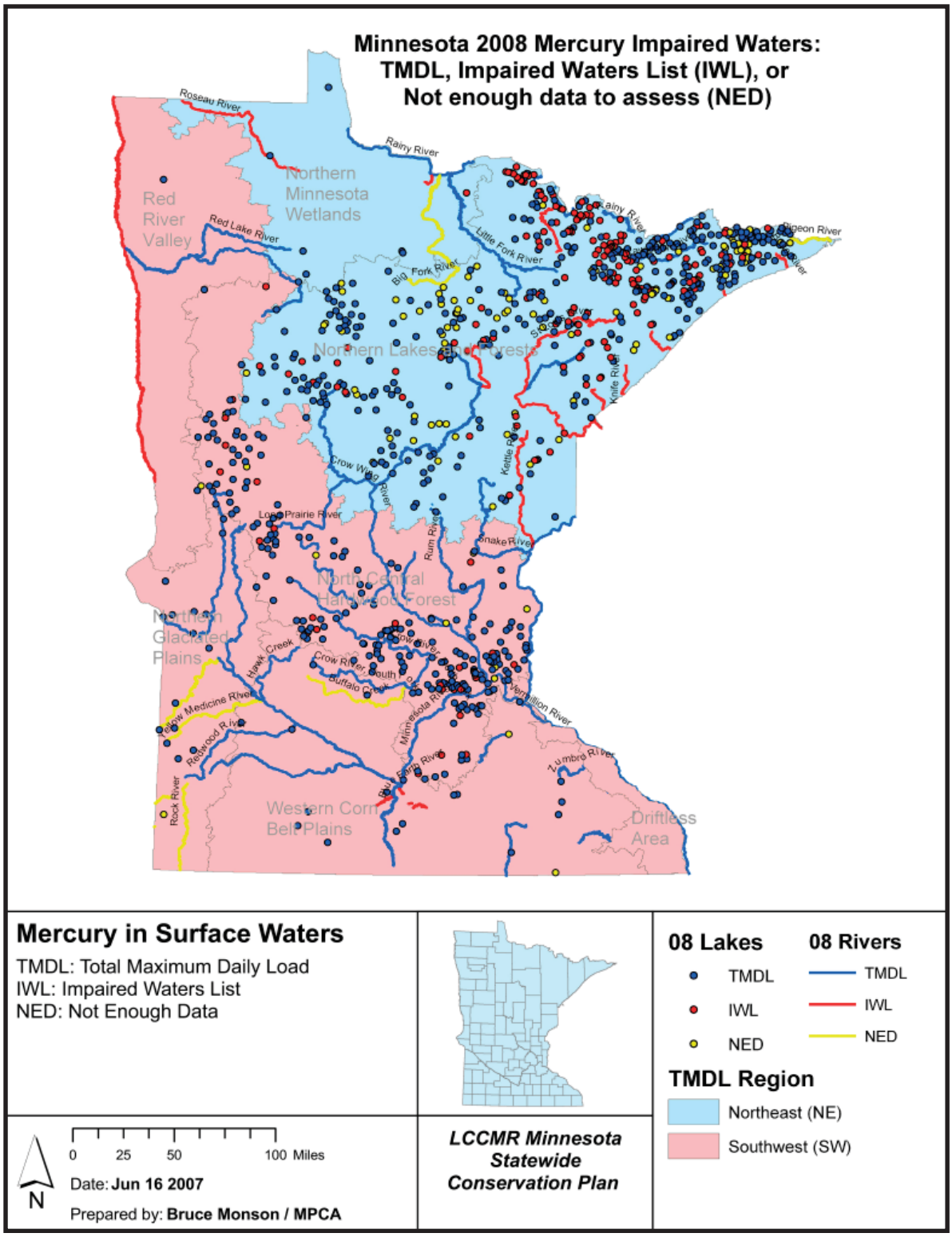

Figure 1: Mercury Impaired Waters in Minnesota. Poor air quality not only has direct effects on the health of Minnesota residents, but air-borne pollutants also impair other natural resources. Mercury emissions, for example, have had a widespread and severe negative impact on Minnesota's waters. Credit: Bruce Monson, MPCA.

