Environmental Quality

For centuries, humans have been intensively altering Minnesota's landscape through agriculture, industry, urban development, natural resource extraction, and the transportation network that connects these activities. Like the state's population, demands on transportation and natural resources have grown and diversified over the past few decades. This paper examines how these interactions will change over time, focusing on the transportation system and its relationship with the quality of Minnesota's natural environment.

AIR QUALITY

Criteria Pollutant Emissions

While air quality in Minnesota and across the nation has improved significantly over the past few decades, recent research indicates that pollution levels are still high enough to negatively impact health.[1] Air is most closely monitored for six "criteria pollutants" for which there are National Ambient Air Quality Standards (NAAQS): particulate matter, ground-level ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, and lead.[2] These pollutants are monitored at locations across the state to determine compliance with federal and state ambient air quality standards. State and federal programs regulate criteria pollutant emissions from a diverse set of sources. Statewide, traditional permitted point-sources of air pollution contribute about 25% of air pollution emissions. The remaining 75% come from smaller-more diverse sources including on-road vehicles (28%), non-permitted commercial and residential sources (26%) and off-road vehicles and equipment (19%).[3] Overall, annual emissions of volatile organic compounds, sulfur dioxide, nitrous dioxide, and directly emitted fine particles declined by 40% between 1990 and 2013. This was largely due to heightened air pollution controls resulting from the Clean Air Act, which established NAAQS and linked attainment of these standards to federal transportation funding.

Degraded air quality from road transportation is now estimated to be responsible for more early deaths than collisions.[4] Even though vehicular pollution levels have fallen relative to those observed in the early 2000's and are projected to remain stable as fuel economy improves and as stricter emissions standards are implemented, addressing vehicular pollution continues to be a priority.[5]

Looking ahead, continued air pollution emission reductions are needed to protect public health and to ensure ongoing compliance with air quality standards. Research continues to show that lower levels of air pollution contribute to adverse health effects. The Clean Air Act requires the U.S. Environmental protection agency to evaluate air quality standards every five years. If the EPA finds that existing air quality standards no longer provide adequate protection for public health and the environment, the EPA is required to revise standards to ensure such protection. While all areas of Minnesota currently meet federal air quality standards, ozone and fine particle pollution are measured at levels near the standard.

