runoff and nutrient loss, avoid runoff concentration, protect areas where runoff concentrates, reduce peak flows to reduce erosion, maintain agricultural productivity, improve water quality and habitat, and reduce flooding. Multipurpose drainage practices help make working lands as well as artificial and natural drainage systems more resilient to high intensity rainfall.



## Increasing Landscape Resiliency

A variety of restoration and land management strategies are promoted for conservation projects to increase resiliency to extreme storms and other landscape stressors. Examples include:

- 1) Restoring healthy natural systems where they can have the greatest landscape benefits.
- 2) Decreasing fragmentation of intact plant communities, and creating habitat corridors.
- 3) Restoring plant communities and vegetation that fit current and expected project site conditions.
- 4) Promoting individual species for projects that can handle expected conditions and provide ecological functions.
- 5) Promoting species diversity to increase resiliency and promote habitat for a wide range of wildlife species including pollinators.
- 6) Using deep rooted plants to promote infiltration and groundwater recharge.
- 7) Restoring high quality habitat for pollinators and other beneficial insects.
- 8) Managing invasive species across geographic and ownership boundaries to minimize their competitive advantage.
- 9) Adapting project design, implementation and management approaches based on project experience.
- 10) Taking a long-term view to the management of natural resources

## Adaptive Landscape Management

Disturbances associated with climate change can give invasive species a competitive advantage over native species. BWSR's Cooperative Weed Management Area (CWMA) program is focused on forming local organizations that share invasive species management expertise and resources across ownership boundaries. CWMA's are also focusing on controlling emerging weed threats that benefit from warming climate such as woody invasive species that are invading northern forests. By promoting adaptive landscape management practices such as forest management and prescribed burning, BWSR is also working to increase the landscape's ability to sequester carbon and withstand large rain events.



## Northern Forest Management

BWSR is working through partnerships to protect the integrity of northern forests. Recent efforts include the protection of wild rice lakes and surrounding forests through the RIM Program, an effort to protect and restore white cedar wetlands that are becoming less common, and support of CWMA's in northern Minnesota to address emerging weed threats. BWSR also promotes managing forests for high diversity to adapt to climate variation, large storms, diseases, and pathogens.



*Flooding in southeast Minnesota.*

## Disaster Response

Flooding has caused significant damage to private lands and conservation practice infrastructure in Minnesota. Since 2000 BWSR has provided \$53 million for flooding in southeast,

northeast and northwest Minnesota with a focus on rebuilding infrastructure that will be resilient to future storms.

**Case Study:** Restored wetlands and prairies provide an important in adapting to climate change by increasing the resiliency of watersheds. The Ellefson Group Wetland Restoration in Norman County was a combined effort by four landowners and state, federal, and local agencies. The site was previously farmland that frequently had crop failure due to flooding. Through hydrology restoration and the planting of diverse seed mixes the site was restored to 448 acres of restored prairie and wetland and contains eight wetland basins. It now provides a refuge to a wide range of wildlife including pollinators, amphibians, reptiles, shorebirds and waterfowl.

The site also decreases downstream flooding by detaining water from large storms. Surface runoff from the site is estimated to be reduced by 88%.



## BWSR Action Steps and Proposed Outcomes to Guide Future Direction

**1)** Further guide the implementation of plan content requirements for One Watershed, One Plan stating: "Planning partners are strongly encouraged to consider the potential for more extreme weather events and their implications for the water and land resources of the watershed in the analysis and prioritization of issues. While these events cannot be predicted with certainty as to time and occurrence, the meteorological record shows increased frequency and severity of extreme weather events, which has a direct effect on issues in local water planning".



*Flooding following an extreme weather event*

Outcomes: BWSR staff work with partners in new watersheds conducting plan development to incorporate climate adaptation planning for landscape resiliency to more extreme precipitation events.

**2)** Provide information to LGU's about what practices, policies and programs they should consider promoting (and how) to address climate adaptation, including design standards and approaches to assessing sites and updating water plans. An example is promoting use of NOAA Atlas 14 rainfall frequency data and good BMP/landscape planning and design practices to address larger storm events.

Outcomes: Develop a new/expanded "Landscape Resiliency Toolbox" and a "Landscape Resiliency and Climate Adaptation webpage" to guide LGU partners about key practices, policies and programs (developed during winter 2017).

**3)** Further promote practices that provide year-long cover on agricultural fields such as no-till and strip-till farming, cover crops and perennial vegetation to promote soil health and the ability of soils to capture and store rainfall, reduce runoff and erosion, store carbon, and decrease heat absorption from tilled ground.

Outcomes: Implement new cost-share policy to incorporate cover crops as a new practice. Coordinate the development of the Working Lands Watershed Restoration plan and study to determine how to efficiently implement a pilot program to match perennial and cover cropping biomass establishment and harvest for use in processing facilities producing advanced biofuels, biobased chemicals, or thermal and electrical energy.

**4)** Promote and support implementation of conservation drainage and drainage water management practices, as well as water storage at various scales, that help reduce runoff and nutrient loss, avoid runoff concentration, protect concentrated flow areas, reduce peak flows to reduce erosion, maintain agricultural productivity, improve water quality and habitat, and reduce flooding.

Outcomes: Provide outreach about the updated Minnesota Public Drainage Manual and redesigned BWSR Drainage Webpage, as well as for the Clean Water Fund Multipurpose Drainage Management Program and other potential sources of technical and financial assistance.

**5) Targeted conservation practice selection and restoration in habitat complexes and corridors informed by the Minnesota Prairie Conservation Plan and other key plans to promote resiliency to landscape stressors and to provide refuge for wildlife species.**

Outcomes: Use the Minnesota Prairie Conservation Plan and other landscape ecology planning documents to help guide the selection and implementation of RIM and other habitat plantings.

**6) Increase focus on the restoration of high quality pollinator habitat to support declining pollinator populations. Pollinators play a key role in supporting landscape resiliency by pollinating about 30% of crops and 70% of native plants that in turn provide many landscape functions.**

Outcomes: Through the Governor's Pollinator Executive Order and BWSR's Pollinator Initiative, incorporate high quality pollinator habitat into BWSR programs, collaborate with local conservation partners, and provide guidance and technical resources for pollinator efforts.

**7) Identify natural resource concerns (and landscapes at risk) related to climate change and extreme weather events and provide potential climate adaptation solutions.**

Outcomes: Work with conservation partners to identify landscape categories and regions at greater risk from climate change and summarize this information in the new Landscape Resiliency Toolbox.

**8) Feature the stories of successful projects that accomplish landscape resiliency and climate adaptation benefits on a BWSR Landscape Resiliency and Climate Adaptation webpage.**

Outcomes: Feature six new climate adaptation efforts on the new Landscape Resiliency and Climate Adaptation webpage along with the new Landscape Resiliency Toolbox, and update periodically.

## **Additional Focus Areas Identified Through Partner Discussions**

### **Data Collection**

Summarize the costs of Climate change on infrastructure and natural resources to help show the importance of climate adaptation actions.

### **Conservation Programs and Practices**

Promote the Minnesota Ag Water Quality Certification Program that is a voluntary program that is designed to accelerate adaption of on-farm conservation practices that protect soils and restore water quality in Minnesota's lakes and rivers. Producers who implement and maintain approved farm management practices will be certified and in turn assured that their operation meets the state's water quality goals and standards for a 10-year period.

### **Ecological Resiliency**

Investigate and implement methods to restore wetlands that are more resilient to landscape stressors with improved site assessment, installation and maintenance techniques. Refine and increase the use of BWSR Wetland Resiliency Calculator.

Protect stored carbon by preserving natural shoreline forest lands around shallow wild rice production lakes via permanent riparian easements in northern Minnesota forest region.

### **Ecological Restoration and Conservation Plantings**

Focus on Restoration of high quality, diverse, and resilient wetlands to replace wetland losses. Evidence suggests more carbon is sequestered by a richer mix of native species (such as mixed forests) and communities are more stable over time.

Promoting plant species diversity to increase landscape resiliency and promote habitat for a wide range of wildlife species including pollinators.

Promoting individual species for projects that can handle expected conditions (such as prairie species for drought, and rhizomatous emergent plants for fluctuating water levels) and provide ecological functions.

Increased focus on tree planting in urban and previously forested rural areas to sequester carbon, improve air quality, reduce stormwater runoff, decrease the heat island effect in urban areas, control erosion, promote biodiversity and stabilize watersheds.

### **Landscape Management and Invasive Species Control**

Promote long-term monitoring and management of wetlands to control invasive species and promote plant diversity and study the long-term resiliency of restored wetlands and how wetland functions change over time.

Promote Cooperative Weed Management Areas (CWMA) that are local organizations that provide a mechanism for sharing invasive species management expertise and resources across jurisdictional boundaries in order to achieve widespread invasive species prevention and control in a broader geographic region.

Increase focus on controlling emerging weed threats that are benefitting from warming climate such as woody invasive species that are starting to invade northern forests.

Promote landscape management practices such as forest management and prescribed burning that can increase the landscapes ability to sequester carbon. Soils rich in organic carbon are better able to withstand large rain events.

Develop resources for LGUs to give to farmers/landowners to explain practices that can be used for climate adaptation.

### **Planning for Altered Hydrology and Extreme Storms**

Ensure a strong technical structure is in place to address disaster response with a focus on disaster preparation and rebuilding infrastructure that will be resilient to future storms.



*Native prairie holds potential as a source of biofuel production.*

## Appendix A: Summary of Recent Climate Reports

[NOAA Atlas 14](#) – New National Oceanic and Atmospheric Administration rainfall frequency data (NOAA Atlas 14) show that the amount of rainfall for given frequencies has risen substantially.

[Minnesota Environment and Energy Report Card](#) (2012) – shows that lakes are thawing sooner.

[Minnesota Sea Grant](#) – Since 1980 surface water temperatures on Lake Superior in summer has warmed twice as much as the air above it. Over the winter, the area of the lake covered by ice is decreasing by about .5% per year. Ice cover in Lake Superior has decreased from 23% to 12% over the last century.

[National Climate Assessment and Advisory Committee](#) – Concludes that by the middle of the century, the average temperature of the Midwest Region will increase by approximately 3.8 degrees Fahrenheit, relative to the average for 1979 to 2000. If the current high emissions trend scenario is followed, the increase will be approximately 4.9 degrees Fahrenheit.

[Working Group 1 Contributions to the IPCC Fifth Assessment Report “Climate Change 2013: The Physical Science Basis Summary for Policymakers”](#) - At continental, regional and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones.



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## Appendix C: Strategies for Restoring Resilient, Functional Landscapes

The following information summarizes strategies for restoring landscapes that are resilient to climate change and other stressors and will provide important landscape functions and services into the future. These strategies borrow from the disciplines of conservation, ecological restoration, landscape ecology, and sustainable farming and are key methods for developing landscapes that are resilient to climate change.

**1) Strategic Site Selection** - Work with project partners to identify the functions that are most beneficial for an individual landscape and where projects should be located to best provide those functions. In many cases this involves restoring habitat complexes or buffering key water resources or plant communities to restore natural, nutrient cycling and plant and animal populations. Site projects in locations where ecological stressors such as unnatural water fluctuations, decreasing water tables, or invasive species will not significantly detract from key functions into the future.

**2) Designing for Multiple Functions** - Be strategic in the selection of primary and secondary goals. Be hydrology selective in making certain functions a priority, but remember that multiple functions including wildlife habitat, plant diversity, food production, stormwater treatment, soil quality and nutrient cycling can often be accomplished at once.

**3) Making Landscape Connections** - Establish strong connections through landscapes. Create habitat and genetic dispersal corridors and decrease landscape fragmentation. Or, create a network of conservation practices in agricultural areas. Pulling together small parts plays a key role in restoring landscape resiliency and providing refugia for pollinators and other at-risk species.

**4) Matching Plant Communities to the Site** - Match your targeted vegetation to the native plant community that best fits the topography, soils, hydrology, and climate conditions (including the potential future climate) of your site. Also restore natural hydrologic regimes to aquatic and wetland systems. Historic plant community information can be used as a guide for decision making. Determine the kinds of native wildlife that live in the area or migrate through, and include native plants natural to the site that will provide food and shelter for many animal species.

**5) Restoring and Maintaining Diversity** - Plant diversity (and structural diversity of plant communities) supports wildlife species and increases resiliency by helping plant communities and agricultural systems to continue functioning as intact systems during climate variation. Filling niches with native species also prevents the establishment of invasive species. Restoring natural disturbances such as prescribed fire, grazing and water fluctuations plays a key role in maintaining diversity. In addition to plant species diversity protect genetic diversity of individual plant species by using site appropriate sources that can adapt to future conditions.



**6) Working with Ecological Adaptation** - Natural plant communities have the ability to adapt. They develop a natural dynamic through genetic adaptation, succession and natural colonization. Incorporate these processes into projects to complement restoration efforts, provide desired ecological functions, and buffer the community during future changes in climate and associated disturbance. Assisted migration may be needed in some ecosystems to help maintain plant community integrity.



**7) Providing Habitat for Pollinators and other Beneficial Insects** - Pollinators and other insects play an essential role in supporting ecosystems by pollinating around 70% of flowering plants and providing food sources for a wide range of wildlife species. Support insect populations by minimizing pesticide use, buffering natural areas and diverse plantings from pesticide exposure, restoring habitat complexes and wide natural corridors, increasing plant diversity, and restoring clean water sources.



**8) Effective Water Management, Treatment and Use** - A variety of practices including perennial crops, conservation tillage, conservation drainage, cover crops, buffer strips, infiltration basins, raingardens and wetland restoration help manage water resources. Incorporate these practices in urban and rural landscapes to reduce runoff, recharge groundwater, maintain agricultural productivity, improve water quality, and reduce flooding. Promote the wise use of water resources and the use of catchment systems to help ensure adequate supplies into the future.



**9) Preserving and Restoring Soil Health** - Soils that have good soil structure, organic content and microorganism populations translate into healthy and productive ecological and cultural landscapes. Soil health can be restored through planting cover crops, no-till farming, and establishing perennial vegetation.



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**10) Managing Invasive Species Across Boundaries** - Invasive species are effective at dispersal, giving them an advantage in adapting to climate change. Plan to work in partnerships and manage invasive species across ownership boundaries to restore resilient landscapes.



**11) Practicing Adaptive Management** - Adjust management practices based on monitoring efforts and experience with successes and failures to improve the long-term effectiveness of management practices and resiliency of plant communities. Practices such as prescribed burning, water level management and prescribed grazing may replicate natural disturbances and promote diversity and resiliency.

**12) Learning from Project Experience** - Information about project successes and innovative practices is valuable. What practices provide the most benefits in our landscapes? What common activities are not worth the cost or, worse, make a problem worse? BWSR's "[What's Working](#)" information summarizes real-world outcomes.

