



# Minnesota Environment and Energy Report Card



WATER



LAND



AIR



ENERGY



CLIMATE

Environmental and  
Energy Measures  
Critical for Our  
Quality of Life



# Acknowledgements:

The Minnesota Environment and Energy Report Card relied on the effort of staff from several state agencies, including:

- The Minnesota Environmental Quality Board
- The Minnesota Department of Agriculture
- The Minnesota Board of Water and Soil Resources
- The Minnesota Department of Commerce
- The Minnesota Department of Employment and Economic Development
- The Minnesota Department of Health
- The Minnesota Department of Natural Resources
- The Minnesota Pollution Control Agency
- The Minnesota Department of Transportation

For more information, go to the Environmental Quality Board (EQB) website at: [www.eqb.state.mn.us](http://www.eqb.state.mn.us)

# Table of Contents



WATER ..... 1



LAND ..... 7



AIR ..... 11



ENERGY ..... 14



CLIMATE ..... 19

# INTRODUCTION

If our environment is to be a true reflection of our values, we must regularly assess its quality, prioritize our efforts and measure our progress. This Environment and Energy Report Card is an important step in that direction.

As federal regulations and state standards and priorities evolve or shift, the Report Card will be useful in setting and evaluating new benchmarks for performance.

It also sets the stage for an upcoming series of citizen forums to gather public input on the environment statewide and leads up to an Environmental Congress to be held in 2013 involving citizens, public- and private-sector and nonprofit leaders. Together, the events encompass one of the most wide-ranging public discussions on the environment and energy in decades.

## Progress and Challenges

It has been two decades since the last report of this kind, and much good has happened in that time. Just a few important highlights:

- Minnesotans took the unprecedented step of approving the Clean Water, Land and Legacy Amendment to the state constitution, increasing the state's sales tax to provide hundreds of millions of dollars in funding for environmental priorities ranging from protecting drinking water; to restoring prairies, forests and wetlands; to providing game and wildlife habitat; to cleaning up polluted lakes, streams, rivers and groundwater.
- Comprehensive monitoring of watersheds, lakes and streams is well underway.
- Reductions in air pollution emissions from coal-fired power plants and industry smokestacks have been dramatic.
- Improved community wastewater treatment has reduced phosphorus discharged into lakes, rivers and streams by more than 50 percent.

But other challenges persist or are growing worse. And new ones are emerging. Groundwater supply and management, impaired lakes and streams, increased air pollution from cars and trucks, and climate change are among the most pressing and difficult issues we face now and in the future.

## Understanding the Indicators

Each section of this report contains several key indicators that illustrate important points about our water, land, air, energy use and climate. They are not the only important measures being tracked – far from it.

The science being conducted and the data gathered and analyzed is far more extensive than what is presented here in each topic area.

But in the same way that your doctor chooses only a handful of tests to assess your general health, these specific indicators have been chosen because they reflect fundamental elements of the state of our environment and our energy consumption.

## Making the Connections

Any report on the environment must acknowledge the interconnection between climate change, the condition of our water, land and air, and the types and amounts of energy we consume.

Emissions from smokestacks and tailpipes pollute the air and surface water, and are the prime contributors to climate change. Climate change affects temperature, water quality, groundwater quantity, and weather patterns that are increasing the frequency of very heavy rains. Erosion from heavy rains, increased development, and poor land management practices can affect the amount of sediment and chemical pollutants that wash into lakes, streams and rivers. All of these factors affect the health and well-being of people, animals and plants and have the potential to disrupt or permanently alter entire natural systems.

Each of these problems contributes in some way to the others. The good news is an improvement in one area can lead to improvements in others.

## Just the Beginning

It is fitting that this Report Card is issued on the 40th anniversary of the Clean Water Act and so near the 40th anniversaries of the Clean Air Act and the Safe Drinking Water Act. These landmark pieces of federal legislation have spurred innovations and energy efficiencies, creating entire clean-tech and water industries, and delivered environmental improvements in the process.

How will we improve upon and expand that legacy in the future? How will we meet the needs of our environment and our economy?

Each section of this report concludes with a series of such key questions. They illustrate the challenges and tough choices that citizens and lawmakers and advocates must confront now and in the future as we work together on environment and energy issues.

And there is one important question that each Minnesotan must ask – and answer: What is my role? Together, it is our shared responsibility to be good stewards of Minnesota's natural resources. The decisions we make as individuals, community, and as a state will have long-lasting implications for our children, grandchildren, and future generations.

# WATER for drinking, fishing and swimming

As the Land of 10,000 Lakes, we are a state defined by our relationship with water. Even the name given to this place by the Dakota people – Minnesota – (meaning land of sky-tinted waters) reflects that intimate and enduring bond.

We monitor Minnesota's water bodies to protect water quality and the quantity of our water, to understand how we affect the entire system, and to conserve and preserve this precious and limited resource.





# WATER for drinking, fishing, and swimming

## Growing Demand and Biggest Users

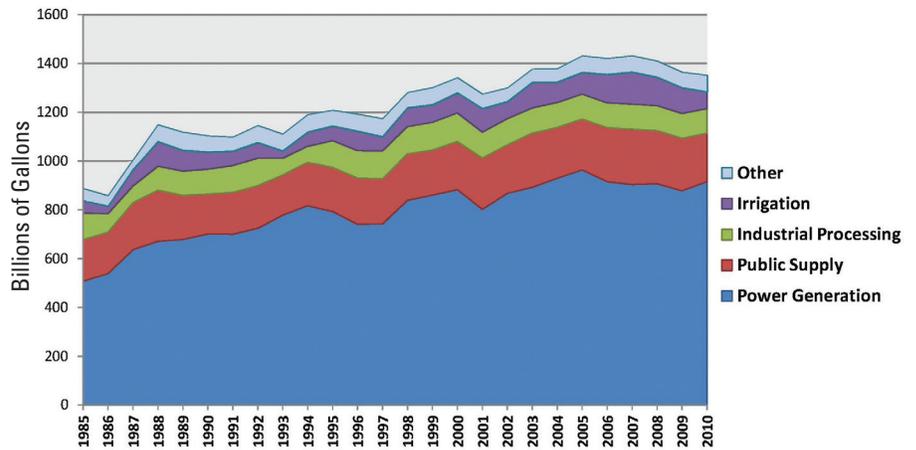
Over the past 25 years, our thirst for water has grown faster than our population. All sectors – businesses, industry, homes and farms – are using more and more.

The electric industry is far and away the state's biggest user, though the water is really more borrowed than consumed. Drawn from rivers and other surface sources, water is used to cool equipment at power plants and all but about 2 percent is returned to the stream.

The water used by cities and towns, mostly for drinking, household and commercial use ranks second on the list of consumers. Underground aquifers supply about 75 percent of Minnesota's drinking water, and management of groundwater supplies is an emerging issue. Water drawn from lakes and rivers makes up the rest of community use.

Water-intensive industrial processing (everything from pulp and paper processing to ethanol plants and oil refineries) and crop irrigation rank a close third and fourth on the list of users.

Minnesota Water Use by Category



Source: Department of Natural Resources.

## Community Water Supplies Are Clean and Safe

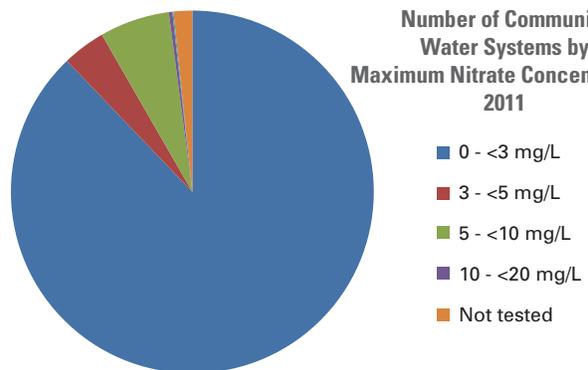
For most of us, concerns about water quality begin at the tap. For drinking, cooking, bathing and preserving our health, the purity of our household water is of utmost importance.

Once treated to remove impurities, Minnesota's communities have some of the highest quality drinking water in the nation, and all but a few meet federal drinking water standards. So, public drinking water supplies are safe and healthy.

Community water systems statewide are monitored for over 100 compounds, including nitrate. Nitrate is a contaminant that makes its way into ground and surface water, mostly as runoff from fertilizers, sewage, animal waste or manure. In too high a concentration, nitrate is a health hazard.

After treatment, the vast majority of community water systems fall well below the federal standard of 10 milligrams of nitrate per liter of water. Only four systems (0.4 percent) exceeded the standard in

Number of Community Water Systems by Maximum Nitrate Concentration 2011



Source: Minnesota Department of Health.

# WATER for drinking, fishing, and swimming



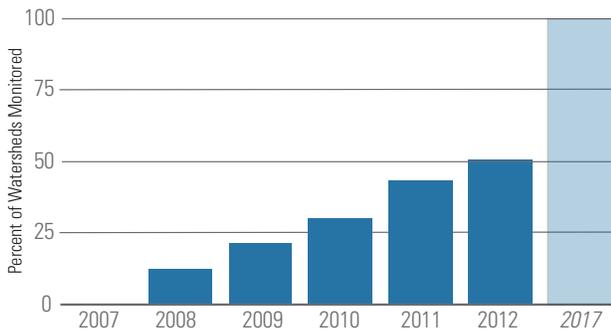
## Surface Water Quality Varies

All of our water is contained within an immense and interdependent circulatory system made up of 81 major watersheds, 5,600 minor watersheds, nearly 12,000 lakes, 105,000 miles of rivers and streams, 10.6 million acres of wetlands, and trillions of gallons stored in 14 major aquifers beneath the ground. These veins and arteries of water refresh and recharge each other.

A watershed is really just a term for how water collects and flows over the contours of the land as gravity pulls it downhill.