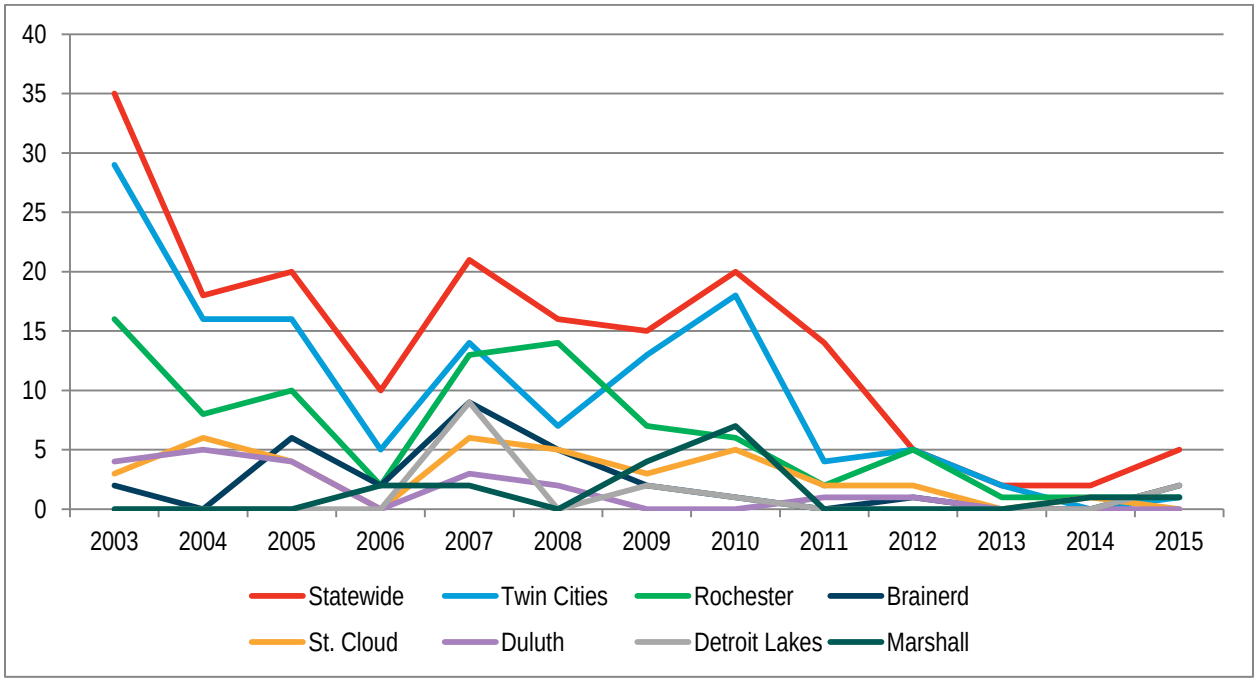
Air Quality Measures

The Air Quality Index (AQI) is a measure developed by the United States Environmental Protection Agency (EPA) for reporting daily air quality conditions to the public based on health benchmarks that rank pollutant concentrations as good, moderate, and alert-level. Within the alert level, there are three sub-categories: unhealthy for sensitive groups, unhealthy, and very unhealthy. The Minnesota Pollution Control Agency (MPCA) uses this index to report air quality at 30 stations across the state based on concentrations of four pollutants: particulate matter, ozone, sulfur dioxide, and

[1] Minnesota Department of Health Air Quality Index: Facts & Figures
[2] EPA, 2015. Six Common Air Pollutants.
[3] MPCA, 2015. Air Quality in Minnesota: 2015 Report to the Legislature
[4] Caiazzo et al. 2013. *Air pollution and early deaths in the United States. Part I: Quantifying the impact of major sectors in 2005.* Atmospheric Environment. doi:10.1016/j.atmosenv.2013.05.081
[5] MnDOT, 2014. Minnesota 2014 Transportation Results Scorecard.

carbon monoxide. Variation in air quality between years can be driven by weather, though generally there has been an overall downward trend between 2003 and 2013 in the number of "alert" days statewide and by region, as shown in Figure 1 below.[6]

Figure 1: Air alert days based on current Air Quality Index Standards[7]



To track air quality trends at the state level, the highest AQI, or worst air quality, measured across all monitoring stations is used to represent the statewide AQI for the day. Air quality alerts have been tracked for both ozone and fine particle pollution. From 2008-2013, the number of days with a "Good" AQI more than doubled statewide, and maintained an overall upward trend. 2015 saw a slight uptick in air alert days, largely due to expansive forest fires across Canada that covered vast swaths of North America in smoke.