"Air pollution is the inevitable consequence of neglect. It can be controlled when that neglect is no longer tolerated. It will be controlled when the people of America, through their elected representatives, demand the right to air that they and their children can breathe without fear."

—Lyndon Baines Johnson

History

The air resource is in its best state when it's unnoticed in the day-to-day lives of Minnesotans. Pollution in the form of smog, smell, and noise all contaminate the air resource and can diminish its benefit to people's lives. Choices made at the state level, in particular energy and transportation choices, impact air quality to the point where it does become noticed, with impacts on the lives of Minnesotans ranging from nuisance to health-risk.

Air is a free-flowing resource that knows no political boundaries. The energy and transportation choices of other states affect our air quality in Minnesota, while our policy choices can can have an impact on air quality elsewhere. This lack of problem containment can be a challenge to policymakers attempting to improve air quality in Minnesota. However, there are direct policies that, when adopted, can protect and increase the quality of air for all Minnesotans.

Air is an important resource whose quality has far-ranging impacts in Minnesota. The respiratory health of Minnesotans, particularly children, is affected by air particulates, ozone levels, and other air pollutants. According to the Minnesota Pollution Control Agency (MPCA), air pollution can contribute to cancer, heart attacks and other serious illnesses. A 2003 study by the federal Office of Management and Budget noted that the estimated value of the health benefits of cleaner air is often several times the cost of making air pollution reductions.

Air pollution has wide-ranging impacts on land and water resources in Minnesota, as well. Mercury, an air pollutant from burning fossil fuel sources like coal, is deposited in lakes and rivers through precipitation (see Figure 1, facing page). It then contaminates aquatic ecosystems, fish, and humans who consume them.

The health of portions of Minnesota's economy depends on the air quality of the region. The contamination of fish by mercury from coal-fired power plant emissions hurts fishing-based tourism. Scenic landscapes blurred by smog negatively affect tourism. In the agricultural sector, air pollution can cause lower crop yields. Forests that are impacted by air pollution may be less resistant to invading pests and disease.

Baseline Air Quality Conditions in Minnesota

Air is comprised mainly of the elements nitrogen (78%) and oxygen (21%), with very small amounts of argon, carbon dioxide and other trace gases. It is reasonable to assume that air quality at the time of European settlement was excellent, with the exception of the impacts of occasional fires caused both by lightning and prairie fires deliberately set by humans.

Air Quality Trends (1985-present)

Air pollutants can be categorized by their source, or by the regulatory structure of the federal Clean Air Act. The Clean Air Act regulates "criteria" pollutants (lead, nitrogen oxides NOx, and sulfur oxides SOx) particulate matter (PM_{10} and $PM_{2.5}$, particulates