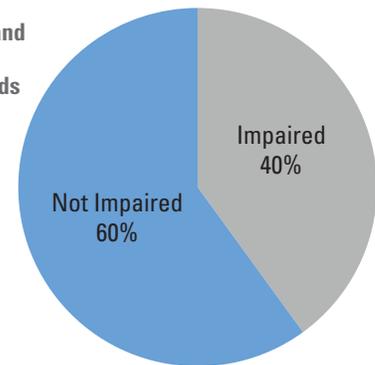
Monitoring our watersheds helps us evaluate whether surface water quality is suitable for recreational uses like fishing, swimming or boating, and whether it supports aquatic life. Monitoring includes field and lab testing of lake water and stream chemistry and biology, such as fish populations. To date, slightly more than half of the major watersheds have been comprehensively monitored.

Percent of watersheds monitored



Source: Minnesota Pollution Control Agency.

Percentage of lakes and streams meeting water quality standards



Source: Minnesota Pollution Control Agency.

In general, 60 percent of Minnesota lakes and streams meet federal standards for clean, fishable and swimmable waters. The remaining water bodies are considered impaired, meaning that they contain pollutants (sediments, nutrients, bacteria, among others) at levels too high to meet the standards.

By the year 2017, all of the state's major watersheds are expected to be monitored. And the following year, the monitoring cycle begins again. The continued testing will help to assess whether the condition of impaired waters is improving or worsening, whether efforts to address problems are succeeding or if new measures may be necessary, whether clean waters are remaining so, and how human and natural changes may affect entire systems.

## A Clear Picture of Lakes, Rivers and Streams

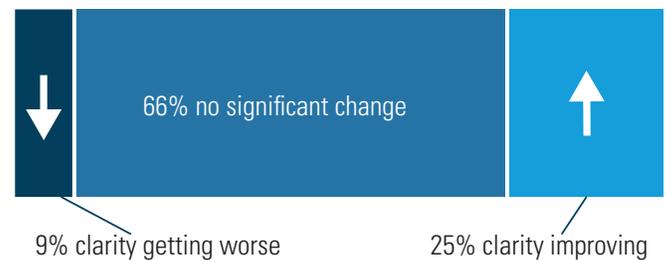
Scientists can learn a lot about water quality by testing clarity. Simple tests, taken by hundreds of volunteers statewide, tell how far down light can penetrate lakes, rivers and streams and provide a general sense of how much suspended solids are in the water.

Too little light can impede healthy plant growth. And in many cases, turbid water is a sign of sediment and nutrient runoff, algae and other underlying pollution problems.

Over the past decade, clarity has improved in about one-fourth of Minnesota's lakes. Most have experienced no significant change, and a small number show reduced water clarity.

Washed from farm fields, lawns, streets and parking lots, and many other surfaces, sediment can also clog rivers and streams. A pollutant all by itself, sediment also carries phosphorus into the water. The combination can seriously harm plants, aquatic life and animals.

Clarity changes in Minnesota lakes 2000-2010



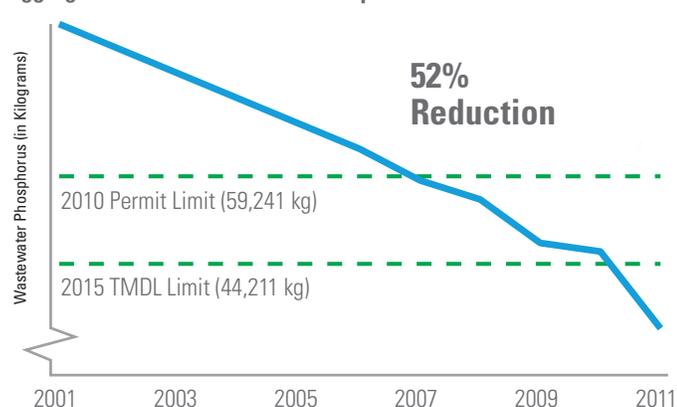
Source: Minnesota Pollution Control Agency and Citizen Lake Monitoring Program.



# WATER for drinking, fishing, and swimming

While a number of Minnesota rivers and streams are affected by sediment, nowhere is the problem more striking than at the confluence of the Minnesota and Mississippi rivers. Above the point where the rivers meet, sediment levels are well below federal standards. At the confluence, levels rise dramatically as the sediment laden Minnesota spills pollutants into the Mississippi and degrades water quality downstream, especially in Lake Pepin.

## Aggregate Load of Wastewater Phosphorus in the Minnesota River



Source: Minnesota Pollution Control Agency.

The level of phosphorus in the Minnesota River has been greatly reduced, driven in large part by tighter permit limits and good compliance from community wastewater treatment plants. Phosphorus contained in sediment runoff from cropland is a persistent problem.

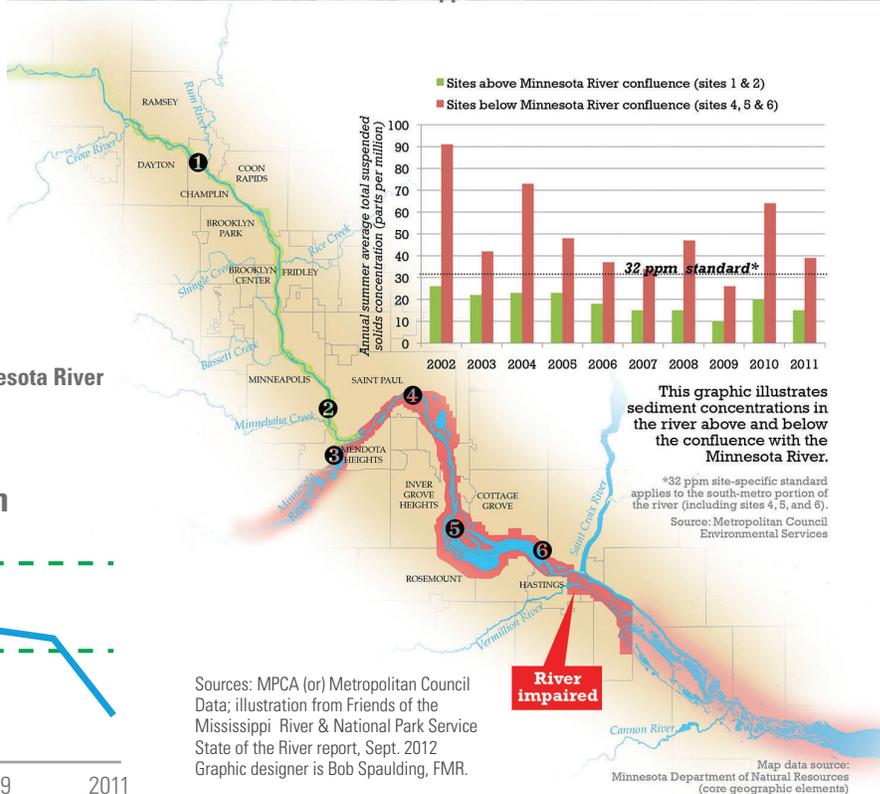
## Healthy Aquatic Life and Ecosystems

The health of our lakes, streams and wetlands matters as much to plants, fish and other aquatic life as it does to us. Ecosystems can be disrupted, transformed or destroyed by pollution and invasive plant and animal species. And the health and quantity of our fish is an important gauge of water quality.

Walleye remain abundant in most lakes. While stocking occurs, most walleye caught in Minnesota are from natural reproduction in self-sustaining lakes. Cisco—an important food source for walleye, pike, and lake trout—have declined in inland lakes by 42 percent since 1975. Recent evidence suggests that declines are primarily due to climate change.

Invasive plant and animal species, such as Eurasian Milfoil, Asian Carp and Zebra mussels, continue to be found in new locations.

## Sediment in the Mississippi



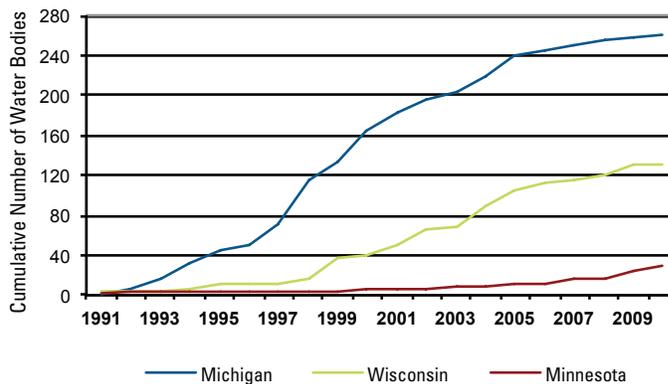
Sources: MPCA (or) Metropolitan Council Data; illustration from Friends of the Mississippi River & National Park Service State of the River report, Sept. 2012. Graphic designer is Bob Spaulding, FMR.

This graphic illustrates sediment concentrations in the river above and below the confluence with the Minnesota River.

\*32 ppm site-specific standard applies to the south-metro portion of the river (including sites 4, 5, and 6). Source: Metropolitan Council Environmental Services

Map data source: Minnesota Department of Natural Resources (core geographic elements)

## Rate of growth of water bodies infested with Zebra Mussels in the Upper Great Lakes States

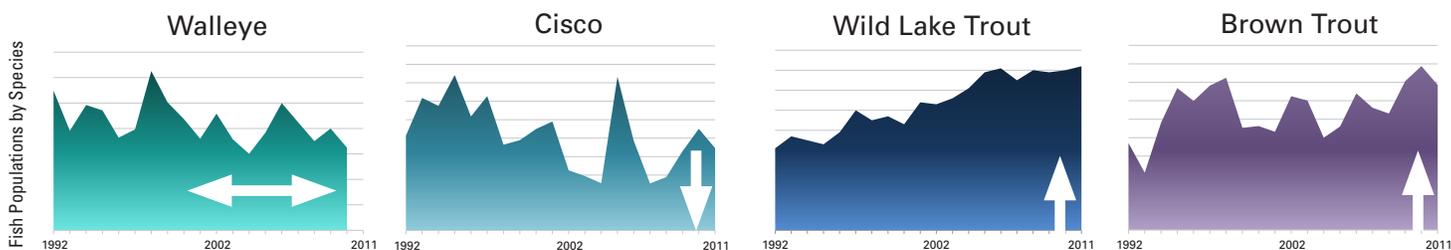


Source: Minnesota Department of Natural Resources.

