TREND ANALYSIS SUMMARY

ENVIRONMENT

Climate Change & Environmental Quality

Minnesota's environment is changing. Land development, technological changes, population shifts, and the ways that we travel all have an impact on our state's natural resources and the well-being of our climate. Understanding how Minnesota's transportation system contributes to these changes can help us to plan in ways that limit the negative impacts of our system on the environment. This is an essential part of ensuring that our transportation system maximizes the health of Minnesota's environment. Two key trends emerge when discussing Minnesota's environmental future: climate change and environmental quality.

Climate Change

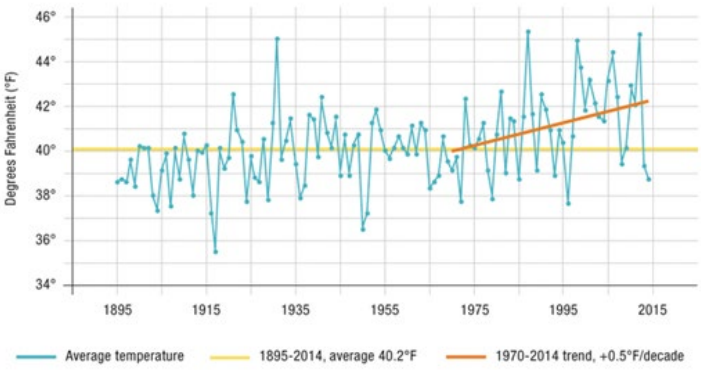
There is broad consensus that climate change will alter the natural environment, economy, and quality of life in Minnesota over the next century and beyond, though specific impacts remain uncertain. Increased temperature variation, precipitation levels, and frequency of extreme weather events are expected to stress the transportation system's design, construction, maintenance, and operations; generally increasing the lifecycle costs of infrastructure. To maintain security and enhance financial efficiency over the next 20 years, it is critical to consider climate vulnerability in transportation planning and investments.

CLIMATE CHANGE IN MINNESOTA

While climate change is a global phenomenon, its effects have been particularly acute in Minnesota, where annual average temperatures have risen two degrees over the past century 25 percent more than the global average, and up to three degrees in the northern part of the state. Within the U.S., Minnesota's winter temperatures have risen more than that of any other state over the past 40 years. The most dramatic temperature rises in Minnesota since 1895 have occurred in the months of January (2.5-4.5˚F degree rise), February (5-7˚F degree rise), and March (3-5˚F degree rise). Figure 1 shows the average annual temperature in Minnesota back to 1895. In addition to greater temperature rises, Minnesota has experienced more large storms.

Minnesota's ecosystems are particularly sensitive to a changing climate.[1] Species at the edges of these ecosystems will be most vulnerable to climate change.

Figure 1: Minnesota's Average Annual Temperature, 1895-2014[2]



To counteract the impacts of a changing climate, Minnesota must work to adopt strategies that focus on adaptation and mitigation. While these two concepts are commonly thought of in the same light, they have distinct meanings. Adaptation focuses on building resilience and reducing the vulnerability of systems, while mitigation focuses on reducing greenhouse gas emissions to limit the severity of effects brought about by climate change.