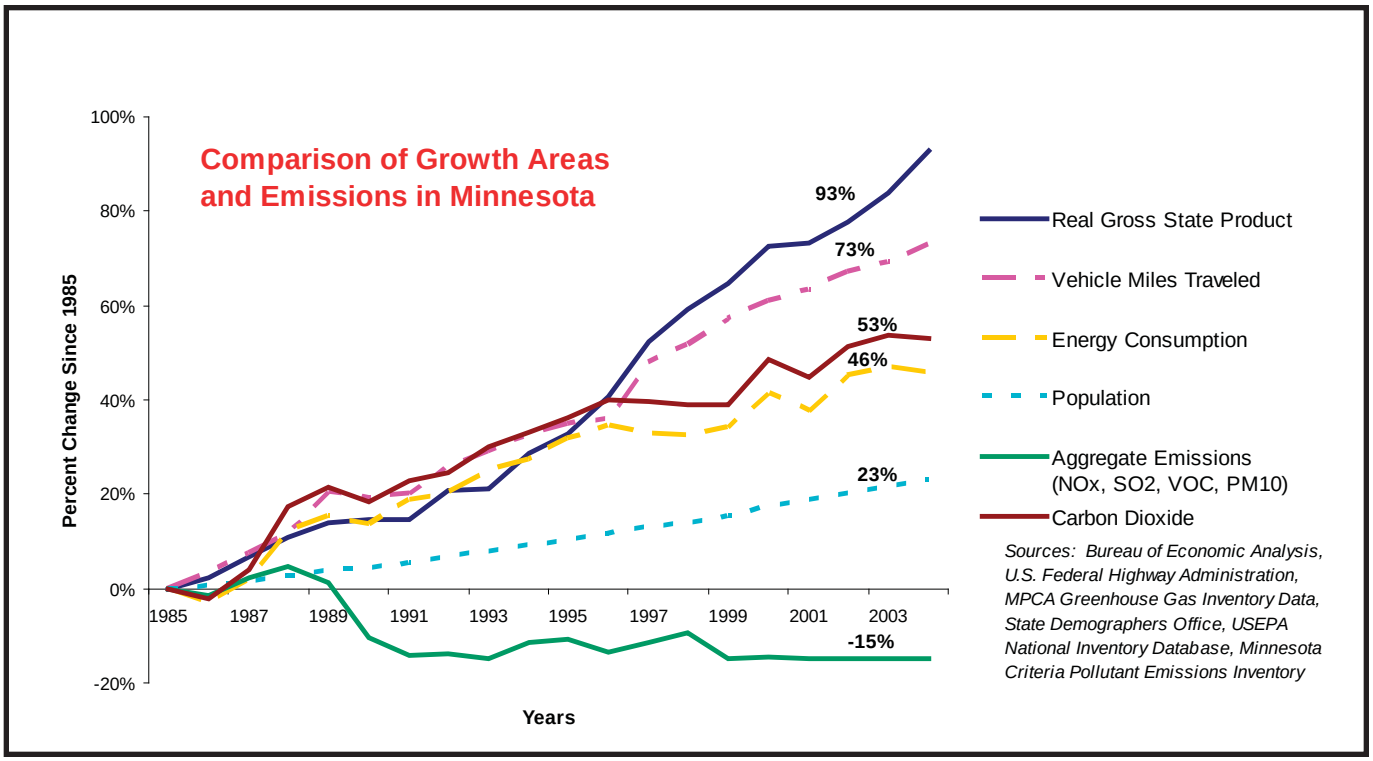

Figure 2: Comparison of economic and emission growth factors in Minnesota from 1985 to 2005. Credit: MPCA

less than 10 µm and 2.5 µm respectively), carbon monoxide (CO), and ozone (O_3). These compounds have National Ambient Air Quality Standards (NAAQS) that specify the maximum concentration that is allowed in ambient air for protecting public health and materials. In addition, the Clean Air Act regulates an additional 188 hazardous air pollutants, often called "air toxics". These compounds are regulated based on allowable emissions, rather than resulting air concentrations. Carbon dioxide (CO_2), the primary greenhouse gas responsible for global warming, is not currently regulated by the Clean Air Act.

The main driver of air quality change is the consumption of energy, and in Minnesota, the top two drivers of energy consumption are electrical power generation and transportation (see Drivers of Change, below). While Minnesota's energy consumption for electricity and transportation has increased, progress has been made on air quality with regards to specific pollutants over the past twenty years (see Figure 2). Minnesota's real gross state product grew 93% between 1985 and 2005, with corresponding growth in the number of vehicle miles traveled, energy consumption, and population. On the plus side, due to pollution control measures, the aggregate emissions of pollutants such as NOx, SOx, volatile organic compounds, and particulate matter – all of which are covered in the state's implementation plan under the federal Clean Air Act – have actually decreased 15% during that time period.

During that same time period, however, CO_2 emissions have increased 53%. While the state has successfully reduced aggregate emissions of "criteria" pollutants, the growth of carbon dioxide emissions and the resulting exacerbation of climate change is one of the top air quality challenges for the state.

Current Air Quality in Minnesota

The Air Quality Index (AQI) is a tool developed by the United States Environmental Protection Agency (USEPA) to provide a standard method for reporting daily air quality conditions around the country. The AQI number is reached by hourly measurement of four pollutants: ground-level O_3, SO_2, CO and $PM_{2.5}$. The pollutant with the highest value determines the AQI for that hour.