# WATER for drinking, fishing, and swimming



## Population Levels of Select Fish Species



Minnesota Department of Natural Resources.

## Summing It Up

In order to protect our lakes, rivers, streams and aquifers, our focus must continue to shift from the shoreline to the whole watershed and the land within.

Water quality is often a reflection of the activities that take place within a watershed and many water quality challenges are directly related to land use. Management practices on agricultural land, urban runoff from streets and parking lots, and storm water and wastewater discharges all affect the amount of sediment and chemicals that end up in our water.

Water is especially vulnerable when new development is underway. The land is far more prone to erosion during earth-moving and construction. How we plan our development projects to prevent runoff is increasingly important to water quality.

Minnesota's water quality efforts are tied to the federal Clean Water Act, which provides the regulatory framework to clean up and prevent water pollution, with a goal of ensuring that the state's waters are fishable and swimmable. Not long before the act became law, a fish survey of the Mississippi between Hastings and St. Paul showed just two fish.

We've made significant progress in cleaning up our waters since then, with dramatic reductions in pollutants from sewage wastewater, storm water and industrial waste.

Still, 40 percent are considered impaired by pollution. Chemical contaminants are a persistent concern. Despite dramatic reductions, mercury is still far commonly found in fish. And a slew of new chemicals (many unregulated) are believed to be affecting endocrine systems in fish and other aquatic life. These also may signal concerns for human health.

What do we do about these impaired waters? Our regulatory agencies are setting and enforcing limits on pollutants discharged into these water bodies, and working with federal, state and local partners and individuals to address unregulated sources of pollution. They're establishing and funding cleanup plans. A lot of work is underway, but the race is a marathon, not a sprint. Some waters can be restored sooner, while others may take many years.

Looking below the surface, groundwater management is one of the most important issues that communities statewide will face.

The state's population is expected to grow by 16 percent by the year 2030. Demand for water is rising and most communities will pump more groundwater to satisfy the needs of households, business and industry. And many Minnesotans get their drinking water from private wells on their own property.

Ideally, the draw down from our aquifers should not exceed what nature can replenish through soaking rains, snowmelt and other recharge. But in some parts of the state, the rate that water is drawn by communities from ground sources is not sustainable, a condition that may become more widespread as statewide population grows. And most groundwater withdrawn does not return to the aquifers after use, but ends up in rivers via sewers and drainage systems.

More frequent use of storm water retention ponds to hold water while it filters back down into aquifers may be one solution. Conservation is another piece of the puzzle. The future lies in developing new, more efficient ways to use or reuse groundwater.

## Key Questions to Consider

How will we meet the increasing demands for water as population rises and water-intensive industry continues to develop?

How will we manage and use our precious groundwater supplies?

How will we address the nonpoint sources of water pollution from farmlands and urban areas that contribute to our many impaired waters?

Which water-quality issues deserve our highest priorities for research, funding and action?

As climate change increases the frequency and severity of heavy rains, how will farms and cities deal with the storm runoff?

How will we adapt to the challenges of warmer water temperatures and their effects on lakes, rivers and streams?

# LAND for business, recreation and life

Homes and habitat, towering forests and city skylines, sprawling croplands and suburbs, grasslands and manicured lawns, Minnesota is a patchwork of many different types of land.

Because it provides the basics of life and forms the foundation of a very diverse state economy, understanding our land use and management is in the vital interest of all Minnesotans. The way we use land to live, foster business and industry, and build communities has an important and positive impact on the quality of our lives.

But there are trade-offs. Those land uses can also have lasting negative consequences that are felt at all levels of our environment. We monitor land use and management practices to understand how changes great and small can reduce pollution or make it worse.



# LAND for business, recreation and life

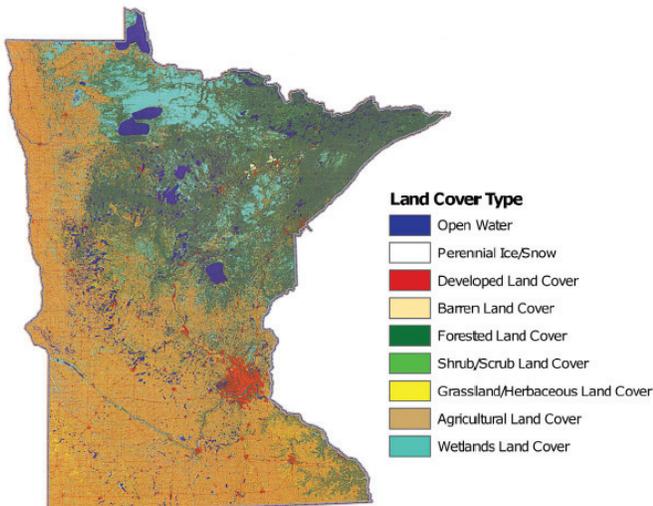


## How We Use Our Land

Minnesota's land and the way we use it have changed dramatically over the last 150 years. Large areas of prairie, wetlands, and forests have been converted to pasture, cropland, and residential and commercial development. Over the past three decades, however, land-use and cover have changed very little.

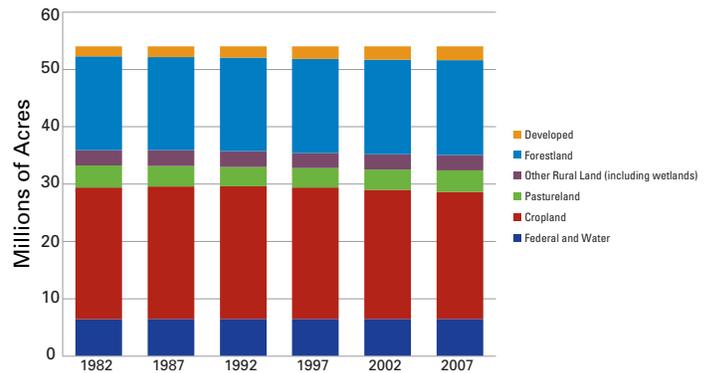
More than half (54 percent) of land statewide is dominated by agriculture, including cropland, pasture, wetlands, and other rural land. An additional 31 percent is forest. Since 1982 there has been a slight loss of agricultural land (2 percent) and slight increases in developed and forest land (1 percent each).

Current Minnesota Land Cover



Source: U.S. Forest Service/U.S. Geological Survey.

Surface Area of Minnesota Land Cover/Use, 1982-2007 (in millions of acres)



Source: 2007 National Resources Inventory, USDA/NRCS.  
Note: Minnesota has 50.96 million acres of land area.

From a statewide vantage point these changes may seem small, but at local and regional levels the consequences can be significant, fueling public policy debates and disagreements about the loss of cropland, prairie and forest.

## Managing Our Cropland

Conservation tillage and cropland retirement are two important measures that Minnesota's farmers use to protect valuable cropland.

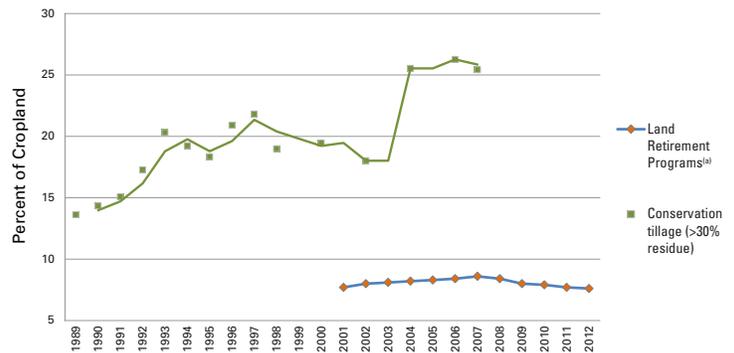
Why is the way a farmer tills or plows the land so important? Cropland on steep slopes and next to waterways can be a source of sediment, nutrients and chemical pollutants that flow into our lakes, rivers and streams. Conservation tillage methods leave crop residue on the surface or immediate soil profile, which reduces runoff. Farmers have learned that leaving at least 30 percent of crop residue on the land after harvest reduces costs without sacrificing productivity.

In 2007 more than 25 percent of cropland was farmed with conservation tillage methods to reduce soil erosion.

Cropland retirement programs provide financial incentives to landowners to take land out of agricultural production and establish perennial vegetation that slows soil erosion, improves water quality and restores wildlife habitat.

In 2012, nearly 1.75 million acres of cropland were taken out of production and enrolled in some type of land retirement conservation program, about 7.6 percent of the total reported cropland statewide.

Percent of MN Cropland<sup>1</sup> in Conservation



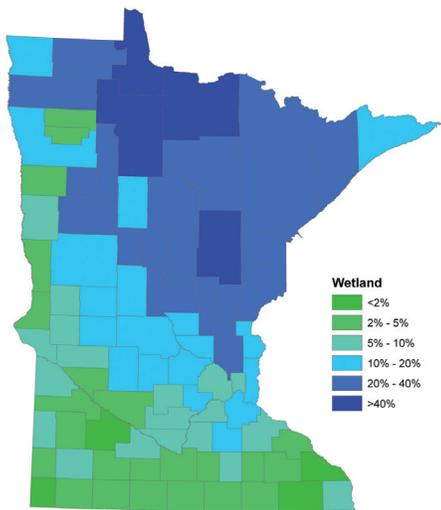
<sup>1</sup> Based on cropland of 23,071,285 acres  
<sup>(A)</sup> Conservation Reserve Program (CRP, Continuous CRP, CREP), Reinvest in Minnesota, Wetland Reserve Program

Source: Minnesota Board of Soil and Water Resources; Fisher and Moore (Water Resources Center 2008).



# LAND for business, recreation and life

## Current Abundance of Wetlands in Minnesota



Source: Minnesota Department of Natural Resources.

## Managing Our Wetlands and Native Prairies

Wetlands provide wildlife habitat, nutrient uptake, water retention and aquifer recharge. Although an exact number is not known, our best estimates put Minnesota's wetlands at more than 10.6 million acres covering about one-fifth of the state.

About 42 percent of pre-settlement wetlands have been converted to other land uses. Most losses have occurred in western and southern reaches of the state where prairie pothole wetlands were long ago converted to agricultural use.