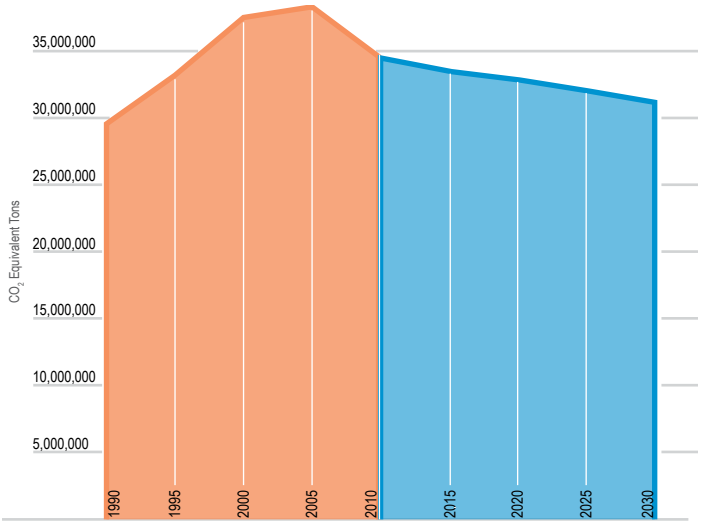
EMISSIONS PROJECTIONS & MITIGATION

Figure 2 shows historic emissions from the transportation sector in Minnesota in addition to projected future emissions. While emissions are trending downward, the pace of decline is not enough to meet the targets set as part of the Next Generation Energy Act of 2007. Reducing emissions from the transportation sector will require improvements in efficiency from motor vehicles, encouraging the use of transit and high-occupancy vehicles, and non-motorized transportation options.

ADAPTATION

By taking actions to reduce vulnerability and build system resilience, adaptation can reduce the impacts of climate-related stresses (long-term trends that increase vulnerability) and shocks (extreme events). Adaptation considerations can be incorporated into asset management,

Figure 2: Past and projected transportation emissions in MN



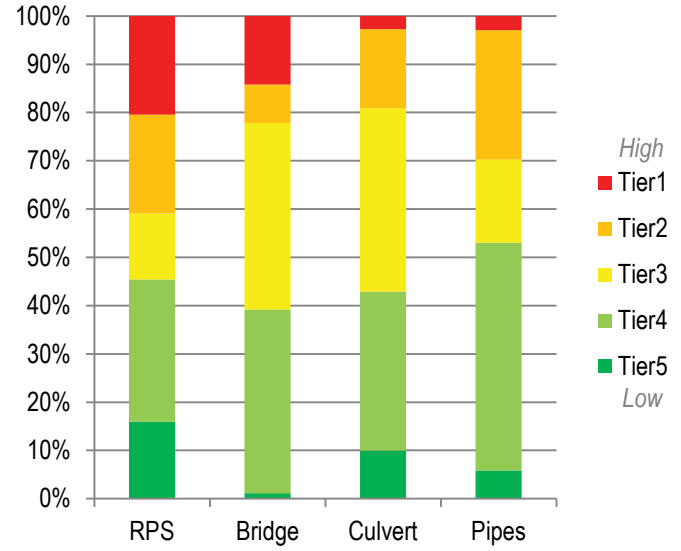
long range transportation planning, design and construction, operations and maintenance, and emergency management. Adaptation is usually informed by vulnerability assessments, though the two are distinct processes.[3]

MEASURING RISK & VULNERABILITY

Understanding the ways that a system is vulnerable to the impacts of climate change informs what adaptive strategies will be most beneficial.

CLIMATE CHANGE IMPACT	CONFIDENCE IN CHANGE IN NEXT 20 YEARS	EFFECT TO TRANSPORTATION SYSTEM
Heavy precipitation / flooding	Very High	• Damage to highway and rail infrastructure, airport runways • Overtopping roads will slow operations and performance
Warmer winters	Very High	• More ice • Reduced pavement conditions and life cycles • Downed power lines with ice storms
New species ranges	High	• Changes in roadside vegetation mixes • Soil erosion • Increase in invasive species populations • Increased exposure of construction and maintenance crews to vector-borne diseases
Drought	Medium	• Reduced river navigability for barges • Stress on roadside vegetation, which may reduce rainwater storage and increase soil erosion in the long term
High heat	Low	• Pavement and rail buckling • Vehicles overheating • Electrical system malfunctions • Limitations on construction hours
Wildfires	Unknown	• Road closures • Immediate and significant threat to human safety • Damage to roadside infrastructure

Figure 3: Asset vulnerability in MnDOT District 6



MnDOT completed a Flash Flood Vulnerability and Adaptation Assessment pilot project in early 2015, focused on Districts 1 and 6 in the Northeastern and Southeastern parts of the state, respectively. The project assessed the vulnerability of bridges, culverts, pipes, and roads along streams to flash flood events – one of the most likely impacts of climate change in Minnesota. An example of the assessed vulnerability of Minnesota's transportation assets from District 6 can be found in Figure 3. Tier 1 assets are most at risk of failing due to heavy precipitation and resulting flooding.