According the MPCA, air quality in Minnesota is usually ranked as Good, Moderate or Unhealthy for Sensitive Groups with an occasional Unhealthy For All ranking. Air Pollution Health Alerts are issued for one (or more) of the four pollutants based on monitoring or forecasting from weather patterns. More alerts for Unhealthy for Sensitive Groups and Unhealthy days are expected in the future as a result of the tightening of the daily O_3 and $PM_{2.5}$ standards by the USEPA. Minnesota currently meets all National Air Quality Standards set by the USEPA.

In the Twin Cities area, three air quality alerts for Sensitive Groups were issued in 2006. Rochester experienced two days of Unhealthy for Sensitive Groups. No other alerts were issued in 2006.

In 2005, the cleanest air was in Ely with nearly all Good air days and only 19 Moderate days. The worst air quality was in the Twin Cities with more Moderate days than Good, five Unhealthy for Sensitive Group days and three days that were considered Unhealthy for All (see Figure 3).

Minnesota has been a leader in monitoring concentrations of air toxics, and controls their point source emissions as much as possible through the state's air permit system. A number of studies have been conducted by the MPCA to assess air toxics across the state and in the Metro area. Their most recent study (2005) analyzed the results of monitoring 73 toxic air pollutants, and found that benzene, formaldehyde, and carbon tetrachloride were the only toxics that were found above the health benchmark concentrations during the period of 1995-2001. (For more information, see http://www.pca.state.mn.us/air/toxics/at-monitoringstudy-9601.html). Since then, the concentrations of benzene and carbon tetrachloride have decreased below the health benchmarks. The major source of formaldehyde is from direct and indirect emissions of gasoline powered vehicles.

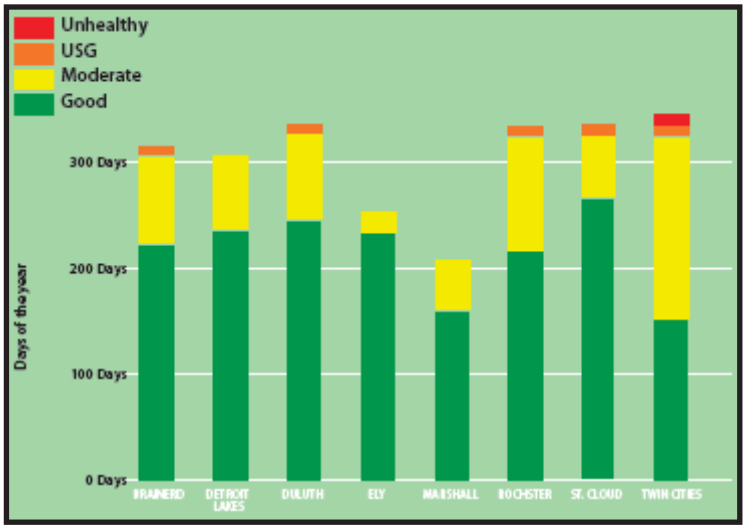

Figure 3: The Air Quality Index (AQI) is measured at locations around Minnesota. Some regions do not show 365 days of readings due to monitoring problems or the phase in timing for new region. Credit: MPCA

Drivers of Change

The main drivers of change for outdoor air quality in Minnesota (and nationally) are

- electrical power generation;
- and transportation.

These drivers of change affect our climate, human health, ecological health, and other valued features of our society.

Electrical Power Generation

As Minnesota's economy and population have grown, so too has the state's energy consumption, which in turn has led to sharp increases in electrical power demand. This increase in demand has been largely met by coal-fired power plants. In 2004, 65% of electricity generated in Minnesota was derived from coal (see Figure 4, next page). The next largest sources of electricity generation were nuclear power (25%) and natural gas (3%).

Carbon dioxide (CO_2) is a greenhouse gas that forms from combustion reactions such as burning coal for electricity or powering a gasoline engine vehicle. When released into the atmosphere, CO_2 acts as a greenhouse gas and is the most significant human contribution to global warming. Carbon dioxide