Recent improvements in remote sensing techniques allow for a more accurate inventory and for monitoring future changes. Laws and regulatory programs are in place to minimize further loss of wetlands.

Prairie once covered about one-third of Minnesota, nearly 18 million acres. The soils that developed under prairie plants over thousands of years provided the foundation for Minnesota's large agricultural economy and thus have been converted to croplands over the last 150 years. As a result, only 1 percent of native prairie remains in Minnesota. Of the 235,000 acres remaining, half has been permanently protected. Conserving native prairies requires restoration and management activities such as prescribed burning and invasive species control to remain healthy.

## Managing Our Forests

Covering about one-third of the state, Minnesota's forests are diverse, productive and beautiful. And the benefits they deliver are wide-ranging.

They generate jobs in forest products manufacturing, stimulate outdoor recreation and tourism, provide crucial fish and wildlife habitat, and help renew the environment through water filtration, erosion control and carbon sequestration.

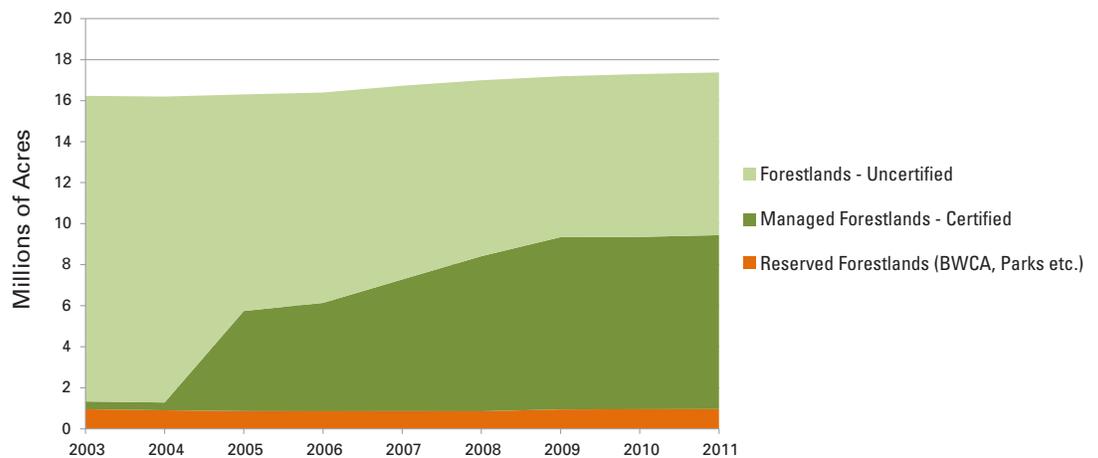
Our forest lands are managed in different ways to help ensure that they continue to be productive and provide a variety of commercial and recreational uses and wildlife habitat.

Some forest lands are reserved from commercial timber

harvesting and provide unique recreational opportunities and important natural resource protection. These include the Boundary Waters Canoe Area Wilderness, Voyageurs National Park and many state parks. Reserved areas account for 6 percent of current forest acreage.

The most significant change in forest management is Minnesota's commitment to third-party forest certification programs. Since 2003, the area of private and public forest lands certified by external auditors as sustainably managed has increased dramatically. Today more than half (52 percent) of Minnesota's non-reserved forestlands are certified. Consumers can be confident that products displaying a forest certification logo were grown, harvested and produced in a sustainable manner.

### Acres of Forestland by Management Status

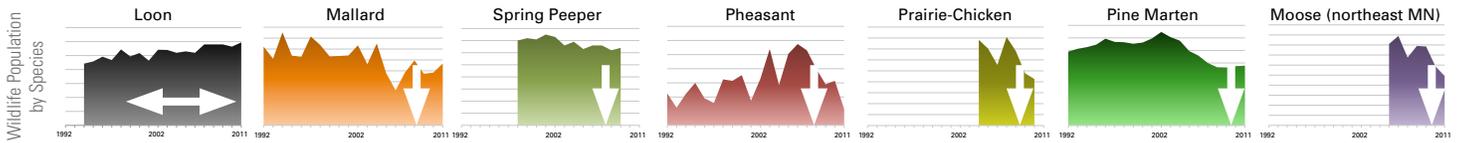


Source: Minnesota Department of Natural Resources and U.S. Forest Service, Forest Inventory and Analysis Program.

# LAND for business, recreation and life



## Population Levels of Select Wildlife Species



Source: Minnesota Department of Natural Resources.

## Managing Our Wildlife

Our diverse wildlife is an important part of the state's natural and cultural heritage. The health and abundance of wildlife populations reflects the conditions on the land, in the water, and in the state's weather and climate.

By examining a few selected species we can get a general picture of how some common species are doing and highlight some current and future resource management issues we face.

The loon, our state bird, is doing well on the central and northern Minnesota lakes where it spends the summer. While still abundant, other wildlife species have shown a shift from stable to declining populations in the past decade. This includes mallard ducks, spring peeper frogs, pheasants, and prairie chickens.

Pheasant numbers have increased since long-term land retirement conservation programs resumed in the 1980s, but have dropped over the last several years due to severe winter weather in some years and recent loss of acres in land retirement programs and other habitat acres converted to cropland.

In the forested regions, the American marten has declined in the last decade, but populations have leveled off in the last few years. Careful monitoring is needed to determine whether fluctuations are part of a true, declining trend for these species.

Of these Minnesota species, the moose has suffered the greatest losses. The northwestern moose population declined by more than 90 percent since the 1980s, and the northeastern population has fallen by 40 percent in the last six years, possibly due to climate change-related heat stress and associated factors.

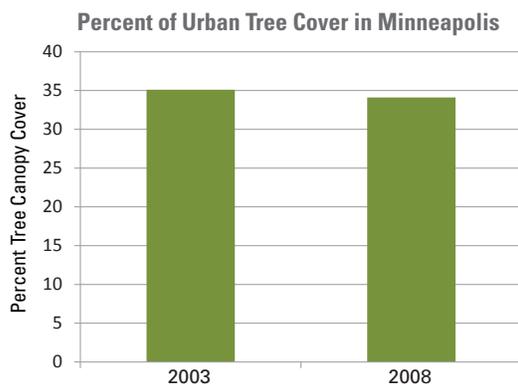
## Managing Our Communities

The vast majority of Minnesotans live in cities and smaller communities. These areas occupy only about 5 percent of the state's land area.

Trees are an important part of the urban landscape. Besides their beauty, healthy trees help reduce air pollution and storm water runoff. They help reduce air temperatures and their shade is a source of energy conservation for buildings and houses.

In a recent national study of 20 urban areas, Minnesota's largest city, Minneapolis, had the fifth-highest tree canopy cover (35.1

percent). But like most other cities, that canopy is shrinking, declining more than 1 percent in just five years.

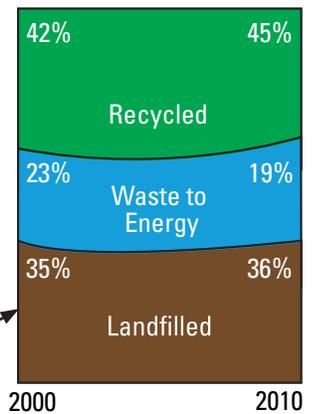


Source: Nowak and Greenfield 2012; U.S. Forest Service.

### How do we manage our solid waste?

Waste studies show that more than 70 percent of landfilled waste could be recycled, which would conserve resources and landfill capacity.

Waste studies show that more than 70 percent of this could be recycled or composted.



Source: Minnesota Pollution Control Agency.

Despite nearly 40 years of promoting waste reduction, recycling, composting and energy recovery over landfilling, Minnesotans still send 36 percent of their solid waste to landfills, a rate virtually unchanged in the past 10 years.

Studies show that more than 70 percent of waste going into landfills could be avoided by intercepting the recyclables and compostable material for recovery, which would conserve resources and preserve landfill capacity. Resource recovery and landfilling rates are tracked to measure progress in minimizing the amount of material buried in landfills.



# LAND for business, recreation and life

## Managing Our Minerals and Mines

Like croplands and forests, the state's mineral resources play a major role in our state's economy. Minnesota is the largest producer of taconite in the United States, producing over 35 million metric tons in 2010. However, the resources go well beyond taconite.

The Duluth Complex, which extends along the northern shore of Lake Superior, is a nationally and internationally significant reserve for copper-nickel and titanium resources, as well as other strategic minerals such as chromium and platinum.

It contains all of the known U.S. reserves of nickel, most of the cobalt reserves, and more than half of platinum reserves. With the recent, dramatic growth in world demand for metals—spurred mostly by growth in Asia and emerging markets—the Duluth Complex has drawn significant interest.

## Summing It Up

Great gains have been made over the past 25 years in the preservation and restoration of wetlands, prairies and grasslands through federal, state, and local programs and partnerships. This work has become more focused and effective with funding from the state's Clean Water, Land and Legacy Amendment, as agencies and nonprofits have teamed up to provide leadership. Partners in the Prairie Region have collaborated to develop a 25-year strategy for conservation.

However, high global demand for food and fuel has begun to offset these gains as more cropland that had been idled through conservation programs is put back into production.

Within the next five years, nearly 50 percent of the cropland currently enrolled in land retirement programs could return to production as contracts expire.

The amount of our forest land is stable – even increasing slightly. But as large tracts of privately owned forest are sold or developed, the forest can become fragmented, wildlife habitat degraded and public access limited. Still, the state has been successful at purchasing conservation easements that ensure public access for hunting, trails and recreational uses, and keep the lands in private ownership.

Urban tree cover is important, too. As expected air temperature, energy demands and large rainstorms increase, trees in our cities, suburbs and smaller communities will be even more valuable. Yet, as urban areas and other communities develop, tree canopy cover can be lost to make room for buildings, residences, parking lots and other impervious cover that typically increases storm water runoff. In addition, urban and community trees are susceptible to invasive species such as the emerald ash borer.

With increased demand for electronics and other products, interest in extracting Minnesota's extensive reserves of non-ferrous metals has never been greater. With advances in processing technology and environmental impact mitigation, extraction is now economically and environmentally viable.