WATER QUALITY

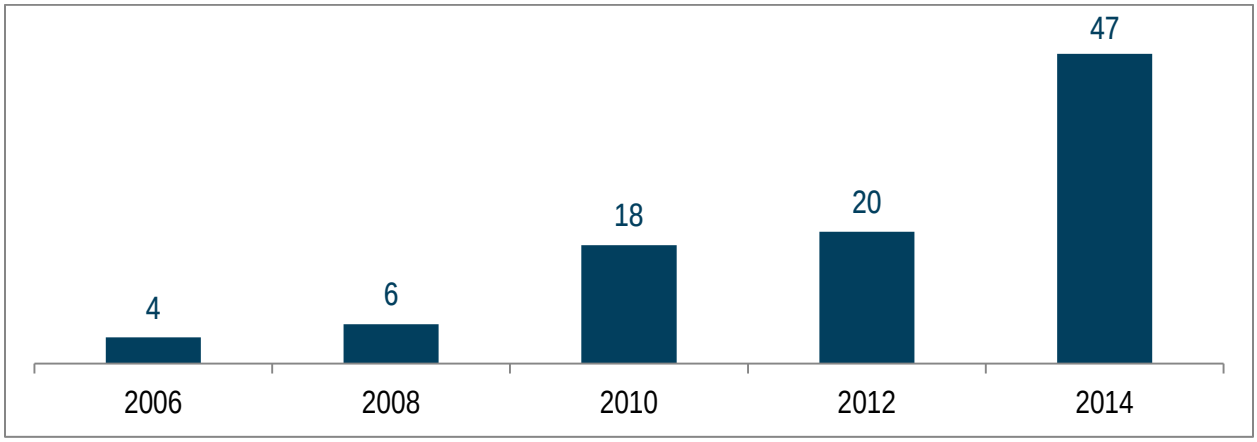
Transportation infrastructure and adjacent land development stress water quality by generating pollutants and also disrupting natural filtration systems. Finding ways to limit these impacts is an important goal in keeping Minnesota's waters clean.

Chloride

Chloride is a pollutant that can inhibit plants' ability to take up water and nutrients. [8] It is commonly used in water softeners and salts used for winter road maintenance, after which it frequently enters surface waters, groundwater, and soil after snow melts. In addition to negatively impacting plants and wildlife, high chloride concentrations in surface and ground water pose potential concerns for drinking water supplies.[9] The number of lakes that have been impaired by chloride can be found in Figure 2. Once chloride has contaminated water, the only effective way to remove it is through reverse osmosis. This process would be very difficult and costly for surface waters and can be cost-prohibitive for treatment facilities – it is likely that chloride concentrations in ground and surface waters will continue to accumulate over time.[10]

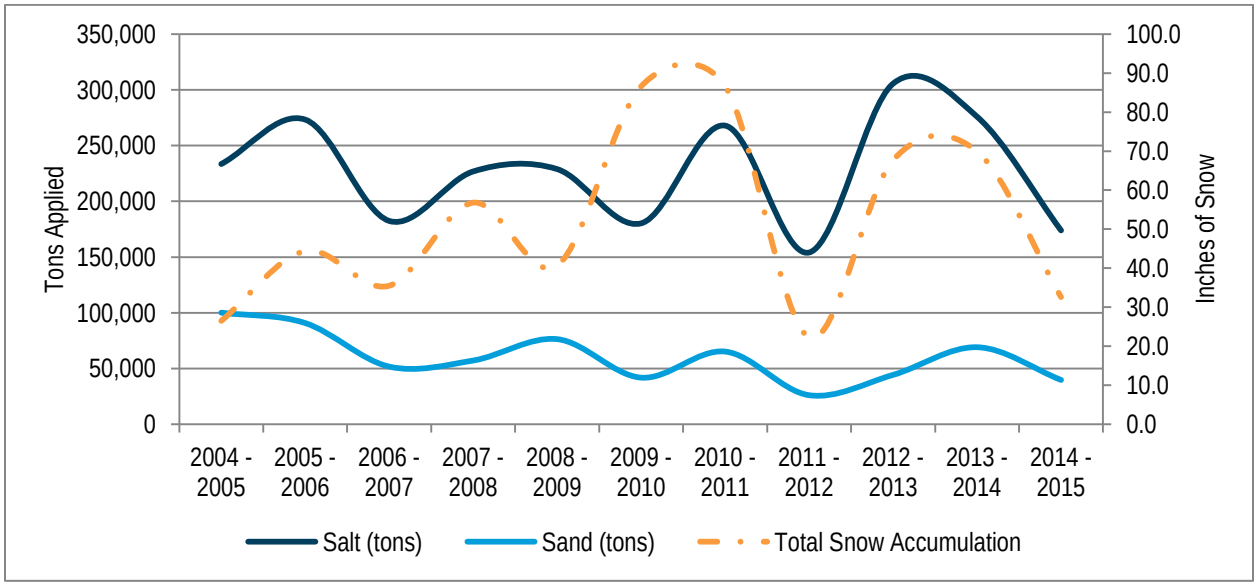
[6] MDH Air Quality Index: Facts & Figures
[7] Data from Minnesota Department of Health (MDH) MN Public Health Data Access
[8] MnDOT, 2012. Statewide Highway Systems and Operations Plan 2012-2015
[9] Minnesota Environmental Quality Board (EQB) Water Policy Report, 2015
[10] MPCA, 2015. Twin Cities Metropolitan Area Chloride Management Plan (Draft)