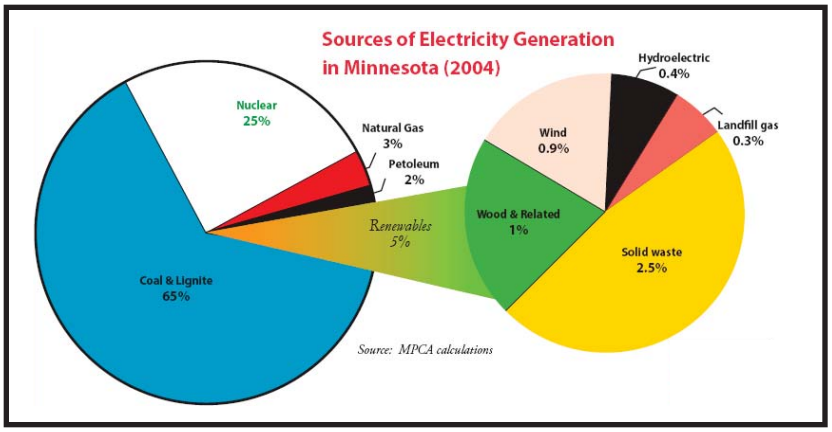

Figure 4: Sources of Electricity Generation in Minnesota for 2004. Credit: MPCA

accounts for three-fourths of all greenhouse gas emissions, both in Minnesota and the nation as a whole.

Most scientists agree that the full impact of climate change will be felt in the future (see the Intergovernmental Panel on Climate Change, 2007 Working Group 1 report). However, over the last 100 years, mean annual temperature in Minnesota has increased about one degree Fahrenheit. This temperature increase is not evenly distributed throughout the four seasons – change has been most pronounced in the winter and spring seasons. On average, the winter season is about four degrees Fahrenheit warmer than in the late 1800's.

Electricity generation accounts for approximately one-third of all CO_2 produced in Minnesota. The vast majority of this CO_2 is from coal-fired power plants. An increased reliance on coal-fired power plants, plus emissions from other sectors of the economy, has increased carbon dioxide emissions in Minnesota (see Figure 5).

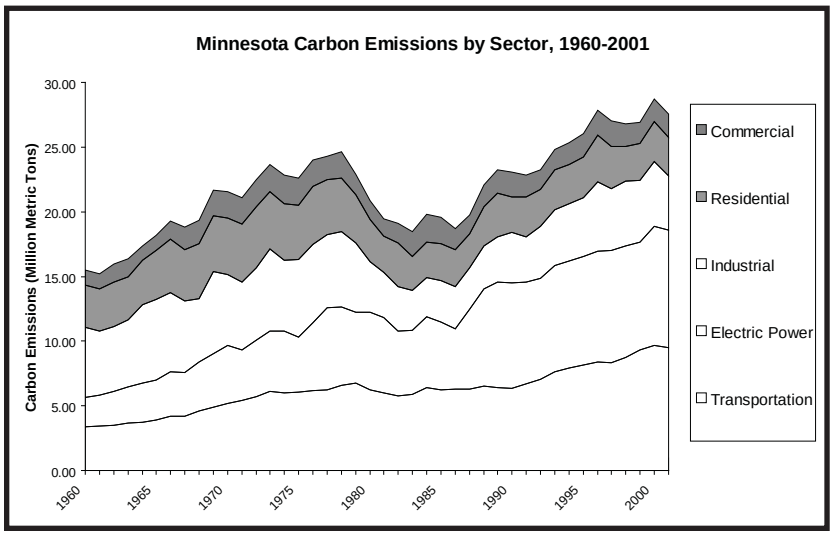

Figure 5: Carbon emissions by sector. Credit: Max Handler, University of Minnesota

Mercury Pollution

Another air pollution problem resulting from electrical generation sources is the emission of the air toxic, mercury. Although mercury pollution effects are manifested through fish contamination (see Water Natural Resource Profile), the problem originates as an air contaminant. When mercury is emitted to the atmosphere by coal-fired power plants, it is eventually deposited into waterways through precipitation. It reaches the sediments where microbes transform it to methylmercury. Methylmercury bioaccumulates in fish, and in humans and wildlife when they consume methylmercury-contaminated fish.

Methylmercury has been linked to birth defects in infants whose mothers had consumed contaminated fish. Impacts on cognitive thinking, memory, attention, language, fine motor, and visual spatial skills have been observed in children exposed to methylmercury as fetuses. A study by the Center for Disease Control shows that most people have blood mercury levels below a level associated with possible health effects. However, pregnant women and women who plan to become pregnant are advised by the EPA and FDA to limit consumption of certain fish.