## Key Questions to Consider

How should we offset the loss of conservation lands once in land retirement programs?

How can we protect and enhance tree cover in our cities and towns?

What avenues should we consider to increase Minnesota's recycling rate?

How should we be preparing to adapt to changes on our land brought about by climate change?

# AIR for people, animals and plants

If you're like most healthy adults, you'll take as many as 10.5 million breaths this year, cycling air into and out of your lungs 12 to 20 times every minute. With each breath, a wide variety of pollutants can hitchhike on the current of air you take in. They're tiny airborne particles – solids and liquids one-tenth the diameter of a human hair – and gases known as air toxins.

Largely the result of combustion and chemical use, these fine particles and gases are air pollutants all by themselves. And some react together to form ground-level ozone, the main ingredient of smog. In too high a concentration, these pollutants can cause heart and lung diseases, brain and nervous-system disorders, even some types of cancer.

We monitor air quality to ensure it is healthy to breathe, to identify the primary types and sources of air pollution, and to better understand what must be done to reduce it.

Of the thousands of substances released into the air, our measurements focus on a core few pollutants: lead, sulfur dioxide, particles, ozone and nitrogen oxides. Why these? They have the greatest bearing on the health of our air and are the focus of federal air quality standards.

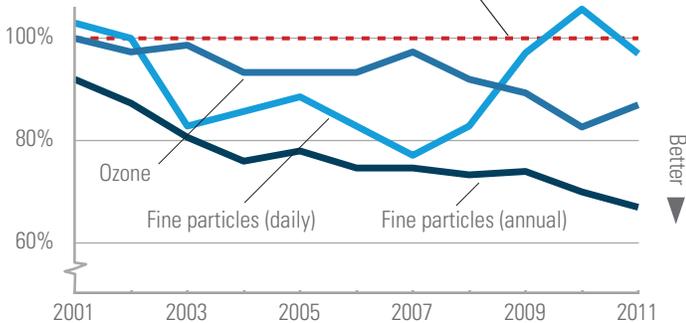


# AIR for people, animals and plants

## Our Air is Healthy to Breathe

By many measures, Minnesota's air quality is good. Even in the Twin Cities Metropolitan area, which includes more than 3 million people, air quality historically meets federal standards. But there are areas of concern. Levels of ozone and fine particles are pushing nearer to federal limits.

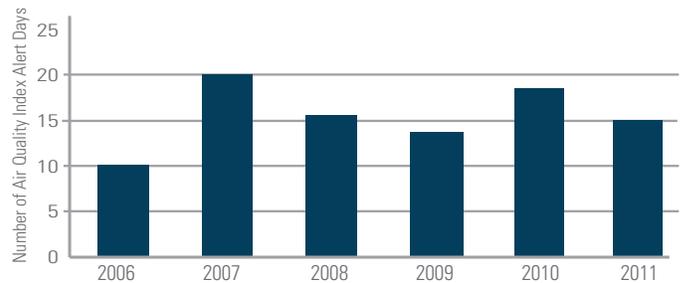
### Percent of National Ambient Air Quality Standard



Source: Minnesota Pollution Control Agency.

And there are days when pollution exceeds safe levels, triggering air quality alerts that often cover large regions of the state. In the last few years, daily concentrations of ozone or fine particles were high enough to trigger air quality alerts 10-20 days annually throughout Minnesota. On these days, a large portion of Minnesota's population may breathe unhealthy air.

### Annual Number of Air Quality Index Alert Days in Minnesota

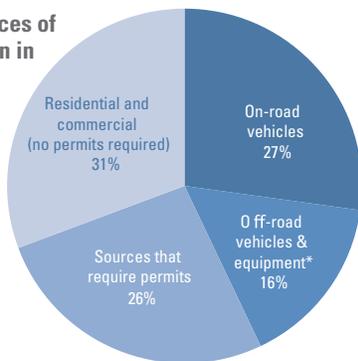


Source: Minnesota Pollution Control Agency.

## Major Sources of Air Pollution

Most air pollution in Minnesota today comes from mobile sources, like cars and trucks, trains and buses, tractors and bulldozers, and from fuel combustion for things like home heating. Large, stationary sources of air pollution (such as factories and other industrial facilities, coal-fired power plants, chemical plants, and oil refineries) are known as point sources.

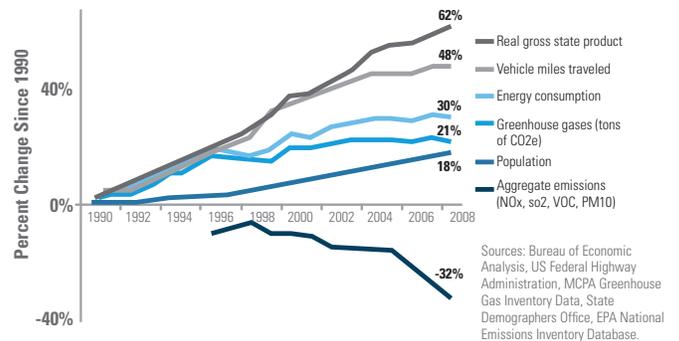
### Major Sources of Air Pollution in Minnesota



Source: EPA's National Emissions Inventory Database, version 2.  
\*Note: Off-road vehicles include agricultural and construction equipment.

Once seen as the prime contributors to air pollution, they bear far less responsibility today. Over the past two decades, air pollution from point sources has decreased significantly, largely due to government and industry efforts to reduce smokestack emissions. And the positive impact those reductions have on the health of Minnesotans cannot be overstated. Lead, particulate matter (PM10), nitrogen oxide (NOx), and sulfur dioxide (SO2), volatile organic compounds (VOC), cause all kinds of health problems from neurological and respiratory disorders to cancer. Each pollutant has seen marked downturns from point sources.

### State Economy, Energy Use, Population, Transportation and Air Pollution



Sources: Bureau of Economic Analysis, US Federal Highway Administration, MPCA Greenhouse Gas Inventory Data, State Demographers Office, EPA National Emissions Inventory Database.

### Point Source Emissions Last Decade



Source: Minnesota Pollution Control Agency.



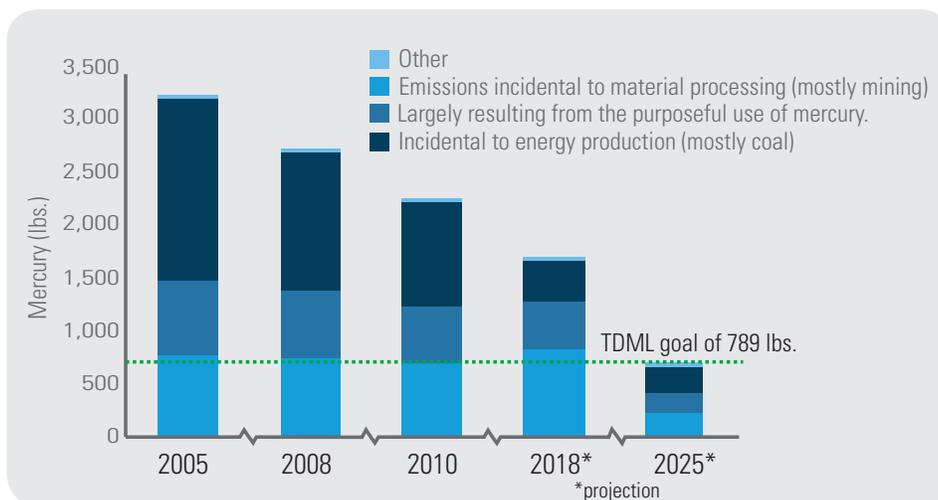
## Mercury Levels Have Fallen

Mercury is a naturally occurring element found in the air, water and soil—and it can be highly toxic. Released into the air whenever we burn coal, improperly dispose of products that contain mercury, and mine and process Minnesota’s iron resources, mercury makes its way into our surface water and then into the food chain, starting with fish and shellfish and moving on to animals and people.

Exposure to mercury can affect the human nervous system and harm the brain, heart, kidneys, lungs, and immune system.

Coal-fired power plants are the largest human-caused source of mercury emissions into the air in the United States, accounting for more than half of the total.

Dramatic reductions in mercury emissions from coal-fired power plants in Minnesota have reduced overall mercury levels considerably statewide. It’s a very important development for our lakes, rivers, aquatic life, wildlife, and human health.



Source: Minnesota Pollution Control Agency.

## Summing It Up

While Minnesota meets current federal air quality standards, tougher regulations are expected in the next few years. And meeting those future standards will be difficult, because the major sources of air pollution have changed.

On- and off-road vehicles and equipment have replaced industry as the heaviest polluters. And they are not as easily controlled under the traditional regulatory structures the state uses today.

Smokestack pollution from large, high-emission industries has been reduced greatly through tighter permitting requirements at state regulatory agencies. The state will continue to seek reductions from those industries.

But it will prove much more difficult to regulate emissions from mobile polluters like cars and trucks, trains and planes, lawnmowers and construction equipment.

The combined effects of more stringent federal standards, regional air masses drifting into Minnesota from other states and increasing temperatures may trigger future air quality violations and compel more air quality alerts and result in increased health impacts.

Continued reductions in mercury are necessary, including further reductions from the taconite mining industry. Meeting greenhouse gas reduction goals set by the state legislature seems unlikely.

## Key Questions to Consider

How do we reduce air pollution from cars, buses, trucks and tractor trailers used for transportation?

What steps would be necessary to reduce pollution in moderately to densely populated areas where emissions come from a wide mix of activities, ranging from home heating to wood burning to the use of small engines like lawnmowers?

How do we sustain the progress made in reducing air pollution from industrial sources while achieving reductions from traditionally non-regulated activities?

Do we need new regulations or incentives for businesses, industries or households? What is the right balance?

# ENERGY for our businesses, farms and homes

Whether to fuel our economy, our homes, our vehicles, or our dependence on gizmos, gadgets and technology, our appetite for energy is tremendous. And it's growing steadily.

Chew on this: In 1960, the average household had just three plug-in gadgets. Today, it's 25. And the energy we use in our homes accounts for only about one-fifth of our total consumption.