Figure 2: Number of lakes impaired by chloride in Minnesota[11]



MnDOT is the single largest user of road salt in Minnesota, and has applied approximately 150,000 to just over 300,000 tons annually to state roads throughout the state over the past 10 years (see Figure 3).[12] Many other entities in addition to MnDOT use salts to aid in their winter maintenance efforts, including county and city road authorities, private snow-clearing companies, individual homeowners, and others. MnDOT road salt applications are relatively low on a per-mile basis but the size of MnDOT's system is over 30,000 lane miles in total. Usage is also driven by winter severity and snowfall is just one factor. Only about 30% of the road salt applied in the Twin Cities Metro Area is carried away and dissolved in the Mississippi River and 70% is unaccounted for.[13] Outside of the Twin Cities, chloride concentrations in surface and groundwater are generally below established surface water contamination and drinking water taste thresholds but were observed as increasing in monitoring wells and areas associated with urban land use.[14] Among groundwater monitoring wells with sufficient data for trend analysis, chloride concentrations have risen significantly within a third of them since the 1980's; this rise was attributed to road salt rather than natural mineral sources.[15] These monitoring wells are predominantly located in shallow gravel aquifers.

Figure 3: MnDOT Salt and Sand Usage



[11] MPCA
[12] MnDOT, 2015. 2014-2015 MnDOT Snow and Ice Report.
[13] Stefan et. al., 2008
[14] MPCA, 2013. The Condition of Minnesota's Groundwater
[15] Ibid.

MANAGEMENT STRATEGIES

Chloride use can be reduced through implementation of best management practices, training, new technology, and alternative chemicals. Management strategies currently being pursued by MnDOT are described below:

- Maintenance Decision Support System/ Automated Vehicle Location and Road Weather Information System (MDSS/AVL and RWIS) technology deployment which uses weather forecasts, current and forecasted pavement conditions, and knowledge of route-specific equipment and materials to make situation-specific treatment recommendations and provide them in real time to operators and field supervisors.[16]
- Pre-wetting, pre-treating and alternative deicers including mixtures of regular road salt treated with brine of various types and amounts have been found to be more efficient for deicing compared to road salt without added moisture. This approach has also been found to keep more salt on the roadway. Alternative chemicals such as calcium chloride and magnesium chloride brines and potassium acetate are also used. Most MnDOT sites have salt brine making capabilities or access to salt brine and usage continues to expand. The additional costs of brine and alternative chemical usage are offset by savings through reduced salt, labor, and fuel use needed to remove compacted ice from roads
- Liquid chemical deicers for anti-icing are applied directly to the pavement before winter weather events to prevent ice build-up or weaken the bond between snow and ice and the pavement. This proactive approach can significantly reduce the resources needed to clear a roadway of snow and ice.
- Underbody plows allow MnDOT to remove compacted snow and ice physically, rather than with chemicals. All new plows are equipped with an underbody plow, and MnDOT has significantly increased the number of trucks with these plows.
- Statewide and District-level training is conducted each year for snow plow operators prior to winter operations. Safety, equipment calibration and operation, chemical management, performance targets, new technology and other necessary training topics are covered at these events.
- The pursuit and implementation of chemical and equipment innovations allows MnDOT to deliver the same level of snow and ice removal with reduced usage of chemical materials by limiting the chemical types, quantities, locations, and times of application to the minimum amount necessary.
- The MPCA has drafted a Twin Cities Metropolitan Area Chloride Management Plan, which includes many of MnDOT's management practices for reducing salt use. The plan also calls for further study of chloride load reductions associated with individual best management practices, environmental impacts of non-chloride de-icers, re-use of wastewater with chloride for de-icing, and alternative pavements that could reduce chloride usage.