Nearly two-thirds of Minnesota's impaired waterways, as defined by the federal Clean Water Act, are impaired because of mercury levels (see Figure 1, page 18). As a result, most of the state's lakes have fish consumption advisories.

The MPCA estimates that total mercury emissions from sources in Minnesota were about 3,340 pounds of mercury in 2005. Energy-related sources (mostly coal-fired power plants) made up 58% of these emissions.

To address the state's largest emissions sources, the state legislature passed the Mercury Reduction Act of 2006. The act requires three large electric power plants in the state to reduce emissions by 90 percent by 2014. This will result in a decrease in emissions of about 1200 pounds of mercury from current levels, a reduction of about 70%. About one-third of the mercury being added to Minnesota's environment by the power industry will be eliminated. The plants affected are: Xcel Energy's Sherco Plant in Becker; Xcel Energy's Allen S. King plant in Oak Park Heights' and Minnesota Power's Clay Boswell plant in Cohasset.

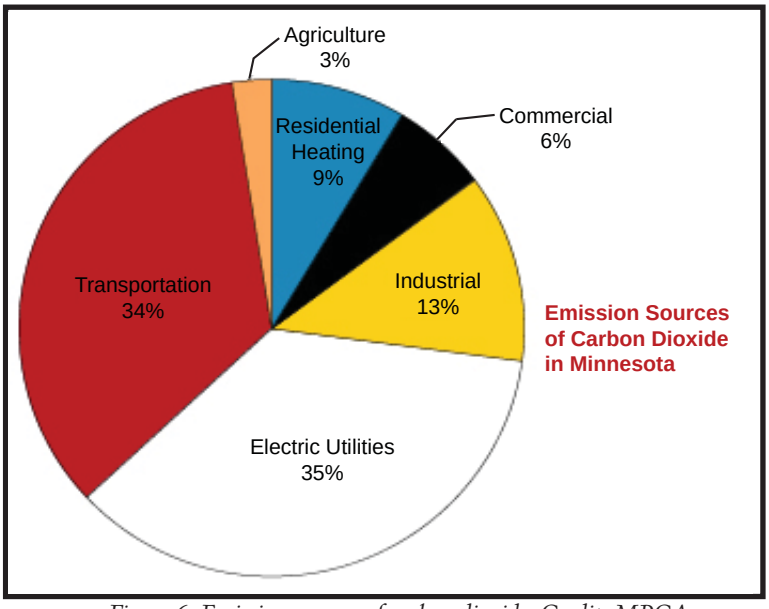

Figure 6: Emission sources of carbon dioxide. Credit: MPCA

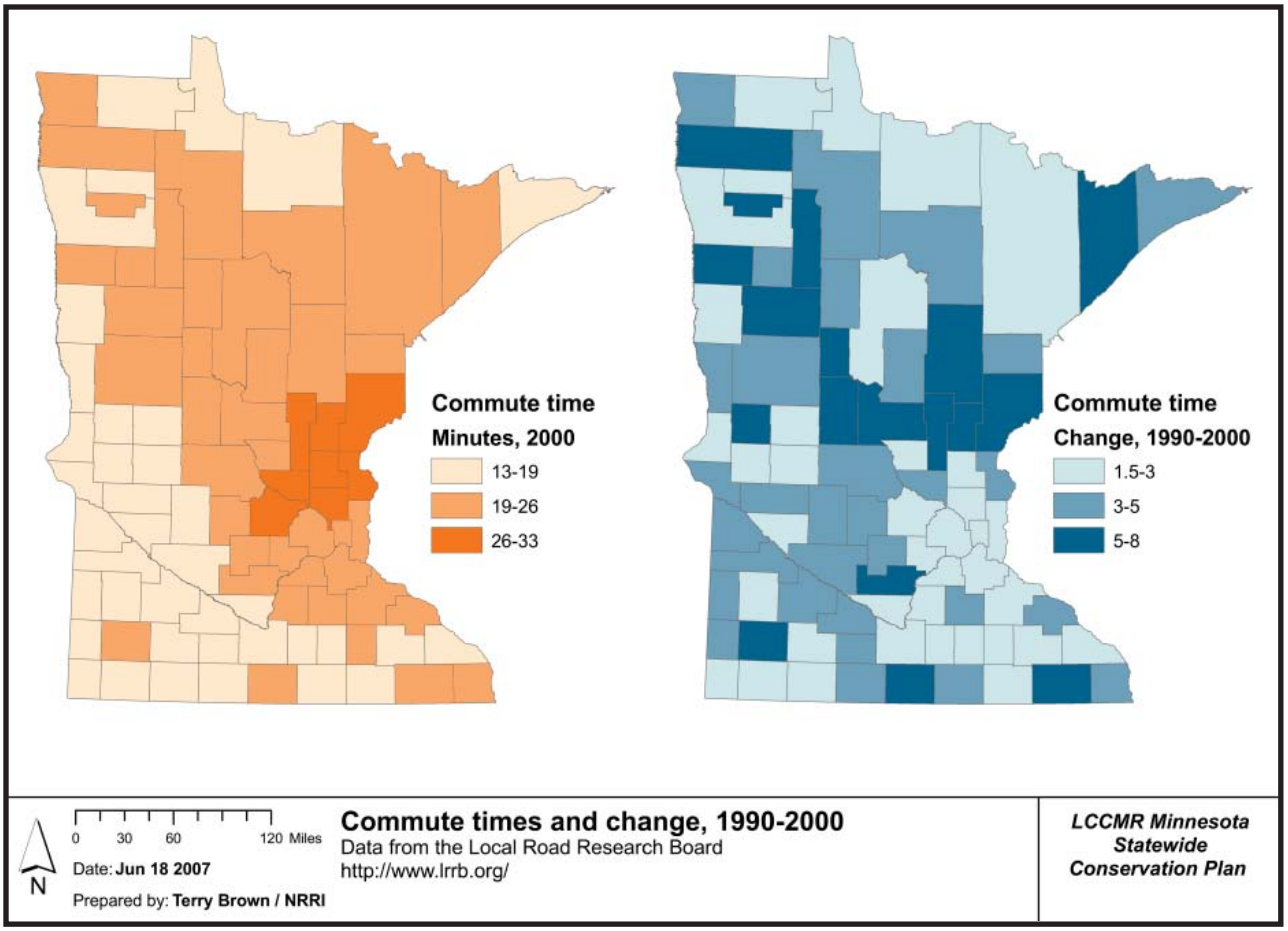

Figure 7: Change in Commute Times (1990-2000); Average Commute Time by County (2000). Credit: Terry Brown, University of Minnesota

Transportation

From 1985 to 2005, the numbers of miles driven by vehicles in Minnesota increased 73%. The carbon dioxide emitted from these vehicles also has contributed to climate change in Minnesota. Vehicles also emit CO, PM, NOx, and contribute significantly to tropospheric O_3 formation. About one-third of greenhouse gases emitted in Minnesota are a result of transportation (see Figure 6).

In addition to the increase in miles driven, traffic congestion and longer vehicle idling times contribute significantly to carbon dioxide emissions.

The map of commute times (see Figure 7) indicates that the counties north of Minneapolis/St. Paul, east of St. Cloud and South of Duluth had the longest average commute times in 2000.

Emissions from vehicles contribute to many health problems including: aggravated asthma; chronic bronchitis; reduced lung function; irregular heartbeat; heart attacks; and premature death in people with existing heart and lung conditions. Reducing emissions can lead to lower health care costs and fewer days that Minnesotans with these health conditions miss work or school.

Hybrid and flex-fuel vehicles that use less petroleum gasoline and/or use alternative fuels like ethanol and biodiesel emit less carbon dioxide than traditional gasoline vehicles.

Indoor Air Quality Issues

Concentrations of many contaminants are often greater indoors than in ambient air. People also tend to spend a majority of their lives indoors. Indoor air contaminants such as volatile organic compounds and radon impact human health. Surprisingly, there are fewer data sets available on indoor air quality compared to outdoor air quality. Information on indoor air quality and human exposures is a relevant data gap that the team recommends for further research.

"In 2050, electricity will be produced in more efficient and environmentally sound ways."

—Minnesota 2050 participant