# ENERGY for our businesses, farms and homes



## Why We Monitor Energy Use

The link between our hunger for energy and the pollution of our air, water and land may be reason enough to monitor energy use. But the concerns aren't solely environmental. Energy use and our economic well-being are tied just as closely together.

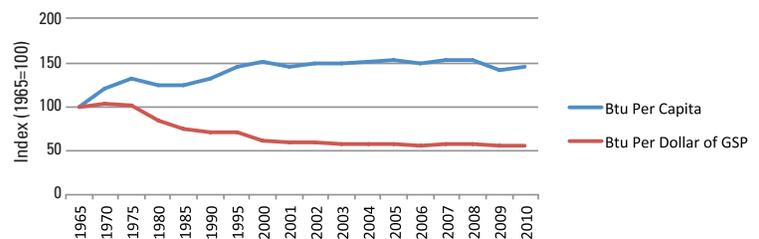
When we have a clear understanding of how much and what types of energy we're using, we're in a better position to reduce certain types of pollution and to identify areas where energy efficiency can be improved. Understanding our energy diet can also motivate us to diversify our energy sources, which can benefit the environment and the economy at the same time by reducing pollution while improving reliability and stabilizing prices.

## How Much Energy We Use

Over the past several decades, the amount of energy each Minnesotan consumes from all sources has risen substantially, though we get far more out of the energy we consume thanks to tremendous improvements in efficiency.

Those improvements have been most dramatic among commercial and industrial users. For a long time, economic growth and increased energy use went hand-in-hand. Not so today. While our economy has grown considerably, our energy consumption per dollar of gross state product has remained relatively flat for a decade.

**Btu Consumption Per Capita and Per Dollar of Gross State Product, 1965-2010**



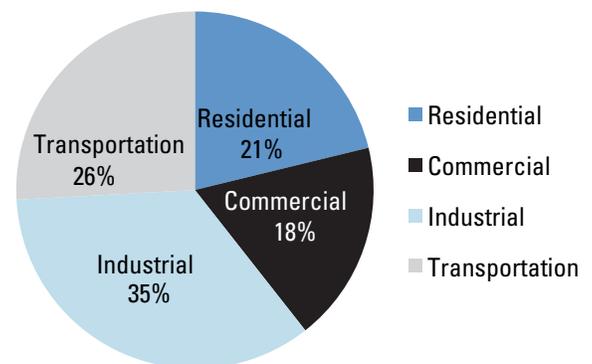
Source: State Energy Data System, Energy Information Administration, U.S. Dept. of Energy, U.S. Census Bureau, U.S. Bureau of Economic Analysis.

## The Biggest Users

Here's the bottom line: We use most of our energy to earn a living. It's the power we need to extract raw materials; to grow, preserve and distribute food; to manufacture products and transport them to market; to offer and deliver services; to power machines (from smart phones to heavy equipment) that do work.

Industrial and commercial uses account for 53 percent of total energy consumption. And when you consider that much of our transportation consumption is actually business-related (whether it's the fuel we use to commute to and from work or to transport products), the energy we use to power our economy makes up the lion's share of our total energy consumption pie.

**Energy Consumption by End Use Sector, 2010**



Source: State Energy Data System, Energy Information Administration, U.S. Dept of Energy.

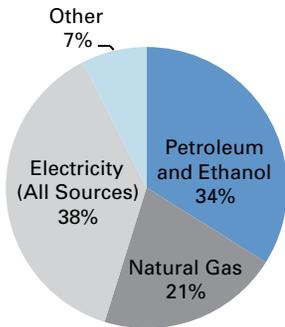


# ENERGY for our businesses, farms and homes

## The Types of Energy We Use

All sources considered, Minnesota's biggest energy buzz comes from electricity, but it's followed closely by petroleum and ethanol, predominantly used as motor fuels. Slightly more than half of our electricity is generated by coal-fired power plants and nearly one-fourth by nuclear power plants.

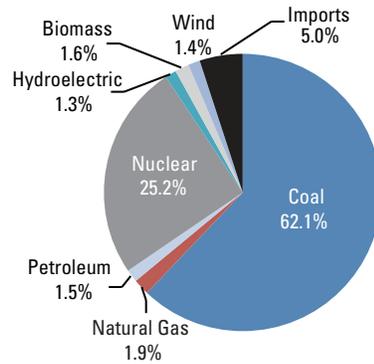
Energy Consumption by Energy Type, 2010



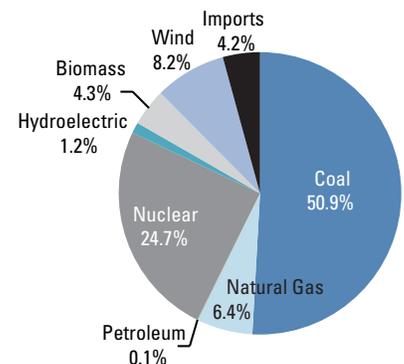
Source: State Energy Data System, Energy Information Administration, U.S. Dept of Energy. Note: Other includes geothermal, coal, hydroelectric, wood and biomass waste and losses and co products from ethanol not used in electricity generation. Electricity includes system energy losses.

## Energy Consumption by Source

Electricity Consumption by Source, 2000



Electricity Consumption by Source, 2010



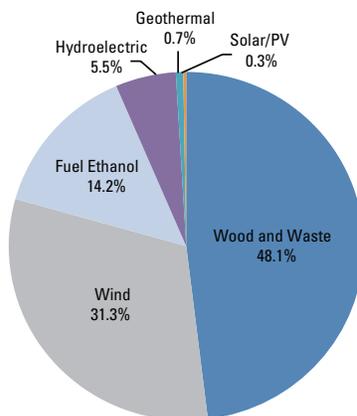
Source: State Energy Data System, Energy Information Administration, U.S. Dept of Energy.

## A Focus on Renewables

Renewable energy sources like wind, solar power, hydropower, biomass, and alternative fuels like ethanol and biodiesel are an increasingly important part of our total energy diet.

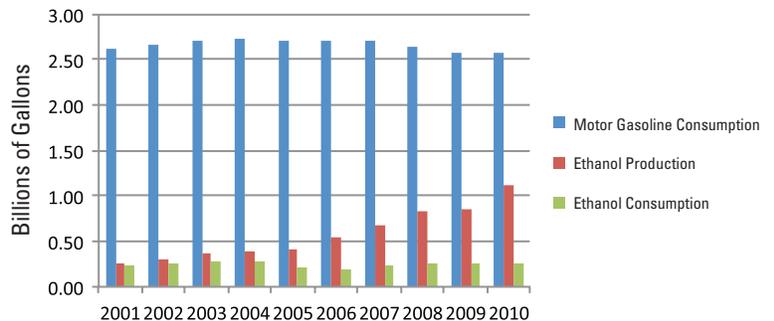
A driving force behind the heightened emphasis on renewables is Minnesota's Renewable Energy Standard, which requires utilities to provide 25 percent of their total electric generation from renewable sources by the year 2025. Xcel Energy will provide 30 percent by 2020.

Sources of Renewable Energy Consumption in Minnesota, 2010, by BTU



Source: State Energy Data System, Energy Information Administration, U.S. Dept of Energy. Notes: Hydroelectric is based on Minnesota production. Excludes losses and co-products from the production of fuel ethanol.

Motor Gasoline and Ethanol Consumption and Production, 2001-2010



Source: Agricultural Marketing Services Division, Minnesota Department of Agriculture. State Energy Data System, Energy Information Administration, U.S. Dept of Energy.

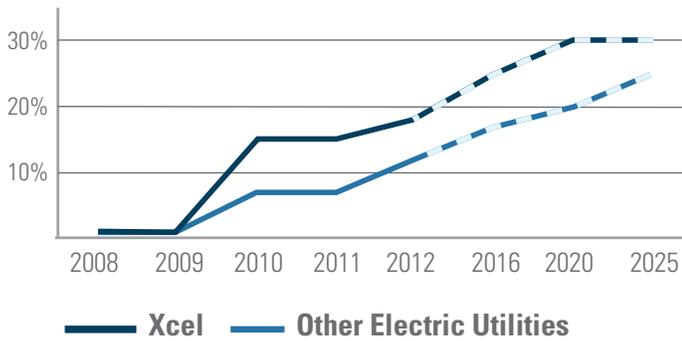
# ENERGY for our businesses, farms and homes



Currently, Minnesota utilities are meeting – and in many cases exceeding – their renewable energy electricity standard milestones. And the economic and environmental benefits are compelling. The renewable energy standard:

- Shifts our focus toward local energy sources instead of imported energy
- Contributes to the growth of in-state businesses
- Provides a hedge against rising costs for electricity generated from fossil fuels
- Reduces emissions of mercury, ozone, carbon dioxide and other pollutants from coal-fired power plants.

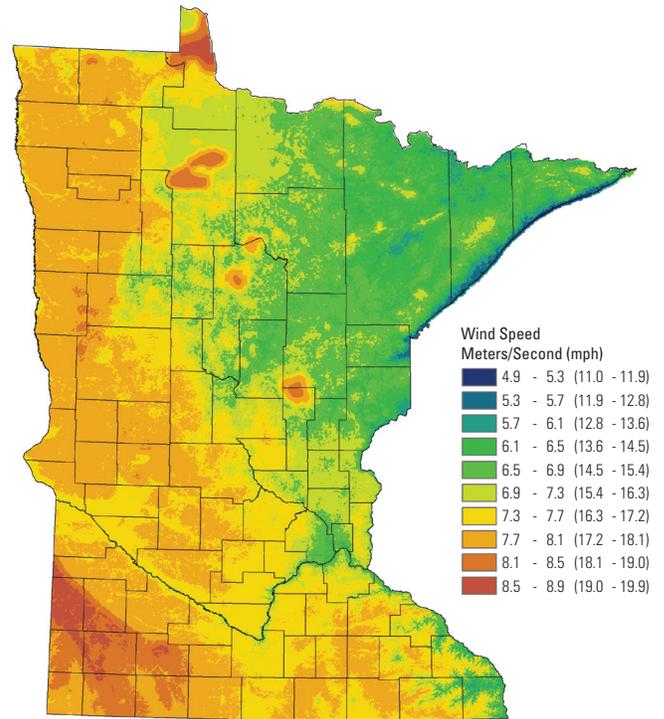
**Portion of Minnesota Electric Generation from Renewable Sources**



Source: Information reported by utilities to the Minnesota Department of Commerce as required by Minn. Stats. 216B.1691.  
Note: Line beyond 2012 indicates trend required to meet Renewable Energy Standard.