Wetlands

Wetlands provide important ecological services, including wildlife habitat, groundwater recharge, water quality protection, and stormwater management. Transportation projects and land development have been transforming the state's landscape and negatively impacting the quantity and health of Minnesota's wetlands for centuries. In fact, Minnesota has lost approximately half of its original wetland acreage through draining and filling for agriculture and development. Based on 2006-2008 field data, current estimates of wetland area are 10.6 million acres.[17] Minnesota's Wetland Conservation Act, passed in 1991, has mandated no-net-loss in the quality, quantity, and biodiversity of wetlands.

The Board of Water and Soil Resources (BWSR) "2001-2003 Minnesota Wetland Report" shows that in the three-year period represented by the report, local road authority projects resulted in 468 acres of total wetland loss – MnDOT projects resulted in 195 acres of wetland loss.[18] According to this report and previous BWSR reports, local road authority projects and MnDOT projects impact an average of 141 acres per year and 67 acres per year respectively. The impacts caused by both local and MnDOT road projects are replaced through the use of wetland bank credits, which have been generated primarily by the restoration of drained wetlands. The wetland replacement ratio required by the Wetland Conservation Act ranges

[16] Minnesota Environmental Quality Board (EQB) Water Policy Report, 2015
[17] MN DNR, 2015. Wetlands
[18] Minnesota Wetland Report, 2003

from 1:1 in NE Minnesota to 2:1 in SW Minnesota, which results in a statewide replacement ratio of approximately 1.5 acres of wetland replaced for each acre of wetland lost.

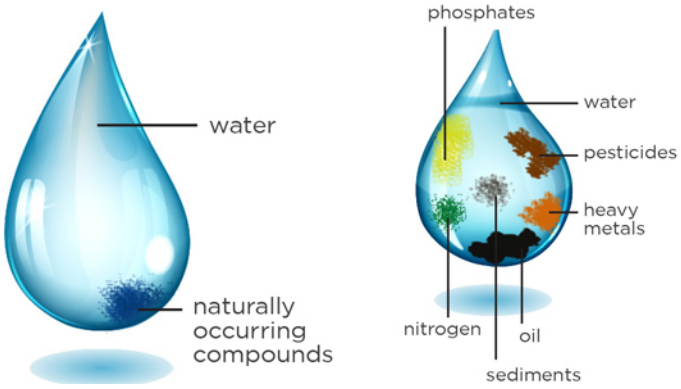
Wetland monitoring from 2006-2011 suggests a small though significant gain in Minnesota's wetland land area of approximately 2,080 acres. Though this is an important achievement, there is still reason to be concerned, because field studies indicate that most of these wetlands are ponds and have limited habitat value.[19] Meanwhile, almost 2,000 acres have undergone conversion from emergent wetlands to cultivated wetlands, which indicates a loss of wetland quality. The most common observed causes of wetland loss within sampled plots were agriculture and rural development, though change in wetland type accounted for a much greater area than wetland loss or gain.

Results from a 2012 survey of wetland quality indicated that high concentrations of the pollutants chloride and phosphorus had similar negative effects on plant and animal communities, and were at high levels in 38 percent and 31 percent respectively of the state's wetlands.[20] Natural and man-made wetlands provide similar levels of flood mitigation, but natural wetlands outperform man-made with regards to habitat and downstream water quality protection.[21]

Stormwater Management and Green Infrastructure

Stormwater has long been seen as a risk to transportation infrastructure and adjacent properties. Environmental issues related to stormwater are now becoming more important, especially in terms of pollutant control and infiltration.[22] In 2013, the MPCA developed Minimal Impact Design Standards, which are a voluntary standard for developments (including roads) that aid in pollutant control and infiltration. So-called "green infrastructure" embodies this increasingly mainstream approach to infrastructure design and stormwater management, which seeks to emulate a site's natural hydrology prior to development. This will continue to be an important strategy for managing the mounting pressures that transportation projects exert on ecological systems, particularly through stormwater management. Managing stormwater is of particular concern as runoff from transportation facilities is often contaminated by vehicular emissions and discharges – preventing these pollutants from reaching natural water bodies is an important step toward maintaining ecosystem health. Figure 4 compares runoff from natural landscapes with developed landscapes.

Figure 4: Graphical representation of runoff from natural and developed landscapes[23]



Green infrastructure is referred to within various engineering and environmental regulation circles as best management practices and low-impact designs. These practices encompass a range of stormwater control measures (some of which are literally "green" in that they involve vegetation) that provide ecological services such as water filtration and species habitat, effectively lowering concentrations and total loads of pollutants. This approach also extends the design life of infrastructure by decreasing the volumes and velocity of stormwater runoff, and thus, potential damage through weathering. More information on green infrastructure is available in the appendix on the following pages.

[19] Minnesota Department of Natural Resources, 2013. Status and Trends of Wetlands in Minnesota: Wetland Quantity Trends from 2006 to 2011.
[20] MPCA, 2012. Depressional Wetland Quality Status and Trends Report
[21] Ibid.
[22] MPCA, 2014. Minimal Impact Design Standards (MIDS): Enhancing stormwater management in Minnesota
[23] MN EQB, 2015

Current Water Quality Regulation

Transportation projects are subject to numerous federal and state regulations that manage negative impacts of infrastructure and operations on water quality. Following the National Pollutant Discharge Elimination System regulations, construction activity that disturbs more than one acre of land must obtain a Construction Stormwater Permit for the project from the Minnesota Pollution Control Agency. Prior to submitting the permit application, construction activity owners such as MnDOT must develop a Stormwater Pollution Prevention Plan, which is meant to outline best management practices for soil erosion and runoff, and may include post-construction measures. In addition to construction stormwater management, MnDOT is required to apply for a Municipal Separate Storm Sewer System (MS4) Permit in areas of the state where MnDOT highways are within a municipal boundary that meets the criteria for this permit. Under this permit MnDOT must develop a Stormwater Pollution Prevention Program for these areas. The program must include a minimum of six control measures to mitigate discharge of pollutants from the storm sewer system.[24]

The Wetland Conservation Act (Minnesota 103F.222) requires that any wetlands lost to development be replaced with acreage that provides the important functions lost. The Cooperative Wetland Replacement Program, an agreement between MnDOT and the Minnesota Board of Water and Soil Resources (BWSR) provides for mitigation of wetland impacts caused by MnDOT projects.

2015 legislation established Minnesota's new buffer initiative, which designated 110,000 acres of land for perennial vegetation buffers up to 50-feet wide along lakes, rivers, streams, and ditches. There are exceptions in the legislation for areas covered by a road or other structures and for municipalities in compliance with federal and state storm water requirements.[25]

Within Minnesota, water management structures are shifting from over thirty years of local government oversight (political boundaries) to be based around the state's 81 major watersheds. Under the One Watershed Plan, water management activity will still be locally-driven, but will be facilitated by a comprehensive approach to water management strategies that are tied to the specific local characteristics of each watershed. City and county core services identified as watershed priority concerns will remain unchanged within the local governance structure.[26]

OTHER AREAS

Aquatic Invasive Species

GREAT LAKES SHIPPING

The opening of the Great Lakes Seaway to modern shipping in the mid-20th century increased the risk of aquatic invasive species spreading on ships or through ballast water.[27] The impacts of aquatic invasive species are wide and varied. The ecological and environmental impacts of invasive species like the zebra mussel, sea lamprey, spiny and fishhook waterfleas, Eurasian milfoil, and purple loosestrife range from being a nuisance to potentially devastating, including some forced extinctions of native plants and animals.[28] Despite recent efforts to prevent the introduction of aquatic invasive species, new discoveries of these species have been made in recent years as a result of aquaculture, intentional or unintentional releases, shipping, recreational boating, and water gardening.[29]

[24] MPCA, MS4 Program/Permit
[25] Minnesota Department of Natural Resources, 2015. Implementing Minnesota's New Buffer Initiative.
[26] Local Government Water Roundtable, 2013. Comprehensive Water Planning and Management Policy Paper.
[27] Transportation Research Board Special Report 291
[28] Ibid
[29] Ibid

MISSISSIPPI RIVER SHIPPING

Several species of invasive carp pose potential negative impacts on Minnesota's aquatic ecosystems, economy, and outdoor heritage. Perhaps the most well-known of invasive carp species in Minnesota is the Silver Carp. Silver Carp are known to jump out of the water when startled, and have injured boaters in the past. Silver Carp and other invasive carp also alter ecosystem food chains and may put severe pressure on native species.[30]

Roadside Vegetation

Integrated Roadside Vegetation Management (IRVM) is an approach to roadside vegetation that encourages native plantings and promotes the most efficient and cost effective use of mechanical, cultural, and chemical management methods. In Minnesota, each MnDOT District is encouraged, though not required, to create an IRVM plan to proactively address state laws related to noxious weeds, mowing, groundwater protection, and use of pesticides. In 2000, MnDOT collaborated with several agencies to develop guidance on best practices for developing an integrated vegetation management plan and program.[31] Further, MnDOT has implemented progressive practices to curtail the amount of herbicide applied, guided through an internal policy calling for the judicious use of herbicides.[32]

NOXIOUS WEEDS AND TERRESTRIAL INVASIVE SPECIES

There is concern that climate change will create conditions more favorable for terrestrial invasive species and noxious weeds to outcompete desired and/or native vegetation, compounding climate pressures on plant and wildlife diversity.[33] Greater prevalence of noxious weeds would have negative consequences for native ecosystems and could be harmful to Minnesota's biodiversity.

POLLINATORS

The populations of insect pollinators in the U.S. have been declining in recent years – most notably populations of honey bees and monarch butterflies. Pollinators are essential to aid in pollination of hundreds of crop and ornamental plants. In fact, approximately one-third of the plants or plant products consumed by humans are dependent on pollinators. The population decline has been attributed to a variety and combination of factors including loss of habitat, disease, and pesticides. Habitat which benefits pollinators also provides other benefits like soil stabilization, water infiltration, and blowing snow control. Roadsides provide an opportunity to protect, enhance, and create pollinator habitat. MnDOT has approximately 175,000 acres of green space along Minnesota's roads. These roadsides are largely undisturbed following turf establishment and connect larger tracts of conservation lands.

SEED MIXES

MnDOT, in cooperation with the MN Department of Natural Resources and MN Board of Water and Soil Resources, has developed 30+ seed mixes to stabilize soils after disturbances. These mixes serve different functions and include applicable growing zone plants. The species which make up the mix each serve a specific function within the planting. An online tool was created to help designers choose the correct seed mix for their site

Summary of Roadside Vegetation Trends:

- Use an integrated approach for vegetation management is more effective and cost effective
- Climate change and management priorities will affect the ability of terrestrial invasive and noxious weeds to out-compete desired and/or native vegetation
- Establishing diverse, functional vegetation which will meet design objectives and also serve as pollinator habitat
- Protect and enhance existing roadside which have pollinator habitat

[30] National Parks Service
[31] MnDOT, 2000. Best Practices Handbook on Roadside Vegetation Management
[32] MnDOT Roadside Vegetation Management
[33] MN DNR, 2009. Climate Change: Preliminary Assessment for the Section of Wildlife of the Minnesota Department of Natural Resources.