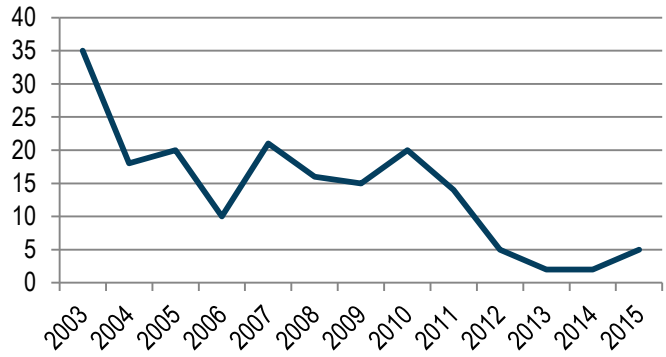
Environmental Quality

Minnesota's transportation system has direct impacts on the air, water, plant and animal resources in our state. As our population grows so too does our demand on natural resources. Examining the ways that the transportation system contributes to these demands shows how our future transportation system could reduce environmental degradation and perhaps even improve environmental quality.

AIR QUALITY

Bring up the relationship between transportation and the environment and many people's minds focus in on images of diesel exhaust billowing from large vehicles. Trucks and other large vehicles certainly contribute to air emissions in Minnesota, but contributions from vehicles extend far beyond diesel exhaust. Transportation has a significant effect on air quality in Minnesota, and as a group, on-road vehicles are now the biggest overall contributor to air pollution in Minnesota. On-road motor vehicles make up approximately 28% of overall emissions in the state, while off-road vehicles and equipment (including machinery used for road construction) contribute another 19% of total emissions.[4] Despite

Figure 4 : Air alert days in Minnesota since 2003



making up a larger percentage of total emissions, the total amount of emissions from highway vehicles have decreased significantly over the last 20 years. Since 1990, overall tons of pollutants emitted from highway vehicles has fallen by nearly 50%.[5]

The downward trend in overall air emissions since 1990 is encouraging, though further work must be done to ensure that gains continue. Permitted sources like power plants have reduced their emissions significantly during the last 20 years. Controls put into place under the Clean Air Act have resulted in a nearly 70% reduction in emissions from Minnesota's power plants, and smaller reductions from other permitted sources.[6] This has helped to reduce the number of air quality alert days that have occurred in Minnesota over the last 10 years. To continue making improvements, it is important to address non-permitted sources like on and off-road vehicles in addition to residential and commercial sources of pollution. Figure 4 shows the number of air alert days that have occurred both statewide and in individual communities.

The impacts of air pollution extend far beyond the environment. Despite reductions in the volume of air pollutants emitted in the state over the last two decades, current air pollution levels are high enough to cause significant negative health impacts for Minnesotans. Breathing in polluted air can cause a wide range of problems that range in effect from irritating to potentially fatal. Some of the known health problems linked to air pollution include asthma, increased susceptibility to allergens, cancer, heart attacks, and bronchitis.[8]

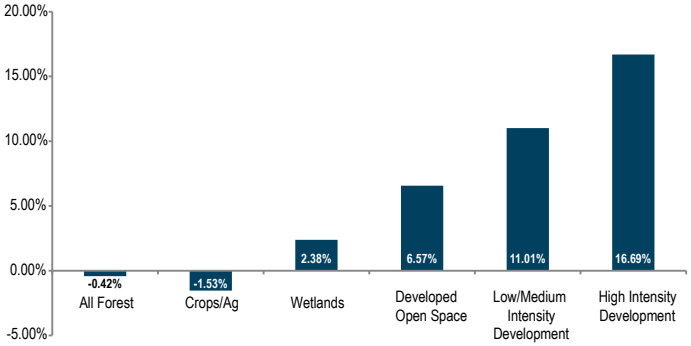
WATER QUALITY

Transportation infrastructure and land development both increase the amount of stress on Minnesota's water resources. Replacing natural land cover with hard surfaces (Figure 5) increases run-off into water bodies and contributes to the movement of pollutants from land surfaces into bodies of water, including wetland areas.