The spinning turbines that dot the landscape statewide are testament to Minnesota's commitment to wind energy. The state ranks second nationwide in electricity produced from wind and has one of the nation's strongest and most reliable wind resources.

**Minnesota's Wind Resource by Wind Speed at 80 Meters**



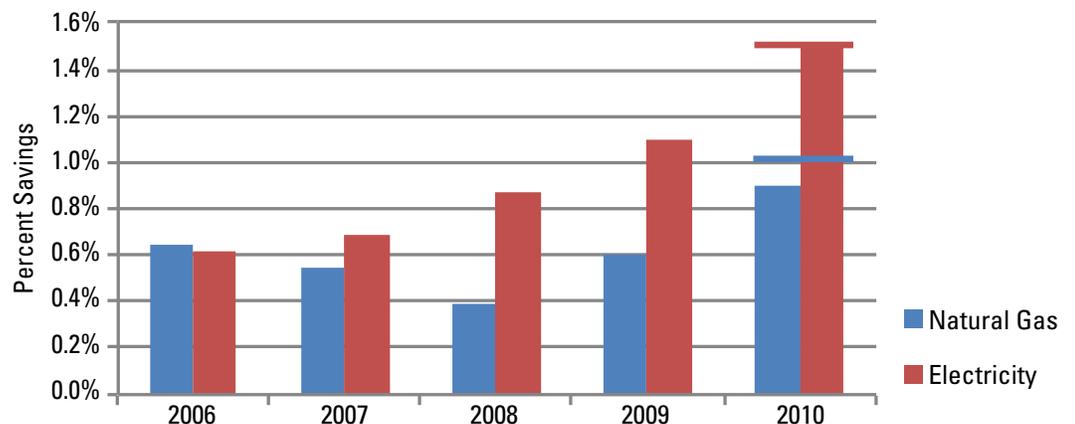
Sources: Minnesota Department of Commerce and WindLogics®

## Conservation and Efficiency

Not that long ago, our consumption of electricity and natural gas was growing at a rate of 3 percent per year. State-mandated energy efficiency programs enacted by utilities have cut those growth rates in half.

More efficient heating, cooling and lighting systems for commercial and industrial users, as well as better appliances, furnaces and weatherization in homes have yielded tremendous energy savings. Through these efforts alone, the state has conserved enough energy to avoid building two new 1,000-megawatt power plants that would otherwise have been needed to meet electric demand. Needless to say, avoiding the extra air and water pollution that would result from two new power plants is just as compelling as the pocketbook benefits of conservation.

**Savings From Energy Efficiency for Natural Gas and Electric Utilities**



Source: Conservation Improvement Program, Minnesota Department of Commerce.



# ENERGY

for our businesses, farms and homes

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## Summing It Up

When it comes to our energy consumption, balancing the interests of our environment and our economy is never simple. But we must be good stewards of both.

Over time, we've become more efficient in our energy use. That has been good for the environment and for the competitiveness and profitability of our businesses and industries. We've seen firsthand how much energy we can conserve without harming economic growth or job creation.

Big gains have come from a patchwork of small but important changes. Still, there's much more to be done. The state is still strongly dependent on coal for electricity. And despite our gains, the potential for energy efficiency is still largely untapped. Other countries currently use techniques and technologies that we could adopt and exploit.

Many questions arise as we address our energy future. It will take a great deal of energy to find answers.

## Key Questions to Consider

How do we find the right balance between coal, natural gas and renewable energy resources?

What public policies should help us identify, create, or encourage new efficiencies at all levels?

How do we capture more savings in the commercial and industrial sectors without undermining their success?

How do we best promote clean energy resources while maintaining baseload needs and reasonable prices for consumers and businesses?

# CLIMATE long-term changes in Minnesota weather trends

In ways plain and subtle our climate is changing.

A slight increase in air temperature (1.4 degrees Fahrenheit in the past century) has been accompanied by not-so-slight changes in precipitation and extreme weather. The signs are increasing around the world and are becoming more apparent here at home.

And the risk those changes pose to people, animals, plants and the natural systems we all rely on is significant and wide-ranging.

Although nature contributes to the problem without our help, the primary cause is very likely greenhouse gases generated by a variety of human activity. On this much, climate scientists worldwide agree.

Despite that consensus, there is still considerable social and political debate about climate change – about its causes and the appropriate responses. It is not the purpose of this report to examine that debate in all its dimensions. The issue is too big and too complex.

But the enormity of the problem does not mean Minnesotans can shrink from the challenges of climate change. It is a shared responsibility and we must do our part. And that begins with understanding how we affect climate change, how climate change is already affecting us, and how we adapt to climate change.





# CLIMATE long-term changes in Minnesota weather trends

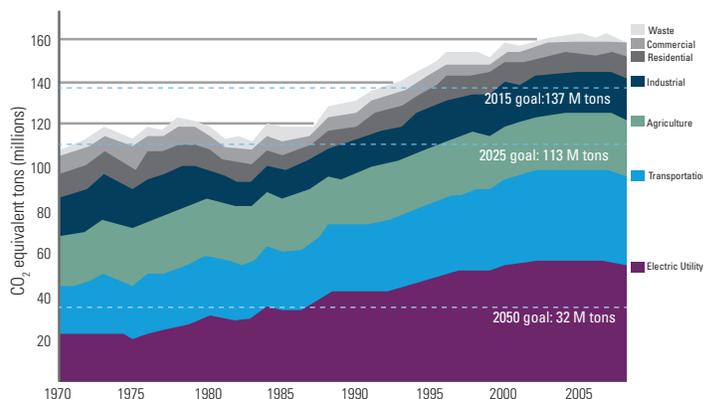
## Greenhouse Gases

Greenhouse gases keep heat in our atmosphere. It's supposed to work that way. It's what keeps us warm and makes life on the planet possible. But like all good things, you can get too much.

Whenever we burn fossil fuels (coal, natural gas, oil, gasoline and diesel), whenever organic waste decays, or whenever we use certain industrial processes more greenhouse gases are emitted into the atmosphere, making our planet warmer. That vast majority is carbon dioxide, followed by much smaller amounts of methane, nitrous oxide and fluorinated gases.

The amount of carbon dioxide we produce in Minnesota each year exceeds 160 million tons. And our total emissions are increasing. Electric utilities (which burn coal and natural gas to generate power) are the single largest contributor; followed by cars, trucks, trains and other vehicles used in transportation; agriculture; and industry.

### Greenhouse Gas Emissions from Minnesota by Economic Sector



Source: Environmental Analysis and Outcomes Division, Minnesota Pollution Control Agency.

## Temperature on the Rise

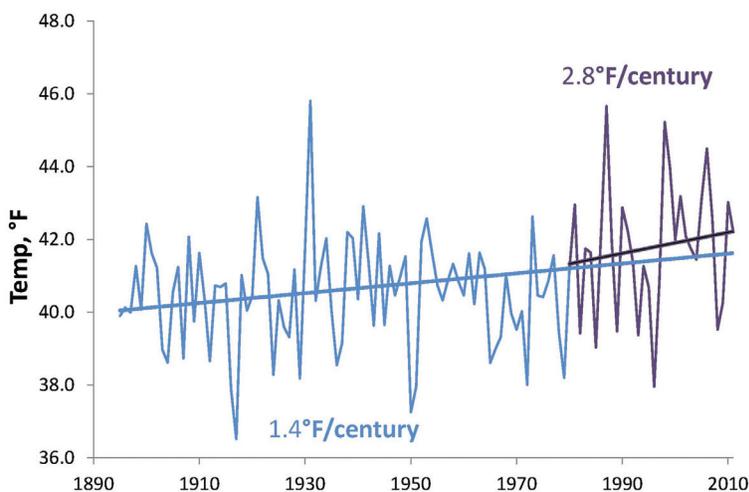
From 1895 to 2011, Minnesota's average annual temperature increased by 1.9 degrees Fahrenheit, or a rate of 1.4 degrees Fahrenheit per century. But over the past three decades or so, the pace of warming has picked up dramatically.

Since 1980, the rate of increase is 2.8 degrees Fahrenheit per century, indicating not only an upswing in average temperature but also an accelerating warming rate.

The daily high, low, and average temperatures all have risen across the northern, central, and southern regions of the state in little more than a century. The rise in daily low temperature has been most pronounced, especially in winter. Since 1980, the warming rate for winter lows is 8.1 degrees Fahrenheit per century. That's more than double the rate from 1895 to 2011.

Warming rates have been higher in the northern than in the southern reaches of the state, a pattern that has been consistent throughout the entire hemisphere, where warming rates are greater at higher latitudes.

### Minnesota Average Annual Temperature



Source: Minnesota State Climatology Office.

# CLIMATE long-term changes in Minnesota weather trends



## Steamy and Stormy Weather

It's not the heat, it's the *humidity*. How many times have you uttered those words while mopping your brow on a hot, muggy, summer day? Chances are they've been more frequent.

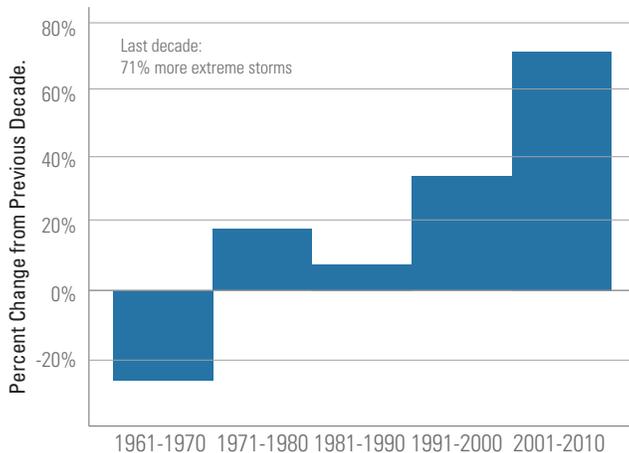
Warmer temperatures increase the amount of water vapor in the atmosphere. By measuring the dew point (the temperature at which air is so saturated that the vapor forms dew), we can tell how much moisture is in the air.

Dew point temperatures at or above 70 degrees Fahrenheit are considered tropical. And we're seeing spikes in those tropical days. Record-breaking and tying dew points (82 to 86 degrees) caused misery statewide during the summer of 2011.

An atmosphere saturated with water vapor also provides ideal conditions for more intense and frequent storms and rainfall. Heavy downpours in the Midwest are far more common than they were a century ago.

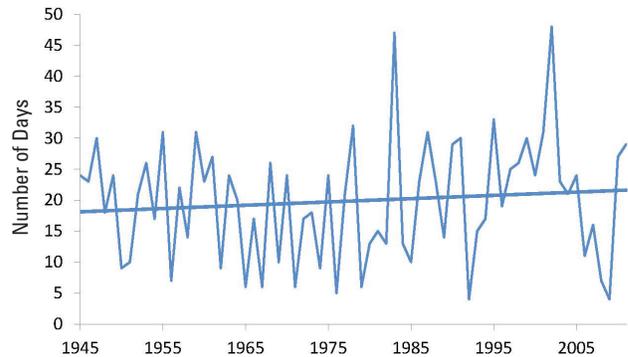
And the yearly frequency of the largest of storms – those with 3 inches or more of rainfall in a single day – has more than doubled in just more than 50 years. Over the past decade, such dramatic rains have increased by more than 70 percent. The runoff from heavy rains has implications for everything from farming to water pollution to flood control and storm water management.

### Changes in Frequency of 3-Inches-Plus Storms in Minnesota



Source: Rocky Mountain Climate Organization and Natural Resources Defense Council, analysis of National Climate Data Center data.

### Annual Number of Twin Cities Days With Dewpoint Temperatures At or Above 70°F



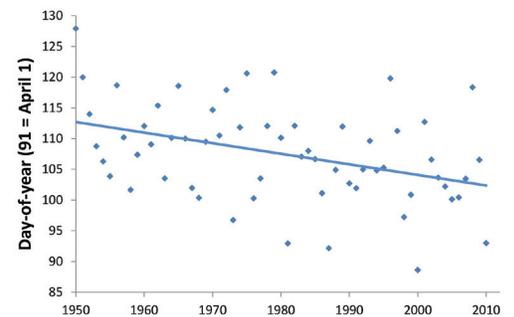
Source: Minnesota State Climatology Office.

## Breaking the Ice

Winter on the frozen expanses of Minnesota's lakes is nothing short of a seasonal celebration. But ice is arriving to the party later and leaving earlier.

Depending on whose definition you use, ice-out is official when the lake is completely free of ice, 90-percent free of ice, or the moment when navigation is possible. But no matter the measure, a trend is emerging: lakes are thawing sooner.

### Minnesota Average Ice-Out Date



Source: Minnesota State Climatology Office.

Between 1973 and 2010, ice cover on Lake Superior has declined dramatically (79 percent according to a recent study). And the earliest ice-out dates ever recorded have occurred on lakes in every region over the past decade, many of them thawing 20 to 30 days ahead of average.

The date of ice-in is occurring later, too. Between freezing later and thawing early, the total number of days that Minnesota lakes are covered with ice are fewer. Summer water temperatures are increasing too, and there are noticeable impacts. Warm-water fish like largemouth bass and bluegill are becoming more common in northern Minnesota lakes. And presence of cisco, a cold-water fish that is an important food source for walleye, pike, trout and other prized game fish, has declined by 42 percent since 1975.



# CLIMATE

## long-term changes in Minnesota weather trends

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### Summing It Up

There are early signs that climate change has had an impact on Minnesota. It's a matter of degrees.

Minnesota is getting warmer and wetter. Nights are warming faster than days. Winter faster than summer. And the magnitude of change is expected to increase, with annual average temperatures projected to increase by 5 to 9 degrees Fahrenheit by the end of the century.

Our location at the intersection of three major air masses and the crossroads of three major biomes (prairie, deciduous, and coniferous forests) makes Minnesota especially vulnerable to the stresses of climate change. The impact on those biomes could be pronounced.

Wetlands and aquifers could shrink. Levels of lakes and streams could fall. Invasive species, insect pests, and tree diseases could flourish. Woods could give way to prairie. Already, 11 tree species such as aspen, paper birch and sugar maple are migrating north at rates approaching 6 miles per decade.

By the year 2069, some Minnesota regions will likely have climates that today are found much farther south. Imagine transplanting the Twin Cities climate to Duluth. Common northern tree species such as spruce and fir may become rare in Minnesota. Imagine the Boundary Waters dominated by oaks instead of birch and spruce.

Of course, changes in the land and water have implications for all living creatures that call them home. Fish, wildlife large and small, insects. Us.

There are bright spots, too.

The nation's forest, grasslands and wetlands absorb 40 percent of our greenhouse gas emissions. And Minnesota's 16 million acres of forestland, 6 million acres of peatlands, and grassland-wetland complexes store vast amounts of carbon. They could store more if managed to do so.

In addition, a broad range of public-sector, private-sector and nonprofit leaders recognize that the stakes are high and that the time for short-, mid- and long-term action is now.

With broad bipartisan support, state lawmakers set benchmarks to reduce greenhouse gas emissions statewide across all sectors, with an ultimate goal of reducing emissions to a level at least 80 percent below 2005 by the year 2050.

Many other efforts focus on renewable, cleaner-burning motor fuels; renewable electricity from wind, solar power and biomass; increased energy efficiency and conversion; and recycling.

Greater efforts, innovations, tough choices, and shared sacrifices will be necessary as we confront climate change now and in coming decades. Decisions about how we use energy – and how much we use – in our homes, cars, businesses and industries will affect us all in the near future and for years to come.

### Key Questions to Consider

In which sectors will Minnesota find the most promising or dramatic reductions in greenhouse gases over the short-, mid- and long-term?

What kinds of policies, regulations, or incentives will be necessary to bring about those reductions?

Which of the negative effects of climate change should concern us most?

How do we anticipate, address, and adapt to the negative impacts of climate change?

What adaptation practices might be necessary to maintain agriculture, forests, physical infrastructure, and fish and wildlife populations in the face of climate change?

# GLOSSARY of key terms



**British Thermal Unit (Btu):** The amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit.

**Carbon Sequestration:** The process of capture and long-term storage of atmospheric carbon dioxide (CO<sub>2</sub>).

**Fine Particles:** Tiny particulate matter with an aerodynamic diameter less than 2.5 microns or approximately 1/30 the width of a human hair. Also known as PM<sub>2.5</sub> and called soot. Fine particles are a complex mixture of very small liquid droplets or solid particles in the air. Exposure to fine particles is associated with adverse respiratory and heart effects and they significantly contribute to reduced visibility (haze). The primary source of fine particles is the combustion of fuels.

**Impaired Waters:** Lakes, streams and wetlands that fail to meet one or more water quality standards. These standards define how much of a pollutant (bacteria, nutrients, turbidity, mercury, etc.) can be in the water and still meet designated uses, such as drinking water, fishing, and swimming.

**Mercury:** A naturally occurring metal with the atomic symbol Hg, mercury is liquid at room temperature. It is emitted to the atmosphere from combustion of fossil fuels and mineral processing, and is transported across continents and oceans by the wind, falling to earth in rain, snow and dust. Mercury also may be released from improper disposal of mercury-containing products such as thermometers, switches, fluorescent light bulbs and thermostats. It bioaccumulates in the aquatic food chain, and is a developmental toxin to humans if inhaled or ingested.

**Nitrates (NO<sub>3</sub>):** A nutrient that can contribute to excessive growth of algae in water and that can be toxic to humans, particularly newborns. The most significant sources are fertilizers and human and animal wastes.

**Nitrogen Oxides (NO<sub>x</sub>):** The collective term for nitrogen compounds such as NO and NO<sub>2</sub>. Nitrogen oxides are an environmental and public health concern due to adverse respiratory health effects. NO and NO<sub>2</sub> are also involved in the production of ground-level ozone and fine particles. Nitrogen oxides form when fuel is burned at high temperatures.

**Ozone:** A colorless gas consisting of three atoms of oxygen O<sub>3</sub>. Ozone is found in two layers of the atmosphere, the stratosphere and the troposphere. In the stratosphere, ozone provides a protective layer shielding the Earth from ultraviolet radiation's potentially harmful health effects. At ground level, the troposphere, ozone is a pollutant that affects respiratory health and causes vegetation and crop damage as well as contributing to the formation of smog. Ground-level ozone is created in the atmosphere from a reaction of volatile organic compounds (VOCs) and nitrogen oxides in the presence of heat and sunlight.

**Phosphorus (P):** A nutrient that can contribute to excessive growth of algae in water and in turn threaten aquatic animals. The most significant sources are agricultural runoff and municipal and industrial wastewater.

**PPM:** Parts per million.

**Sulfur Dioxide (SO<sub>2</sub>):** Sulfur dioxide is a heavy, pungent, colorless gas formed primarily by the combustion of coal, oil, and diesel fuels. Elevated levels can impair breathing, lead to other respiratory symptoms and aggravate heart disease. Sulfur dioxide also contributes to acid rain, which can damage plants, lakes and buildings and is involved in the production of fine particles.

**Total Maximum Daily Load (TMDL):** A regulatory term in the U.S. Clean Water Act (CWA), describing the maximum amount of a pollutant that a body of water can receive while still meeting water quality standards.

**Volatile Organic Compounds (VOC):** Compounds containing the elements carbon and hydrogen that exist in the atmosphere primarily as gases because of their low vapor pressure. VOCs are defined in federal rules as chemicals that participate in forming ozone. Many VOCs are also air toxics (including chemicals like benzene, toluene, and styrene) and can have harmful effects on human health and the environment.