Chloride Contamination

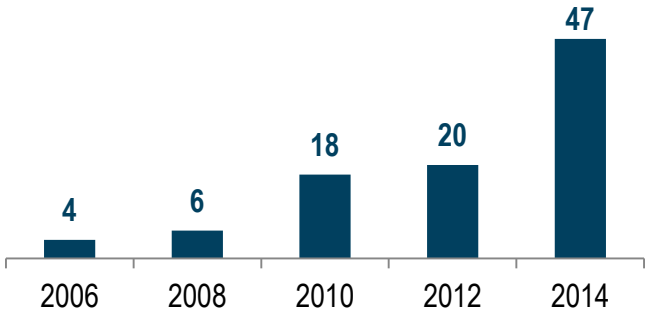
Chloride is a water pollutant used in road salts for de-icing, and enters

Figure 5: Land cover changes in Minnesota from 2001-2011[8]



surface waters, groundwater, and soil after snow melts. It takes only one teaspoon of road salt to contaminate five gallons of water.[9] Plants have a difficult time taking up contaminated water, influencing the entire ecosystem.[10] In addition to negatively impacting plants and wildlife, high chloride concentrations in surface and ground water pose hazards for human consumption.[11] Once chloride has contaminated water, it can only be removed through complex and energy-intensive reverse osmosis procedures that cannot practically be carried out in ponds, streams, lakes, or rivers. Figure 6 shows the number of contaminated surface waters in Minnesota. Using salt-tolerant road-side turf mixes to absorb runoff, mixing road salt and sand on roads that are pre-treated with salt brine, and utilizing underbody plows all offer ways to reduce the amount of road salt needed for deicing purposes.

Figure 6: Number of water bodies impaired by chloride in Minnesota



Wetlands

Wetlands provide important ecological services, including wildlife habitat, groundwater recharge, water quality protection, and stormwater management. Over the course of the last century, Minnesota has lost approximately half of its original wetland acreage through draining and filling for agriculture and development.

Data that tracks total wetland acreage show that Minnesota has added wetlands in recent years. This is an achievement to be celebrated for sure, but concerns linger as most of the wetlands counted in this survey are ponds that have limited habitat or filtration value.[12] Despite gains in the total acreage of wetlands, many of Minnesota's wetlands are undergoing conversions from more natural types of wetlands to cultivated wetlands. This indicates a reduction in many of the ecological qualities that make wetlands valuable to ecosystems. The most common causes of wetland loss are agricultural and rural development.

INVASIVE SPECIES & ROADSIDE VEGETATION

Minnesota's ports and commercial waterways provide gateways through which invasive species like Asian carp and zebra mussels can enter Minnesota's ecosystems. Roadside vegetation plantings can provide habitat for native and threatened species, including polinators.

CONCLUSION

Minnesota's environment faces significant pressure as a result of climate change forces and continued strain on the state's natural resources. Despite these pressures, some recent trends provide cause for optimism. While the drop in greenhouse gas emissions since 2007 does not appear to be enough to meet the goals of the Next Generation Energy Act, the downward trend can be built upon to further reduce Minnesota's contribution to climate change.

Emerging technologies and innovative practices have the potential to reduce the impact of the transportation system on Minnesota's natural resources. Implementing winter road-clearing technologies that reduce the use of chloride-heavy road salts will help to limit damage to surface waters throughout the state. Incorporating vegetation that is salt-tolerant along roadsides can help to minimize the amount of chloride that enters bodies of water in the first place. Planting other native vegetation along roadsides can provide valuable habitat for animals while maintaining biodiversity in Minnesota's ecosystems.

CITATIONS

1. Climate Change in Minnesota: an MPR News Special Report, 2015
2. FHWA Assessment of Incorporating Climate Change Adaptation Measures into Transportation Projects, 2013
3. 2015 Air Quality Report to the Minnesota Legislature
4. 2015 Air Quality Report to the Minnesota Legislature
5. 2015 Air Quality Report to the Minnesota Legislature
6. 2015 Air Quality Report to the Minnesota Legislature
7. MN EQB Draft Water Policy Report, 2015
8. National Land Cover Database, 2011
9. MnDOT Statewide Highway Systems & Operations Plan, 2012-2015
10. MN EQB Draft Water Policy Report, 2015
11. MN DNR Status and Trends of Wetlands in Minnesota, 2011

For more information about the the Statewide Multimodal Transportation Plan update please visit our website: www.minnesotago.org or contact: