Minnesota

Statewide Conservation and Preservation Plan

Final Plan - June 30, 2008

Revised November 1, 2008

Funding for this project was provided by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR).

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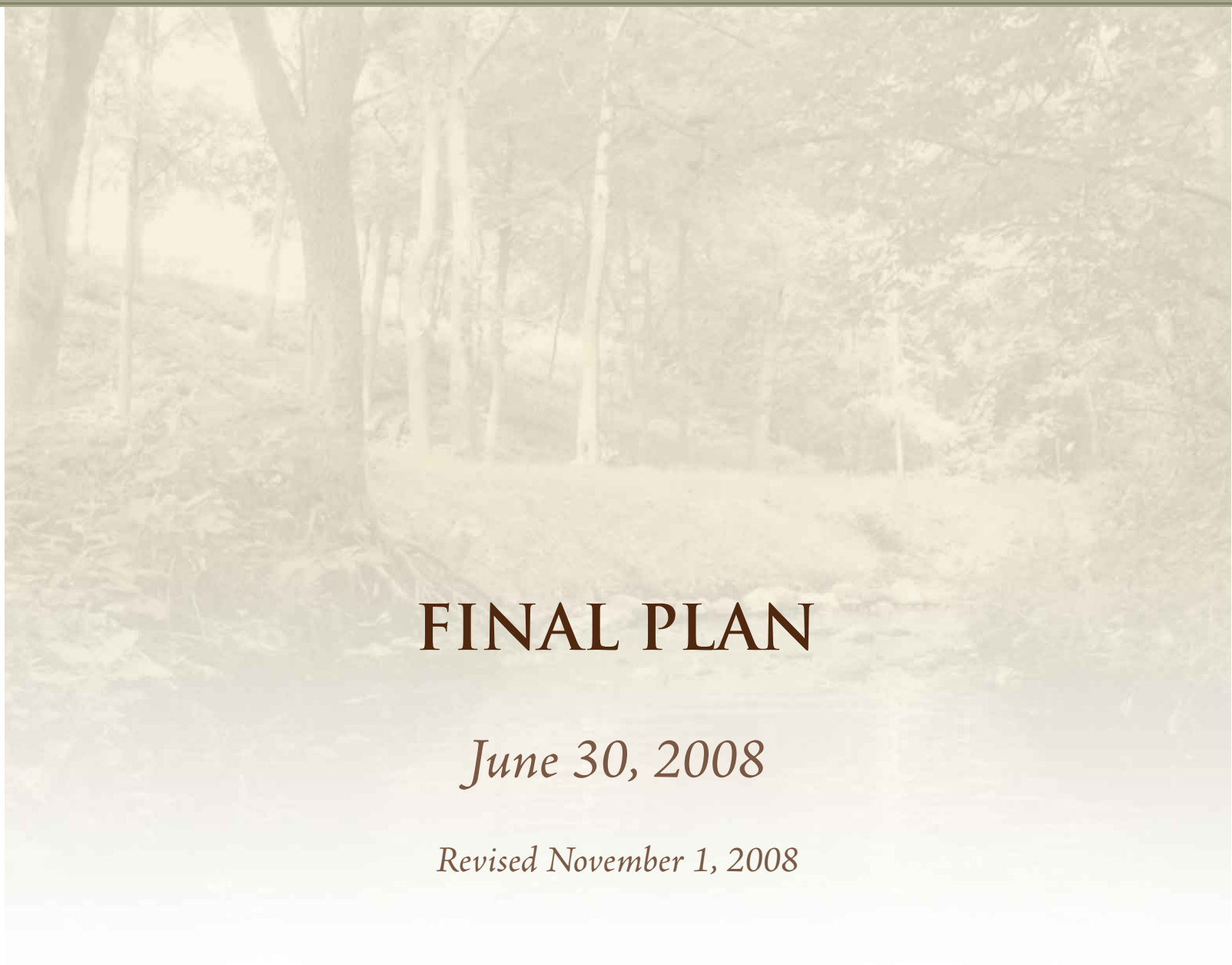

FINAL PLAN

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INSTITUTE ON THE
ENVIRONMENT

UNIVERSITY OF MINNESOTA

CR Planning Bonestroo

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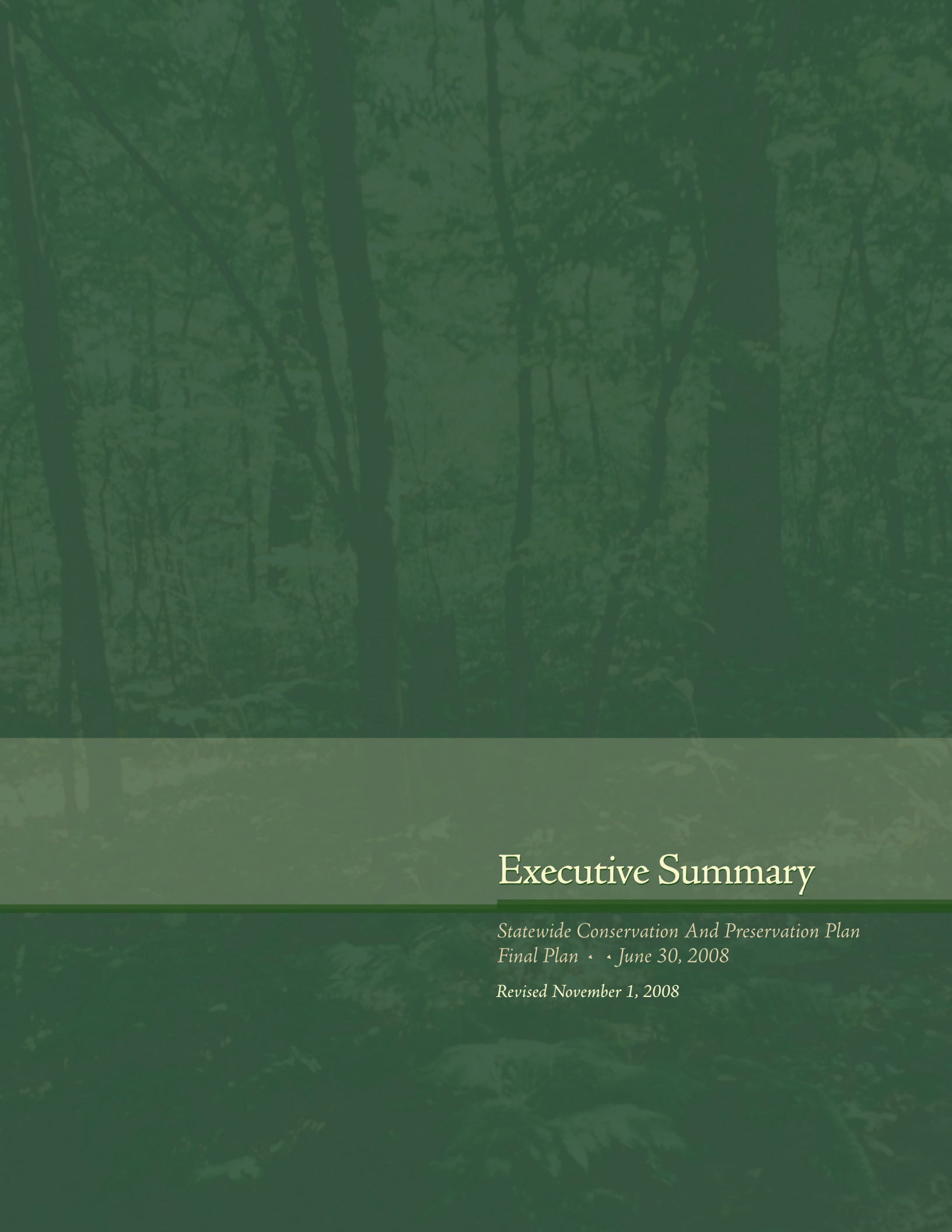
List of Acronyms

AOC - Area of Concern
AMA - Aquatic Management Area
AQI - Air Quality Index
ARS - Agricultural Research Service
ATP - Area Transportation Partnership
ATV - All-Terrain Vehicle
AUAR - Alternative Urban Areawide Review
BMPs - Best Management Practices
BWCAW - Boundary Waters Canoe Area Wilderness
BWSR - Board of Water and Soil Resources
C-BED - Community-Based Energy Development
CCRP - Continuous Sign-up Conservation Reserve Program
CEQ - Council on Environmental Quality
CHP - Combined Heat and Power
CO - Carbon Monoxide
CO_2 - Carbon Dioxide
CPUE - Catch per Unit of Effort
CREP - Conservation Reserve Enhancement Program
CRP - Conservation Reserve Program
CSD - Context-Sensitive Design
CSP - Conservation Security Program
CSS - Context-Sensitive Solutions
DDT - Dichloro-diphenyl-trichloroethane
DEET - N,N-diethyl-meta-toluamide
DNR - Department of Natural Resources (Minnesota)
DOE - Department of Energy
DOT - Department of Transportation
EA - Environmental Assessment
EAW - Environmental Assessment Worksheet
ECS - Ecological Classification System
EDC - Endocrine Disrupting Compound
EDTM - Efficient Transportation Decision Making
EIS - Environmental Impact Statement
EQB - Environmental Quality Board
EQIP - Environmental Quality Incentives Program
ETAT - Environmental and Technical Advisory Team
FHWA - Federal Highway Administration
FDA - Food and Drug Administration
FIA - Forest Inventory and Analysis
FRPP - Farm and Ranchland Protection Program
FTA - Federal Transit Administration

GAP - Gap Analysis Program
GD - General Development
GEIS - Generic Environmental Impact Statement
GHG - Greenhouse Gas
GIS - Geographic Information Systems
GMO - Genetically Modified Organism
HC - Hydrocarbon
HEL - Highly Erodable Land
HPDP – Highway Project Development Process
IGERT - Integrative Graduate Education and Research Traineeship
IPCC - Intergovernmental Panel on Climate Change
LAHC - Land and Aquatic Habitat Conservation
LCCMR - Legislative-Citizen Commission on Minnesota Resources
LEETF - Legislative Electric Energy Task Force
LGU - Local Government Unit
LID - Low-Impact Development
LIDAR - Light Detection and Ranging
MCBS - Minnesota County Biological Survey
MCCAG - Minnesota Climate Change Advisory Group
MDA - Minnesota Department of Agriculture
MDH - Minnesota Department of Health
MFRC - Minnesota Forest Resources Council
MICA - Minnesota Interagency Community Assistance
MLCCS - Minnesota Land Cover Classification System
MnDOT - Minnesota Department of Transportation
MNEQB - Minnesota Environmental Quality Board
MPCA - Minnesota Pollution Control Agency
MPO - Metropolitan Planning Organization
MS4 - Municipal Separate Storm Sewer Systems
MSW - Municipal Solid Waste
MTSH - Mt. Simon/Hinckley
NAAQS - National Ambient Air Quality Standards
NE - Natural Environment
NEPA – National Environmental Policy Act
NOx - Nitrogen oxide
NPS - National Park Service
NPDES - National Pollutant Discharge Elimination System
NRCS - Natural Resources Conservation Service
NRI - Natural Resources Inventory
NRRI - Natural Resources Research Institute
NURP - National Urban Runoff Program
OIM - Office of Investment Management
ORC - Organic Rankine Cycle

PAHs - Polycyclic Aromatic Hydrocarbons
PBDEs - Polybrominated Diphenyl Ethers
PCBs - Polychlorinated biphenyls
PM - Particulate Matter
ppm - Parts per Million
RD - Recreational Development
RGU - Responsible Governmental Unit
RIM - Reinvest in Minnesota
RUSLE2 - Revised Universal Soil Loss Equation, Version 2
SAFETEA-LU - Safe Accountable Flexible Efficient Transportation Equity Act
SCPP - Minnesota Statewide Conservation and Preservation Plan
SCORP - State Comprehensive Outdoor Recreation Plan
SGCN - Species of Greatest Conservation Need
SHPO - State Historic Preservation Office
SOBS - Sites of Biodiversity Significance
SOx - Sulfur Oxides
STIP - State Transportation Improvement Program
SWCD - Soil and Water Conservation District
TAB - Technical Advisory Board
TAC - Technical Advisory Committee
TDM - Transportation Demand Modeling
TIP - Transportation Improvement Program
TMDL - Total Maximum Daily Load
TNC - The Nature Conservancy
TP - Total Phosphorus
TSP - Transportation System Plan
UM - University of Minnesota
USDA - U.S. Department of Agriculture
USEPA - U.S. Environmental Protection Agency
USFWS - U.S. Fish and Wildlife Service
USGS - U.S. Geological Survey
UWM - University of Wisconsin Madison
VHS - Viral Hemorrhagic Septicemia
VMT - Vehicle Miles Traveled
VOC - Volatile Organic Compound
WARSSS - Watershed Assessment of River Stability and Sediment Supply
WRP - Wetland Reserve Program



Executive Summary

Statewide Conservation And Preservation Plan
Final Plan • • June 30, 2008

Revised November 1, 2008

Executive Summary

The remarkable place known as Minnesota is situated at the convergence of the Great Lakes, the Great Rivers, and the Great Plains. The citizens of Minnesota cherish and take pride in the abundant and varied natural resources of this place. We also value our quality of life and our standard of living, and desire the same for our children. All of these values and desires are intricately connected: continued economic prosperity depends on a healthy and sustainable environment, and vice versa. To foster the conditions we value, we must balance long-term plans for conserving and protecting our priceless natural resources with those for ensuring a healthy public and healthy economy. This document, the Minnesota Statewide Conservation and Preservation Plan (SCPP), lays out a deliberate strategy for doing so in a unified, integrated fashion, that employed an interdisciplinary approach with multiple perspectives and expertise.

The Environmental and Natural Resources Trust Fund funded a unique partnership among the University of Minnesota and the consulting firms of Bonestroo and CR Planning to evaluate the state's natural resources, identify key issues affecting those resources, and make recommendations for improving and protecting them. More than 125 experts, including University scientists and public and private natural resource planners and professionals, participated in the 18-month effort.

The team addressed Minnesota's Constitutionally identified natural resources of air, water, land, wildlife, fish, and outdoor recreation in two distinct phases. In the first phase of the project, the project team assessed the past and present condition of each of these six natural resources. They identified and described (where possible) the drivers of change immediately impacting them, and identified key issues that could be addressed to protect and conserve them in an integrated fashion. This information was published as the Preliminary Plan (http://www.lccmr.leg.mn). In the second phase of the project, the team addressed the key issues in depth, developing recommendations that would positively impact as many natural resources as possible while taking into account demographic change, public health, economic sustainability, and climate change. These recommendations then were synthesized into a framework with five strategic areas. Recommendations were identified as being either policy and action recommendations (those that could be put into effect directly by the legislature) or recommendations that add to our knowledge infrastructure (research needs, data gathering and monitoring needs, or educational activities). This framework and its recommendations were published as the Final Plan (http://www.lccmr.leg.mn). The steps and outcomes for the entire project are shown in Figure 1.

Preliminary Plan. Initially the team identified drivers of change that negatively impact each natural resource. These included both proximate drivers, those that are closest to and have the most direct impact on the resource (e.g., nutrient loading impacting water quality) and higher-order drivers, which are those that are further removed from the resource and impact the resource through other drivers of change (e.g., shoreline development causing the nutrient loading that impacts water quality). The team mapped these relationships among each other, noting that many drivers of change impact multiple resources and a given resource is impacted by multiple drivers of change. Finally, the team used a matrix prioritization process to objectively identify the key issues that, if addressed, would benefit the greatest number of natural resources to the greatest degree. The seven key areas identified were:

- Land and water habitat fragmentation, degradation, loss, and conversion

- Land use practices
- Transportation
- Energy production and use
- Toxic contaminants
- Impacts on resource consumption
- Invasive species

Each of these key issues is more fully described in the Preliminary Plan.

Final Plan. A subset of these issues was chosen for investigation in the second phase of the project. The key issues for which recommendations are made in this report are:

- Land and water habitat fragmentation, degradation, loss, and conversion
- Land use practices
- Transportation
- Energy production and use, and mercury as a toxic contaminant related to energy production

Figure 2 shows the action or policy recommendations for each of the key issues, arranged according to the degree of integrated benefits across all values associated with natural resources. The knowledge infrastructure and mercury recommendations were not evaluated by this process, and are not included in this figure. This gives an overall snapshot of how much integrated value a given recommendation has. For example, the first recommendation under the key issue of habitat has significant impact across the majority of the resource values, and has little impact on air quality and human health. This figure also identifies which recommendations benefit a given resource value the most. For example, habitat and land use–forestry recommendations have the most impact on biodiversity.

The Final Plan is organized in such a way as to take the reader through the project evolution in great detail. Following this Executive Summary and an Introduction section, the overall Strategic Framework is presented and described (also see below) to provide a context for the series of sections that follow, in which each of the key issues is described in detail. The section on land and water Habitat Recommendations contains a unique approach to priority mapping that combines geo-spatial data on a series of stress indicators that culminate in maps showing areas of the state with highest water and land habitat quality superimposed with areas of highest ecological stress. These maps help decision makers and natural resource managers prioritize which parts of the state to protect, conserve, or restore in order to best address our water and habitat natural resources. The Land Use Recommendations section is organized around three main types of land use, including urban/community land use practice, agricultural land use practice, and forest land use practice. Recommendations focus on water management, crop management, low impact development, and adoption of best practices for all types of land use. This is followed by a section on Transportation Recommendations, which stresses how transportation development choices are interwoven with land use choices, and have multiple impacts on water quality, habitat fragmentation, energy use, and air quality. This section also recognizes the current inefficiencies in permitting for transportation projects. The next section on Energy Recommendations focuses specifically on the strategies for renewable energy and conservation practices that will reduce dependence on fossil fuels and promote environmental co-benefits. It also links these recommendations directly to promoting a health economy. This section also addresses how decreases in fossil fuel use might change mercury emissions in the state, and how changes in these emissions translate to changes in concentrations of this toxic chemical in fish as a result.

The Final Plan contains nine appendices. The first contains a list of the recommendations that resulted from the Preliminary Plan; the second contains a list of the project participants and their affiliations; the third is a detailed report on the mercury assessment referenced in the Energy Recommendations section; the fourth is a summary of a study that predicts the future impacts of climate change on biodiversity in

Minnesota; the fifth is a cost benefit analysis of 7 of the major recommendations; the sixth is the result of an expert panel discussion of the value and investment prioritization of the action and policy recommendations; the seventh is a summary of the public engagement and outreach efforts and a summary of the public comments; the eighth is a list of the sources used in preparing the Plan; and the ninth is a short description of each of the recommendations in the Final Plan.

The Strategic Framework

The collection of recommendations was organized into a comprehensive framework, the Strategic Framework for Integrated Resource Conservation and Preservation, as shown in Figure 3. The five strategic areas of the framework identified at the top of the five boxes, are:

- Integrated Planning
- Critical Land Protection
- Land and Water Restoration and Protection
- Sustainability Practices
- Economic Incentives for Sustainability

Recommendations for each of these strategic areas are listed within a given box. Action or policy recommendations are at the top, with recommendations having the broadest impact across multiple resources listed first, followed by those that are more targeted or specific in their scope. Recommendations for building the knowledge infrastructure for that strategic area are at the bottom of the box. All of these recommendations are described in detail in the Final Plan.

This framework is a comprehensive and integrated environmental strategic plan. The recommendations taken together provide a holistic look, and are not meant to be viewed in isolation or to be acted on in a piecemeal fashion. Each of the strategic areas is summarized below.

Strategic Areas

Integrated Planning

Natural resource management is interwoven within a larger fabric of economic health, complex regulatory frameworks, human health, and changing demographics and climate. No one agency can address this comprehensively, nor can it be done in individual agency stovepipes. In addition, there are multijurisdictional responsibilities on the geographic scale, from communities to small units of government to soil and watershed districts to statewide agencies.

Planning, whether for transportation, energy, community development, water resources, agriculture, or forestry, should be integrated across all agencies and across the multijurisdictional scale. Doing so can make planning more efficient by removing redundancies. Our strongest, most effective federal environmental laws require cross-agency review or partnership, and this approach should be embraced on the state level for holistic natural resource protection.

Our recommendations address land use practices, transportation policy, and energy production and use policy as related to natural resource protection. For example, we specifically recommend the development of a state land use, development, and investment guide to align investment objectives across social, environmental, and economic sectors. We recommend that the state embrace a conservation-based community planning approach. Enhanced cross-consultation in governance and planning for transportation, land development, and energy projects is essential for protecting and conserving our natural resources.

Critical Land Protection

Be it farmland, wetlands, greenways in urban areas, or forestland, a clear and comprehensive strategy must be developed that establishes long-term and short-term protection and acquisition priorities. An array of perspectives should inform this strategy, integrating needs for biodiversity protection, critical agricultural land protection, ecological services, recreational opportunities, and opportunities for climate change adaptation and/or mitigation.

This strategy should build on the excellent work already accomplished by the DNR critical habitat studies, the Metro and Outstate Conservation Corridors initiatives, and the work of many nonprofit land-protection organizations.

Our recommendations in this strategic area focus on the protection by easement or acquisition of critical stream and lake shorelines, priority land habitats, and large blocks of forestland.

Land and Water Restoration and Protection

This strategic area addresses both the restoration of critical land and water habitat and the protection of strategic land and water habitat that has not yet been degraded. It not only addresses the inherent and intrinsic direct benefits of habitat restoration and protection, but also emphasizes the benefits of such strategy for strengthening biodiversity and enhancing resilience to climate change. The recommendations in this area reinforce and strengthen Minnesota cultural values, ethics, appreciation of outdoor recreation, and economic health.

The recommendations include specific actions to restore shallow lakes, wetlands and wetland associated watersheds, and the habitats contained within lakes and rivers, as well as actions to protect critical landscapes.

Sustainability Practices

A healthy environment requires a healthy economy, and a sustainable economy requires a sustainable environment. To reach both goals requires promoting, facilitating, encouraging, and regulating practices that will lead to a sustainable environment and economy. These sustainable practices must cross multiple fronts - sustainable agriculture, sustainable forestry, sustainable water resources, and sustainable economy and standard of living - all in the context of energy production, shifting demographics, and climate change.

Specific recommendations promote the sustainable management of forestlands and action to keep water on the landscape. These include reviewing drainage policy and actions to move water more slowly across and through the landscape to return to more natural conditions to reduce flooding, improving water quality, and improving biological diversity through habitat protection.

Economic Incentives for Sustainability

Moving toward sustainable practice requires specific incentives to move the state and its citizens and stakeholders in a transformative direction. These are broad-scale ideas for achieving a sustainable economy specifically through natural resource policies: Energy policy, agricultural policy, forestry policy, and transportation policy can be used to grow and nurture Minnesota's economic future. For example, the team recommends the development and implementation of incentive programs to develop renewable energy programs and to promote a successful transition of Minnesota's vehicle fleet to electric power.

Minnesotans share a vision for a healthy and sustainable future. This framework of strategic recommendations is a collective roadmap for moving forward to achieve this future. We hope that the citizens, resource managers, and policy-makers of the state embrace this opportunity to deliberately protect and conserve Minnesota's remarkable natural resources before they are futher degraded or lost.

Figure 1. Process and outcomes of the Statewide Conservation and Preservation Plan

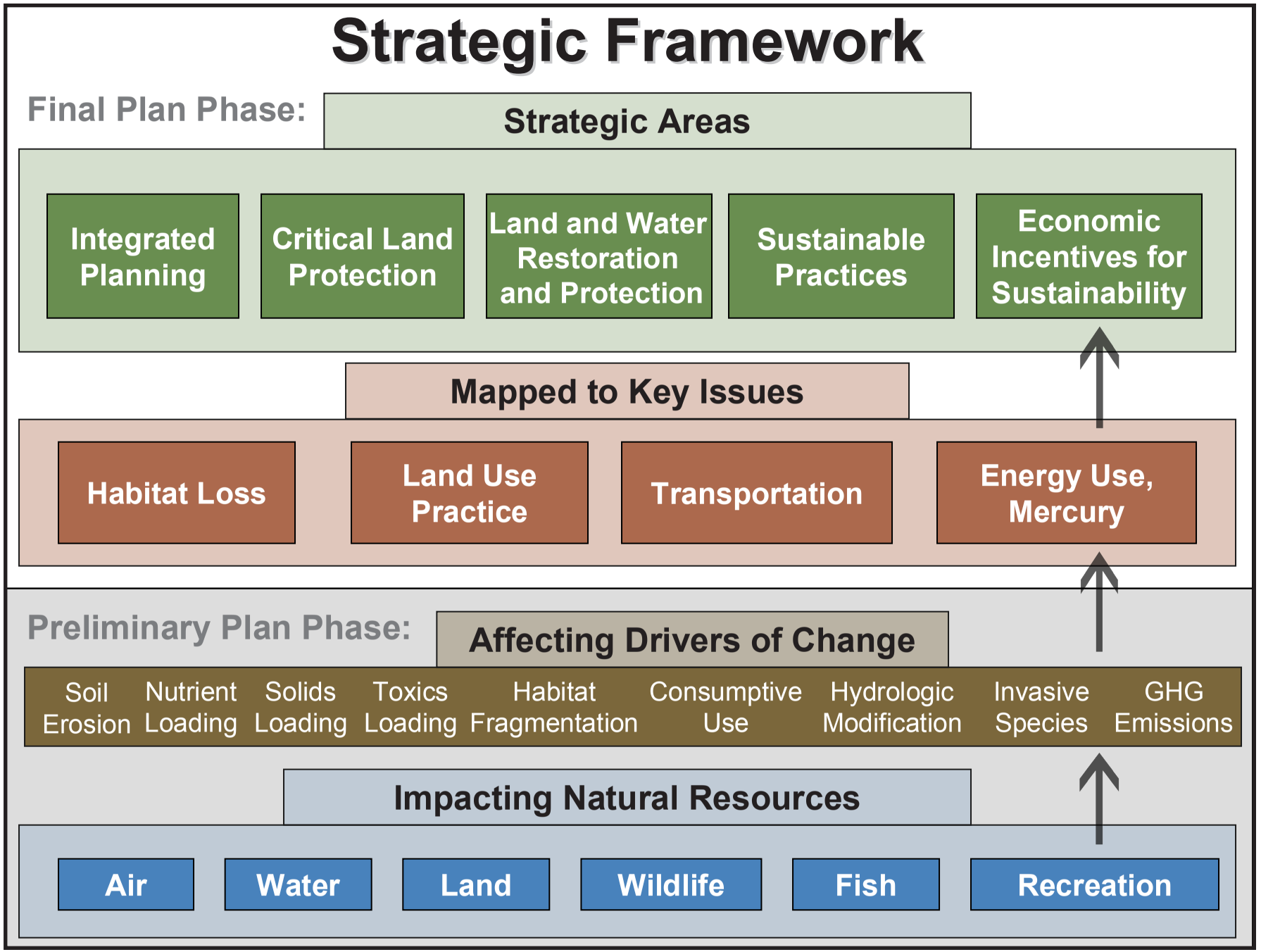


Figure 2. Natural resource values assessment of policy and action recommendations

Natural Resource Values Assessment of Recommendations

LEGEND: ● = Critical Impact ◑ = Significant Impact ○ = Negligible Impact

	Number	Recommendation	Air Quality	Water Quality/Quantity	Terrestrial Habitat Quality	Soil/Land Quality	Human Health	Biodiversity	Community Health	Aquatic Economic Health	Recreational/Cultural/ Spiritual/Aesthetic Value	Climate Change Mitigation/Adaptation	
HABITAT	H2	Protect critical shoreland of streams and lakes	○	●	●	●	○	●	●	●	●	●	
	H1	Protect priority land habitats	○	●	●	●	○	●	●	◑	●	●	
	H4	Restore and protect shallow lakes	○	●	●	◑	○	●	●	●	●	◑	
	H5	Restore land, wetlands and wetland-associated watersheds	○	●	◑	◑	◑	●	●	◑	●	●	
	H6	Protect and restore critical in-water habitat of lakes and streams	○	●	◑	◑	◑	●	●	◑	●	●	
	H7	Keep water on the landscape	○	●	◑	●	○	●	●	◑	◑	●	
	H8	Review and analyze drainage policy (ditch laws)	○	●	◑	●	○	◑	●	◑	◑	●	
	H3	Improve connectivity and access to recreation	○	○	◑	○	●	◑	○	●	●	○	
LAND USE	LU1	Fund and implement a state Land Use Development and Investment Guide	◑	◑	◑	◑	◑	◑	◑	◑	◑	◑	
	LU2	Support local and regional conservation-based community planning	◑	◑	◑	◑	◑	◑	◑	◑	◑	◑	
	LU3	Ensure protection of water resources in urban areas	○	◑	○	◑	○	◑	◑	◑	◑	◑	
	LU4/E4	Transition renewable fuel feedstocks to perennial crops	○	◑	◑	◑	○	◑	◑	◑	◑	◑	
	LU5	Reduce streambank erosion through reduction in peak flows	○	◑	◑	◑	○	◑	◑	◑	◑	◑	
	LU6	Reduce upland and gully erosion through soil conservation practices	○	◑	◑	◑	○	◑	◑	◑	◑	◑	
	LU8	Protect large blocks of forest land	○	◑	◑	◑	○	◑	◑	◑	◑	◑	
	LU10	Support and expand sustainable practices on working forested lands	○	◑	◑	◑	○	◑	◑	◑	◑	◑	
TRANSPORTATION	T1	Align transportation planning across all agencies; streamline and integrate environmental transportation project review	●	◑	◑	◑	●	◑	◑	●	●	●	
	T2	Reduce per capita vehicle miles of travel	◑	◑	◑	○	◑	○	○	◑	◑	●	
	T3	Develop and implement transportation polices that minimize impacts on natural resources	○	●	◑	○	○	◑	●	◑	◑	◑	
ENERGY	E1	Develop coordinated laws, policies and procedures across state agencies	◑	●	●	●	◑	◑	●	●	◑	●	
	E13	Invest in research and policies for "green payment" program	○	●	●	●	○	●	●	○	◑	●	
	E17	Promote policies and incentives that encourage C-neutral businesses, homes, communities and other institutions	●	◑	◑	◑	◑	◑	◑	●	◑	●	
	E2	Invest in farm and forest preservation to prevent fragmentation due to development	○	◑	●	●	○	◑	◑	◑	◑	◑	
	E18	Implement policies and incentives to lower energy use of housing stock	◑	◑	○	○	●	○	◑	●	◑	●	
	E16	Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power and renewable electricity production	●	◑	○	○	●	○	○	◑	○	●	
	E21	Develop standards and incentives for energy capture from municipal sanitary and solid waste, and minimize landfill options	◑	◑	○	○	◑	○	◑	◑	◑	◑	
	E19	Promote policies and strategies to implement smart meter and smart grid technologies	◑	○	○	○	◑	○	○	●	◑	●	
	E14	Investigate opportunities to provide tax incentives for individual renewable energy investors	◑	◑	○	○	◑	○	○	◑	○	●	
	E20	Develop incentives to encourage widespread adoption of passive solar and shallow geothermal heat pumps in new construction	◑	◑	○	○	◑	○	○	◑	○	●	
	E15	Invest in efforts to develop community-based energy platforms	○	◑	○	○	○	○	○	●	◑	◑	

Note: Policy and action recommendations are grouped by topic (Habitat, Land Use, etc.) and then ordered starting with those recommendation having the broadest impact across multiple resource values followed by those having more targeted impact.

Strategic Framework For Integrated Resource

INTEGRATED PLANNING IP		CRITICAL LAND PROTECTION LP		LAND AND WATER RESTORATION AND PROTECTION RP	
Rec. No.	**Broad Policy and Action Recommendations**	**Rec. No.**	**Broad Policy and Action Recommendations**	**Rec. No.**	**Broad Policy and Action Recommendations**
E1	Develop coordinated laws, policies and procedures across state agencies	**H2**	Protect critical shorelands of streams and lakes	**H4**	Restore and protect shallow lakes
LU1	Fund and implement a state Land Use Development and Investment Guide	**H1**	Protect priority land habitats	**H5**	Restore land, wetlands, and wetland-associated watersheds
LU2	Support local and regional conservation-based community planning	**LU8**	Protect large blocks of forest land	**H6**	Protect and restore critical in-water habitat of lakes and streams
T1	Align transportation planning across all agencies; streamline and integrate environmental transportation project review				
E23	Develop mercury reduction strategies for out-of-state sources				
Rec. No.	**Targeted Policy and Action Recommendations**	**Rec. No.**	**Targeted Policy and Action Recommendations**	**Rec. No.**	**Targeted Policy and Action Recommendations**
LU3	Ensure protection of water resources in urban areas	**E2**	Invest in farm and forest preservation to prevent fragmentation due to development	**LU5**	Reduce streambank erosion through reduction in peak flows
T3	Develop and implement transportation polices that minimize impacts on natural resources	**H3**	Improve connectivity and access to recreation	**LU6**	Reduce upland and gully erosion through soil conservation practices
Rec. No.	**Knowledge Infrastructure Recommendations**	**Rec. No.**	**Knowledge Infrastructure Recommendations**	**Rec. No.**	**Knowledge Infrastructure Recommendations**
LU2C	Provide communities with the tools and technical assistance for conservation-based planning	**H9**	Invest in overall research on land and aquatic habitats	**H10**	Invest in research on near-shore aquatic habitat vulnerability
E24	Continue state enforcement programs to reduce mercury contamination of the environment	**T3A**	Develop research programs in habitat fragmentation	**H11**	Improve understanding of groundwater resources
LU3B	Simplify modeling for TMDLs	**LU9**	Assess tools for forest land protection	**LU5A**	Invest in research that quantifies the relationship between artificial drainage and stream flows
LU3C	Monitor TMDL BMP implementation			**H12**	Improve understanding of watershed responses to multiple drivers of change
LU2D	Invest in databases and tools needed to support land use and conservation decisions			**E11**	Invest in research and enact policies to protect existing prairies from genetic contamination
LU2A	Fund demonstration projects for conservation-based community planning			**LU10E**	Develop and test new management policies to test ecosystem resilience
				H13	Encourage conservation education and training programs for all MN citizens
				E12	Invest in efforts to develop sufficient seed stocks for large scale plantings of perennial crops
				LU3D	Expand water quality media campaign

Figure 3. Strategic framework for integrated resource conservation and preservation

Conservation And Preservation

SUSTAINABLE PRACTICES SP

ECONOMIC INCENTIVES FOR SUSTAINABILITY ES

Rec. No.	Broad Policy and Action Recommendations				
LU10	Support and expand sustainable practices on working forested lands				
H7	Keep water on the landscape				
H8	Review and analyze drainage policy (ditch laws)				
T2	Reduce per capita vehicle miles of travel				
Rec. No.	**Targeted Policy and Action Recommendations**	**Rec. No.**	**Targeted Policy and Action Recommendations**	**Rec. No.**	**Targeted Policy and Action Recommendations**
E13	Invest in research and policies for "green payment" program	E19	Promote policies and strategies to implement smart meter and smart grid technologies	E16	Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power and renewable electricity production
E17	Promote policies and incentives that encourage C-neutral businesses, homes, communities, and other institutions	E20	Develop incentives to encourage widespread adoption of passive solar and shallow geothermal heat pumps in new construction	E21	Develop standards and incentives for energy capture from municipal sanitary and solid waste, and minimize landfill options
LU4/E4	Transition renewable fuel feedstocks to perennial crops	E15	Invest in efforts to develop community-based energy platforms	E14	Investigate opportunities to provide tax incentives for individual renewable energy investors
E18	Implement policies and incentives to lower energy use of housing stock				
Rec. No.	**Knowledge Infrastructure Recommendations**	**Rec. No.**	**Knowledge Infrastructure Recommendations**	**Rec. No.**	**Knowledge Infrastructure Recommendations**
E3	Invest in perennial biofuel crop research and demonstration projects on a landscape scale	E22	Invest in public education focusing on benefits and strategies for energy conservation		
E6	Invest in research to determine removal rates of corn stover and to establish incentives and BMPs	E25	Develop public education on actions that individuals and communities can take to reduce mercury contamination of the environment		
E7	Invest in research to review thermal flow maps	LU7	Invest in statewide high resolution digital elevation data, watershed delineation, maps of artificial drainage network, and other data to support decision making		
E8	Invest in applied research to reduce energy and water consumption and emissions in ethanol plants	LU10B	Educate landowners and forest managers on BMPs to protect working forests		
E9	Invest in research to determine the life cycle impacts of renewable energy production systems				
E10	Invest in research and demonstration projects to develop, and incentives to promote, combination electricity production projects				
T3B	Reduce non-point source pollution to surface and ground waters from transportation infrastructure				
LU4A	Invest in research on parameters that control successful perennial feedstocks				
E5	Invest in data collection to support energy production assessment				

Note: Recommendations having the broadest impact across multiple resources are listed first in each column followed by those having more targeted impact, and supported by knowledge infrastructure recommendations.

The following icons are used throughout the plan to quickly identify recommendations by type:

Integrated Planning Recommendations

Critical Land Protection Recommendations

Land and Water Restoration and Protection Recommendations

Sustainable Practices Recommendations

Economic Incentives for Sustainability

Introduction

Statewide Conservation And Preservation Plan
Final Plan • • June 30, 2008

Revised November 1, 2008

Introduction

The remarkable place known as Minnesota is situated at the convergence of the Great Lakes, the Great Rivers, and the Great Plains. The citizens of Minnesota cherish and take pride in the abundant and varied natural resources of this place. We also value our quality of life and our standard of living, and desire the same for our children. All of these values and desires are intricately connected: Continued economic prosperity depends on a healthy and sustainable environment, and vice versa. To foster the conditions we value, we must balance long-term plans for conserving and protecting our priceless natural resources with those for ensuring a healthy society and economy. This document, the Minnesota Statewide Conservation and Preservation Plan (SCPP), lays out a deliberate strategy for doing so.

Project Overview

Too often, natural resource policies work at cross purposes by addressing issues in isolation or protecting one value at the expense of another. The impetus for the SCPP arose from the desire to create a comprehensive plan for protecting all of Minnesota's natural resources in a unified, integrated fashion, using an interdisciplinary approach with multiple perspectives and expertise.

The Legislative-Citizen Commission on Minnesota Resources (LCCMR) funded a unique public-private partnership to develop the SCPP. The University of Minnesota (UM)-Twin Cities, the Natural Resources Research Institute (NRRI) at the UM-Duluth, and the UM-Morris joined forces with the consulting firms of Bonestroo and CR Planning to evaluate the state's natural resources, identify key issues affecting those resources, and make recommendations for improving and protecting them. Those recommendations were placed within a strategic framework to form the backbone of the plan. More than 125 experts, including University scientists and public and private natural resource planners and professionals, participated in this 18-month coordinated effort to design a secure future for Minnesota's natural resources.

Although the recommendations in this plan should be considered those of the project team, the knowledge, information, and perspectives of all the team members and advisors were necessary to bring this plan to fruition. (Appendix II includes a listing of project team members and advisors.)

This plan not only provides a synthesis of the knowledge of the project team and advisors, but also draws upon many complementary efforts. The Governor's Clean Water Council and Climate Change Advisory Group, the Campaign for Conservation, Ducks Unlimited's Shallow Lakes Initiative, the Minnesota Department of Natural Resources (DNR) Commissioner's Advisory Team's Minnesota Forests for the Future report, The Nature Conservancy's (TNC) Portfolio Lakes data, and many other efforts all contributed to the analysis of key issues leading to the recommendations.

The SCPP was developed in two phases: a preliminary plan (completed in July 2007) and a final plan (this document). The objectives of the preliminary plan were to provide a status check on Minnesota's natural resources, describe the drivers that are influencing changes in resources, and identify key issues that, if addressed, would alter the drivers of change to produce a better outcome for our natural resources. The preliminary plan included a series of preliminary recommendations that the LCCMR considered for its 2007 strategic planning. Those recommendations are included in Appendix I to this report and are endorsed by the project team.

Seven key issues were identified in the preliminary plan as possible research topics for the final plan. The seven key issues were:

- Land and water habitat fragmentation, degradation, loss, and conversion
- Land use practices
- Impacts on resource consumption
- Toxic contaminants
- Transportation
- Energy production and use
- Invasive species

Each of these key issues is more fully described in the preliminary plan. Because of time constraints, a subset of these issues was chosen for investigation in the second phase of the project. The key issues for which recommendations are made in this report are:

- Land and water habitat fragmentation, degradation, loss, and conversion
- Land use practices
- Transportation
- Energy production and use/mercury as a toxic contaminant related to energy production

The other key issues should be investigated in the near future to ensure a comprehensive plan for natural resource protection.

The recommendations in this report are provided to the LCCMR for consideration as it updates its strategic plan. In addition, they offer guidance to a broader Minnesota audience: citizens, administration, legislature, agencies, local units of government, and advocacy organizations. The hope of the project team is that the recommendations will spark change in individuals, organizations, and agencies, and that the SCPP as a whole will provide direction to the state over the next 50 years.

Structure of the Plan

The SCPP presents recommendations from research teams charged with investigating the four key issues addressed in the second phase. While each individual recommendation is important, the recommendations are also designed to work in concert. To this end, the plan provides an integrated strategic framework for the recommendations in Section 3.

Section 4 includes reports from the research teams. Each team report includes:

- A description of the team's key issue, research question, and general context for the recommendations
- The relationship of the recommendations to the drivers of change identified in the preliminary plan
- The expected outcome for our natural resources (altering the drivers of change) if the recommendations are implemented
- Full text of each recommendation, including descriptions of the:
  - Recommended action
  - Impact on natural resources
  - Relationship to existing programs, laws, or regulations
  - Time frame for implementation
  - Geographical area that will be affected
  - Political, institutional, financial, or other challenges that exist for implementation
  - Categories of costs associated with the recommendation

Short descriptions of the recommendations are included in Appendix IX.

Public Outreach

In order to reach beyond our team members and advisors and tap additional experience and expertise, project team members made nearly 50 presentations reaching more than 2,000 people. Three public outreach forums were held around the state during May and June to present and gather comments on a set of draft recommendations. The discussion following the presentations and at the outreach forums influenced the final recommendations in this report. Appendix VII details our outreach efforts and includes a summary of comments made during the forums and through the project Web site.

Drivers of Change

The preliminary plan identified and analyzed key drivers of change affecting six natural resource categories: air, land, wildlife, water, fish, and outdoor recreation. The drivers of change are compelling factors that are causing significant changes in Minnesota's natural resources—changes that are occurring now and changes that are projected into the future. For example, for surface water the most important drivers of change identified were solids loading, nutrient loading, aquatic habitat loss, contaminants, and hydrologic modification. Some of the drivers affect multiple resource areas. This is significant because it means that addressing these drivers of change would positively impact multiple resources.

The project team has assessed how the recommendations in this plan would affect multiple drivers of change, and ultimately multiple natural resources. The chart on the following pages lists the recommendation number and the potential the recommendation has for reducing the effect of the drivers listed across the top. The symbols H, M, and L stand for high, medium, and low potential for reducing the effect of the environmental driver (stressor).

Drivers of Change

Recommendation	Soil Erosion	Soil Sructure	Solids Loading	Nutrient Loading	Toxics Loading/ For Habitat Recs - Contaminants	CO_2 Emission	Hydrological Modification/ For Habitat Recs - Man-made Structures	Consumptive Use
Habitat 1	H	H	H	H	L	L	L	L
Habitat 2	H	M	H	H	L	L	M	L
Habitat 3	M	M	M	M	L	L	L	H
Habitat 4	H	M	M	M	M	L	H	H
Habitat 5	H	M	H	H	L	L	M	L
Habitat 6	H	M	M	M	M	L	M	H
Habitat 7	H	H	H	H	M	M	M	M
Habitat 8	M	H	H	H	L	L	H	M
Habitat 9	M	H	H	H	M	H	L	L
Habitat 10	H	M	H	H	L	L	M	L
Habitat 11	L	H	M	H	M	L	L	H
Habitat 12	H	L	H	H	L	L	M	M
Habitat 13	H	L	H	H	M	H	M	H
Land Use 1	M	L	M	M	M	H	H	H
Land Use 2	H	L	H	H	M	H	M	L
Land Use 3	M	L	H	H	M	L	H	L
Land Use 4	H	H	H	H	M	M	M	L
Land Use 5	H	L	H	M	L	L	H	L
Land Use 6	H	H	H	M	M	L	M	L
Land Use 7	H	M	H	M	L	L	H	L
Land Use 8	M	M	M	M	L	M	M	L
Land Use 9	L	L	L	L	L	L	L	L
Land Use 10	M	M	M	M	L	M	M	L
Trans 1	L	L	M	L	M	H	H	L
Trans 2	L	L	M	L	M	H	H	L
Trans 3	H	M	H	M	H	H	H	L
Energy 1	M	L	M	M	M	M	M	M
Energy 2	L	L	L	L	L	M	L	L
Energy 3	H	M	H	H	L	M	M	L
Energy 4	M	M	M	M	L	L	L	L
Energy 5	M	L	M	M	M	L	M	M
Energy 6	H	M	H	H	L	L	L	L
Energy 7	L	L	L	L	H	H	L	M
Energy 8	L	L	L	L	L	L	L	H
Energy 9	L	L	L	L	M	M	L	M
Energy 10	L	L	L	L	M	M	L	L
Energy 11	L	L	L	L	L	L	L	L
Energy 12	M	L	M	M	L	M	L	L
Energy 13	H	M	H	H	L	L	M	L
Energy 14	L	L	L	L	M	M	L	M
Energy 15	L	L	L	L	M	M	L	L
Energy 16	L	L	L	L	H	H	L	M
Energy 17	L	L	L	L	H	H	L	L
Energy 18	L	L	L	L	M	M	L	L
Energy 19	L	L	L	L	M	M	L	L
Energy 20	L	L	L	L	M	M	L	L
Energy 21	L	L	L	L	M	L	L	L
Energy 22	L	L	L	L	H	H	L	M
Energy 23	L	L	L	L	H	M	L	L
Energy 24	L	L	L	L	M	L	L	L
Energy 25	L	L	L	L	M	L	L	L

Figure 4. Assessment of recommendations' effect on drivers of change

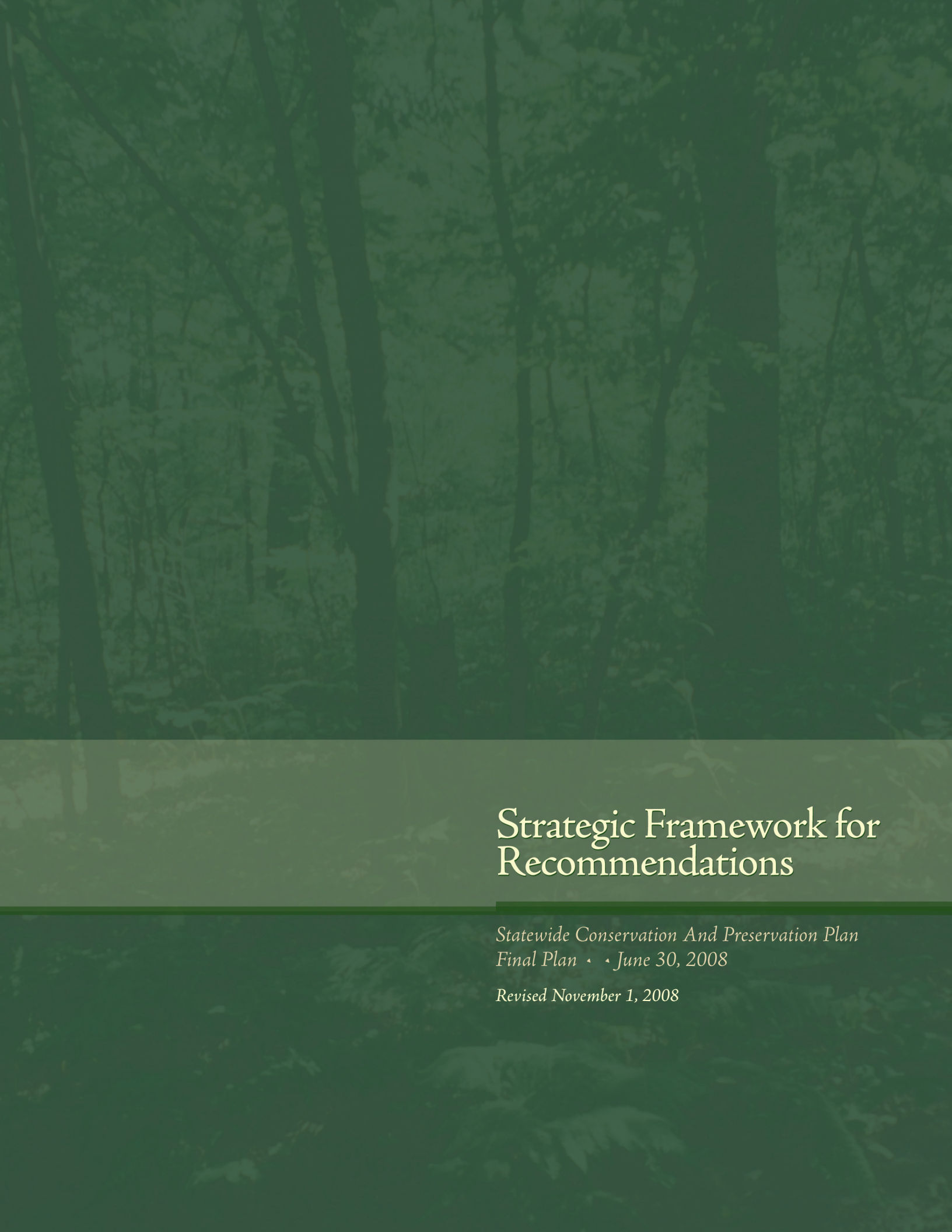
	Drivers of Change							
Recommendation	Habitat Degradation/ Fragmentation	Habitat Loss	Invasive Species	Recreational Pressure/ For Habitat Recs - Wildlife Persecution/ Overexploitation	Dissolved Oxygen	Temperature	Fish Stocking	Disease
Habitat 1	H	H	M	M	L	L	L	M
Habitat 2	M	H	M	L	M	M	L	L
Habitat 3	H	H	M	L	L	L	L	L
Habitat 4	H	H	H	L	H	H	M	M
Habitat 5	H	H	M	M	M	M	L	L
Habitat 6	M	H	M	L	H	H	H	M
Habitat 7	H	H	M	L	M	M	M	L
Habitat 8	M	L	M	L	L	H	L	L
Habitat 9	M	M	H	L	M	M	M	H
Habitat 10	L	M	L	L	M	M	L	L
Habitat 11	M	L	L	L	L	M	L	L
Habitat 12	H	H	M	L	L	M	L	M
Habitat 13	H	H	H	H	M	M	M	M
Land Use 1	H	H	M	M				
Land Use 2	H	M	L	M				
Land Use 3	M	L	L	L				
Land Use 4	M	M	n/a	n/a				
Land Use 5	L	M	n/a	n/a				
Land Use 6	L	M	n/a	n/a				
Land Use 7	L	L	n/a	n/a				
Land Use 8	H	H	H	H				
Land Use 9	M	H	M	M				
Land Use 10	M	H	H	M				
Trans 1	M	M	M	M				
Trans 2	M	M	L	L				
Trans 3	H	H	L	L				
Energy 1	M	M	M	M				
Energy 2	H	H	M	L				
Energy 3	H	H	L	L				
Energy 4	M	M	L	L				
Energy 5	M	M	M	M				
Energy 6	L	L	L	L				
Energy 7	L	L	L	L				
Energy 8	L	L	L	L				
Energy 9	L	L	L	L				
Energy 10	L	L	L	L				
Energy 11	L	M	M	L				
Energy 12	M	M	M	L				
Energy 13	M	M	L	L				
Energy 14	L	L	L	L				
Energy 15	L	L	L	L				
Energy 16	L	L	L	L				
Energy 17	L	L	L	L				
Energy 18	L	L	L	L				
Energy 19	L	L	L	L				
Energy 20	L	L	L	L				
Energy 21	L	L	L	L				
Energy 22	L	L	L	L				
Energy 23	L	L	L	L				
Energy 24	L	L	L	L				
Energy 25	L	L	L	L				

H = High effect

M = Medium effect

L = Low effect

Figure 4. Assessment of recommendations' effect on drivers of change



Strategic Framework for Recommendations

Statewide Conservation And Preservation Plan
Final Plan • • June 30, 2008

Revised November 1, 2008

Strategic Framework for Recommendations

This document presents an integrated strategic framework (Figure 5) for a Minnesota Statewide Conservation and Preservation Plan (SCPP), which consists of a series of recommendations for the state to consider in holistic fashion. The recommendations are designed to conserve and protect Minnesota's natural resources in a comprehensive approach, while being mindful of demographic change, public health, the state's economy, and climate change. The final plan was constructed by identifying **drivers of change** affecting natural resources, assessing the **impacts** of these drivers, and mapping the impacts to **key issues**. The seven key issues identified in the preliminary plan are those that, when addressed, would have the largest and most beneficial impacts on multiple resources. The preliminary plan contains the details of the drivers of change, the assessment of impacts, and the key issues. The **recommendations** in this final plan were developed to address a selection of these key issues, which were then further assessed for their **integrated impact** across all natural resource values. This allowed us to place the recommendations in a framework having **five main strategic areas**, with **recommendations for action or policy change** being placed within these areas. We also have identified recommendations for expanding our **knowledge infrastructure**. By this we mean actions or activities, including research, monitoring, data collection, and education, that will enhance our knowledge and support the recommendations for action or policy change.

Figure 6 shows the **action or policy change recommendations** for each of the final plan key issues, arranged according to the degree of integrated benefits across all the natural resource values. This gives an overall snapshot of how much integrated value a given recommendation provides. For example, the first recommendation under the key issue of Habitat Loss has significant impact across the majority of the resource values, and has little impact on air quality and human health. This figure also identifies which recommendations benefit a given resource value the most. For example, the Habitat recommendations have the most impact on biodiversity.

The strategic framework is shown in Figure 5. The five strategic areas are identified at the top of the five boxes, and the recommendations are listed within the boxes. The action or policy change recommendations are at the top, with the recommendations having the broadest impact across multiple resources listed first, followed by those that are more targeted or specific in their scope. Recommendations for building the knowledge infrastructure for that strategic area are at the bottom of the box. These are ordered according to the key issue they address.

This framework is a comprehensive and integrated environmental strategic plan. The recommendations taken together provide a holistic look, and are not meant to be viewed in isolation or to be acted on in a piecemeal fashion. Each of the strategic areas is discussed below.

Integrated Planning

Natural resource management is interwoven within a larger fabric of economic health, complex regulatory frameworks, human health, and changing demographics and climate. No one agency can address this comprehensively, nor can it be done in individual agency stovepipes. In addition, there are multijurisdictional responsibilities on the geographic scale, from communities, to small units of government, to soil and watershed districts, to statewide agencies.

Planning, whether for transportation, energy, community development, water resources, agriculture, or forestry, should be integrated across all agencies and across the multijurisdictional scale. Doing so can make planning more efficient by removing redundancies. Our strongest, most effective federal environmental laws require cross-agency review or partnership, and this approach should be embraced on the state level for holistic natural resource protection.

Critical Land Protection

Be it farmland, wetlands, greenways in urban areas, or forestland, a clear and comprehensive strategy must be developed that establishes long-term and short-term acquisition priorities. An array of perspectives should inform this strategy, integrating needs for biodiversity protection, critical agricultural land protection, ecological services, recreational opportunities, and opportunities for climate change adaptation and/or mitigation.

This strategy should build on the excellent work already accomplished by state agencies, local governments, and the work of nonprofit land conservation organizations, among others.

Land and Water Restoration and Protection

This strategic area addresses both the restoration of critical land and water habitat and the protection of strategic land and water habitat that has not yet been degraded. It not only addresses the inherent and intrinsic direct benefits of habitat restoration and protection, but also emphasizes the benefits of such strategy for strengthening biodiversity and enhancing resilience to climate change. The recommendations in this area reinforce and strengthen Minnesota's cultural values, ethics, appreciation of outdoor recreation, and economic health.

Sustainable Practices

A healthy environment requires a healthy economy, and a sustainable economy requires a sustainable environment. To reach both goals, we must promote, facilitate, encourage, and regulate appropriate practices that will lead to a sustainable environment and economy. These sustainable practices must cross multiple fronts—sustainable agriculture, sustainable land use planning, sustainable forestry, sustainable water resources, and sustainable economy and standard of living—all in the context of energy production, shifting demographics, and climate change.

Economic Incentives for Sustainability

Moving toward sustainable practice requires specific incentives to move the state and its citizens and stakeholders in a transformative direction. Broad-scale ideas exist for achieving a sustainable economy through natural resource policy: Specific natural resource policy, energy policy, agricultural policy, forestry policy, and transportation policy can be used to grow and nurture Minnesota's economic future.

Section 4 contains detailed descriptions of the recommendations assessed and placed in the strategic framework.

Knowledge Infrastructure

Additional research, monitoring, data collection, and education will be necessary to support the action and policy recommendations for integrated planning, critical land protection, land and water restoration and protection, sustainable practices and economic incentives for sustainability. With continual improvement in our knowledge infrastructure, action and policy will become more effective and precise over time.

Strategic Framework For Integrated Resource

INTEGRATED PLANNING IP		CRITICAL LAND PROTECTION LP		LAND AND WATER RESTORATION AND PROTECTION RP	
Rec. No.	**Broad Policy and Action Recommendations**	**Rec. No.**	**Broad Policy and Action Recommendations**	**Rec. No.**	**Broad Policy and Action Recommendations**
E1	Develop coordinated laws, policies and procedures across state agencies	**H2**	Protect critical shorelands of streams and lakes	**H4**	Restore and protect shallow lakes
LU1	Fund and implement a state Land Use Development and Investment Guide	**H1**	Protect priority land habitats	**H5**	Restore land, wetlands, and wetland-associated watersheds
LU2	Support local and regional conservation-based community planning	**LU8**	Protect large blocks of forest land	**H6**	Protect and restore critical in-water habitat of lakes and streams
T1	Align transportation planning across all agencies; streamline and integrate environmental transportation project review				
E23	Develop mercury reduction strategies for out-of-state sources				
Rec. No.	**Targeted Policy and Action Recommendations**	**Rec. No.**	**Targeted Policy and Action Recommendations**	**Rec. No.**	**Targeted Policy and Action Recommendations**
LU3	Ensure protection of water resources in urban areas	**E2**	Invest in farm and forest preservation to prevent fragmentation due to development	**LU5**	Reduce streambank erosion through reduction in peak flows
T3	Develop and implement transportation polices that minimize impacts on natural resources	**H3**	Improve connectivity and access to recreation	**LU6**	Reduce upland and gully erosion through soil conservation practices
Rec. No.	**Knowledge Infrastructure Recommendations**	**Rec. No.**	**Knowledge Infrastructure Recommendations**	**Rec. No.**	**Knowledge Infrastructure Recommendations**
LU2C	Provide communities with the tools and technical assistance for conservation-based planning	**H9**	Invest in overall research on land and aquatic habitats	**H10**	Invest in research on near-shore aquatic habitat vulnerability
E24	Continue state enforcement programs to reduce mercury contamination of the environment	**T3A**	Develop research programs in habitat fragmentation	**H11**	Improve understanding of groundwater resources
LU3B	Simplify modeling for TMDLs	**LU9**	Assess tools for forest land protection	**LU5A**	Invest in research that quantifies the relationship between artificial drainage and stream flows
LU3C	Monitor TMDL BMP implementation			**H12**	Improve understanding of watershed responses to multiple drivers of change
LU2D	Invest in databases and tools needed to support land use and conservation decisions			**E11**	Invest in research and enact policies to protect existing prairies from genetic contamination
LU2A	Fund demonstration projects for conservation-based community planning			**LU10E**	Develop and test new management policies to test ecosystem resilience
				H13	Encourage conservation education and training programs for all MN citizens
				E12	Invest in efforts to develop sufficient seed stocks for large scale plantings of perennial crops
				LU3D	Expand water quality media campaign

Figure 5. Strategic framework for integrated resource conservation and preservation

Conservation And Preservation

SUSTAINABLE PRACTICES SP

ECONOMIC INCENTIVES FOR SUSTAINABILITY ES

Rec. No.	Broad Policy and Action Recommendations				
LU10	Support and expand sustainable practices on working forested lands				
H7	Keep water on the landscape				
H8	Review and analyze drainage policy (ditch laws)				
T2	Reduce per capita vehicle miles of travel				
Rec. No.	**Targeted Policy and Action Recommendations**	**Rec. No.**	**Targeted Policy and Action Recommendations**	**Rec. No.**	**Targeted Policy and Action Recommendations**
E13	Invest in research and policies for "green payment" program	E19	Promote policies and strategies to implement smart meter and smart grid technologies	E16	Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power and renewable electricity production
E17	Promote policies and incentives that encourage C-neutral businesses, homes, communities, and other institutions	E20	Develop incentives to encourage widespread adoption of passive solar and shallow geothermal heat pumps in new construction	E21	Develop standards and incentives for energy capture from municipal sanitary and solid waste, and minimize landfill options
LU4/E4	Transition renewable fuel feedstocks to perennial crops	E15	Invest in efforts to develop community-based energy platforms	E14	Investigate opportunities to provide tax incentives for individual renewable energy investors
E18	Implement policies and incentives to lower energy use of housing stock				
Rec. No.	**Knowledge Infrastructure Recommendations**	**Rec. No.**	**Knowledge Infrastructure Recommendations**	**Rec. No.**	**Knowledge Infrastructure Recommendations**
E3	Invest in perennial biofuel crop research and demonstration projects on a landscape scale	E22	Invest in public education focusing on benefits and strategies for energy conservation		
E6	Invest in research to determine removal rates of corn stover and to establish incentives and BMPs	E25	Develop public education on actions that individuals and communities can take to reduce mercury contamination of the environment		
E7	Invest in research to review thermal flow maps	LU7	Invest in statewide high resolution digital elevation data, watershed delineation, maps of artificial drainage network, and other data to support decision making		
E8	Invest in applied research to reduce energy and water consumption and emissions in ethanol plants	LU10B	Educate landowners and forest managers on BMPs to protect working forests		
E9	Invest in research to determine the life cycle impacts of renewable energy production systems				
E10	Invest in research and demonstration projects to develop, and incentives to promote, combination electricity production projects				
T3B	Reduce non-point source pollution to surface and ground waters from transportation infrastructure				
LU4A	Invest in research on parameters that control successful perennial feedstocks				
E5	Invest in data collection to support energy production assessment				

Note: Recommendations having the broadest impact across multiple resources are listed first in each column followed by those having more targeted impact, and supported by knowledge infrastructure recommendations.

Figure 6. Natural resource values assessment of recommendations

Natural Resource Values Assessment of Recommendations

LEGEND: ● = Critical Impact ◑ = Significant Impact ○ = Negligible Impact

	Number	Recommendation	Air Quality	Water Quality/Quantity	Terrestrial Habitat Quality	Soil/Land Quality	Human Health	Biodiversity	Community Health	Aquatic Economic Health	Recreational/Cultural/ Spiritual/Aesthetic Value	Climate Change Mitigation/Adaptation
HABITAT	H2	Protect critical shoreland of streams and lakes	○	●	●	●	○	●	●	●	●	●
	H1	Protect priority land habitats	○	●	●	●	○	●	●	◑	●	●
	H4	Restore and protect shallow lakes	○	●	●	◑	○	●	●	●	●	◑
	H5	Restore land, wetlands and wetland-associated watersheds	○	●	◑	◑	◑	●	●	◑	●	●
	H6	Protect and restore critical in-water habitat of lakes and streams	○	●	◑	◑	◑	●	●	◑	●	●
	H7	Keep water on the landscape	○	●	◑	●	○	●	●	◑	◑	●
	H8	Review and analyze drainage policy (ditch laws)	○	●	◑	●	○	◑	●	◑	◑	●
	H3	Improve connectivity and access to recreation	○	○	◑	○	●	◑	○	●	●	○
LAND USE	LU1	Fund and implement a state Land Use Development and Investment Guide	◑	●	●	◑	◑	◑	●	●	●	●
	LU2	Support local and regional conservation-based community planning	◑	●	●	◑	◑	◑	●	●	●	●
	LU3	Ensure protection of water resources in urban areas	○	●	○	◑	○	◑	●	◑	◑	◑
	LU4/E4	Transition renewable fuel feedstocks to perennial crops	○	●	◑	●	○	◑	●	●	◑	●
	LU5	Reduce streambank erosion through reduction in peak flows	○	●	◑	●	○	◑	●	◑	◑	◑
	LU6	Reduce upland and gully erosion through soil conservation practices	○	●	◑	●	○	◑	●	◑	◑	◑
	LU8	Protect large blocks of forest land	○	◑	●	●	○	●	◑	●	●	●
	LU10	Support and expand sustainable practices on working forested lands	○	◑	●	●	○	●	◑	●	●	●
TRANSPORTATION	T1	Align transportation planning across all agencies; streamline and integrate environmental transportation project review	●	◑	◑	◑	●	◑	◑	●	●	●
	T2	Reduce per capita vehicle miles of travel	◑	◑	◑	○	◑	○	○	◑	◑	●
	T3	Develop and implement transportation polices that minimize impacts on natural resources	○	●	◑	○	○	◑	●	◑	◑	◑
ENERGY	E1	Develop coordinated laws, policies and procedures across state agencies	◑	●	●	●	◑	◑	●	●	◑	●
	E13	Invest in research and policies for "green payment" program	○	●	●	●	○	●	●	○	◑	●
	E17	Promote policies and incentives that encourage C-neutral businesses, homes, communities and other institutions	●	◑	◑	◑	◑	◑	◑	●	◑	●
	E2	Invest in farm and forest preservation to prevent fragmentation due to development	○	◑	●	●	○	◑	◑	◑	◑	◑
	E18	Implement policies and incentives to lower energy use of housing stock	◑	◑	○	○	●	○	◑	●	◑	●
	E16	Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power and renewable electricity production	●	◑	○	○	●	○	○	◑	○	●
	E21	Develop standards and incentives for energy capture from municipal sanitary and solid waste, and minimize landfill options	◑	◑	○	○	◑	○	◑	◑	◑	◑
	E19	Promote policies and strategies to implement smart meter and smart grid technologies	◑	○	○	○	◑	○	○	●	◑	●
	E14	Investigate opportunities to provide tax incentives for individual renewable energy investors	◑	◑	○	○	◑	○	○	◑	○	●
	E20	Develop incentives to encourage widespread adoption of passive solar and shallow geothermal heat pumps in new construction	◑	◑	○	○	◑	○	○	◑	○	●
	E15	Invest in efforts to develop community-based energy platforms	○	◑	○	○	○	○	○	●	◑	◑

Note: Policy and action recommendations are grouped by topic (Habitat, Land Use, etc.) and then ordered starting with those recommendation having the broadest impact across multiple resource values followed by those having more targeted impact.

Recommendations

Statewide Conservation and Preservation Plan
Final Plan June 30, 2008

Revised November 1, 2008

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The following icons are used throughout the plan to quickly identify recommendations by type:

Integrated Planning Recommendations

Critical Land Protection Recommendations

Land and Water Restoration and Protection Recommendations

Sustainable Practices Recommendations

Economic Incentives for Sustainability

Habitat

Recommendations

Introduction

Habitat fragmentation, degradation, and loss are of concern for nearly all landscapes and watersheds of Minnesota, ranging from prairies, forests, and wetlands to lakes, streams, and rivers. The preliminary Statewide Conservation and Preservation Plan (SCPP) summarized the major human activities that drove negative changes between European settlement and the present and that continue to be a challenge. The preliminary plan also identified land and aquatic habitat degradation and loss as a driver of negative change to six resource categories: land, wildlife, water, fish, air and outdoor recreation. Thus, habitat problems are both a cause and consequence of drivers of change. The preliminary plan concluded that habitat issues are arguably the most important issues facing the conservation and preservation of natural resources throughout Minnesota.

The habitat team developed its recommendations based on a fundamental understanding that multiple drivers of change are combining their negative effects at landscape and watershed scales. This is true throughout Minnesota, although the details vary across ecological regions, depending on the dominant drivers and the kinds of native habitats within landscapes and watersheds of the region. The habitat team thus conducted a statewide but regionally specific habitat analysis.

Conserving Minnesota's rich diversity of wildlife, fish, plants, and habitats for the enjoyment of future generations requires an integrated approach. Integrated approaches would address multiple drivers of change together and within and across entire landscapes and watersheds.

Habitat Loss, Degradation, and Fragmentation

Habitat loss refers to the complete eradication of a parcel of habitat, such as conversion of native wetlands, lake and stream shoreline plant communities, prairies, forests, or brushlands to agricultural, residential, or industrial uses. **Habitat degradation** occurs when the habitat is still present but its value to native plant, wildlife, and aquatic communities has been impaired or changed significantly. For example, wildlife habitats in urban and exurban developments retain some but not all important natural characteristics, so that some wildlife species can persist while others disappear or greatly decline. In lakes, near-shore habitats (needed by many aquatic species for breeding and juvenile rearing) become degraded when too much native vegetation is removed from shorelines and woody debris and aquatic plants are removed from near-shore waters. **Habitat fragmentation** is the breakup of large contiguous areas of habitat into smaller and smaller parcels and fragments. The fragments are no longer close enough or sufficiently connected to allow fish, wildlife, and other native organisms to move freely among habitats in order to use optimal breeding and rearing sites. For example, road construction can fragment prairie, wetland, brushland, or forest; low-head dams in rivers and various water control structures in lakes disrupt natural movements of fish and amphibians. Habitat fragmentation may degrade the genetic capacity of wild populations to adapt to future environmental change because it fragments larger populations—which harbor more genetic variation—into smaller breeding groups. A cumulative effect of habitat loss, degradation, and fragmentation is large declines in abundance and productivity of wild populations, threatening their ability to adapt to future environmental changes and to persist for the enjoyment of future generations.

It will be a tremendous challenge to shift from many separate habitat conservation efforts to more integrated approaches. Most terrestrial habitat efforts stress protection of individual species and the specific habitats they require. Most aquatic habitat efforts stress protecting ecological processes, and thus certain habitat features. But we need to strategically integrate both approaches. Integration is also needed because many actions on land can affect both land and aquatic habitats, especially in shorelands of lakes, streams, rivers, and wetlands. The habitat team has therefore developed a set of recommendations designed to foster a more integrated approach that will benefit habitats in all regions of the state.

Habitat recommendations were designed to strategically prevent, reduce, or reverse the harmful effects of multiple drivers of change. Figure 4 shows the relationship between the recommendations and their potential to prevent or reverse problems due to drivers of change defined in the Preliminary Plan.

Habitat recommendations fall under four strategic areas:

I. **Critical Land Protection**—to resist or reduce further loss and degradation of habitats by counteracting or stopping the most direct drivers of change

II. **Land and Water Restoration and Protection**—to reverse some of the past damage to habitats, focusing strategically on actions that benefit multiple natural resources and increase adaptation to climate change and other environmental changes, which are inherently hard to predict

III. **Sustainable Practice**—to resist further habitat degradation in agricultural, forested, and developed landscapes, while continuing economic benefits from working landscapes and watersheds

IV. **Knowledge Infrastructure**—to conduct priority research that will complement adaptive conservation and management of habitats, and to educate all citizens about the critical need to protect and restore landscapes and watersheds across the state.

The habitat team also endorses the state land use, development, and investment guide recommendation by the land use team, but is not repeating it here.

Climate Change Adaptation

Conservation and preservation of Minnesota's living natural resources must now include adaptation to a certain amount of climate change (see Appendix IV). Numerous scientific studies indicate that modern civilization needs to dramatically reduce human sources of greenhouse gas (GHG) emissions in order to avoid truly dangerous levels of climate change. Assuming we meet this grand challenge, Minnesota's climates and water bodies will still continue to warm over the next 50 to 100 years because of inertia in the earth's climate system. This makes it urgent to accelerate the pace and scale of protection and restoration of priority landscapes and watersheds within each ecological region of the state. Protection and restoration of functional habitats will maximize chances that Minnesota's biodiversity—its plants, wildlife, fish, amphibians, and other organisms—can adapt to climate changes within our state or through range shifts northward.

Recent research suggests that climate change will alter most landscapes and watersheds in Minnesota, although scientists cannot fully predict the exact nature of alterations to specific habitats (see Appendix IV). For example, current understanding is that most wetland ecosystems of Minnesota will likely have shorter wet periods, probably leading to major changes in plant communities and possibly favoring the spread of invasive species. For another example, many existing forests may become savannas, with forests restricted to cooler, wetter refuges. The northernmost boreal forest will likely be lost from Minnesota and shift northeastward, while cold-temperate deciduous forests may persist only on north slopes in northern Minnesota.

Climate change also has the potential to exacerbate existing stressors on aquatic communities in Minnesota. Protection and restoration of in-lake and in-stream habitats will ensure resilience of Minnesota's valued aquatic communities as climate change unfolds. Various studies suggest increased evaporation, greater extremes between wet and dry periods, changing stream-flow patterns, longer growing seasons, increased storm frequency causing greater runoff, and warming water temperatures. These changes, in turn, will exacerbate existing negative effects of degraded and lost aquatic habitats on fish, wildlife, and entire aquatic communities.

Mapping Habitat Quality: Methods and Results

The primary goal of habitat mapping is to collate the available information for Minnesota that can be used to prioritize important areas for conservation (protection, acquisition, and restoration) by integrating both positive (resources) and negative (threats to resources) information on biodiversity, habitat quality, outdoor recreation (e.g., hunting and fishing), and water quality. Positive components include features such as known occurrences of rare species, sites of biodiversity significance, or high levels of game species abundance, while negative components include the dominant drivers of environmental change as identified in the preliminary plan of the SCPP. Negative influences on natural resources include such information as human development, land use, and road density. By acquiring and objectively processing information related to these components, it is possible to rank areas in Minnesota according to their conservation priority.

The habitat analyses for the statewide plan are unique for several reasons. First, the habitat team comprised the major natural resource management agencies in the state, including several divisions of the Department of Natural Resources (DNR), Minnesota Pollution Control Agency (MPCA), Board of Water and Soil Resources (BWSR), Minnesota Department of Agriculture (MDA), and others. This provided us with access to not only the most comprehensive and up-to-date statewide data sets, but also a wealth of expert knowledge, particularly as they relate to current issues facing the state. Second, the analyses were highly integrated: Suites of habitat and stressor layers were combined using an additive modeling approach. This allowed us to generate composite maps of critical terrestrial and aquatic habitat that integrate across taxa and habitats, providing a weight-of-evidence approach to the habitat rankings. Similarly, we were able to integrate data layers describing the fundamental drivers of change, using factors such as land use, population and road density, and others, to describe how environmental stressors, individually and cumulatively, are spatially distributed across the state. Finally, the intersection of high-quality terrestrial and aquatic habitat with the composite environmental risk map identifies regions of the state where critical habitats are most at risk (Figures H7 and H15). To our knowledge, there have been few, if any, other statewide conservation plans that have been able to conduct this kind of comprehensive assessment across the spectrum of natural resources.

High-resolution data were used in this study; most of the data were derived or gridded to 30- meter cells, the native resolution of the Landsat satellite imagery used for many of the statewide land-cover classification and subsequent habitat analyses. These data were summarized, however, by township (terrestrial data, Figure H16) or lakeshed (watersheds surrounding lakes, Figure H15). There are multiple reasons for aggregating data to these scales. First, the terrestrial habitat analysis parallels the work of the state wildlife plan, which also summarized data by township. Also, this resolution improves the ability to print habitat maps at a statewide scale. But most importantly, the objective of these analyses is to identify the general areas across the state with

high conservation value, based on statewide data. For explicit land acquisition or planning purposes, it would be necessary to conduct more specific analysis and use the most detailed information that is available for that specific area. The results presented below should be considered a regional roadmap to conservation planning.

Analysis of Terrestrial Habitat

Twelve terrestrial data sets were identified and compiled from a variety of sources (Table H1; Figures H2 through H7; H16). Each of these data sets was identified as important by the habitat team and was, to the degree possible, available statewide.

Each of these data sets has an important influence on the conservation value of a piece of land. The spatial data layers were combined to produce an integrated map (Figure H7). All input maps had 30-meter spatial resolution, but the final integrated map is presented at a township scale. Some of these factors were binary- for example, land is either in or out) of the conservation reserve program (CRP, Figure H4). Others, like sites of biodiversity significance (SOBS, Figure H2), are mapped in classes, such as medium, high, and outstanding. These were converted to ranks such as 0, 1, 2, and 3, where 0 is used for land not mapped as SOBS. Other factors had continuous numeric ranges. For example, bird habitat models may record the probability of a species occurring at a location as a number between 0 and 100. Seventeen such models were added together so that any given piece of land may score between 0 and a theoretical maximum of 1,700.

All of the variables were normalized (i.e., the minimum value of a given data set was subtracted from all values in the data set, and the resulting values were divided by the difference between the minimum and maximum values in the data set). This has the effect of changing all values into a 0 to 1 range. A data set that had contained values of 0, 1, 2, and 3 would now contain values of 0, 0.33, 0.66, and 1, and a data set originally ranging from 0 to 1,700 would have values ranging from 0 to 1, where a value of 0.5 would correspond to 850. Normalizing the values in this way makes it possible to map their combined effects simply by adding them up for any given piece of land. Before this was done, however, weightings were collected by survey from habitat team members to reflect the relative importance of different data sets. For a given piece of land, for example, the integrated value depends 33% on its SOBS class, 5% on its CRP status, and 4% on its housing density in 2000 (Table H1). The SOBS data set was weighted more heavily because it is based on a number of data layers.

At a broad spatial scale, three regions received low priority scores (light areas in Figure H7) due, in part, to data gaps in the SOBS layer: the Red Lake region, northern St. Louis County, and southern Minnesota along the Iowa border near Austin. In the case of the two northern areas, an attempt was made to include surrogate data such as peatland wildlife management areas and peatland scientific and natural areas. Data for the southern data gap region should be available in mid-late 2009. The Red River and Minnesota River valleys also received low-priority scores, presumably due to extensive land conversion to agriculture. Other areas received low scores due to more local patterns of human development and habitat quality.

The Boundary Waters Canoe Area Wilderness (BWCAW) is the most obvious broad region of high conservation priority (indicated by dark shading in Figure H7); this area also is currently well protected. Other broad areas receiving high conservation priority include the North Shore of Lake Superior, the St. Croix River Valley, the region north of Willmar, and the blufflands of southeastern Minnesota.

Input	Weighting	Description
SOBS	33	A multifaceted assessment of this land for its importance from a regional perspective in terms of biodiversity and ecosystem function. Higher values indicate higher biodiversity significance.
DNR GAP terrestrial vertebrate models—game species	7	The number of game species for which this land may be habitat. Higher values indicate higher numbers of game species potentially using this land.
DNR GAP terrestrial vertebrate SGCN models	10	The number of species of greatest conservation need (SGCN) for which this land may be habitat. Higher values indicate higher numbers of SGCN potentially using this land.
Bird potential habitat models—USFWS	9	Probable number of bird species (from a set of 17) using this land. Higher values indicate more species.
DNR GAP habitat by protection level	8	Number of terrestrial vertebrate species potentially using this land weighted by the current level of habitat protection statewide for each species. Higher values indicate more species potentially using this land.
Wildland- urban interface	6	Wildland-urban interface maps' initial encroachment of development into areas of largely intact natural cover. Decisions made here determine whether natural areas are preserved or pressured. Higher values indicate land classified as wildland urban interface (yes/no).
Wildland- urban intermix	5	Wildland-urban intermix maps' intermixing of development and significant natural cover. Connectivity can be maintained or lost by decisions made in these areas. Higher values indicate land classified as wildland urban intermix (yes/no).
CRP lands	5	Lands enrolled in the CRP (yes/no).
Road density	5	A measure of the density of roads within the township. Major roads receive a higher weighting. Higher values indicate higher density of roads in the township.
Housing density 2000	4	Housing density from census data (census blocks) for 2000 for this land. Higher values indicate higher housing density.
Projected housing density 2030	4	Projected housing density by census blocks for 2030 for this land. Higher values indicate higher projected housing density.
Housing density change 2000 to 2030	5	Projected change in housing density by census blocks for 2000 to 2030 for this land. Higher values indicate an increase in housing density.

Table H1. Input data sets and weightings for terrestrial habitat analyses. Credit: Terry Brown and Nick Danz, NRRI.

Input	*Weighting (Maximum Statewide Score)*	*Description*
Key rivers	3	Key rivers from *Tomorrow's Habitat for the Wild and Rare (Minnesota Department of Natural Resources 2006a)*, buffered 300 feet both sides
Wetland communities	3	MCBS wetland native plant communities–areas of high-quality habitat for plants and animals
Trout streams	2 (3 in NSU)	Designated trout streams, buffered 300 feet both sides
Trout lakes	2 (3 in NSU)	DNR lakes containing lake trout or stream trout (rainbow, brook, brown, and splake)
The Nature Conservancy (TNC) lakes	2	TNC portfolio lakes with a high ranking
Lakes with sturgeon, walleye, and cisco	2 (3 in NSU, DLP, MOP)	DNR fisheries–lakes with long-lived fish or self-sustaining walleye populations
All water and wetlands	1	All open water and wetlands
Wetland habitat analysis	3	
Shallow lakes	2	DNR shallow lakes program
Wildlife lakes	3	DNR Wildlife
Waterfowl lakes	3	DNR Wildlife
Wild rice lakes	2	DNR Wildlife

Table H2. Input data sets for aquatic habitat analyses. Credit: DNR, NRRI.

Analysis of Aquatic Habitat

Twelve data sets that describe the quality of aquatic habitats were identified by habitat team members and compiled from a variety of sources. Each of these data sets met the criteria of being important for some aspect of aquatic habitat quality and being available statewide. (Table H2, Figure H8). The data sets included various lake types, streams, rivers, and wetland communities.

As in the terrestrial analysis, spatial data layers were combined to produce an integrated map (Figures H8 and H9). All input maps had 30-meter spatial resolution, but the final integrated map was summarized by lakeshed, a watershed-type classification identifying the drainage areas associated with individual lakes (Figure H15). Lakesheds were aggregated to HUC12 resolution, which is comparable with the township-scale analyses used for terrestrial habitat. There are 2,746 HUC12 lakesheds in the state, compared with 2,543 townships.

Input	*Description*	*Source Data*
Population density	Census block population data, gridded to 30 m and summarized by HUC12 lakeshed	US Census 2000
Road density	A measure of the density of roads summarized by HUC12 lakeshed. Major roads receive a higher weighting. Higher values indicate higher density of roads in the township.	MnDOT
% agriculture	Percent agricultural land use within the HUC12 lakeshed.	MN GAP Land Use
% urban	Percent urban land use within the HUC12 lakeshed.	MN GAP Land Use
% invasives (lakes)	Combined analysis of DNR fisheries, shallow lakes program, and ecological services aquatic vegetation surveys	NRRI composite of DNR aquatic vegetation surveys (Reschke et al 2005)

Table H3. Input data sets for aquatic environment stressors. Credit: NRRI.

Each aquatic habitat (lake, river, and wetland) in each data layer listed in Table H2 was assigned a habitat value of 1 to 3 (1 = moderate habitat value, 2 = good habitat value, 3 = outstanding habitat value). As in the terrestrial analysis, values were summed to generate an integrated score across layers; possible values ranged from 0 to 18. Values of 0 (not aquatic habitat) were removed from the database, and remaining nonzero values were averaged for each HUC12 lakeshed.

A number of environmental stressors to aquatic ecosystems were also summarized (Table H3; Figures H10 through H14). To map aquatic quality against environment stress, ArcMap's quantile classification was used to divide the composite aquatic habitat and stressor fields into three classes, representing low, medium, and high habitat quality or environmental stress, respectively. For visualization purposes, we created a series of nine unique categories to represent possible combinations of habitat quality and stress (Figure H15). Lakesheds with the combination of high habitat quality and high stress represent critical areas for conservation or preservation.

Data Interpretation

Analyses should be interpreted on the basis of ecological subsections. Subsections are designated regions of the state that are relatively homogeneous in terms of soils, geology, climate, and dominant native plant community, and ecologically distinct from other subsections. Minnesota is divided into 24 subsections (Figure H1), which have been used alone or in combination for regional planning efforts, such as DNR subsection forest resource management plans. Assessing critical habitats by subsection will ensure that (1) future conservation efforts are able to focus on the unique resources and drivers of change affecting a particular region, and (2) critical aquatic and terrestrial habitats identified in this analysis are equitably distributed across the state. Figure H16 illustrates vulnerable terrestrial habitat prioritized within each ecological subsection.

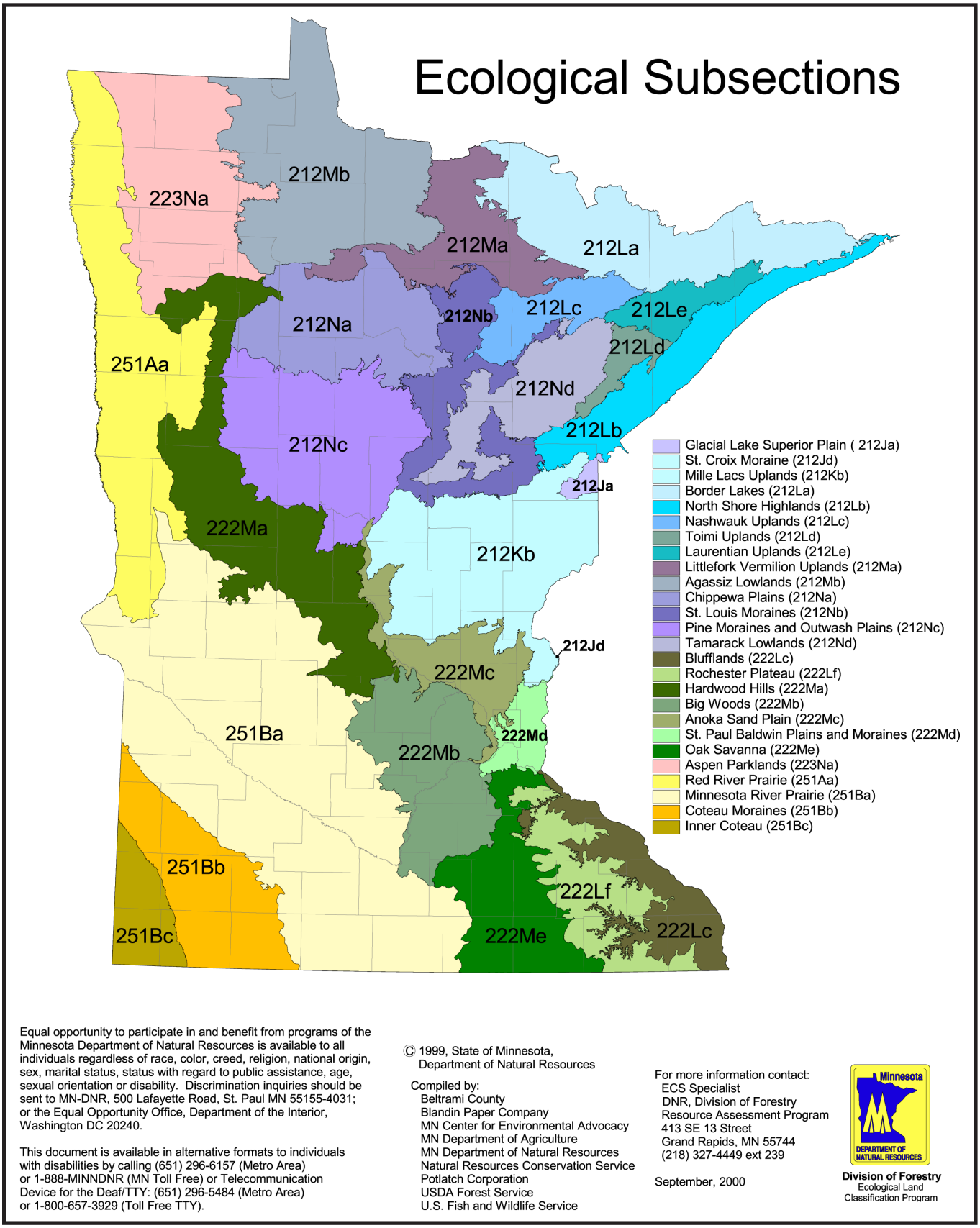


Figure H1. Minnesota Ecological Subsections. Credit: DNR.

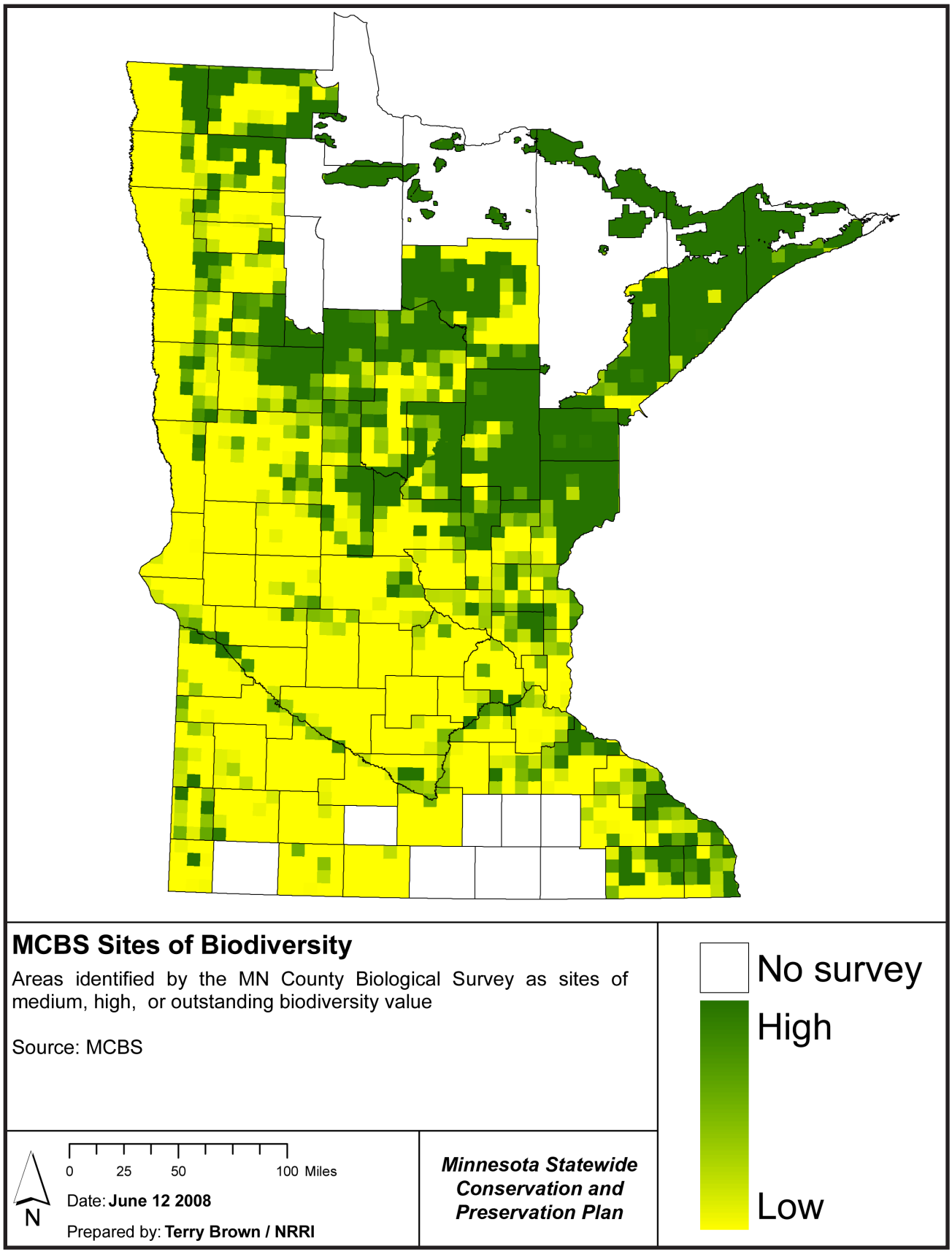


Figure H2. MCBS sites of biodiversity. Credit: Terry Brown, NRRI.

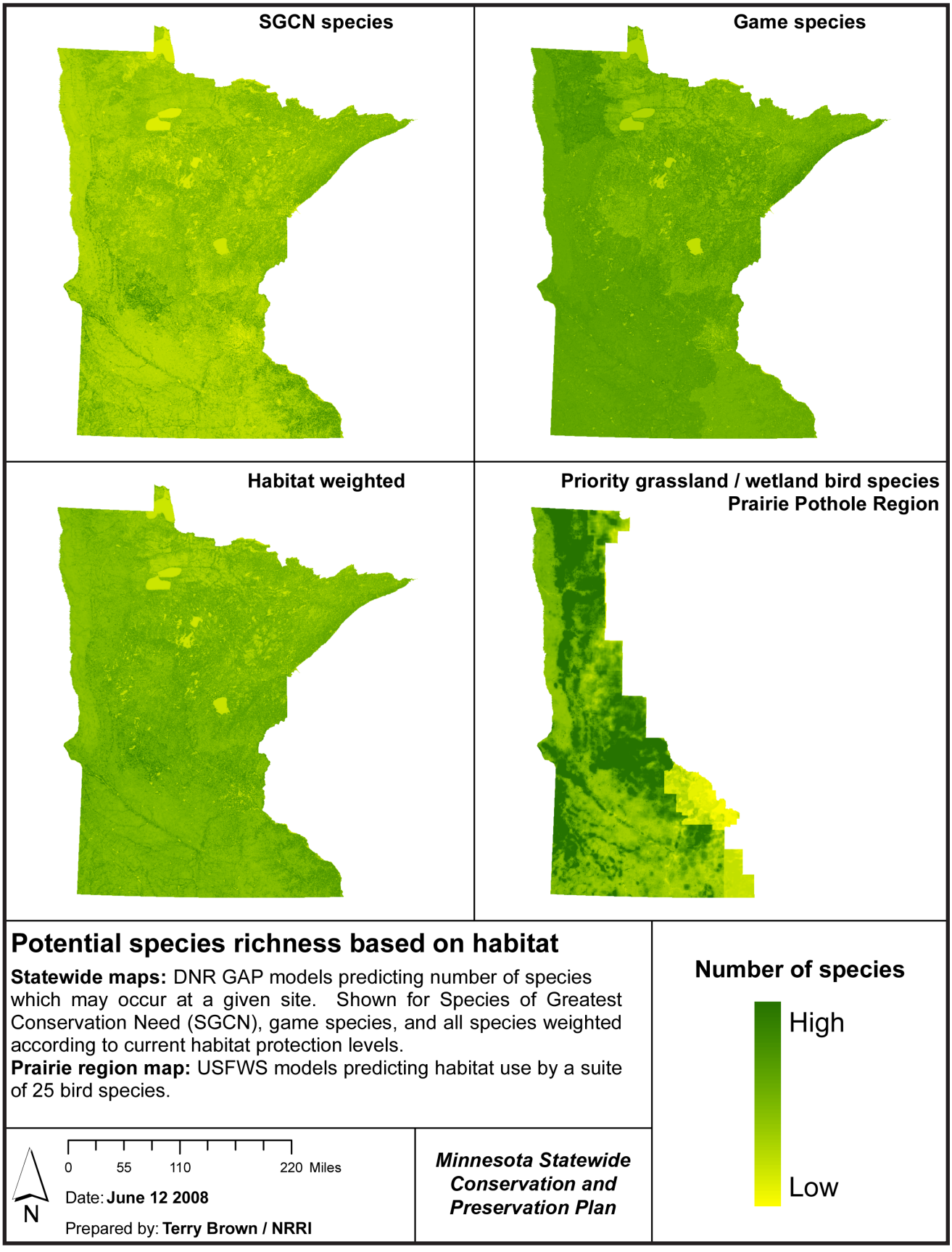


Figure H3. Potential species richness based on habitat. Credit: Terry Brown, NRRI.

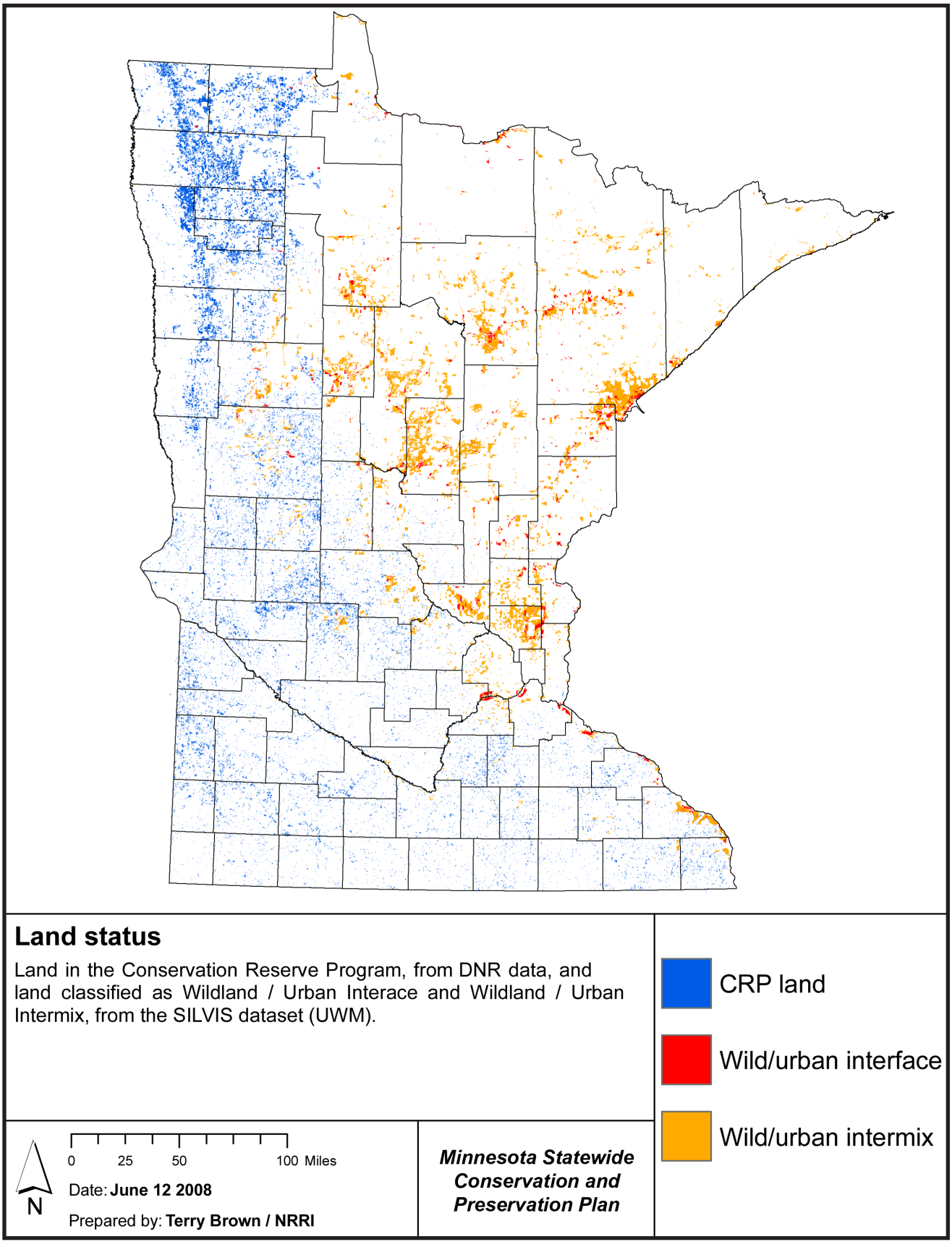


Figure H4. Land status. Credit: Terry Brown, NRRI.

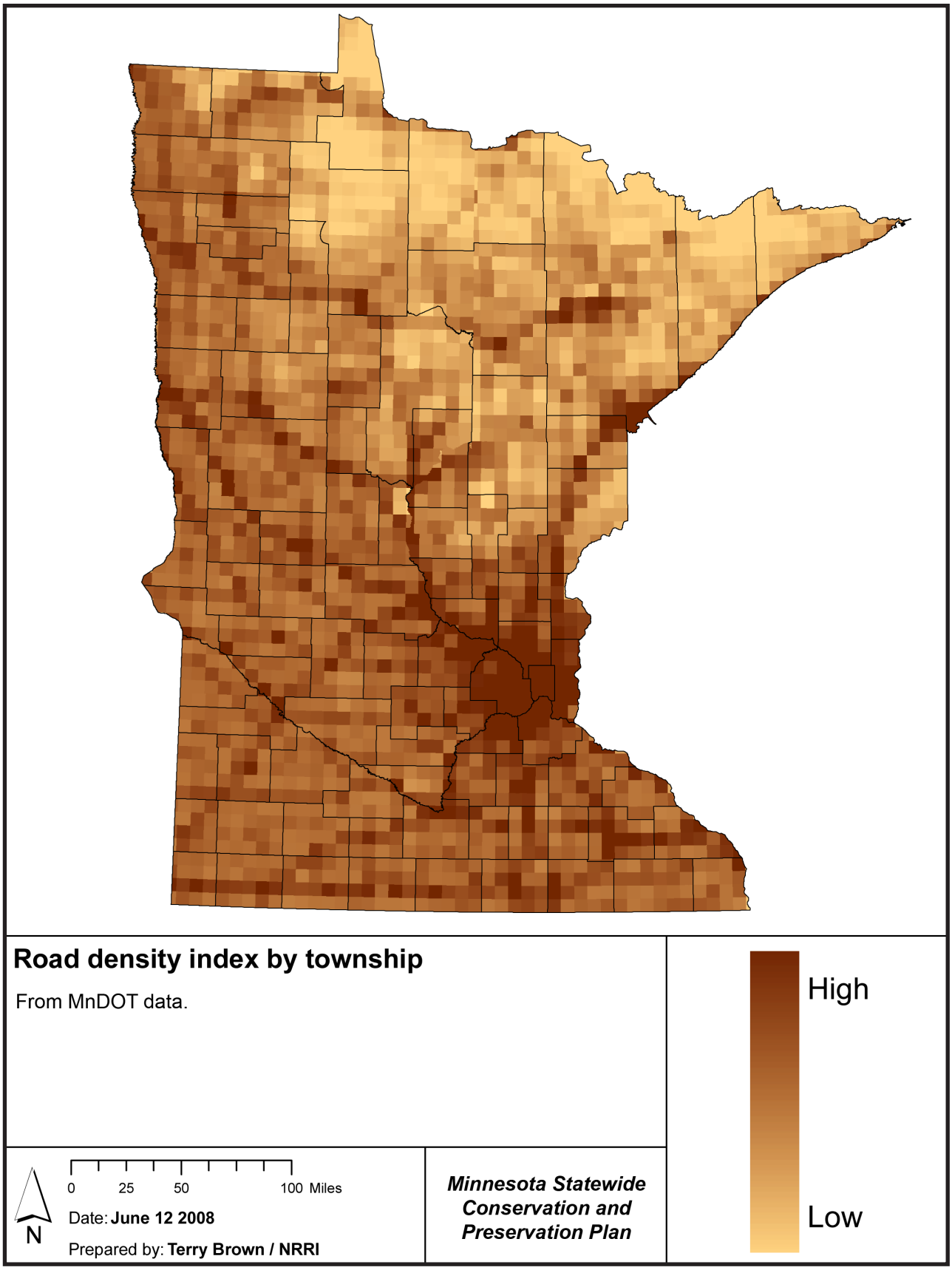


Figure H5. Road density index by township. Credit: Terry Brown, NRRI.

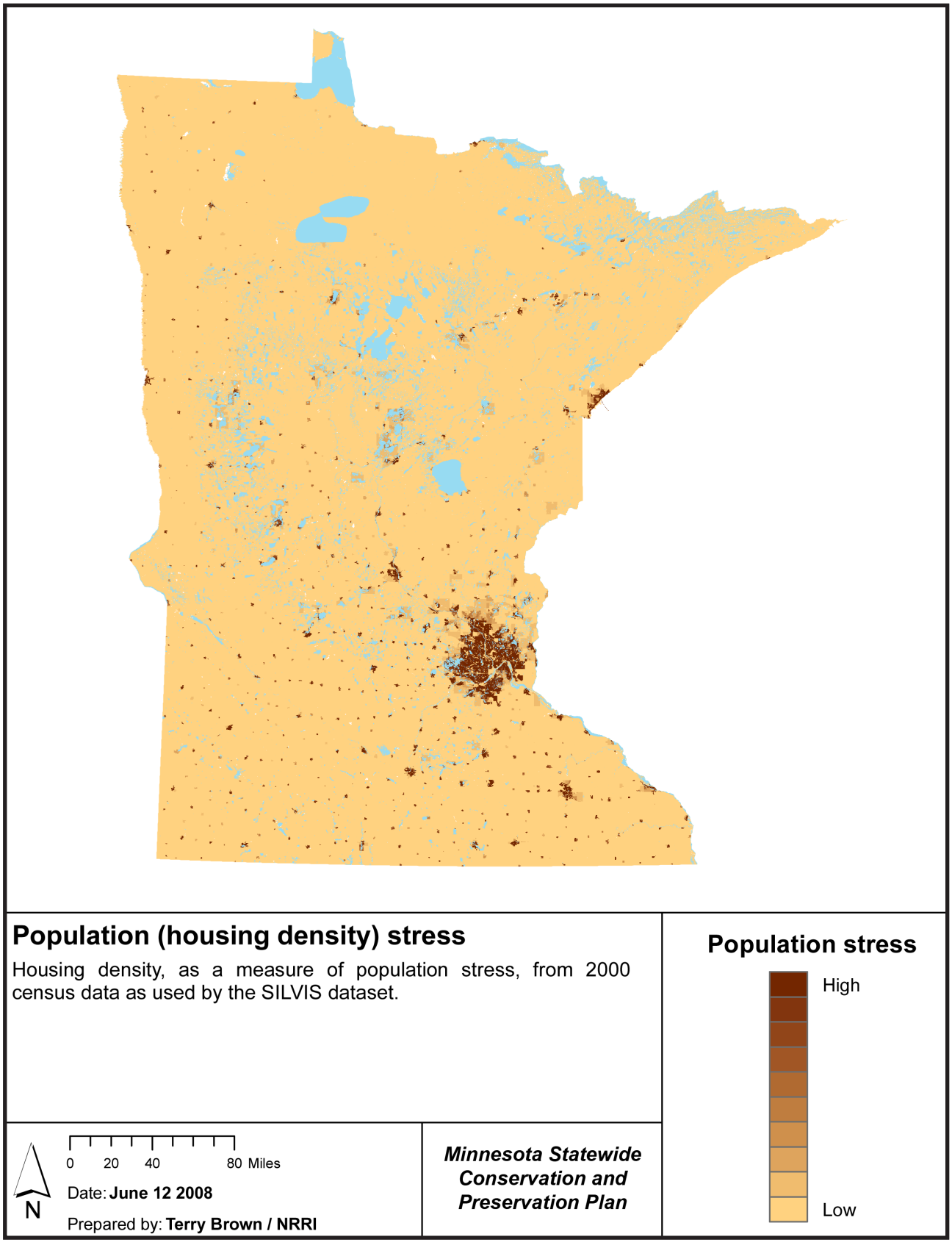


Figure H6. Population (housing density) stress. Credit: Terry Brown, NRRI.

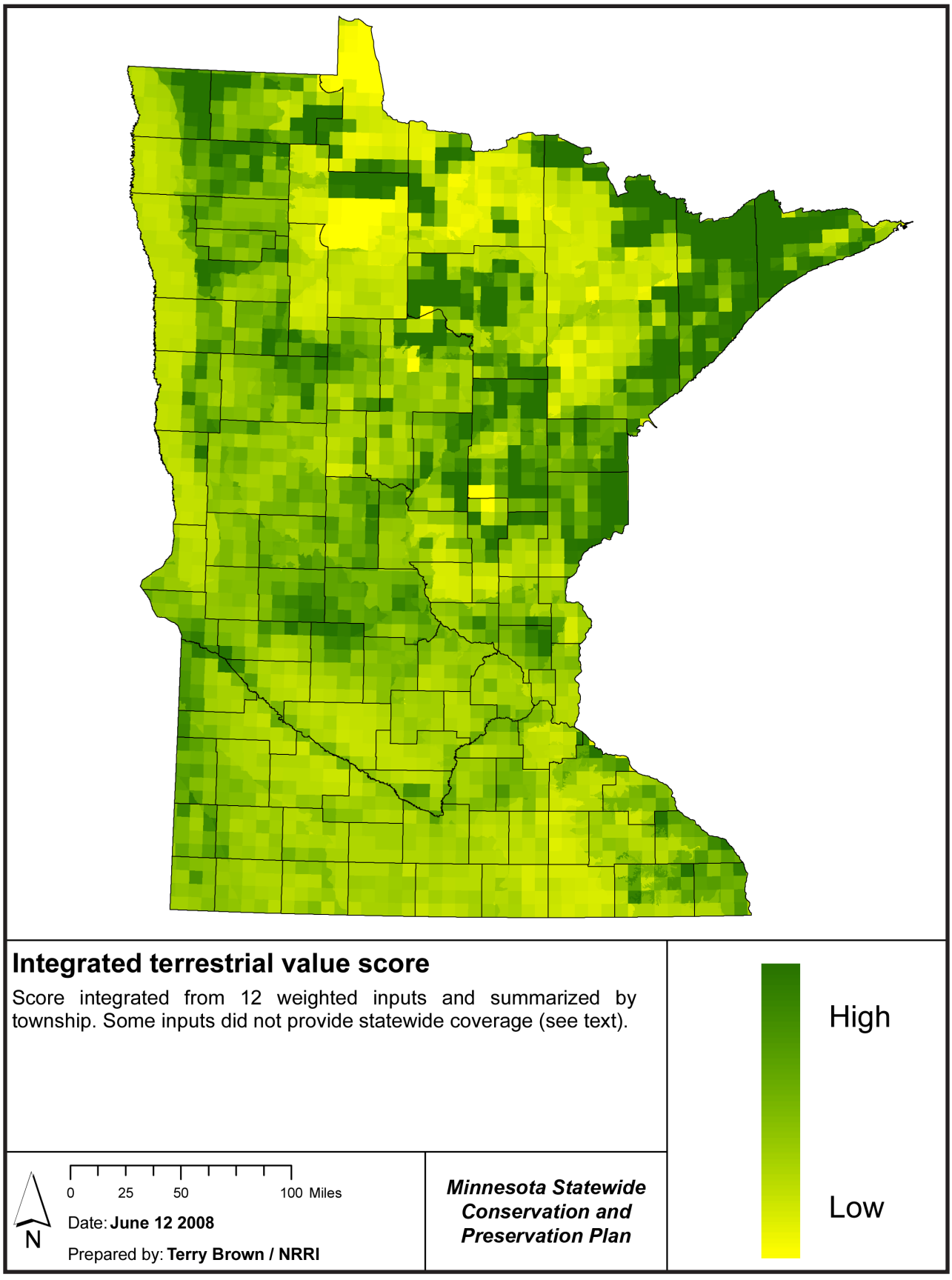
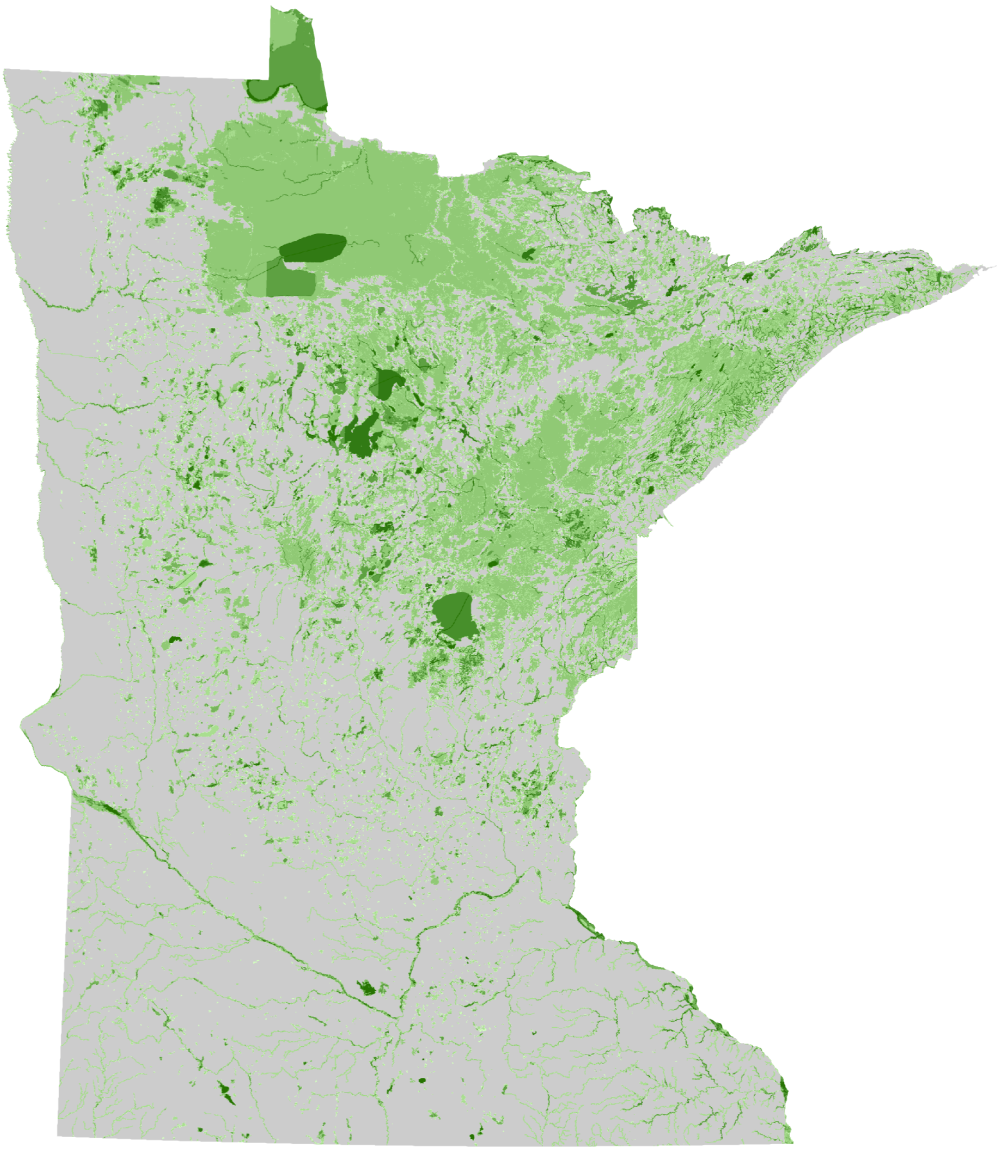


Figure H7. Integrated terrestrial value score. Credit: Terry Brown, NRRI.



Integrated Aquatic Habitat Quality Index

Sum of twelve water quality indicators (see text)

Source: DNR, B. Richardson

0 20 40 80 Miles

N

Date: **June 24, 2008**

Prepared by: **Terry Brown**

Minnesota Statewide Conservation and Preservation Plan

Aquatic Assessment Score

High

Low

Figure H8. Integrated aquatic habitat quality index. Credit: Bart Richardson, DNR.

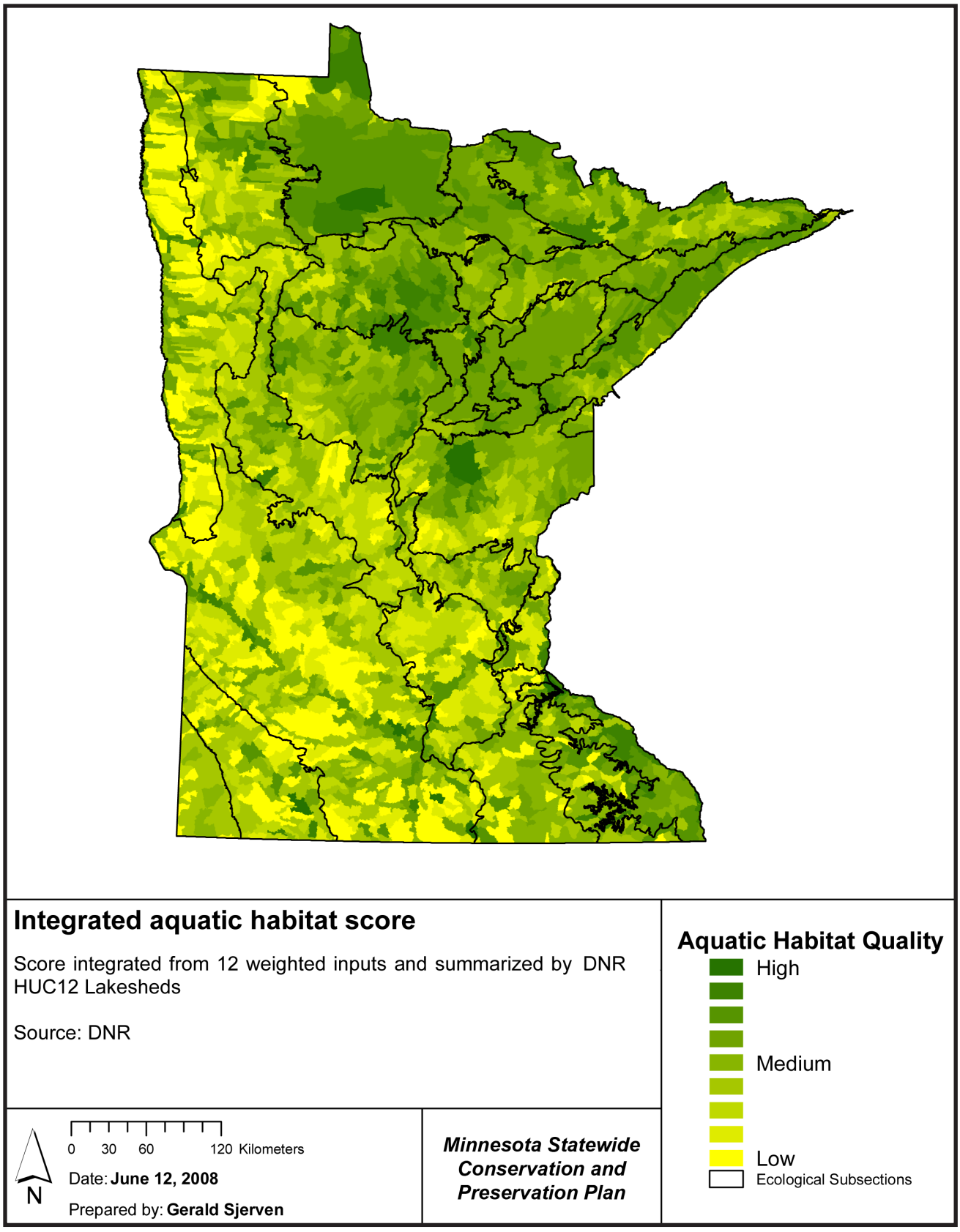


Figure H9. Integrated aquatic habitat score. Credit: Gerald Sjerven, NRRI.

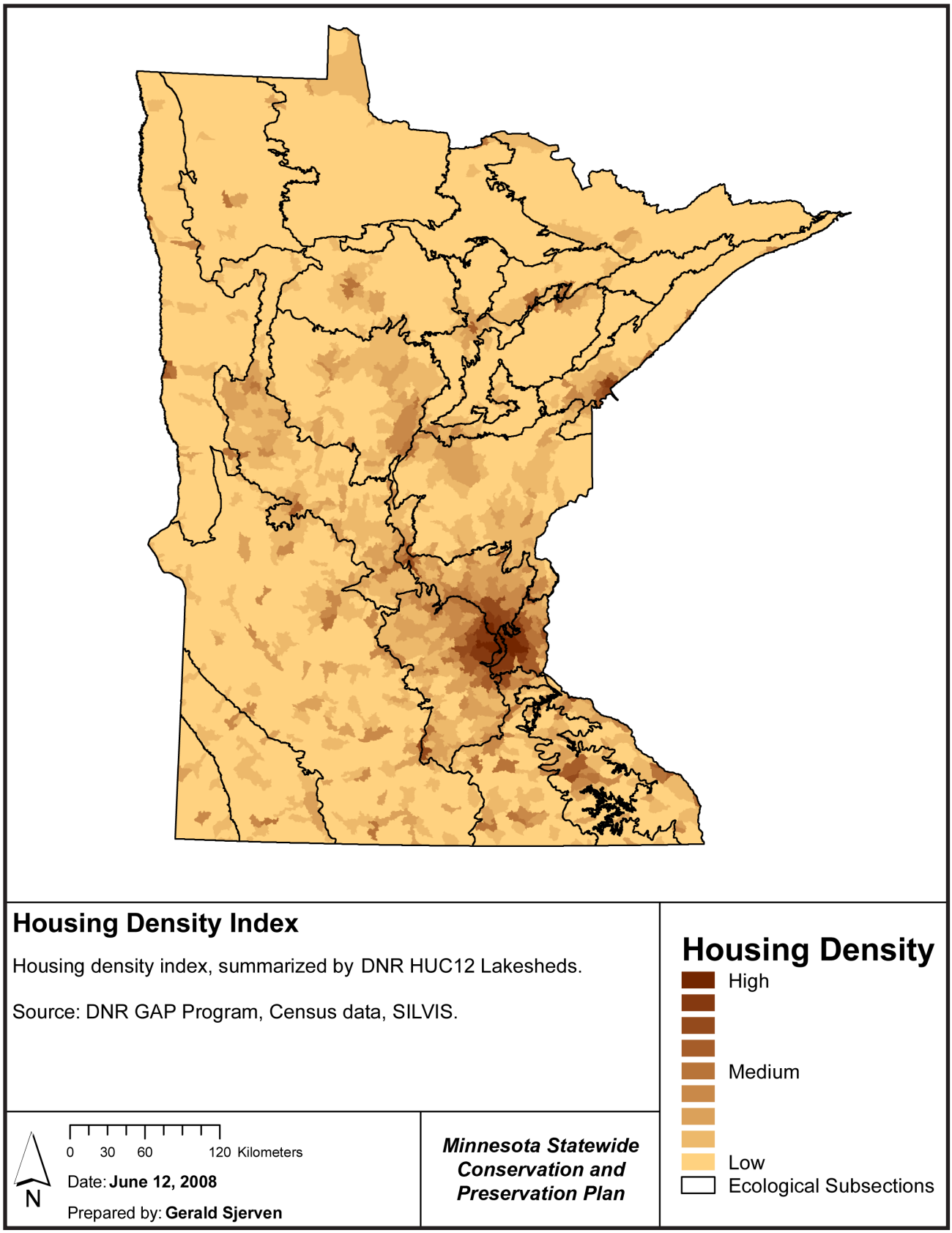


Figure H10. Housing density index. Credit: Gerald Sjerven, NRRI.

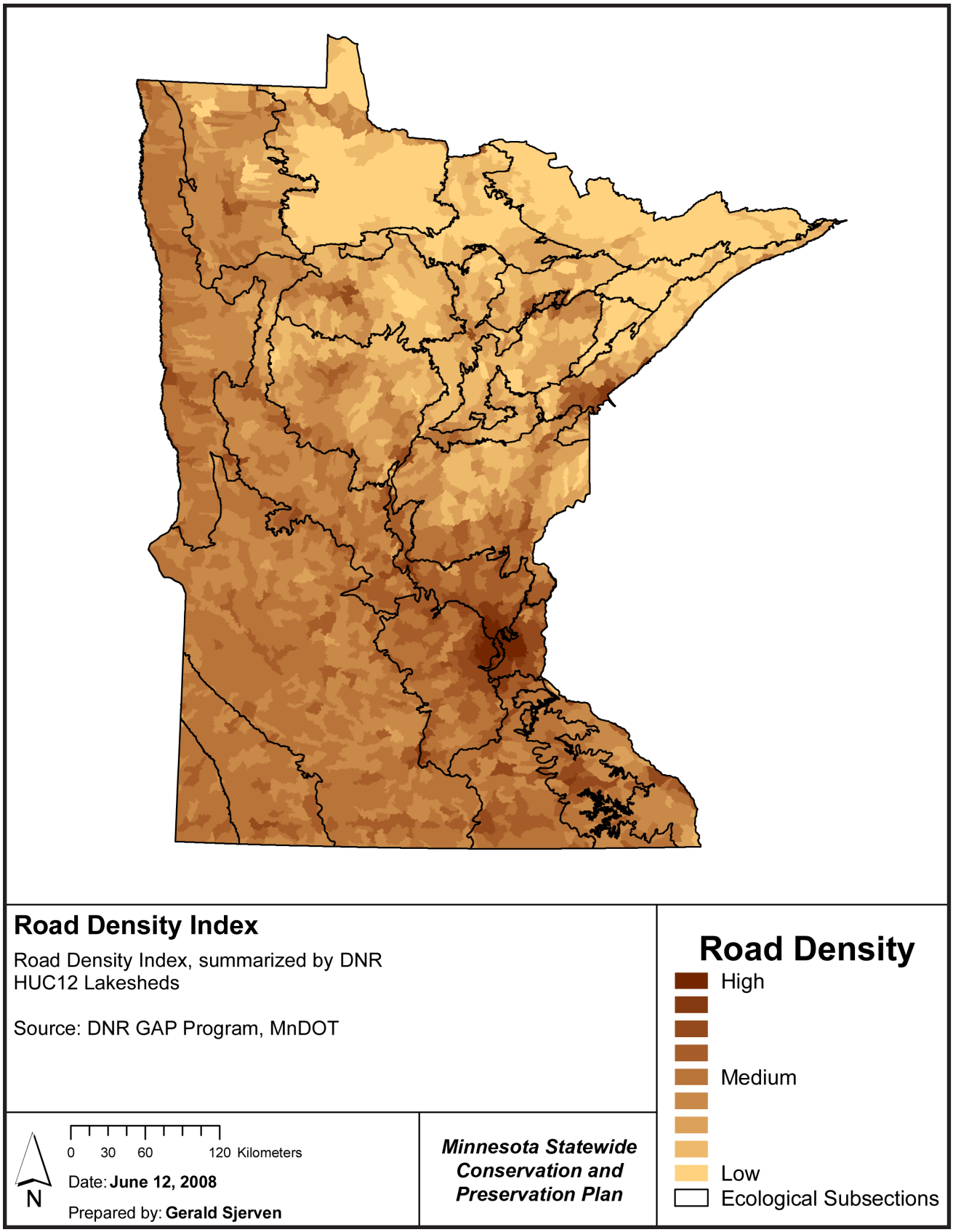


Figure H11. Road density index. Credit Gerald Sjerven, NRRI.

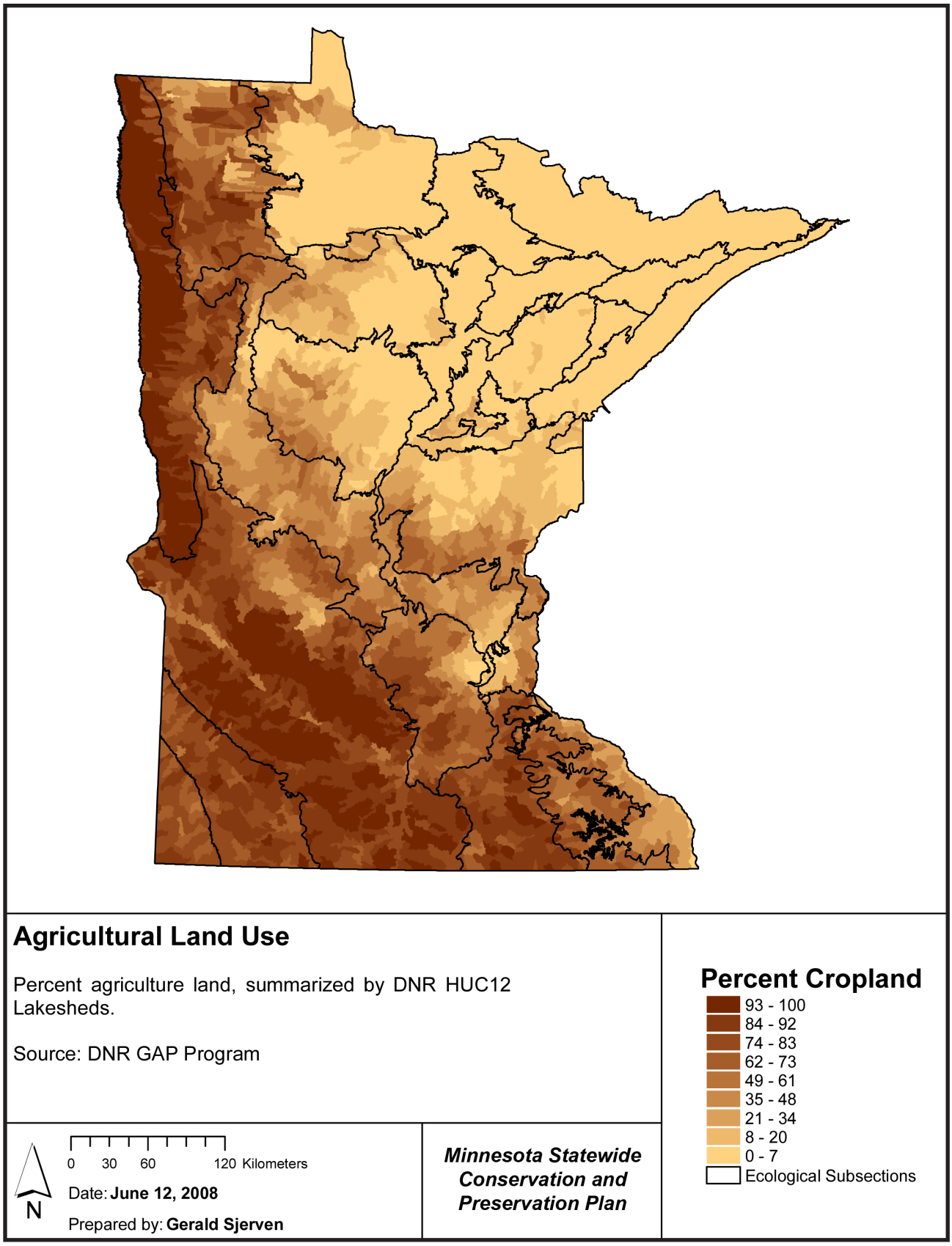


Figure H12. Agricultural land use. Credit: Gerald Sjerven, NRRI.

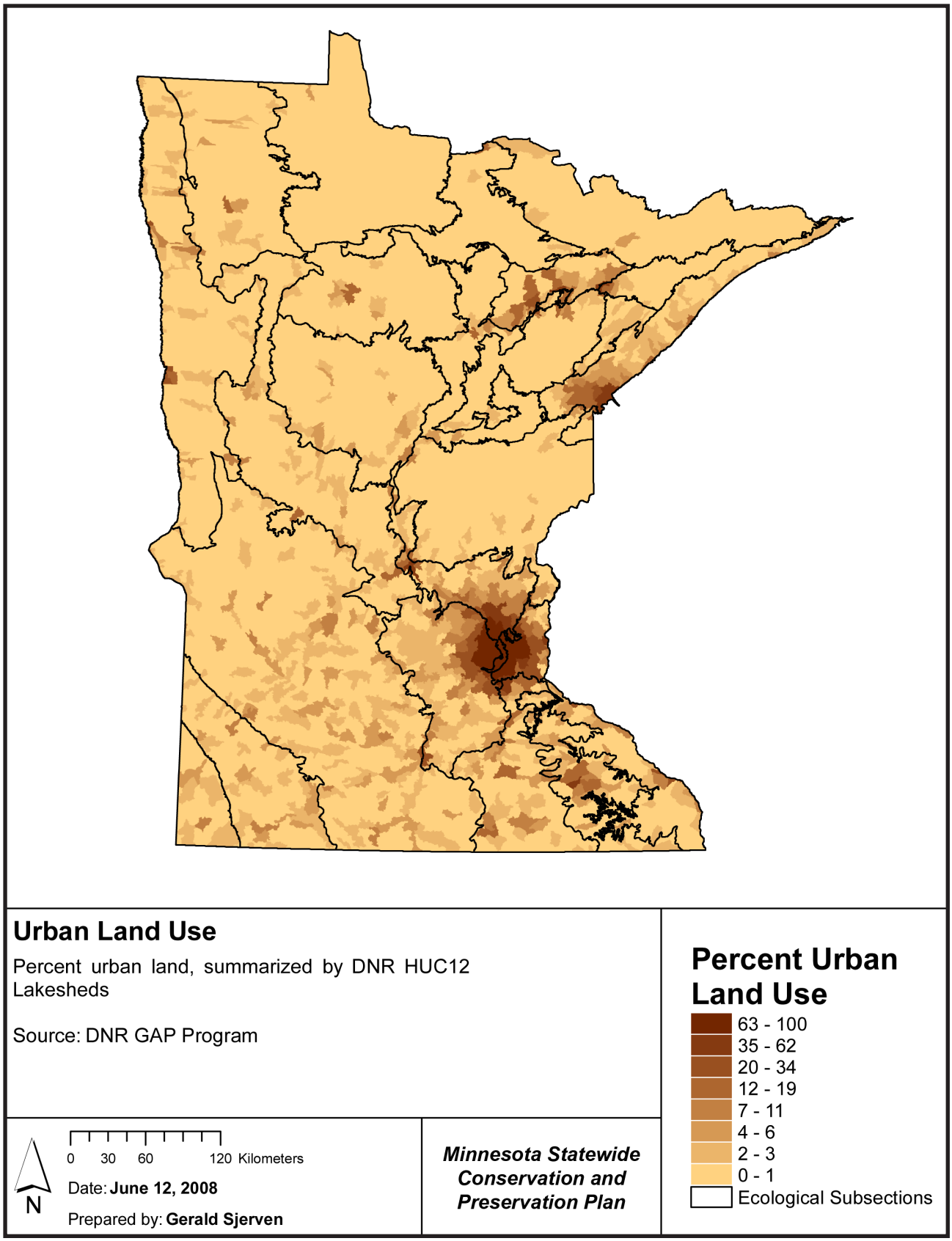


Figure H13. Urban land use. Credit: Gerald Sjerven, NRRI.

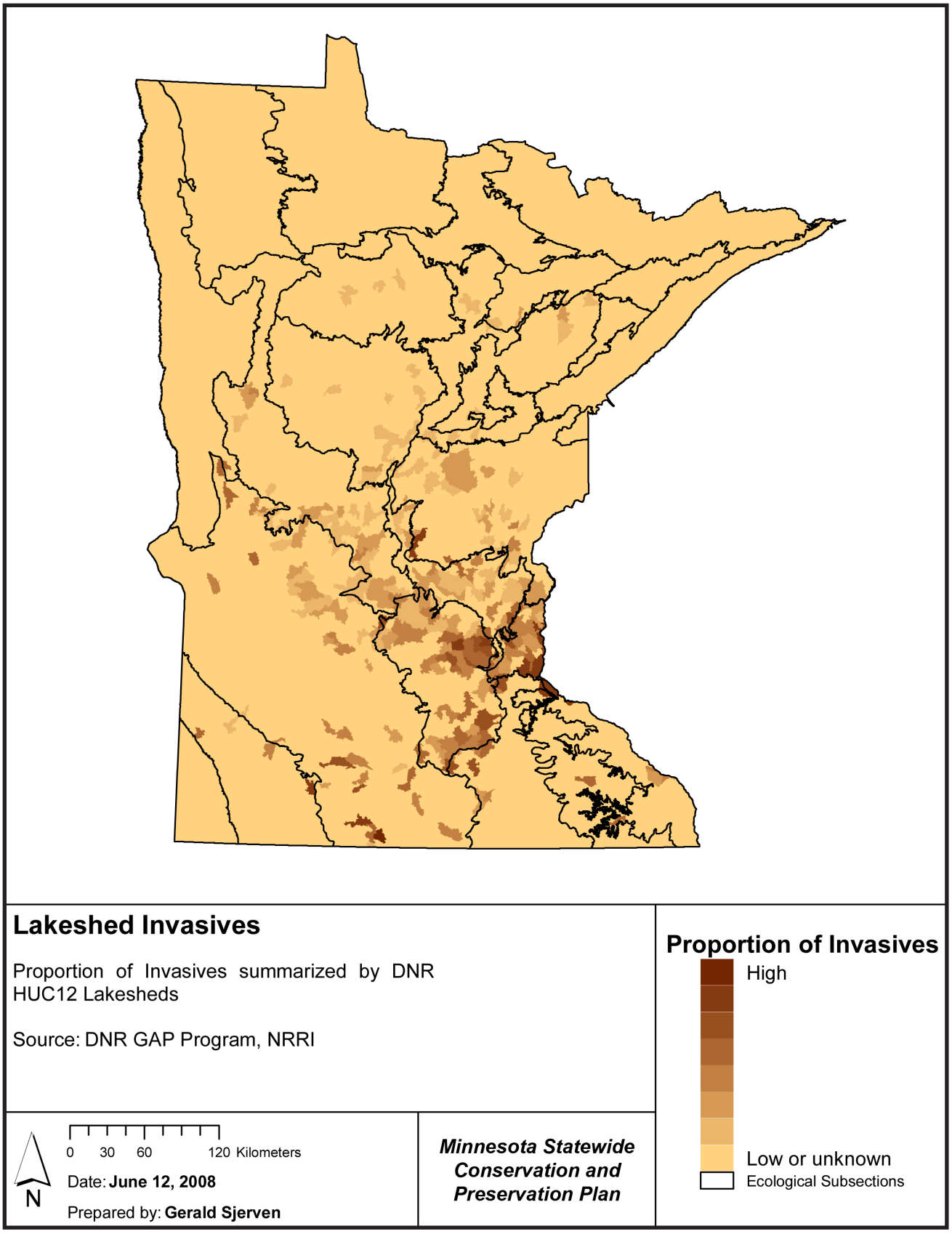


Figure H14. Lakeshed invasives. Credit: Gerald Sjerven, NRRI.

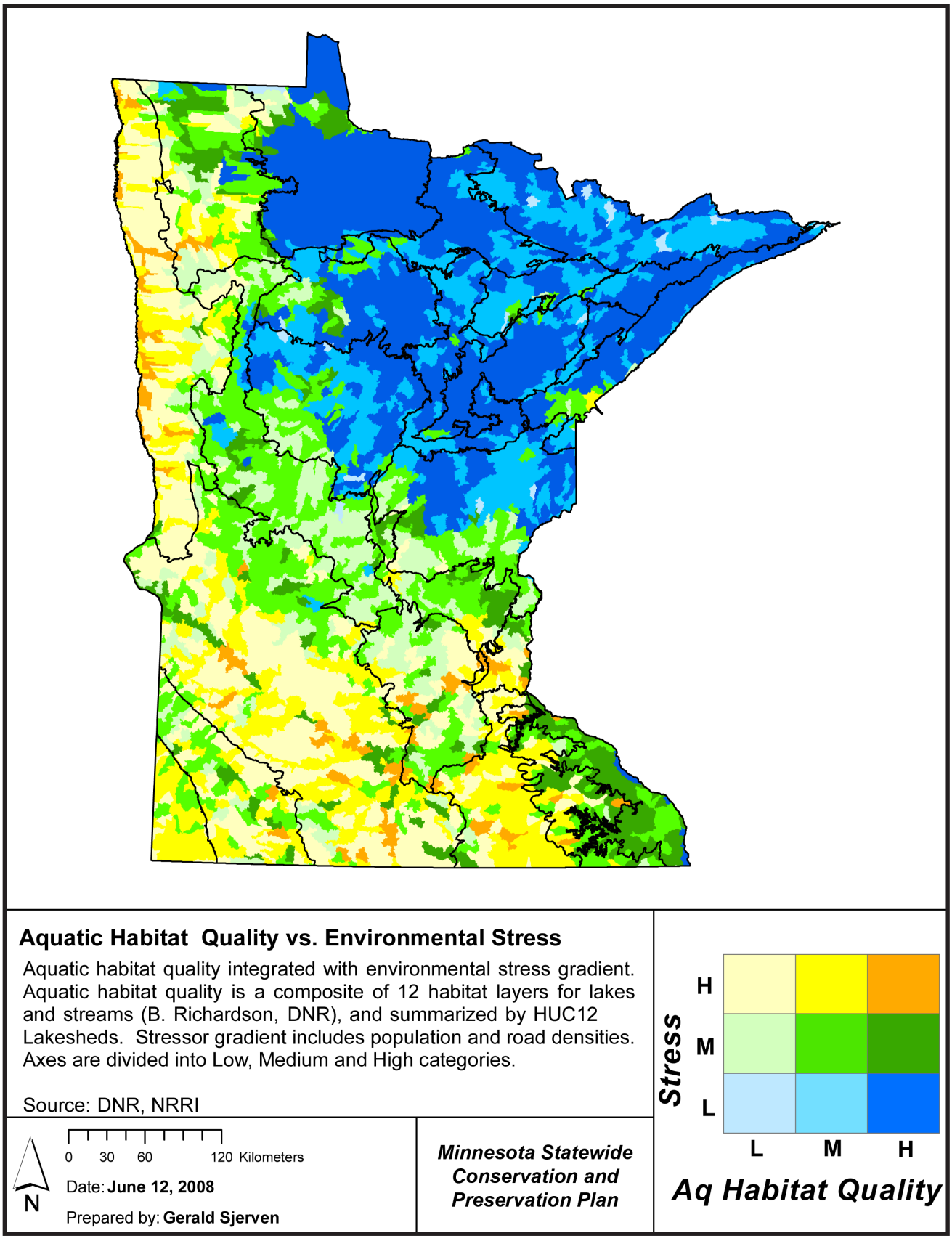


Figure H15. Aquatic habitat quality vs. environmental stress. Credit: Gerald Sjerven, NRRI.

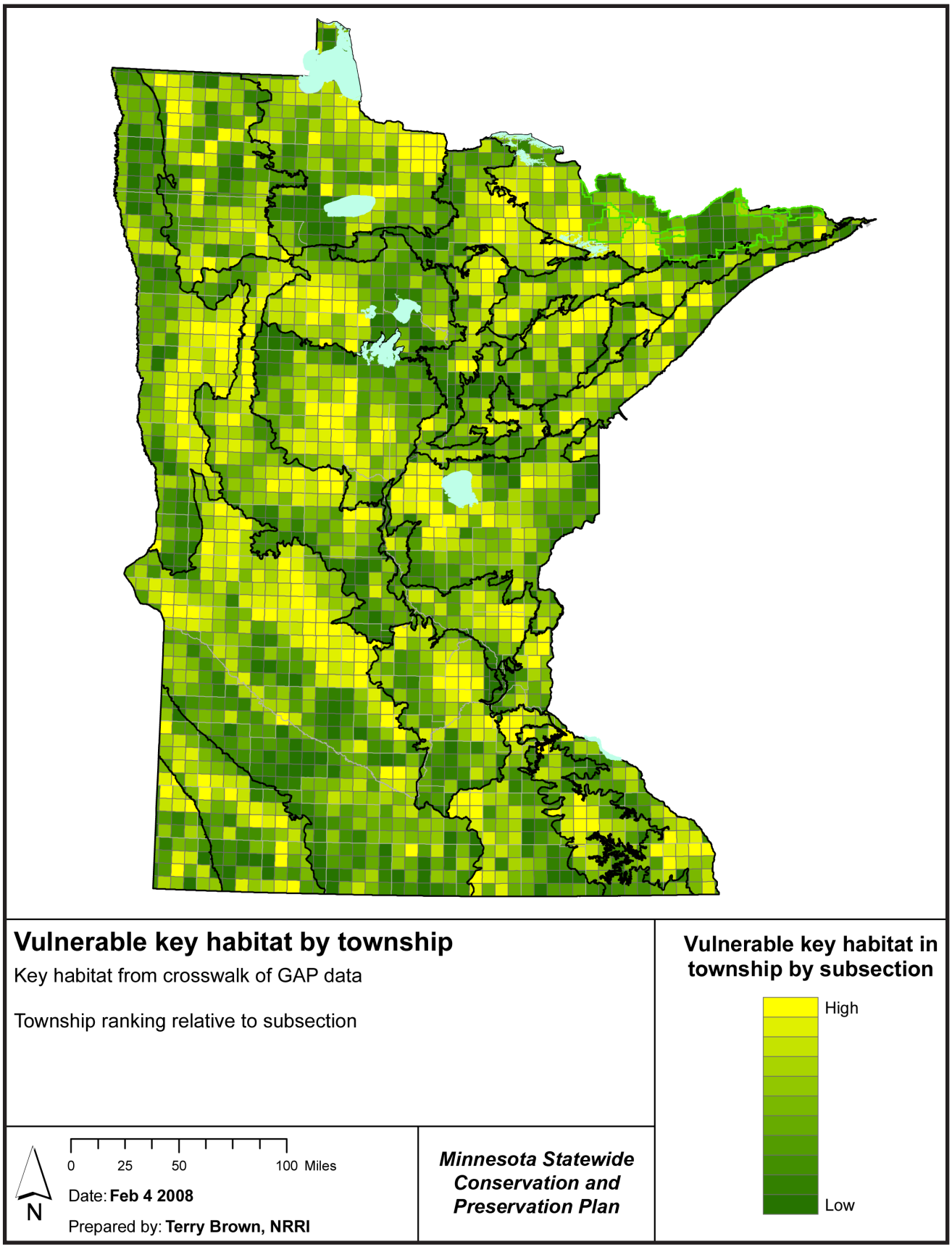


Figure H16. Vulnerable key habitat by township. Credit: Terry Brown, NRRI.

Regional Results: Examples Around the State

Results of this analysis are highlighted by presenting examples from different regions of the state. Each region and each township has unique situations regarding conservation and preservation of land and aquatic habitat resources. Hence, it is impossible to simply illustrate the complex process that occurs in actual acquisition, private land strategies, restoration, or effective management of a subsection or township. Such a process would require, at minimum, an identification of conservation goals for the area, detailed analysis, and public comment. Here we present example results from four regions of the state: the northeast, northwest, west, and Twin Cities metropolitan area (Figure H17). The intent of these examples is to highlight particular natural resources, drivers of change, and conservation issues characteristic of the region; these are not intended for specific policy development. Note that the scales of analysis vary depending on the system under consideration.

Northeastern Minnesota: Grand Marais

The North Shore of Lake Superior is generally an area of high conservation priority statewide (Figure H18). By focusing on one township in this area, we can see that tracts of land display heterogeneity in their conservation priority score. The town of Grand Marais receives low conservation scores because of the prominence of housing and development, while areas to the northeast and northwest receive high scores. Evaluating the individual input layers allows us to identify what variables contributed to these scores. The largest contributor to the high-ranking areas in this township was the SOBS variable—tracts of dark shading correspond to the outline of SOBS. The wildland/urban intermix variable overlaps with a large portion of the SOBS, positively adding to the score. The species of greatest conservation need (SGCN) variable, in combination with the wildland/urban intermix variable, positively influences conservation priority in a narrow zone around the lake in the northwestern corner of the image and has variable effects elsewhere.

This region is in the North Shore Highlands ecological subsection. The township is heavily forested, especially upland deciduous forest. Most of the township is privately owned, but the area surrounding the township is primarily public land. Many SGCN are well distributed across the township. Hunting and fishing opportunities are abundant and well distributed, and aquatic resources are generally of high quality. Issues for consideration in the township include: (1) protection of lakes and streams, especially Lake Superior, or additional buffering to the large public land ownership surrounding the township, and (2) restoration efforts aimed at reducing specific impacts to lakes and streams.

Northwestern Minnesota: Red Lake River Watershed

The Red Lake River flows west from Lower Red Lake to its confluence with the Red River of the North in East Grand Forks, Minnesota (Figure H19). The river traverses a wide range of landscapes, from extensive peatlands and forest regions of the Red Lake Indian Reservation to the highly modified agricultural landscapes of western Minnesota. The river has retained many of its natural meanders, is well known for its recreational opportunities, and is a significant corridor of high-quality aquatic habitat. In addition, at approximately 6,000 square miles, the watershed for the Red Lake River forms the largest contributing area to the Red River basin, with important hydrologic implications for downstream communities, both in terms of flooding potential and water quality. Historic dredging and straightening of stream channels, coupled with dam development and wetland drainage, led to the extirpation of numerous native fish populations, including lake sturgeon, channel catfish, sauger, and other migratory fishes (Aadland et al. 2005). Numerous restoration efforts, including dam removal and development of fishways, have led to some recovery of fish populations. Two primary sources contribute to the high aquatic habitat quality along the river corridor: the value of the river in the stream/reach data

set, and the presence of high-value wetland habitat in the corridor (Figure H19). The Red Lake River rated highly in the DNR's strategic plan for managing SGCN.

In 2005, a corridor development plan was completed for various segments of the Red Lake River. A land use transition model predicted new urban development of approximately 3.8% by 2050, with urbanization strongly related to proximity to water features (Schwalm et al. 2004). Urbanization as expressed in the National Land Cover data set in the current analysis was one of the primary stressors affecting lakesheds along the river corridor (Figure H19). The contributing watersheds to the Red Lake River are predominately agricultural, and inputs of nutrients from agricultural fertilizers are a significant factor in water quality impairments. The river has extensive channelized areas, including 3.5 miles through a wetland complex near its source and approximately 20 miles east of High Landing in Pennington County.

Two other factors represent important emerging issues for the region. First, significant acreages of the Red Lake River watershed are enrolled in CRP. As the price of corn increases based on ethanol incentive programs, it is likely that the more productive CRP lands will not be re-enrolled in the program. This is particularly important for lands in riparian landscape positions. Second, this region spans a major ecological transition from forest to prairie landscape. These transitional areas and the species range boundaries associated with them will be among the first places to receive the influence of climate change effects, particularly those related to precipitation. For that reason, conservation in this region will have implications for biodiversity statewide.

Western Minnesota

The region between Willmar and Fergus Falls in west-central Minnesota was highlighted as having high conservation priority for a number of input variables and the final integrated index (Figure H20). This region occurs in a transition from the wide, flat valley of the Minnesota River to the more topographically rough, morainal landscape to the north and east. This area is on the prairie side of the transition between prairie and broadleaf forest. The landscape is dotted with many small lakes and surrounding wetlands that provide suitable, varied habitat for waterfowl, game species, and especially many upland prairie birds.

Figure H20 focuses on the township surrounding the city of New London, Kandiyohi County. The city is located in the upper-central portion of each panel, while Green Lake is the circular, yellow area in the southeastern corner. The township receives generally high scores for wildland/urban intermix, weighted habitat, and bird habitat suitability, but developed areas receive low conservation values. Overall, the integrated conservation value is well distributed across the township. The township is primarily privately owned and contains large amounts of grassland, deciduous forest (maple-basswood and oak), and agriculture.

The primary areas for consideration for land conservation in the township include areas immediately north of Green Lake. This may be especially valuable due to the relatively large area in SOBS. In particular, the township has potential to improve habitat for many native grassland species of conservation concern in the state. The mix of trees and grasslands, and its position near the edge of the historic prairie, make this area a good example of the oak savanna/grassland complex. People are naturally drawn to such areas, especially with the presence of lakes, which means that development pressures are probably high for this area. Because of this, the area is vulnerable to fragmentation and would benefit from connections to other areas to the north. Similar issues also exist in the northwestern part of the township, where the adjacent township to the west has a large area of fragmented public ownership. The township has potential for prairie restoration, as well as restoration of the aquatic resources that are currently rated of low to moderate quality.

Twin Cities Metro Area

Figure 21 shows a township near Eagan, Dakota County, about 15 miles southeast of downtown Minneapolis. It is experiencing rapid development pressure from suburban expansion. Most of the township is in private ownership, except for relatively large tracts along the Minnesota River in the northwestern quadrant and Lebanon Hills Regional Park in the southern portion (Figure H21). Most of the township is in residential development, with scattered tracts of forests and cropland. The highest conservation values for the township coincide with the two public land holdings along the Minnesota River and Lebanon Hills Regional Park. These scores were primarily influenced by the presence of SOBS, SGCN, low housing density, forests, wetlands, and the wildland/urban interface.

Conservation and protection priorities in the township include (1) protecting public land areas for outdoor recreation and biological diversity, (2) protecting wetlands and water quality of the Minnesota River, and (3) maintaining appropriate land buffers and reducing fragmentation within the public land areas of the township. In presettlement times, portions of this township were composed of oak savanna and lowland deciduous riparian forest. Explorations in opportunities for restoration of these habitats should be encouraged.

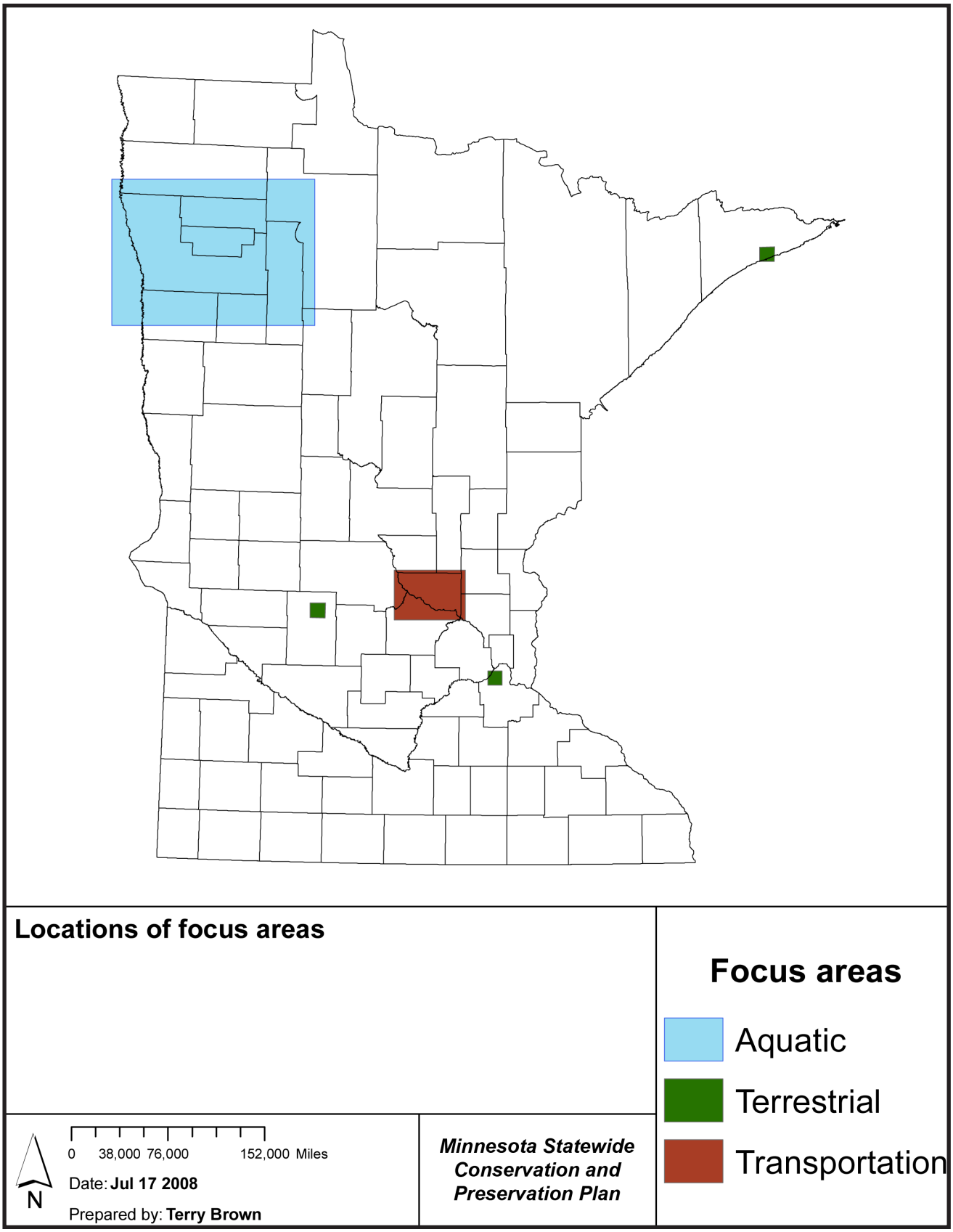


Figure H17. Locations of terrestrial and aquatic focus areas. Transportation example is covered in the transportation recommendations section. Credit: Terry Brown, NRRI.

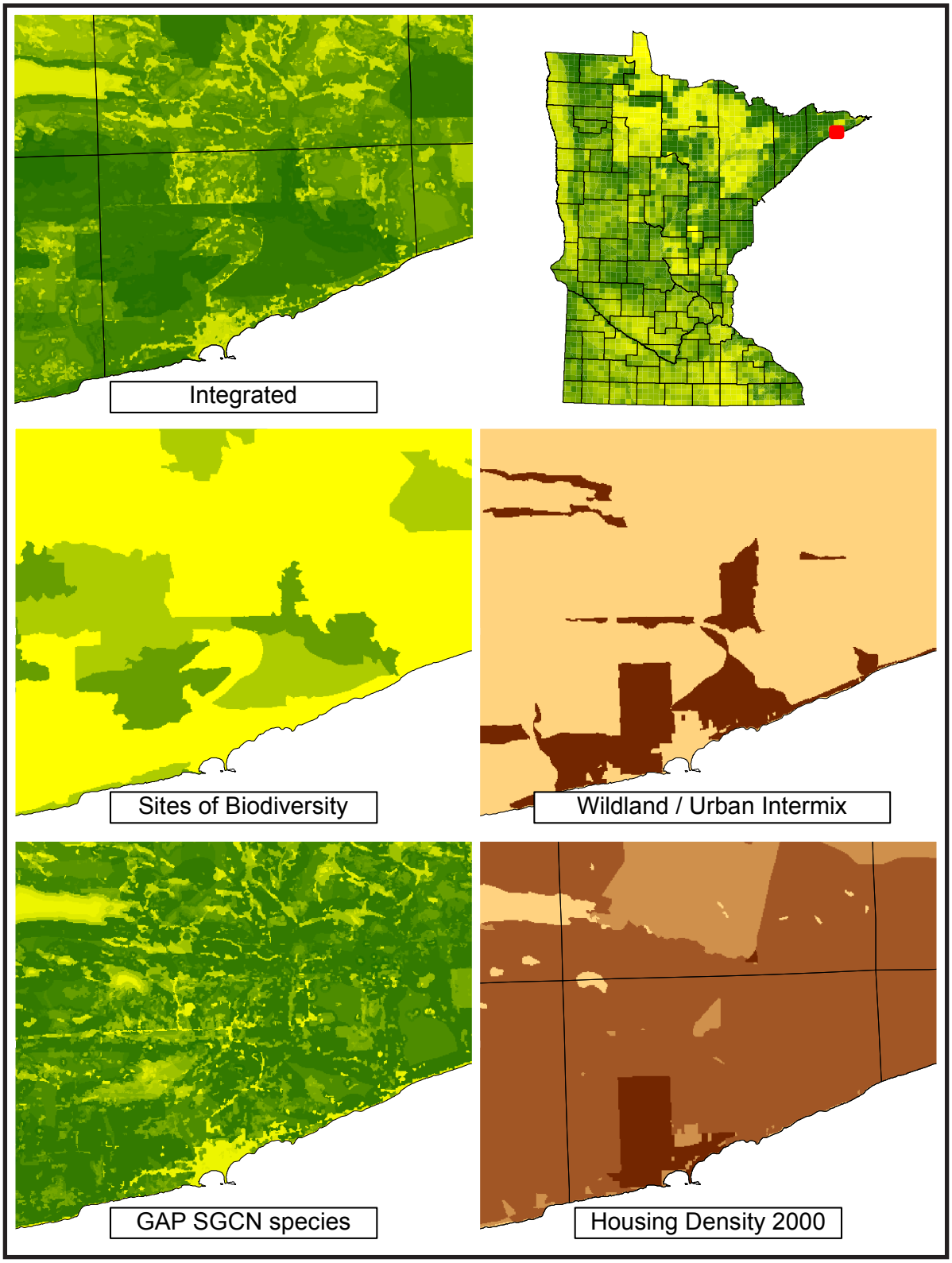


Figure H18. Summary of ecological values and stresses around Grand Marais along the North Shore of Lake Superior, Lake County. Dark areas have higher ecological value and low stress; lighter areas have lower ecological value and high stress. The panel labeled "Integrated" is the final conservation priority map, while the other panels show selected input variables that were significant contributors to the ecological value/stress pattern in this region. Credit: Nick Danz, NRRI.

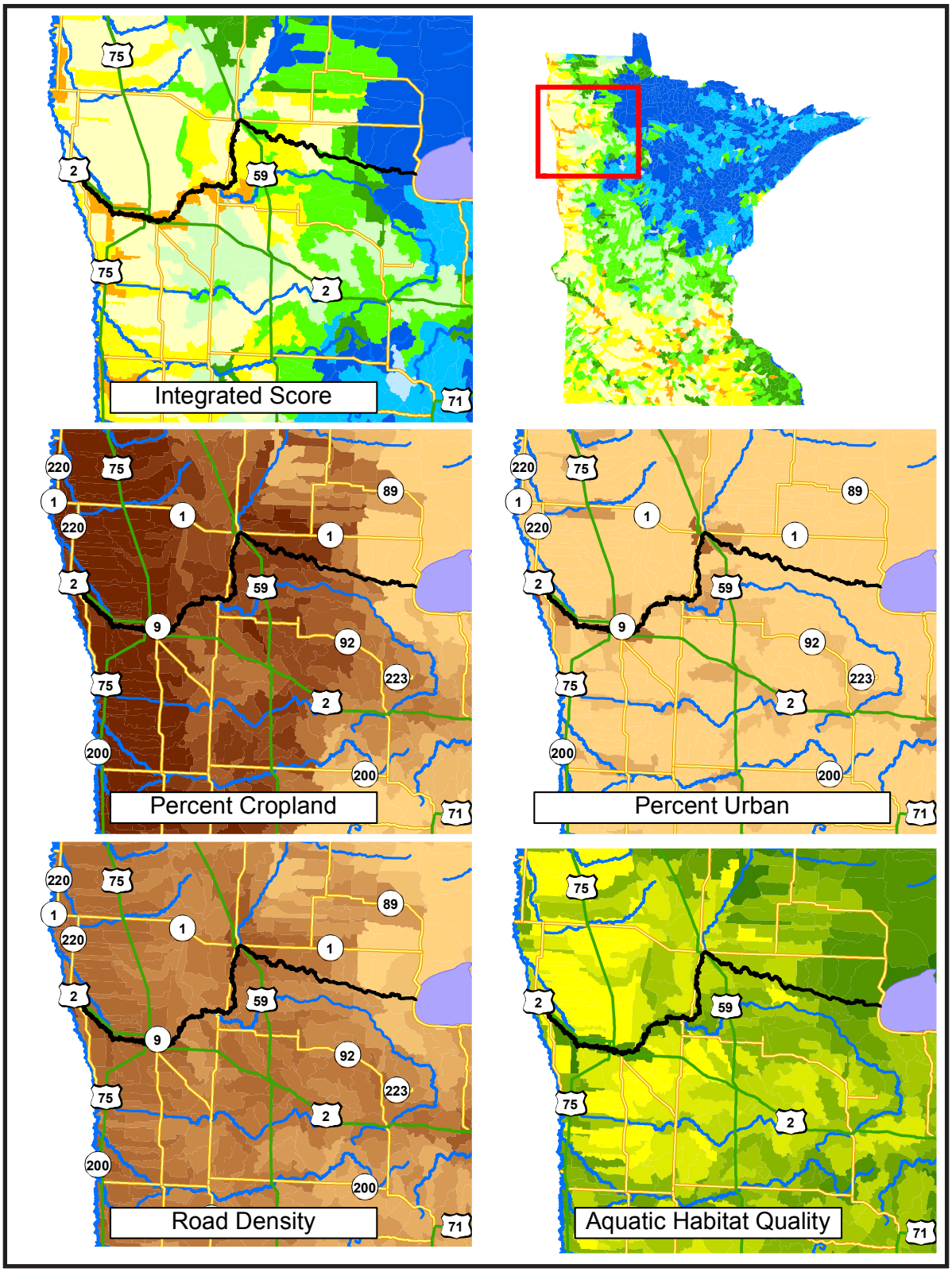


Figure H19. Summary of ecological values and stresses in the Red Lake River watershed in northwestern Minnesota. Orange areas show a combination of high aquatic ecological value and high stress. The panel labeled "'Integrated" is the final ecological values/stress map, while the other panels show selected input variables that were significant contributors to the pattern in this region. Credit: Gerald Sjerven, NRRI.

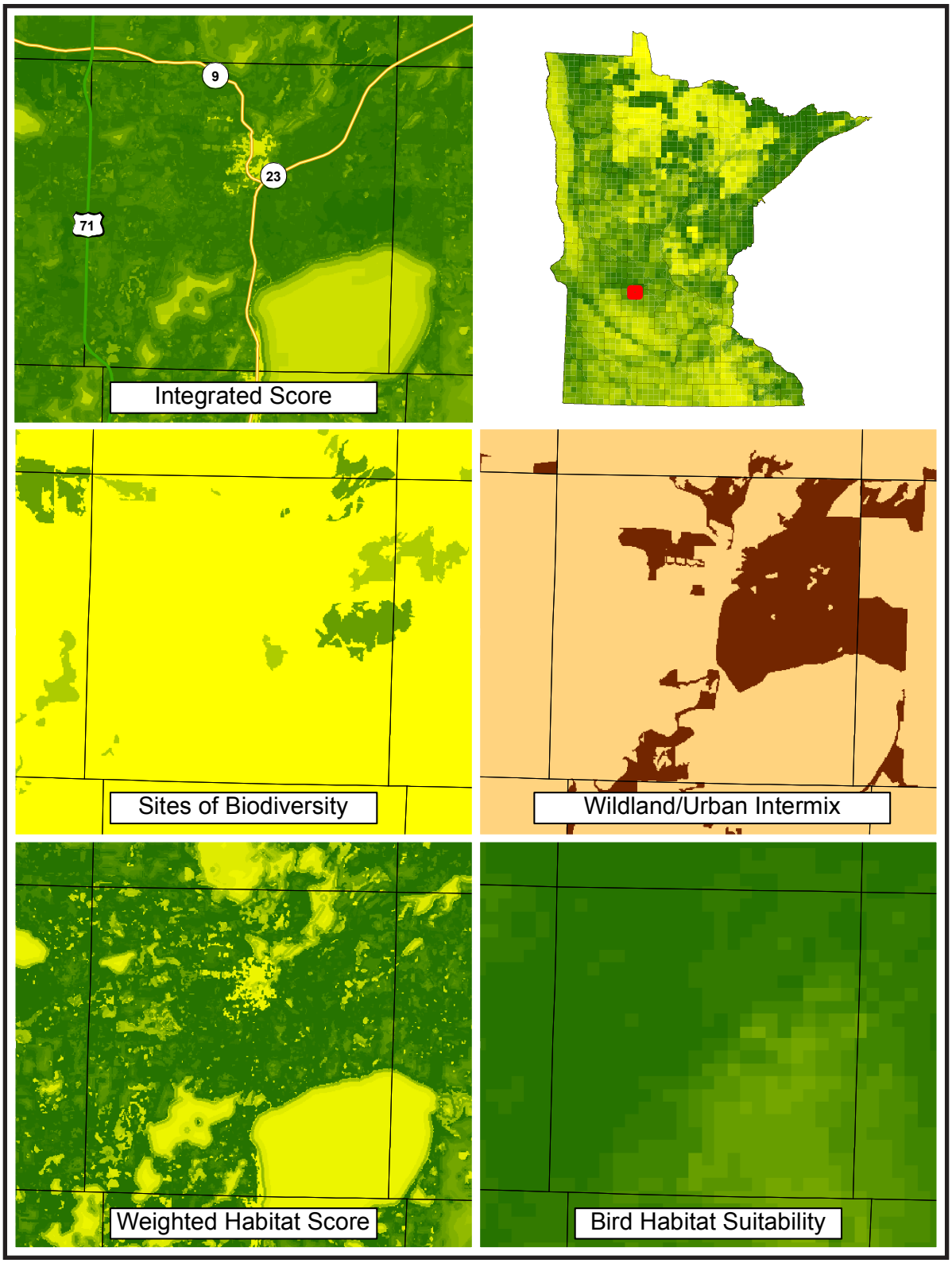


Figure H20. Summary of ecological values and stresses in western Minnesota, near New London (Kandiyohi County) and the Minnesota River prairie ecological subsection. Dark areas have higher ecological values and low stress; lighter areas have lower ecological values and high stress. The panel labeled "Integrated" is the final ecological values/stress map, while the other panels show selected input variables that were significant contributors to the pattern in this region. Credit: Nick Danz, NRRI.

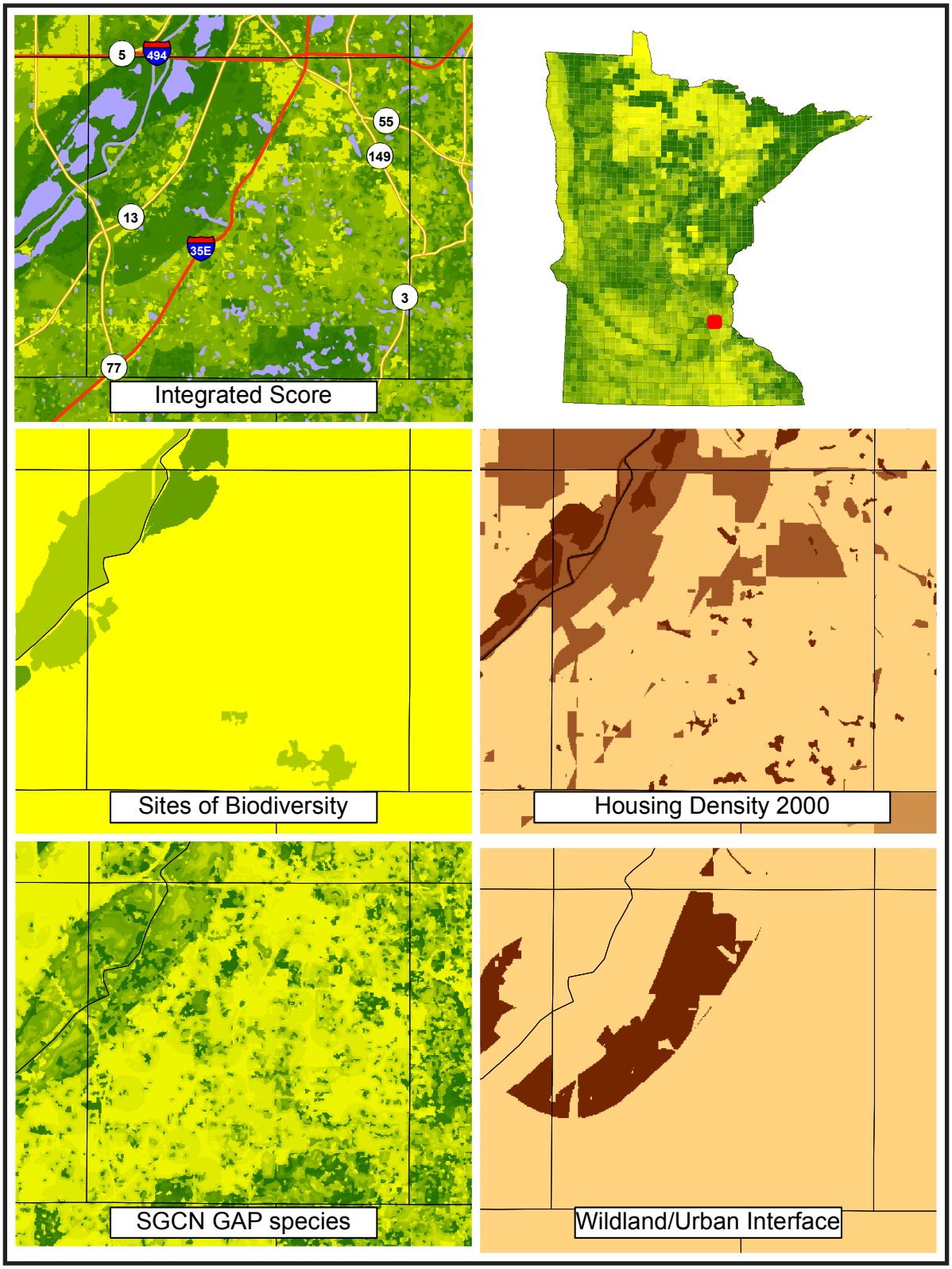


Figure H21. Summary of ecological values and stresses in the Twin Cities metropolitan area near Eagan, Dakota County. Dark areas have higher ecological value and low stress; lighter areas have lower ecological values and high stress. The panel labeled "Integrated" is the final ecological values/stress map, while the other panels show selected input variables that were significant contributors to the pattern in this region. Credit: Nick Danz, NRRI.

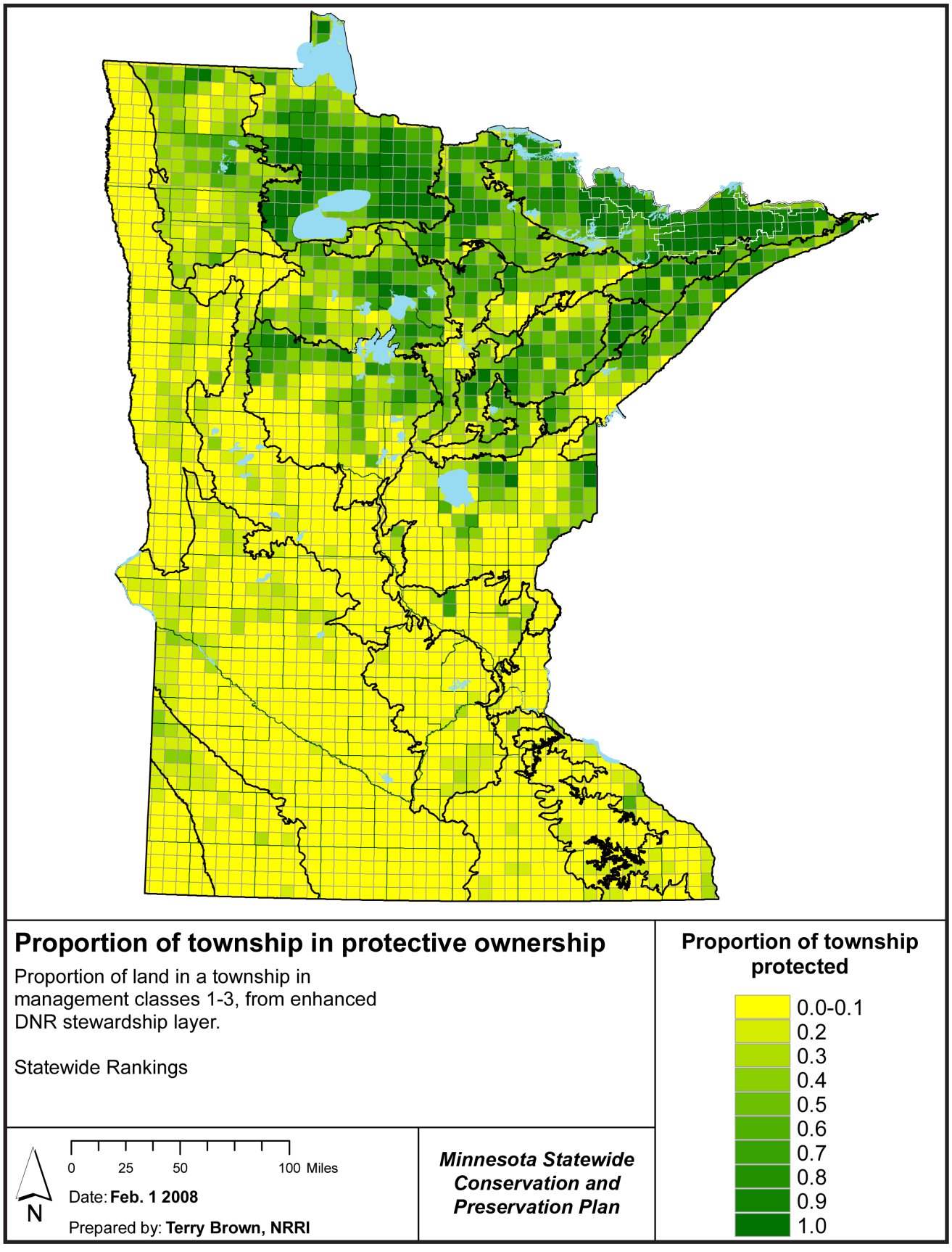


Figure H22. Ownership of land by entity. Credit: Terry Brown, NRRI; DNR.

Habitat Recommendations and Integrated Mapping

The integrated mapping of important natural resource features for Minnesota formed the foundation for the habitat recommendations. For instance, the land ownership layer clearly indicates that there is relatively little need for concern for land acquisition in northeastern Minnesota because of the extensive federal, state, and county ownership (Figure H22). In contrast, the southwest is primarily privately owned. This region of the state has lost most of its native prairie and wetlands (Figures H23 and H24). Consequently, there are many concerns here with the loss of native biological diversity, waterfowl populations, and several upland bird species. In fact, each region of the state has its own unique set of issues on conservation and preservation of natural resources. Even though generalizations on conservation or preservation problems across the state are difficult, the northeastern portion of the state can be characterized as needing an emphasis on protection, while many of the southern and western portions of the state need to be restored.

This plan cannot answer all of the complex questions related to conservation decision-making, but the mapped data and the integration of these data form a strong basis for beginning to make intelligent decisions on conservation and preservation of native land and aquatic habitats. The recommendations that follow were developed from a combination of these concepts, the integrated mapping previously described, and input from a host of experts and stakeholders dedicated to the conservation of Minnesota's natural heritage. The regional and integrated mapping results should be used to guide identification of priority land and aquatic habitats across the state.

Recommendations

Land Protection

Habitat Recommendation 1: Protect priority land habitats **LP**

Description of recommended action. The SCPP has identified many critical land habitats throughout the state based on an integrated approach that considers such issues as SGCN, outdoor recreation such as hunting and fishing, protection of water quality, and threats to these resources (Figure H7). Critical land habitats were identified through a combination of existing government, UM, and selected private data sets. These data sets were spatially explicit and, with rare exception, statewide (Table H1). The criteria for critical habitat identification were developed by a group of public and private stakeholders and optimized to provide the most benefit to the most constituents.

These areas have been prioritized for conservation and preservation. A variety of public and private mechanisms are available to protect these areas, including acquisition, conservation easements, and restoration/remediation of impacted habitats. Public education will play an important role in protecting priority land habitats, and coordination among public, nonprofit, and private entities to protect critical habitats will be increasingly paramount.

The SCPP outlines important land habitats that benefit wildlife, fish, water quality, and outdoor recreation in the context of threats to these important natural resources. The SCPP allows considerable flexibility for conservation of lands and appropriate protection of economic activity such as logging or other compatible uses. Conservation and protection of these land areas will require multiple mechanisms and a coordinated effort among local, county, regional, state, and national public agencies; nonprofits; and private entities. Of particular importance are rare land features and ar-

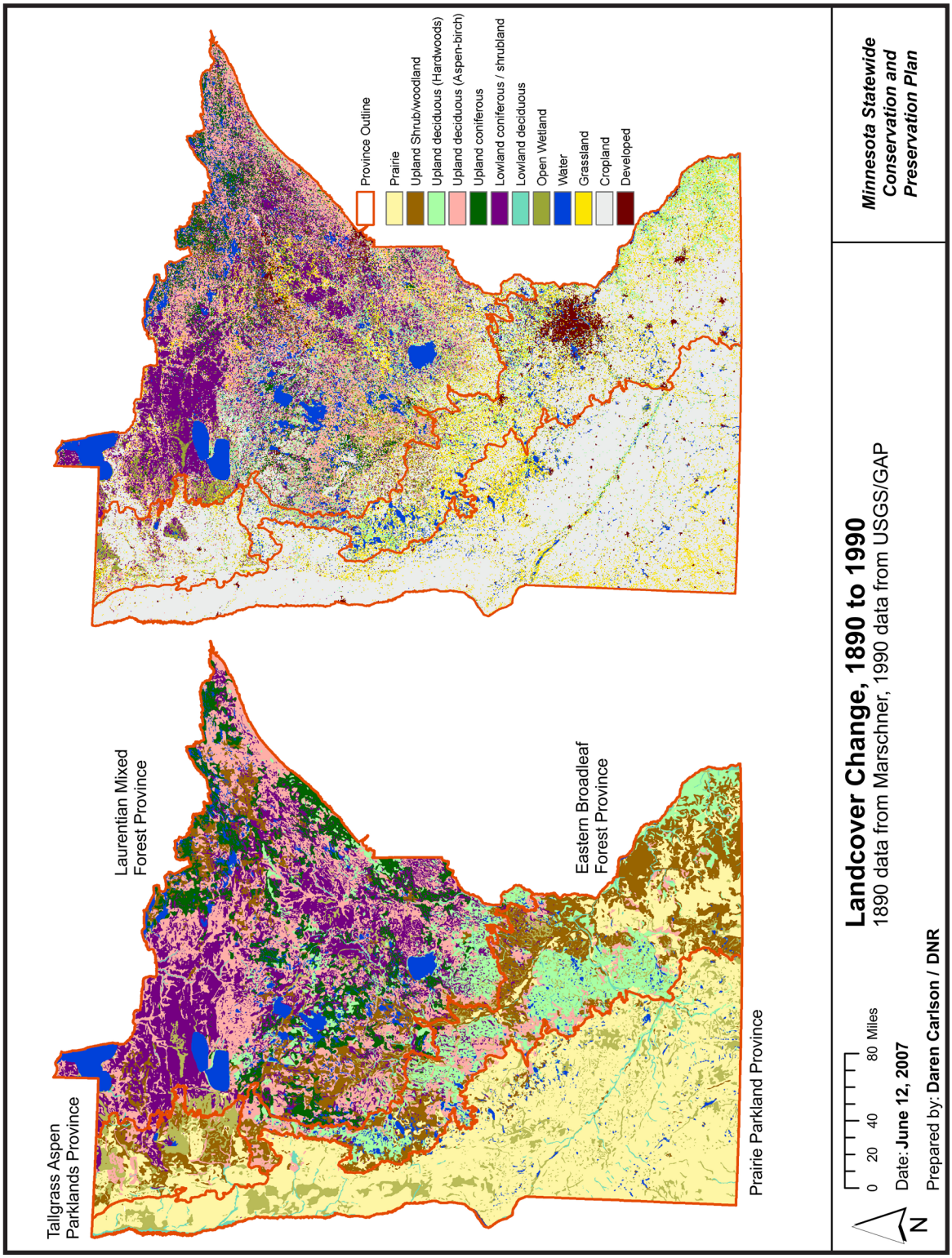


Figure H23. Marschner's map of vegetation around the time of European settlement and contemporary land cover, based on 1990 GAP data. Credit: Daren Carlson, DNR.

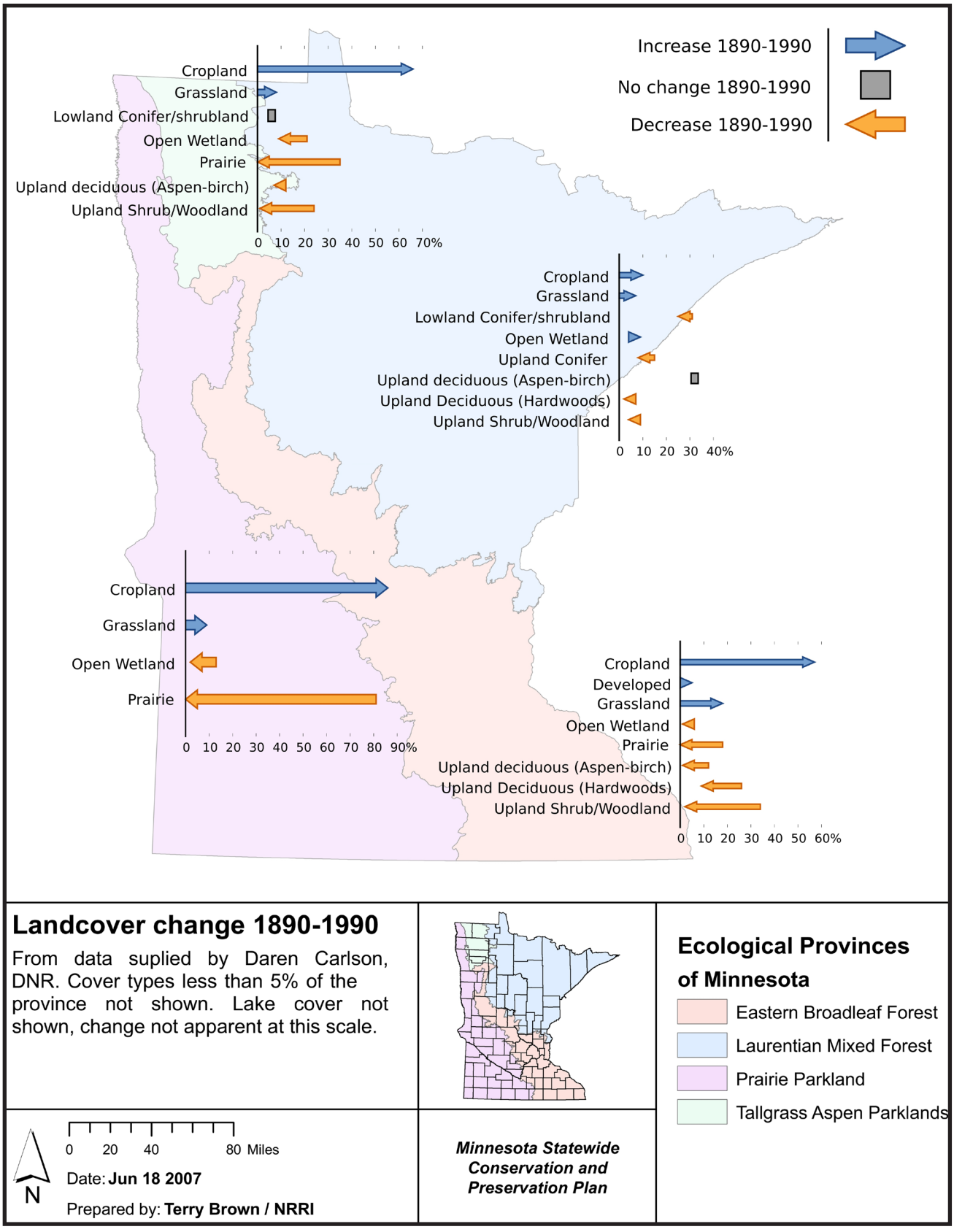


Figure H24. Land cover change, 1890–1990. Credit: Terry Brown, NRRI.

eas such as native prairie and savanna that have been converted to other land uses. This is among the reasons that SOBS received a relatively high weight in the integrated analysis (Table H1).

The state must further strengthen its leadership to coordinate and stimulate efforts for the protection of these critical land areas among current and potential partners. This activity would include identification of relevant landowners; identification of the most cost-effective measures for protection, restoration, and education on the importance of the area; and development of a comprehensive plan to ensure the economic, environmental, and social benefits of protection.

The integrated mapping analyses provide a basis for and opportunity to develop regionally specific strategies for conservation and preservation of Minnesota's critical habitats, using the suite of policy and incentive options from voluntary implementation of BMPs to permanent land acquisition. Implicit within this recommendation is continued support for ongoing programs such as acquisition of the 54,000 acres of private land within state parks. Acquisition of these lands should remain a high priority because they reduce fragmentation and help to maintain large, intact ecosystems. Following are general guidelines for regionally specific protection strategies:

- Focus protection on the critical lands the SCPP has identified by township (Figure H16). Within most highly ranked townships, use detailed analyses to identify specific land parcels for purchase, for development of permanent easements, or for implementation of purchase agreements to acquire these lands (probable range: <1% to 3% of additional Minnesota land area). High- priority examples include native prairie, savanna, old-growth forest, and areas that add to or provide linkages between large, intact ecosystems.
- Within the next tier of habitat ranking (3% to 10% of critical habitat area), identify and implement conservation easement, CRP, Conservation Reserve Enhancement Program (CREP), Conservation Security Program (CSP), Reinvest in Minnesota (RIM) and other incentive-based conservation strategies (e.g., tax credits).
- Within a third tier of habitat rankings (10% to 25% of critical habitat area), identify opportunities for implementation of BMPs to enhance conservation and preservation of critical habitat. Included in this recommendation are multi-owner agreements to maintain large habitat patches and conservation corridors to provide for sustainability of habitats under development pressures and potential climate change.
- Provide regionally specific educational opportunities to enhance public understanding and engagement in habitat conservation efforts.

The following factors should be considered when developing ecoregion-specific strategies for conservation and preservation of Minnesota's critical habitats:

- Restore ecoregion-appropriate, landscape-scale complexes of habitat centered on concentrations of existing remnant habitats with a broader goal of developing/maintaining conservation corridors between existing and restored habitats. Such green infrastructure is important for maintaining biodiversity in the face of increasing development pressure and climate change.
- Contribute to and shape components of the Farm Bill and other federal legislation that supports protecting critical native habitats (e.g., native prairie sodbuster provision of the Farm Bill) and rebuilding landscape-appropriate connections between fragmented critical remnant habitats (e.g., grassland plantings in the prairie region).
- Provide regionally specific educational opportunities to enhance public understanding of and engagement in habitat conservation.

Description of impact on natural resources. Minnesota DNR has 292 species identified as SGCN (DNR 2005). With the exception of white-tailed deer and a

few other species (e.g., Canada goose), many game and wildlife species have declined significantly over the past 50 years (e.g., waterfowl, sharp-tailed grouse, trout, amphibians, and many songbirds). Moreover, public access to land for hunting, fishing, and other recreation has also significantly declined in recent years.

Land and watershed change and degradation have also resulted in degradation of water quality and aquatic habitats in wetlands, streams, rivers, and lakes throughout Minnesota. Implementation of the protection of priority land habitats will begin the process of rectifying this long-term trend of habitat loss and degradation. Restoring native habitats also restores ecosystem processes such as nutrient cycling and its natural regeneration of soil quality. Acquisition and protection of priority land habitats will ensure resilience of Minnesota's valued plant and animal communities as climate change unfolds.

Relationship to existing programs, laws, regulations. The Legislative-Citizen Commission on Minnesota Resources (LCCMR), DNR, the MPCA, BWSR, and the federal government operate under a variety of laws that mandate the protection of wildlife, fisheries, and water quality. The federal Farm Bill is perhaps the greatest single influence on native habitats in the southwestern two-thirds of Minnesota. The DNR Working Lands initiative is currently underutilized by private landowners around the state, primarily as a result of an inability to match high rental rates. The potential of biomass-based fuel production with native, perennial vegetation can be shaped through performance-based incentives, such as those developed by BWSR RIM Clean Energy.

Time frame. Implement as soon as possible and recognize this requires a long-term commitment. Moreover, the state should develop a strategic, long-term plan to continue ongoing programs for land acquisition, protection, and restoration within both the public and private nonprofit sectors. For instance, the RIM program, Forest Legacy Act, and wetland protection, as well as private nonprofit investment are active programs. Should technological improvements and market forces converge, biofuel production from perennial grasslands may be realized in the coming years or next few decades.

Geographical coverage. Statewide

Challenges. Public understanding and acceptance are key barriers for implementation of this recommendation. This includes incentives for conservation of the composition, structure, and function of critical habitats.

Habitat Recommendation 2: Protect critical shorelands of streams and lakes **L P**

Description of recommended action. A holistic approach is needed for shoreline protection that integrates acquisition with diverse private-land protection strategies such as conservation tax credits, trading of conservation tax credits, BMPs, shoreland regulations and incentives, zoning ordinances, conservation development, and technical guidance for shoreland owners. Fully funded acquisition programs are essential, but not sufficient to protect large enough areas of shoreland to ensure water quality and habitat protection, and thus sustain healthy lake, river, and stream ecosystems. It is doubly important to protect these aquatic habitats at a large scale to make them more resilient to the significant warming and altered precipitation projected for Minnesota over the next century (Appendix IV). Therefore, the state needs a diversity of economic incentives and other tools for private landowners.

Shoreline buffers—corridors of natural vegetation along rivers, lakes, wetlands and sinkholes—protect water quality by trapping, filtering, and impeding runoff laden with nutrients, sediments, and other pollutants. Shoreline buffers also stabilize banks, screen shoreland development, reduce erosion, and provide important habitat for shoreline species. Some shorelands are also sites of historic or cultural resources that should be considered for protection.

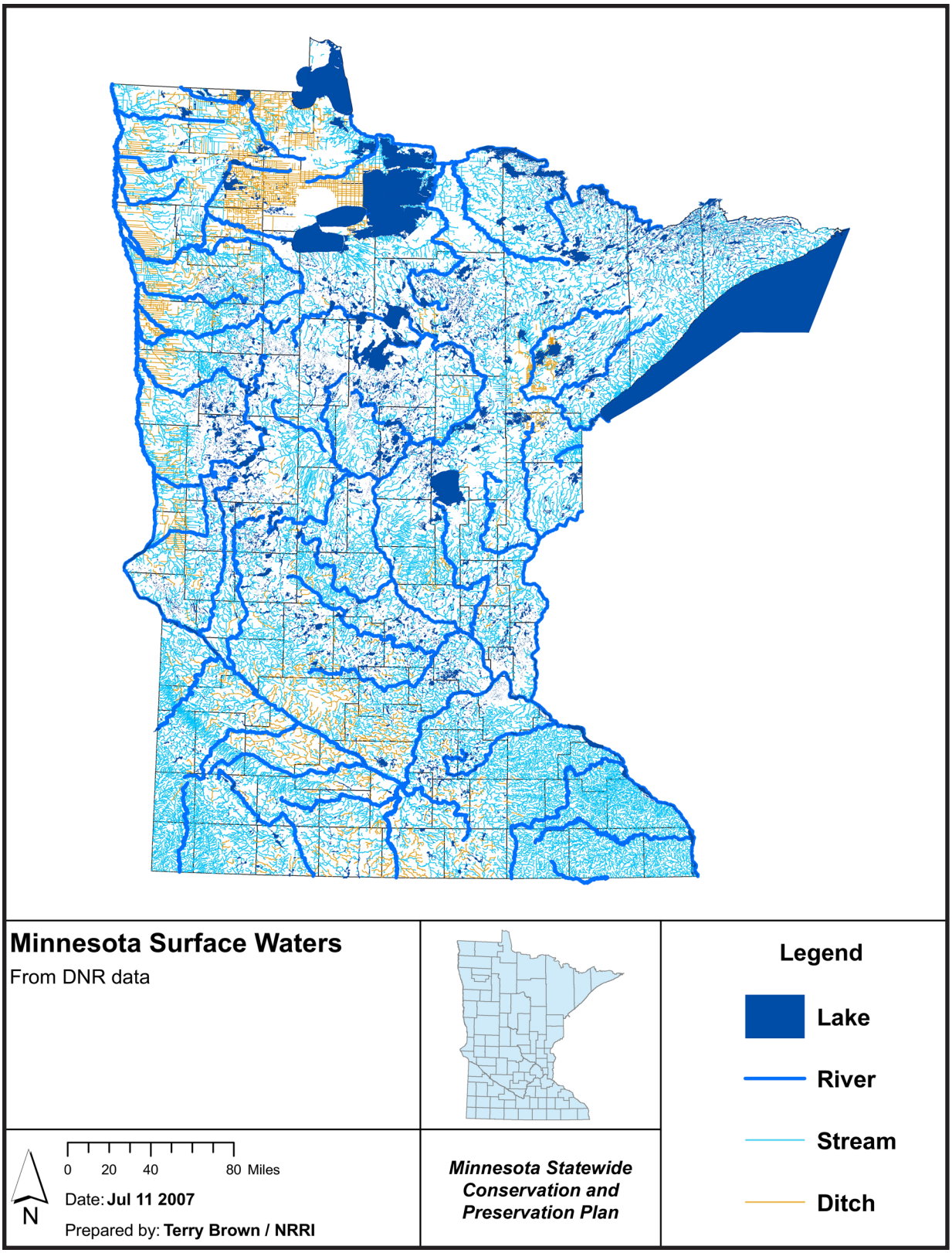


Figure H25. Surface waters in Minnesota. Credit: Terry Brown, NRRI.

Structures and turf-grass lawns have replaced natural shores along many lakes, and have had adverse impacts on water quality and the diverse life that depends on a natural shore. A natural shoreline is more than an aesthetic buffer for the water; it is a complex ecosystem that provides habitat for fish and wildlife and protects water quality for the entire lake. Often, shoreline development results in the loss of these essential shoreline buffers. Rainwater runoff from manicured lawns can be 5 times to 10 times higher than natural shorelines, and runoff from turf lawns can carry up to 9 times more phosphorus to the lake than runoff from natural shorelines.

2A. Acquire high-priority shorelands

The highest priority shorelands within each of Minnesota's 22 ecological subsections should be permanently protected through acquisition. This is one essential component of a multistrategy approach to preserving the clean water legacy that Minnesota's citizens and visitors are used to experiencing. Acquisition may protect critical shoreland habitats from degradation; assure public access for fishing, hunting, wildlife viewing, and natural resource management, which is especially important given the continuing loss of access to natural shores; and provide areas for education and research. Suggestions for prioritizing shoreland acquisition appear in several recent reports, including DNR's 2008 aquatic management area (AMA) acquisition plan, the DNR long-range duck recovery plan, and a 2008 report identifying lake conservation priorities for The Nature Conservancy (TNC).

The AMA acquisition plan outlines the need, value, and short-term and long-term funding recommendations for acquiring cold-water stream and warm-water lake and stream habitats. The vision for cold-water streams is to acquire 1,500 miles of cold-water stream habitat in the next 25 years from willing sellers to provide sustainable populations of trout and greater opportunities for angling recreation for future generations. This would increase the portion of cold-water designated trout streams protected as AMAs from 11% (618 miles) in 2007 to 38% (2,118 miles) by 2032.

The AMA statewide goal for protection of Minnesota's 64,000-plus miles of lake and warm-water stream and river shorelands through public ownership should increase from the current 34% to 39% by 2032. These public lands include federal, state, county, and municipal ownership. These goals are based on the assumption that there will be no loss of shoreland that is currently under public protection. To achieve this goal, the vision is to acquire 1,100 miles of lake and warm-water stream habitat in the next 25 years from willing sellers to provide sustainable populations of fish and other aquatic species and greater opportunities for angling recre-

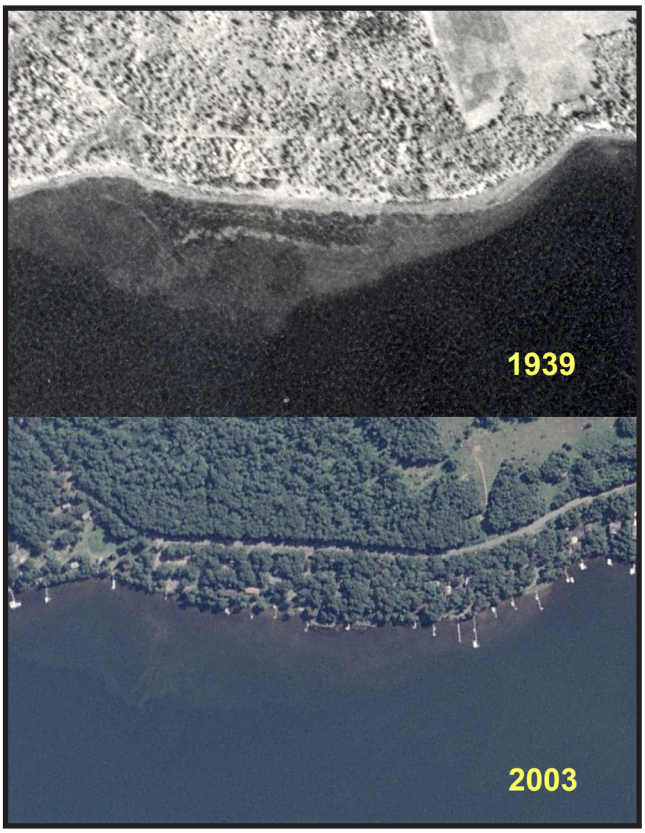


Figure H26. Aerial photographs show the same shore of a Minnesota lake 64 years apart. Note the disappearance of aquatic vegetation along the lakeshore in the 2003 photo.
Credit: 1939, USDA; 2003, USDA Farm Service Agency.

ation for future generations. This would increase the portion of lake and warm-water streams and rivers protected as AMAs from 0.3% (216 miles) in 2007 to 2% (1,316 miles) by 2032.

The vision in the DNR long-range duck recovery plan is that by 2056, Minnesota's landscape will support a productive spring breeding population of ducks averaging 1 million birds and that the landscape necessary to support this population will provide spring and fall migration habitat attracting abundant migrant waterfowl, 140,000 waterfowl hunters, and 600,000 waterfowl watchers. A major need for meeting this vision is to protect, enhance, and manage 1,800 shallow lakes across the state, requiring improved protection or management of 29 additional lakes per year. The plan identifies acquisition as one lake protection method, including fee-title acquisition of land around or containing shallow lakes (e.g., for wildlife management areas) and acquisition of conservation easements on land adjoining shallow lakes through partners (e.g., Ducks Unlimited, Minnesota Land Trust). Other shallow-lake protection methods include local regulatory ordinances and formal designation for wildlife management by the DNR commissioner. Management includes installing water-level controls at lake outlets, reducing negative impacts of invasive plants and fish by removal and other techniques, restricting surface use, restoring watersheds, and resolving competing interests such as fish rearing. Estimated cost of an overall package of protection and management of 1,800 shallow lakes is $151.5 million, for an average expenditure of $3 million per year.

TNC recently developed a statewide lake conservation portfolio to help guide conservation of a range of lake types. The portfolio includes about 1,000 lakes. In addition, this report identifies priority watersheds, which were selected based on viability, lake diversity, and portfolio lakes occurrence, to guide investment in preserving the state's lakes.

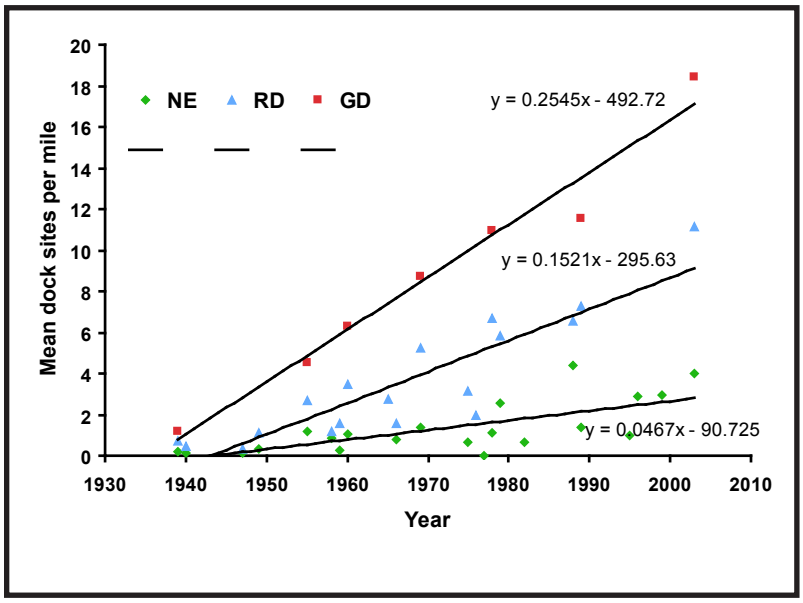


Figure H27. Development around north-central Minnesota lakes, as dock sites per mile, from DNR aerial photos. General development (GD) lakes have a faster rate of development than recreational development (RD) lakes, whereas natural environment (NE) lakes are just beginning to be developed. In 2003, mean development density was 18.5 homes per mile for GD lakes, 11.2 homes per mile for RD lakes, and 4.0 homes per mile for NE lakes.
Credit: Paul Radomski, DNR.

2B. Protect private shorelands via economic incentives and other tools

Minnesota should greatly increase the use of economic incentives and other tools for private landowners to protect shorelines and other sensitive land along lakes, especially along shallow lakes and shallow bays of deep lakes, and streams and rivers throughout Minnesota. This is also needed for riparian buffers around sinkholes in agricultural lands in southeastern Minnesota (see further discussion under habitat recommendation 7).

Protection of private shorelands should combine various tools, such as tax credits, conservation easements for shoreland protection and restoration, BMPs, technical guidance to shoreland owners, shoreland regulations, and zoning ordinances. It is especially important to scale up and combine

these tools, for example, by providing technical guidance to landowners on how to implement BMPs on shorelands put under a tradeable conservation tax credit.

Tax credits could dramatically catalyze private shoreland protection. The idea is to provide state income tax credit for conservation easements. In their simplest form, conservation tax credits are applied to perpetual conservation easements or donations of fee-title land. Perpetual conservation easements could be donated to the state or legal land trusts. A further innovation is to allow trade of conservation tax credits among taxpayers: Landowners with low state tax liability could sell their credits to landowners with higher tax liability, thereby giving landowners with low tax liability an incentive to become interested in making land conservation donations. Although conservation tax credits were initially conceived as a protection strategy for shallow lake habitats in agricultural areas, this approach could expand to protecting a broader array of shorelands (streams, rivers, lakes, wetlands) throughout the state.

Another innovation could be tax credits for major changes in land use practices that are clearly known to protect aquatic habitats. This idea, inspired by a new property-tax-break program for organic farms in Woodbury County, Iowa, could apply to working lands of various kinds. For instance, the state should develop a plan for the implementation of a credit to buyers of lake home properties with intact shoreline buffers, as defined in Minnesota's shoreland conservation standards, and a fee on the sellers of lake home properties without such intact shoreline buffers via revision of the deed tax. The idea would need in-depth exploration because it has not been broadly applied for meeting conservation goals. If done right, it could benefit both habitat and sustainable economic development.

Shoreland development policies should protect existing buffers and require restoration of buffers. Incentives are needed for landowners to plant or protect existing vegetation in riparian areas and should be coupled with technical guidance on site-specific design of buffers, which depends on slope and soils (affecting nutrient and sediment movements) and appropriate environmental conditions for wildlife corridors.

Several trends make it important now to protect shallow wildlife or natural environment lakes and shallow bays of deep lakes. More and more, these aquatic systems are becoming the target of development proposals as deep recreational lakes become more fully developed. Their development would degrade their watersheds and shorelines and increase recreational uses that disrupt these shallow-water habitats, and both the fish and wildlife populations they harbor. Shallow lakes are extremely sensitive to disturbance and are subject to mixing from wind, motorized boats, and fish (especially carp). They typically exist in either a turbid or clear-water state depending on the condition of their lakeshed, their nutrient loading, the abundance of fish, and ecological setting.

Description of impact on natural resources. AMAs provide a critical foundation for shoreland protection and management, while providing public access for Minnesotans who fish, hunt, observe wildlife, and recreate on the state's waters. Protection of

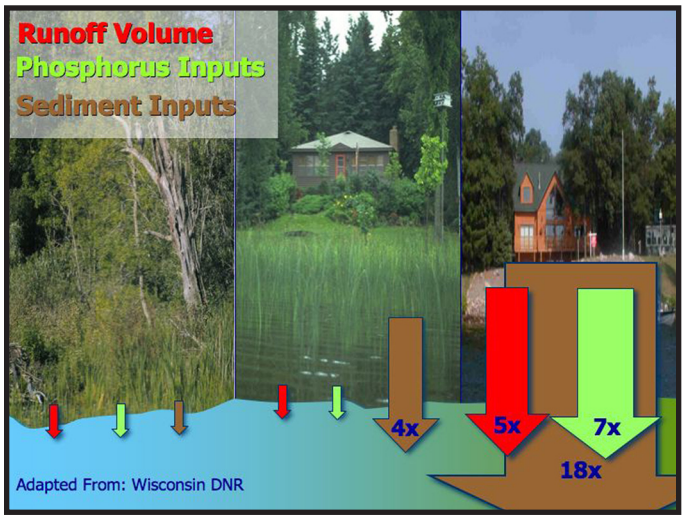


Figure H28. Increasing size of the arrows indicate increasing volume of runoff and nutrients as shorelines. Credit: DNR Waters.

privately held shorelands will directly protect shallow lake shoreline aquatic habitat for both fish and wetland-dependent wildlife species, including several SGCN such as the common loon, black tern, and Blanding's turtle.

Figure H29. Lake Christina, shallow lake with good habitat. Credit: Ducks Unlimited.

Protecting shallow lakes and shallow bays of deeper lakes will also address the habitat goals of the Minnesota duck recovery plan, which calls for the protection and management of 1,800 shallow lakes; help protect Minnesota's wild rice lakes; and help support the goals of the DNR's AMA program, among others. Similarly, protecting shorelines of deeper lakes will provide habitat for shoreland species, such as amphibians, and allow large trees to fall into the water where they provide important habitat for fish and invertebrates.

Protection of shoreline buffers is one of the best ways to reduce several drivers of harmful change to aquatic communities that were highlighted in the preliminary plan: nutrient loading and solids loading, which harm water quality, harm native fish and other aquatic organisms, and degrade lake habitats. Adequate shoreline buffers can also help to reduce contaminant loading into surface waters because microorganisms found in the soils of healthy shoreline plant communities can partly break down some contaminants. Finally, acquisition and protection of shoreland habitats will ensure resilience of Minnesota's valued aquatic communities as climate change unfolds.

Relationship to existing programs, laws, or regulations. Public ownership and protection of these resources is currently accomplished through state ownership (AMAs, state parks, wildlife management areas, state forests, BWSR RIM easements), federal ownership [U.S. Fish and Wildlife Service (USFWS) easements, U.S. Forest Service lands], and local government units (Metropolitan Council, county and municipal parks, watershed districts, lake improvement districts) employing fee title acquisition and conservation easements. Formal designation of wildlife lakes falls under Minnesota Statutes 97a.101, Public Water Reserves and Management Designation through the DNR commissioner's order.

The AMA program was created by the 1992 Legislature as part of the Outdoor Recreation Act. A number of statutes and rules are in place to provide initial guidance for acquiring AMAs. The program provides angler and management access, protects critical shoreland habitat, and provides areas for education and research.

Current Minnesota statute and rules recognize that AMA acquisition requires a two-pronged approach. One approach is for trout-stream angling and management access in the form of permanent easements. (This does not preclude fee title acquisition on trout streams.) The other approach is for lakes and warm-water streams in the form of fee title acquisition, permanent access easement, and conservation easement. These two approaches require two differ-

ent geographic emphases. Minnesota trout streams are located mainly along the North Shore of Lake Superior and in the southeastern counties. Lake resources in greatest need of protection are concentrated in the central portion of the state.

Recent fisheries acquisition spending (fiscal years 2006–08) set strategic goals for both types of acquisition.

- Continue to acquire permanent management and angling easements on Minnesota's designated trout streams as management needs and opportunities to make connections as angler corridors develop, and as annual funding allows.
- Continue to acquire appropriate fee title and conservation easements on lakes and warmwater streams, as parcels with critical habitat become available, as partnership opportunities arise, and as annual funding allows.

No state conservation tax credit program exists in Minnesota, so one would need to be created. State, county, and local shoreland protection regulations do exist in Minnesota, but are generally not effective in protecting shallow lakes and shallow bays in deeper lakes. Often, they simply restrict the setbacks and densities of buildings along shallow lakes and bays, but still allow development and alteration of upland vegetation down to the water's edge. State law protects aquatic plants, but allows for limited manipulation by landowners within guidelines and under permit. Only limited funding exists for shoreland protection and acquisition programs, including land acquisition for the DNR's AMAs, and conservation easements secured by nonprofit organizations.

Given that protection of shoreline buffers on private lands can greatly reduce nonpoint source pollution, the federal Clean Water Act also affects this recommendation through its total maximum daily load (TMDL) process. For shorelines in forested areas, advice for protecting water quality appears in the Minnesota Forest Resources Council's (MFRC) handbook, *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers.*

Minnesota, through the DNR, sets minimum shoreland development standards for local governments to meet or exceed. The goal of the standards is to help guide the use and wise development of Minnesota's shorelands. These guidelines address shoreline vegetation removal, minimum lot size, minimum water frontage, building setbacks, and subdivision and planned unit development regulations. These standards were developed in 1970, when small cabins were the predominant form of development, and were last revised in 1989.

The state's shoreland development standards are now being reviewed to determine if they need to be updated. These standards should be revised to include robust provisions related to the protection and restoration of natural shores along lakes and rivers. Revised regulations need to be responsive to the cumulative impacts of shoreland degradation on aquatic habitats and people's viewsheds.

Time frame. AMA acquisitions will take 25 years. Protection strategies for private shorelands will need to be an ongoing program, funded annually or at least biennially, given the growing trend of development and agriculture pressure on shorelines of Minnesota lakes and streams and the magnitude of the problem statewide. Results should be documented via long-term monitoring and evaluation of both acres of shoreland restored and responses of habitat quality and of fish, wildlife and biodiversity.

Geographical coverage. This recommendation applies statewide. Acquisition and protection of shallow-lake shorelands should target the forest, forest-prairie transition, and prairie zones, and strategically target lakes with outstanding natural resource and wildlife habitat value or greatest potential of habitat improvement through management. Acquisition and protection of stream shorelands should target prairie

zones and southeastern Minnesota, and protection of deep-water lakes should target forest zones.

Barriers. Shoreland owners feel increasing pressure to sell their land. Public and private partnerships must be expanded to maximize financial resources available for acquisitions, conservation easements and tax incentives. A marketing program must be formulated to entice private landowner participation in such strategies. Acquisition processes need to be efficient and effective, and there is the need to develop education programs for potential sellers on topics such as tax benefits. Finally, successful acquisition programs depend on partnerships with nonprofit organizations, government agencies, and stakeholder groups.

Innovative zoning within sensitive shoreland areas of deeper lakes (to protect water quality and near-shore habitat via conservation-based development) may be difficult to adopt in local ordinance or to implement by local government without state guidance. In addition, revision of statewide shoreland development standards (to include robust provisions on protection and restoration of shoreline buffers) will depend on an informed public and courage from state officials.

A transferable tax credit program for conservation land value donations will be expensive (cost the state tax revenue) and challenging to manage (especially the transfer of tax credits), and will require new state legislation and bipartisan support. Conservation easements take time to appraise and negotiate, and many lakes have multiple landowners, so progress will be slow. Many owners of forested land on shallow lakes assume the development value of their land is higher than it may actually be due to influence of realtors and land sales on deeper lakes, so purchasing land or easements at appraised value may be difficult. In the prairie, many shoreline sites are currently being farmed, and adjacent drained wetland basins and converted uplands are simply not for sale—especially in light of high land values resulting from high crop prices. Therefore, the main challenge will be to secure the rights to these lands now without having to buy them all, and to provide enough incentives for land-rich, cash-poor landowners to consider conservation as an alternative to development while still allowing for private land ownership and compatible land use practices.

Habitat Recommendation 3: Improve connectivity and access to outdoor recreation **LP**

Outdoor recreation was not one of the three focal issues chosen for the final SCPP; however, the State Comprehensive Outdoor Recreation Plan (SCORP) has already provided a comprehensive plan and the SCPP preliminary plan provided recommendations for research to support quality outdoor recreation in the future (see Appendix I). To complement these recommendations, the habitat team offers an additional recommendation regarding the important connection between habitat conservation and recreation and considering the distribution of historical and cultural resources in the state.

Description of recommended action. Land use patterns are changing in Minnesota. Lakeshore development is increasing, urban areas are expanding, and forests are being divided into small, privately owned parcels. These changes and others are affecting outdoor recreation. Land needs to be acquired, protected, and restored to provide Minnesotans and visitors an outdoor system where they can recreate.

Action should be taken to improve connectivity of and access to outdoor recreation areas (parks, natural areas, wildlife management areas, etc., Figure H30) and document the connectivity and experience opportunities through a statewide recreation system. Such connectivity would require enhancing connections among state, federal, and local government lands and facilities. Prioritization for acquisition, protection, and restoration of the natural resource

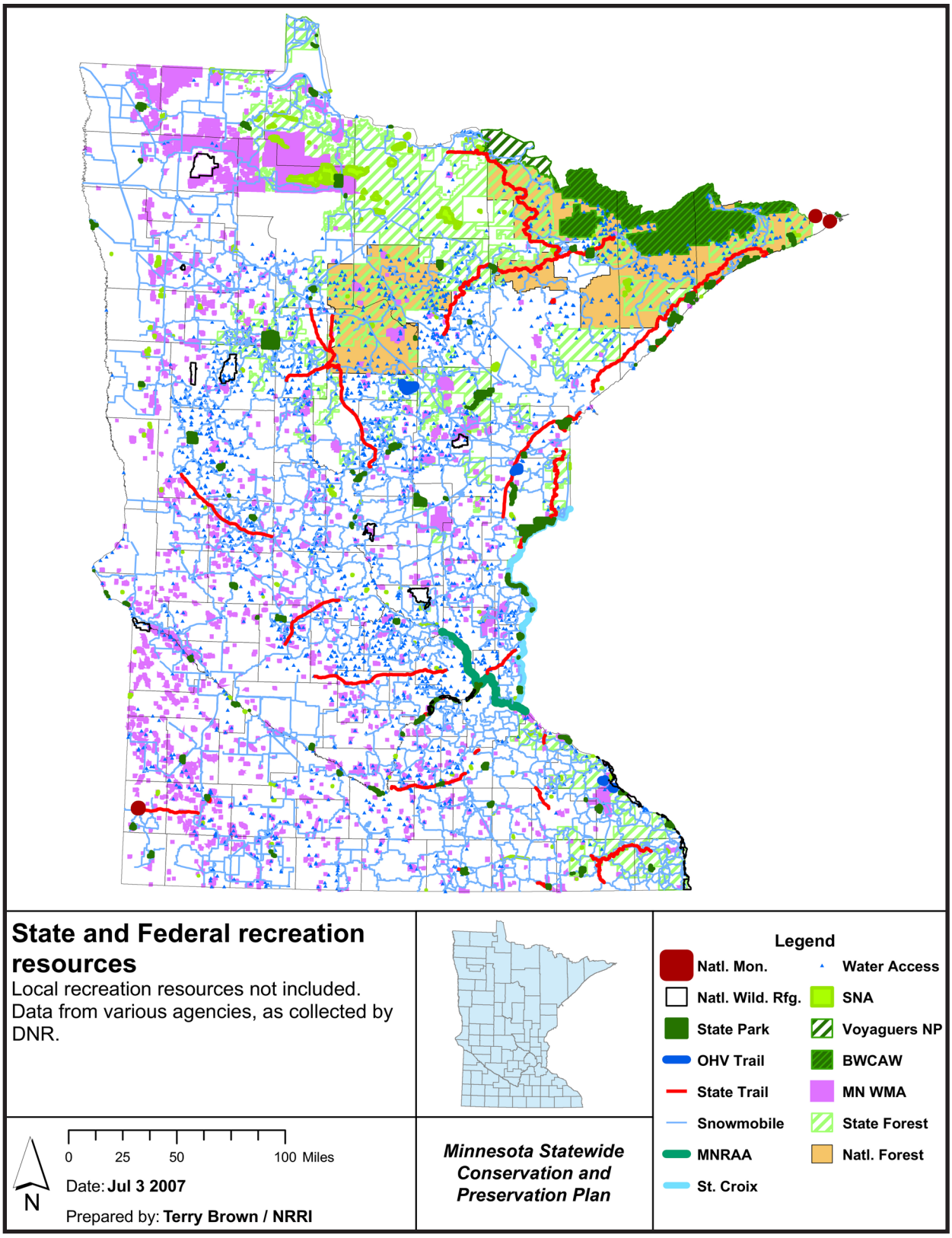


Figure H30. State and federal recreation resources available in Minnesota. Credit: Terry Brown, NRRI.

base that supports outdoor recreation should focus on large, contiguous land areas suitable for: natural resource–based outdoor recreation; shorelands; threatened habitat areas with opportunities to improve connectivity of underserved areas; and rapidly growing areas or areas where land use changes may limit future outdoor recreation opportunities.

The trends in recreational use and changes in land use patterns all support this recommendation. These primary drivers include land use conversion patterns and changes in population demographics in areas such as the Twin Cities metropolitan area and locations with lakes, rivers, and forests. Participation in hunting and fishing continues to decline, while nonconsumptive activities such as wildlife watching and hiking remain stable or are growing. Increasing human population is projected to lead to an estimated rise in state park visitors, from 8.6 million in 1998 to 9.2 million by 2025. If energy costs continue to increase, there will be a growing demand for outdoor opportunities that limit the need to travel great distances for recreation.

A higher priority should be placed on actions that are needed within the next three to five years to ensure adequate outdoor recreation opportunities in future years. This may mean greatly accelerating acquisition of larger intact natural areas, key connection lands, most imperiled habitats, undeveloped shorelands, areas experiencing and anticipated to continue experiencing growth population growth, and areas underserved by recreational systems. The needs for outdoor recreation are a strong complement to many of the habitat recommendations.

Description of impact on natural resources. Outdoor recreation is an important part of Minnesotans' lives. Statistics show that outdoor recreation is very important to 57%, moderately important to 25%, slightly important to 10% and not important to 8% of Minnesota adults. Connectivity will enhance opportunities for environmental protection as well as the individual benefits realized from recreation experiences. Protection of large land areas provides habitat for plant and animal species threatened by fragmentation. It also provides opportunities for outdoor recreational activities that require a large land base.

Access can increase participation opportunities for a variety of generations and racial/ethnic groups. Such participation can impart an increased sense of environmental appreciation and build support for environmental programs and policies. For example, innovative programs that engage participants in the environment, such as wildlife photography for urban minority youth, can inspire appreciation for and value of the environment.

Relationship to existing programs, laws, regulations. A variety of existing laws and programs support this recommendation, including: (1) The state outdoor recreation system (established in state statute), (2) state and local park and trail systems, (3) the Environment and Natural Resources Trust Fund, and (4) existing state and federal grant programs. For instance, the federal land and water conservation fund has assisted in the acquisition of 7 million acres of parkland and 40,000 state and local recreation and natural area projects nationwide since it began in 1964. The programs and governmental structures by which these activities can be conducted are generally in place.

Time frame. Accelerated acquisition and protection within the next 5 to 10 years (or perhaps sooner in some areas of rapid population growth and development) is essential.

Geographical coverage. This recommendation applies statewide. Recent reports identify significant areas of need, such as areas around regional population centers (Figure H31), high-amenity lake areas/scenic areas, shorelines, and (especially) areas that have limited public land.

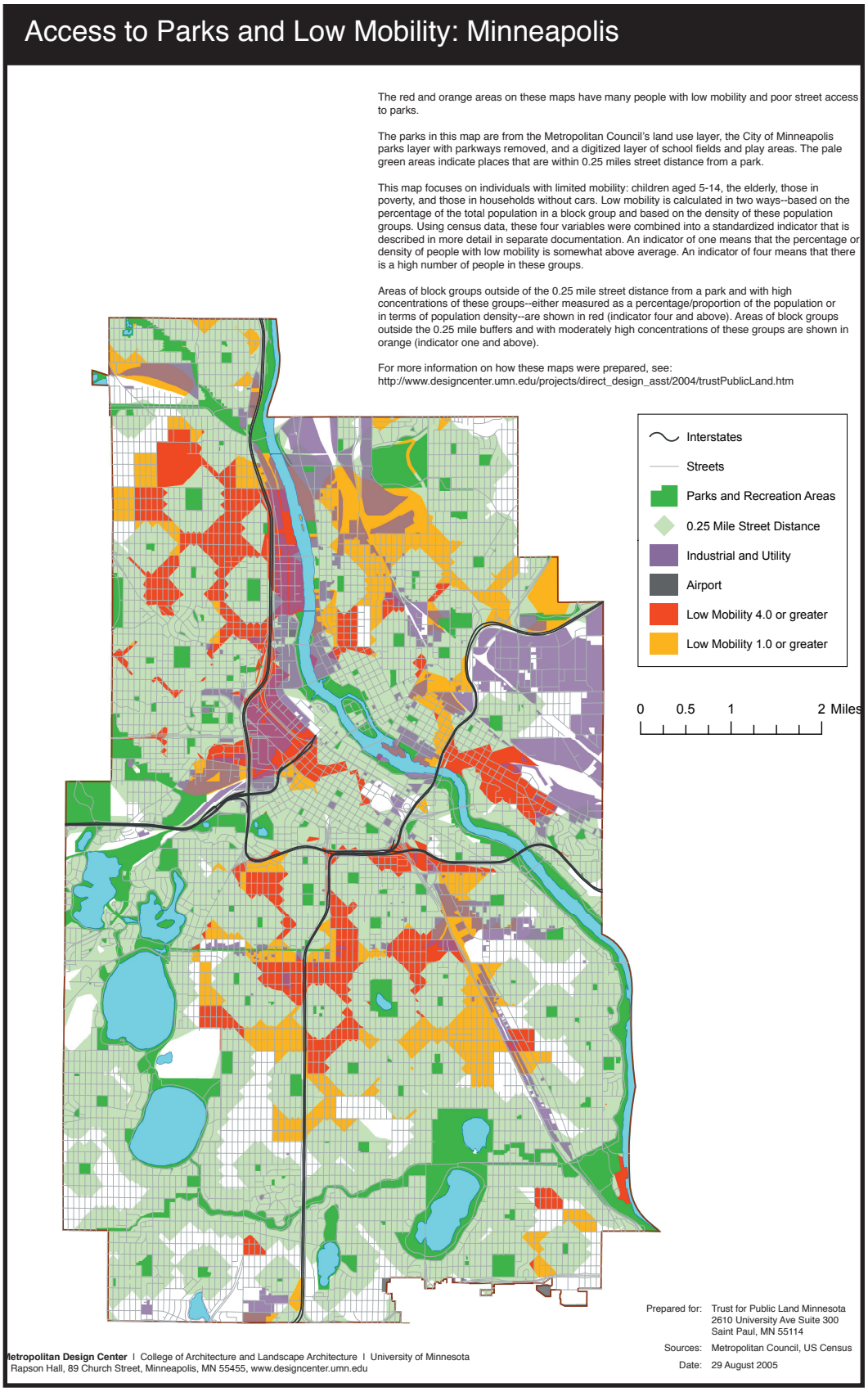


Figure H31. Access to parks and low mobility, Minneapolis.
Credit: Trust for Public Land with assistance from the Metropolitan Design Center, UM.

Challenges. Foremost is the lack of adequate and reliable funding for acquisition and management. In many areas of the state, development pressures have overwhelmed the existing government response and available resources. The resources available for the planning needed to inform acquisition decisions are limited at the state level and very limited at the local level. Planning and management coordination among state and local governments needs improvement.

Land and Water Restoration

Habitat Recommendation 4: Restore and protect shallow lakes **R P**

Description of recommended action. Minnesota should accelerate efforts to restore and improve shallow-lake habitat (including shallow bays of deep lakes) in priority watersheds in order to reduce the number of lakes in a turbid-water state, and to restore some of the 1,000-plus drained shallow lakes in the state. Active management of Swan, Christina, and Thief Lakes shows that many shallow lakes with poor water quality and little habitat can be restored through active management.

Sensitive shallow lakes frequently winterkill (fish); are subject to mixing from wind, surface use, and large fish (carp); and typically exist in either a turbid- or clear-water state. Unfortunately, most shallow lakes in the prairie and forest-prairie transition zones of Minnesota are in the turbid-water state. This is due to the combination of increased flows of water and nutrients into them from intensively drained and cultivated landscapes that surround them, and abundant populations of invasive fish (e.g., carp and black bullhead) that result from increased connectivity (i.e., ditches) and persist due to lack of natural winterkill. Some shallow lakes are so turbid that they are listed as impaired by the MPCA. Dense human housing development and inappropriate surface uses are also increasing threats to shallow lakes.

Funding is needed to purchase conservation easements around shallow lakes to restore their lakesheds (small wetlands and grass buffers) and prevent development. Funding is also needed to install fish barriers to keep out invasive species such as carp. Finally, funding is needed for water control structures that state agency managers can use to conduct temporary drawdowns to consolidate and aerate sediments, induce natural winterkill of fish, and rejuvenate aquatic plants. The level of development and management of the landscapes around shallow lakes necessitates active in-lake management in order to maintain water quality and good habitat.

Description of impact on natural resources. This work will directly improve the water quality of shallow lakes and the wildlife habitat they provide to wetland-dependent wildlife, including several SGCN such as lesser scaup and black tern. This work will address the habitat goals of the Minnesota Duck Recovery Plan. Restoration of shallow-lake watersheds will help many species of prairie wetland and upland species as well. These species suffer from the loss of nearly all native prairie and most prairie wetlands in the state. Strategic restoration of these habitats will improve the breeding habitat base these

Shallow Lake Habitats

Shallow lakes are defined as wetland basins 50 acres or larger with maximum depths no greater than 15 feet, along with deeper basins with at least an 80% littoral zone capable of growing aquatic plants (less than 10 feet deep). Shallow areas of deeper lakes are areas 15 feet deep or less dominated by a rich diversity of aquatic plants. Collectively, these include shallow lakes and bays in the northern forest where wild rice is common, shallow lakes throughout the transition zone between forest and prairie, and shallow lakes and large wetlands in the southern prairie region where agriculture dominates.

species need to successfully reproduce and grow their populations. This will also help reverse the trend of wetland loss in the state. Restoration of shallow lakes will also ensure resilience of Minnesota's wetland-dependent wildlife as climate changes.

Relationship to existing programs, laws, regulations. This recommendation would extend the existing DNR Shallow Lakes Program. Several wetland restoration programs exist in the state, that could be enhanced with additional funding, and other opportunities exist to partner with federal wetland restoration programs. Other ways exist to strategically restore wetlands and associated uplands, such as funding conservation easements that pay landowners to restore drained basins and upland buffers around them. Additional state and federal private land conservation programs exist as well, including the U.S. Fish and Wildlife Service's Partners for Wildlife program.

Time frame. Given the magnitude of the impaired waters in Minnesota and the wetland and prairie loss in southern Minnesota, this will need to be an ongoing program that is funded annually or at least biennially. Results will be documented via long-term monitoring and evaluation of both acres restored and wildlife response.

Geographical coverage. This program should target the prairie and forest-prairie transition zones in Minnesota, and strategically target areas near remaining patches of wetlands and prairie.

Challenges. Conservation easements take time to appraise and negotiate, and many lakes have multiple landowners, so progress will be slow. Many shoreline sites are being farmed, and drained wetland basins and converted prairie sites are simply not for sale—especially in light of high land values resulting from corn ethanol subsidies. Therefore, the main challenge will be to provide sufficient incentives for landowners to restore wetlands and associated uplands, especially larger basins that are partially owned by multiple landowners. A working-lands approach to the restoration of these sites is needed, one that may allow landowners to use the restored sites for hay, grazing, biofuel production, or other wildlife-compatible use that will still result in the hydrological restoration of wetlands and a minimum buffer around them. Currently, the state cannot actively manage water levels of public waters to improve their water quality without acquiring riparian land rights or legally designating certain lakes for wildlife management purposes. Changes to state law that allow the DNR to manipulate water levels for lake improvement should be considered by lawmakers, but will be challenging.

Figure H32. Example of poor shallow lake habitat. Crdit: DNR Shallow Lakes Program.

Habitat Recommendation 5: Restore land, wetlands, and wetland-associated watersheds **R P**

Description of recommended action. Minnesota must invest in prioritized areas to restore degraded and rare land features, wetlands (especially many that have been drained and converted), and watersheds associated with wetlands. This will provide benefits for wildlife, SGCN, water quality, and important ecological processes. This is especially imperative in the prairie and prairie-forest transition zones of the state. Restoration should consider the need to encourage landowners to restore these lands and compensate them above and beyond the fair market value of the land, since most sites are not for sale and high crop prices inhibit conversion of land from agriculture to other uses. Consideration must also be given to using easements on private lands to achieve habitat restoration goals. It is imperative to recognize the huge loss of native prairie and small wetlands in the prairie region of Minnesota (99% and 90%, respectively). Wildlife does not require restored lands to be in public ownership to benefit from them as critical habitat. Restoration, however, is not only needed in the prairie regions, though it is of high priority there. Other land uses such as savanna and forests are also in need of attention. For instance, riparian forests need restoring, and regeneration of oak, white cedar, and white pine requires attention. Similarly, restoration of wetlands alone cannot restore their appropriate structure and function; restoration efforts must also consider the watersheds that drain into wetlands.

Description of impact on natural resources. This work will directly address the habitat needs of many forest, prairie, and wetland-dependent species, including waterfowl and a wide range of non-game bird species listed as SGCN in Minnesota's State Wildlife Action Plan (DNR 2005). This work also addresses the habitat goals of the Minnesota Duck Recovery Plan and the Minnesota Pheasant Plan. These species have declined with the loss of nearly all native prairie and most prairie wetlands in the state. Strategic restoration of these habitats will improve the breeding and migratory habitat base for these species and allow the recovery of their populations. This will also help reverse the trend of wetland loss in the state. It is an especially important climate change adaptation strategy to protect the Upper Midwest region's breeding habitats for waterfowl and upland prairie species. This is because climate change models for the prairie pothole region suggest that favorable wetland conditions will shift eastward, away from the Dakotas and especially favoring southwestern Minnesota. This makes it even more essential to restore lakesheds of shallow lakes (small wetlands and upland grasslands) and protect shallow lakes in southwestern Minnesota, if we want to ensure healthy waterfowl populations in the entire Upper Midwest.

Relationship to existing programs, laws, regulations. Several wetland restoration programs exist in the state, but most (e.g., RIM) are underfunded relative to demand, and other opportunities exist to partner with federal wetland restoration programs (e.g., WRP). Other ways exist to strategically restore wetlands and associated uplands, such as funding conservation easements that pay landowners to restore drained basins and upland buffers around them. Additional state and federal private land conservation programs exist as well, including the U.S. Fish and Wildlife Service's Partners for Wildlife program.

Time frame. Given the magnitude of the wetland and prairie loss in Minnesota, this will need to be an ongoing program that is funded annually or at least biennially. Results will be documented via long-term monitoring and evaluation of both acres restored and wildlife response.

Geographical coverage. This program should have a special emphasis on the prairie and forest-prairie transition zones in Minnesota, and strategically target areas near remaining patches of wetlands and

prairie. However, a wide variety of land areas and wetland-associated watersheds deserve attention for restoration as well (Figure H15). In the forested area of the state, emphasis should be placed on shallow lakes with a history of wild rice production.

Challenges. Restoration efforts will improve both the availability and quality of Minnesota's environment, but the degraded nature of the habitat is not always noticeable. Public education should illustrate why restoration efforts are essential (e.g., to restore the ecological processes that make forests productive or wetlands functional). Many drained wetland basins and converted prairie sites are under private ownership, especially when land values are high and in demand for agricultural production. Therefore, a challenge will be to secure the rights to land needed for wetland restoration, especially larger watersheds with multiple landowners. A working lands approach to the restoration of these sites is needed, one that can allow landowners to use the restored sites for economic benefit, while retaining their value for wildlife.

Habitat Recommendation 6: Protect and restore critical in-water habitat of lakes and streams **R P**

Description of recommended action. Accelerate and expand the relatively small current efforts to restore critical habitat for aquatic communities in near-shore areas of lakes, in-stream areas of rivers and streams, and deep-water lakes with exceptional water quality.

6A. Restore habitat structure within lakes

We recommend developing a program to restore the natural features of lakeshore habitats (shoreland, shoreline, and near-shore areas). The program would add woody habitat where it has been removed, and restore emergent and floating vegetation where it has been lost. The program would also work with lake-home owners and lake associations to achieve restoration goals.

Minnesota's lakes are among its most valuable resources. Lakes provide various recreational opportunities, and are also home to numerous fish, wildlife, and plant species. Many of these species, including SGCN, are highly dependent on naturally vegetated shorelines as habitat for feeding, resting, and mating and as nursery areas for juvenile life stages. For example, loons avoid clear beaches and instead nest in sheltered areas with shallow water where nests are protected from wind and wave action. Mink frogs and green frogs are shoreline-dependent species that prefer quiet bays and protected areas with a high abundance of aquatic plants. Fish such as the least darter, longear sunfish, pugnose shiner, northern pike, muskellunge, crappie, and largemouth bass are strongly associated with large, near-shore stands of aquatic plants.

Increasing development pressure along lakeshores has negative impacts on these species and water quality—and Minnesota's lakeshores are being developed at a rapid rate. The shallow areas in large lakes are crucial to fish, wildlife, and water quality. An estimated 20% to 28% of the near-shore emergent and floating-leaf coverage has been lost due to development in bass and walleye lakes. On average, there is a 66% reduction in aquatic vegetation coverage with shoreland development. These declines in aquatic vegetation coincide with lower fish production and reduced water quality in lakes. Woody habitat losses are also occurring in Minnesota lakes but have not been quantified. Many fish depend on aquatic vegetation, woody habitat, and shorelines to provide spawning habitat, cover, and refuge from predators. Downed trees provide important in-lake structure, habitat, food, and shelter for fishes, frogs, turtles, water birds, and mammals. This woody habitat is also important for aquatic invertebrates such as snails and bryozoans. Turtles need to bask on deadfalls or floating logs. Near-shore downed trees also blunt waves and ice action that scour the lake bed. Because trees often grow slowly and their density has been reduced due to past shoreline alterations,

this important habitat element in Minnesota lakes may not be replenished without substantial efforts.

Docking on lakes has been regulated by the state because lake-home owners put their docks in public waters. Lake-home owners are allowed reasonable access to water because they own the shoreland, and this includes reasonable docking to allow access to navigable depths. Some citizens are concerned that the placement of large docks usurps the public use of water areas near the shore. Conflicts occur when people try to privatize this public space—for example, when lake-home owners try to prevent anglers from fishing near their docks. In addition, there are concerns about increased shoreline habitat loss due to large docks, which are becoming more common.

6B. Protect and restore in-stream habitats

A priority for rivers, particularly the Mississippi River, is to reduce the negative effects of recreational boat traffic, especially from medium to large cruisers, on sensitive shoreline habitats. Stream-bank erosion from recreational boat wakes adds large sediment loads, which increases water turbidity and disrupts the growth of beneficial aquatic plants and reproduction of native mussels and some fish. Other habitat impacts include breakage of aquatic plants; impingement and various disturbances of fish and wildlife; and dislodging of woody debris that normally provides important cover and food production for fish, as well as habitat structure for turtles and birds. Systemic solutions include enforcing no-wake zones or no-wake periods in sensitive habitats, which requires revision of local, state, or federal surface water use regulations; and design of more river-friendly boats, which requires engineering research and development. Past education efforts and voluntary no-wake zones have not worked.

A related problem is increasing demand for structures, including docks, wharves, breakwaters, boat-launching ramps, mooring facilities, marinas, retaining walls, boathouses, boat storage structures, and other facilities. The numbers, diversity, and size of private structures in public waters far exceed those that were present when DNR rules on structures were first written. The spread of built structures has enlarged the coverage of water surface area in near-shore habitats, degrading in-stream habitat for fish and wildlife. Habitat degradation often extends to the shoreline due to removal of native vegetation along riverbanks surrounding these structures. The spread of structures has also negatively affected the viewshed through visual and physical overcrowding and sprawl. DNR rules clearly need to be revised to address negative habitat, socioeconomic, and cultural impacts of structures in order to maintain the quality of public waters that Minnesotans expect and future generations deserve.

A priority for former prairie zones of Minnesota is to reverse the negative effects of stream channelization on in-stream habitats for fish and other aquatic organisms. Channelization has changed the hydrology of streams, which has then made them wider and more deeply incised. In many locations, negative effects of stream channelization have been exacerbated by removal of riparian vegetation and wetlands, and altered upland land use. Several approaches can be implemented to protect and restore in-stream habitats. Riparian vegetation can be restored to stabilize stream banks (several state and federal programs, such as RIM, CRP, CREP and CSP, can provide financial assistance). Two-stage channels (Figures H33 and H34) can be constructed where streams have been channelized to provide a flood plain to dissipate stream energy and allow the channel to remeander, which will provide more diverse habitat for aquatic organisms. Restoring wetlands and altering upland vegetation (state and federal programs provide financial assistance) will hold water on the landscape or allow for increased infiltration, both of which can help mitigate the altered hydrology of streams.

Minnesota has hundreds of low-head dams and culverts that restrict movement of aquatic organisms.

Inappropriately sized culverts also may contribute to localized flooding. Removal of dams and installing culverts with increased capacity would improve connectivity of aquatic systems. An alternative approach to removal of low-head dams is to provide for fish passage through the dam (e.g., recent construction providing passage for lake sturgeon in the Wild Rice River). Opportunities to remove higher dams or alter them to provide fish passage should also be explored.

6C. Protect deep-water lakes with exceptional water quality

Clear lakes with large, oxygen-rich deep-water zones provide critical habitat for native cold-water fish such as cisco, lake whitefish, and lake trout in Minnesota. In the summer, lakes stratify into three layers; an uppermost epilimnion, which is warmest and oxygen poor; a middle thermocline; and the lowest hypolimnion, which is coldest and oxygen rich. During warm summers, cold-water fish find refuge in the cold hypolimnion if it has sufficient oxygen. Only lakes with the most exceptional water quality maintain enough oxygen in the hypolimnion for cold-water fish to thrive. Climate warming and poor land use in Minnesota pose imminent threats to oxygen levels in these deep-water zones. First, increased duration of stratification from climate warming decreases their oxygen content late in the summer. Second, oxygen concentrations are reduced by poor land use when decaying organic matter from algae and plants, stimulated by high nutrient loading, consumes oxygen in deep water. Both of these threats have the potential to severely limit habitat for cold-water fish in Minnesota.

Deep lakes with exceptional water quality will represent important sanctuaries for cold-water fish as the climate warms in Minnesota. However, future deterioration of water quality would greatly jeopardize the ability of these lakes to provide that refuge. These potential refuge lakes are being identified by the DNR and the UM. Many of these lakes are the "crown jewels" of Minnesota and deserve special status in addition to their value as refuges from climate change. Examples include Ten Mile Lake in Cass County, Big Trout Lake in Crow Wing County, Big Sand Lake in Hubbard County, and Trout and Wabana Lakes in Itasca County. Also, these types of lakes are not completely limited to forested ecoregions. Big Watab Lake, located in agricultural Stearns County, and Square Lake, located in the Twin Cities metropolitan area, also represent lakes with excellent oxygen resources in the hypolimnion.

Once identified, lake watershed protection efforts should be initiated with a special commitment. These protection efforts could include land pur-

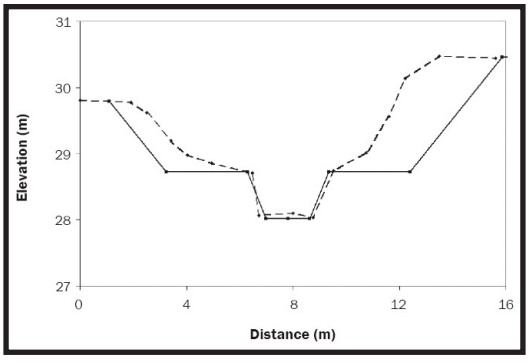


Figure H33. Cross-section of two-stage channel (solid line) constructed within a channelized stream (dashed line). Existing geometry shown in dashed lines and proposed two-stage channel dimensions based on the regional curve shown in solid lines.
Credit: Powell et al 2007.

Figure H34. Two-stage channel just after construction. Vegetation left along main channel reduces erosion. Crommer ditch in Hillsdale County, Michigan.
Credit: Powell et al 2007.

chase, easement protection, and BMP implementation. Many are already "high-profile" lakes with active and dedicated lake associations and local users. Implementation of high-intensity watershed and shoreland protection efforts would largely be welcomed. Protection of these lakes may actually be cost effective (high value for modest investment). Many are characterized by small, forested watersheds and protection efforts can be targeted at relatively few parcels with great cost efficiency.

Description of impact on natural resources. The three parts of this recommendation will address deficiencies in protection and restoration of in-lake and in-stream habitat in Minnesota. These habitats are critical for productive fish, wildlife, native vegetation, and water quality. Implementing all parts of this recommendation will reduce or reverse negative trends in aquatic habitat loss and degradation, which were highlighted in the preliminary plan. Protection and restoration of in-lake and in-stream habitats will ensure resilience of Minnesota's valued aquatic communities as climate change unfolds.

Relationship to existing programs, laws, regulations. Legislation passed in 2008 directed the DNR to revise its entire rule covering the occupation of public waters by structures (Rules 6115.0210); revisions will be relevant to the recommendations regarding habitat structure within lakes and in-stream habitat. The DNR regulates docks in public waters for public safety and resource protection purposes, and docks must meet these standards as stated in Minnesota Rules Chapter 6115.0210. Several existing programs to improve in-water habitats are currently implemented only as small or pilot programs in the state. They include the DNR Shallow Lakes Program, DNR Shoreland Habitat Program, DNR Fisheries watershed coordination projects, RIM, and federal programs, such as CRP, CSP, and CREP.

Time frame. Ongoing program work that is funded annually

Geographical coverage. Statewide

Challenges. Broadening the scale of current small efforts for restoration of in-water habitat will require support from a better informed public. Implementing appropriate restoration measures requires extensive education of and technical support for private shoreland owners. Public support and courageous public officials are needed to support revision of statewide shoreland development standards in ways that will also benefit in-lake habitat beyond the immediate area. A number of drainage laws may also inhibit implementing two-stage channels in areas with stream channelization.

Sustainable Practice

Habitat Recommendation 7: Keep water on the landscape **SP**

Description of recommended action. Retaining water on the landscape over broader areas and for longer periods is critical for improving water quality, reducing flooding, maintaining habitat for wildlife and game species, and enhancing biological diversity. The intent of this recommendation is to have water move more slowly across and through the landscape to return to more natural conditions. This need is acute in agricultural and urban landscapes of Minnesota. We suggest three strategies that complement other landscape-focused recommendations in this plan:

Perennial vegetation. Enhance and expand perennial vegetation (grasses, shrubs, and trees, preferably native vegetation) in order to filter pollutants and sediment, protect aquatic habitats, and provide more terrestrial habitat. This is needed in agricultural zones of the state, as well as in urban and residential areas and transportation corridors (see also Land Use Recommendation 3).

Storm water controls. Help local government maximize storm-water infiltration by identifying land areas

where storm-water infiltration can be best achieved (soils with high rates of transmissivity and available capacity to absorb). Upon identification, consider preserving these areas for future use for local/regional infiltration. Rainwater management controls in the built environment should give preference to designs that increase infiltration by using natural surface drainage, vegetated filter strips, bioretention areas, rainwater gardens, enhanced swales, and natural depressions instead of total reliance on the standard pipes and storm-water ponds. Policy, as well as state and local regulations, should include the key principle of infiltrating most of the rainwater instead of treating this water as a waste product and creating pollution and flooding problems downstream or downhill. Rainwater management controls should be designed to manage peak flows as well as increased duration of high-water events. The latter will grow in importance given that many climate change studies suggest more intense rainstorm bursts.

Riparian buffers. Buffers made up of natural vegetation along shorelines of rivers, lakes, and sinkholes protect water quality by trapping and filtering pollutants and impeding runoff. Buffers stabilize banks, screen shoreland development, reduce erosion, control sedimentation, and provide important habitat for shoreline species (Figure H35). Projections for ongoing climate change in Minnesota include increased frequency of intensive storms, which means increased runoff loaded with solids, nutrients, or other pollutants. Reducing the impact of runoff requires having adequate shoreline buffers. Shoreland development policies, especially in agricultural and urban zones, should protect existing buffers and require restoration of buffers. Potential approaches could be to:

- Maintain and restore important landscape features such as small, geographically distributed headwater wetlands, riparian areas, and flood plains to mitigate water quality, hydrological, and ecological impacts of drainage simultaneously, serving multiple beneficial functions by providing distributed water storage and flood protection; wildlife/aquatic habitat; and uptake, breakdown, and removal of nonpoint source contaminants in surface waters
- Explore how distributed buffers combined with ecologically based drainage designs might be more socially efficient in the long run by reducing maintenance costs and some kinds of disaster and environmental spending, maintaining economically valuable ecological services, and sustaining biodiversity
- Strongly encourage the establishment and protection of vegetated riparian areas of at least 330 feet in width because recent research suggests this would greatly reduce sediment and nutrient loading
- Discourage new surface drainage or new subsurface tiling in the shoreland, and require outlets of subsurface tile to discharge to grassy swales or to areas with natural vegetation.

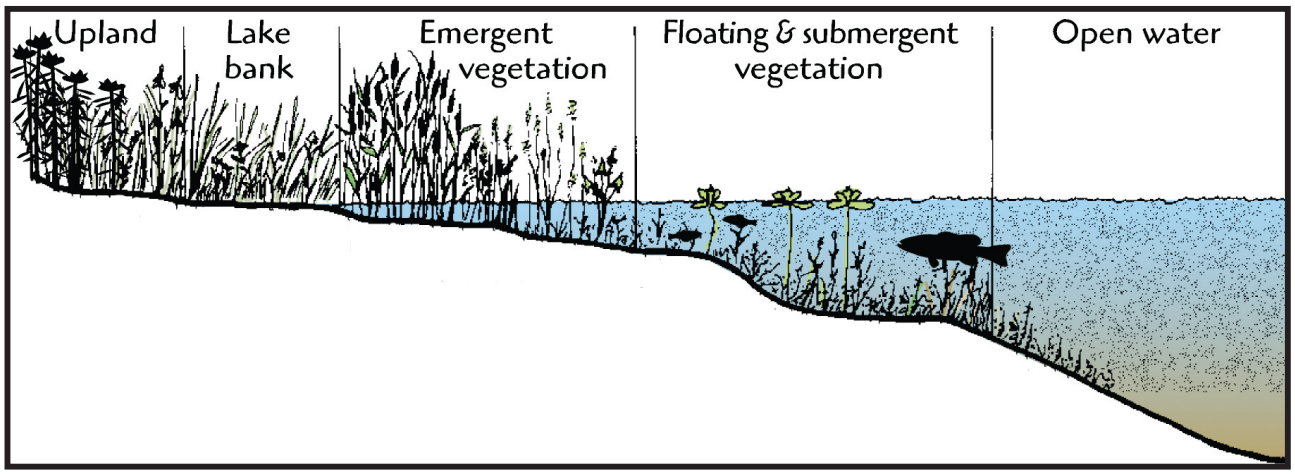


Figure H35. Floating, emergent, and natural vegetation along the shoreline provides habitat for fish and wildlife. Credit: DNR Waters.

Southeastern Minnesota has a unique need for vegetation buffers around sinkholes. Currently, row crops represent 83% of land use in the region's sinkhole basins. A recent study indicated that 100-foot-wide buffers would reduce sediment, nitrogen, and phosphorus pollution by 80% in the runoff to sinkholes. The study concluded that 50-foot-wide buffers may be most cost effective in terms of percent reduction of runoff, total nitrogen, and total phosphorus in relation to the cost to CRP. Buffers of 50 feet wide around all sinkholes would retire approximately 1,077 acres of land from production and cost approximately $260,000 per year, based on CRP payments, while requiring less than 14% of the budget of the program for ground-water protection in southeastern Minnesota.

What Are Sinkholes?

Sinkholes occur in all bedrock units in southeastern Minnesota, but generally occur on flat hilltops adjacent to or between stream valleys. Sinkholes are a direct conduit for surface runoff to streams. There are approximately 8,340 mapped sinkholes in southeastern Minnesota. Pollutants in the water running into a sinkhole will ultimately end up in a stream and affect water quality.

Description of impact on natural resources. Retaining water on the land will reduce overland runoff, erosion, and deposition of some nutrients directly to water bodies. Slower movement of water over the land will allow more water to move into the ground to replenish ground-water, improve water quality, maintain aquatic habitat, and reduce flooding. Various climate change studies suggest that Minnesota will experience increased extremes between wet and dry periods, changing stream-flow patterns, and increased storm frequency causing greater runoff. Although research is needed to understand how climate change will alter different regions of the state, it is clear that we need to slow movement of water over the landscape to ensure resilience of Minnesota's valued aquatic communities as climate change unfolds.

It is necessary to require that local governments control alterations to vegetation, since mismanagement of vegetation and soil adversely impacts shoreland natural resources. Adverse impacts include: (1) erosion and sedimentation (from both uplands and stream banks) to surface waters, impairing or destroying fish and wildlife habitat; (2) soil sedimentation; (3) the intentional filling of areas that previously held and filtered surface-water runoff before drainage or discharge to a water body; and (4) the clearing of shoreland vegetation that once provided natural screening of shoreland development and maintained the scenic vistas of many streams and lakes. Most importantly, the conversion of shorelines has adverse impacts on water quality that violate standards of the Clean Water Act.

Relationship to existing programs, laws, regulations. This recommendation can be accomplished by water management changes and policies that protect and conserve land areas that are most critical to protecting aquatic habitat. A number of state and federal programs, including RIM, CRP, CREP, and the Forest Stewardship Program, focus on water quality primarily by promoting vegetation to retain water and filter sediment, nutrients, and chemicals. Several policies act as disincentives to improve water quality or aquatic habitat, such as drainage laws, commodity support in the Farm Bill, conversion of land to suburbanization with an increase in impervious surfaces, and continued development along streams, rivers, and lakes.

Time frame. Begin new initiatives as soon as possible, but continue ongoing efforts to enhance water quality.

Figure H36. Stream without riparian buffer of vegetation (left); stream with riparian buffer of vegetation (right). Credit: Google Earth.

Geographical coverage. Statewide with an initial focus on areas with highest conservation need

Barriers. The main barrier to establishing and maintaining perennial vegetation on the landscape and in riparian buffers is federal farm policy, especially the existing subsidies for commodity crops. There is a need to consider new approaches such as multifunctional agriculture. Regarding storm-water controls, urban planners and policies have embraced reducing impervious surfaces and retaining water on the landscape. Continued encouragement is needed, including funding for separation of storm-water and domestic sewage and improved strategies for retention ponds and infiltration.

Habitat Recommendation 8: Review and analyze drainage policy

S P

Description of recommended action. The state should invest in a comprehensive review and analysis of laws relating to drainage, including Minnesota Statutes Chapter 103E, and recommend changes to the legislature that would remove barriers and facilitate the restoration of critical wetlands in order to improve water quality and aquatic habitats.

Description of impact on natural resources. Minnesota has a complex array of statutes and regulations pertaining to drainage dating back to 1887. Most of these statutes and regulations were designed to facilitate drainage for agricultural production and to equitably distribute the costs of drainage projects to those who benefit from an agricultural production point of view.

Drainage has transformed nutrient and hydrologic dynamics, structure, function, quantity and configuration of stream and wetland ecosystems. The most significant aquatic ecosystem impact of drainage historically has been the direct loss and alteration of wetland and riparian habitats. Given the fact that more than 90% of the wetlands in Minnesota's prairie region have been converted to primarily agricultural production, it is widely accepted that restoring drained wetlands and other aquatic habitats is necessary to improve Minnesota's water quality, maintain biodiversity, and provide abundant recreational opportunities to hunt and view wildlife, fish, and recreate in clean water. Many statutes and regulations today are still designed to increase drainage, not decrease it, so accomplishing a better outcome for natural resources under the current regulatory framework can be difficult.

Relationship to existing programs, laws, regulations. Minnesota Statutes Chapter 103E addresses drainage. An information brief on Minnesota drainage law, published in January 1999 by Minnesota House of Representatives House Research, briefly describes drainage issues and viewpoints, and is a good starting point for addressing this recommendation.

Knowledge Infrastructure

Habitat Recommendation 9: Overall research on land and aquatic habitats **LP**

Description of recommended action. The SCPP has developed and implemented a mechanism to integrate a portfolio of spatial data layers summarizing important natural resources and environmental threats in Minnesota. These data layers quantify the loss of native biodiversity, distribution of important outdoor resources (e.g., fish and wildlife populations), impairments to aquatic resources, degradation of critical ecological processes (e.g., nutrient cycling, predator-prey interactions), and locations of biologically significant and large, intact natural ecosystems. The spatial data layers were also examined in relation to where housing development was most likely to occur in the future, locations of road networks, current and future agricultural-bioenergy activity, and land ownership (Figures H2–H16).

Understanding the linkages between land and aquatic resources is critical because nonpoint source pollution and shoreline disturbances are a massive threat to the quality of Minnesota water resources. The SCPP is best viewed as an approximation of where future conservation or preservation could be directed to protect, restore, and reconnect important natural resources of the state. Data produced in this analysis will be made available through the LCCMR DataPortal Initiative, and potentially through other data distribution sites such as the Land Management Information Center and the DNR Data Deli.

Research is essential to improve understanding of the risk of extinction of Minnesota's native biological diversity; continuing availability of quality outdoor recreation; and confidence in the ability to protect aquatic resources in the face of risks such as climate change, invasive species, and expanding human population. Information on important historical and cultural resources should also be researched and incorporated into decision making on conservation, protection, or restoration efforts.

The state of Minnesota should continue to appropriate funds for improving understanding of fish and wildlife populations, native biological diversity, and water quality, and mitigating the stressors that affect them. Priority foci for research include:

- Population viability analyses need to be completed for the most threatened and endangered species to identify the acreage and distribution of land and aquatic resources necessary to insure their perpetuation. Specific attention should be given to better understanding species that are habitat specialists and/or thought to require certain sizes or configurations of habitats.
- Sustainable population levels of hunted, trapped, and fished species need to be identified to maintain adequate resources for current and future generations.
- Landscape analyses, coupled with appropriate modeling efforts, are needed to identify what critical land and wetland resources need to be maintained or restored to adequately protect water quality and aquatic biota.
- Land and aquatic habitats most affected by ditches and channelization should be identified to make it possible to evaluate the potential for restoration and inform review and revision of policies to reduce negative impacts.
- Research on the best and most cost-effective management approaches to the conservation, preservation, and restoration of important land and aquatic resources needs to be prioritized on an ecoregional basis. One example is pilot demonstrations of strategies to repair some of

the harmful effects of stream channelization, such as constructing two-stage channels and planting suitable vegetation in riparian buffers.

- Trade-offs in the use of land and water for agriculture, energy, forestry, housing, industry, and transportation need to be studied critically and equally with their societal benefits of carbon sequestration, protection of biological diversity, and outdoor recreation. For instance, how intensively can "working lands" be used for human purposes before there is a significant loss of benefits to wildlife, water quality, and/or recreational opportunities?

Description of impact on natural resources. The citizens of Minnesota have always prided themselves on the outstanding natural features of the state, its wealth of biological diversity, the opportunities for quality outdoor recreation, and the quality and quantity of its aquatic resources. As the climate warms and the state population increases, the quality and quantity of these resources will continue to decline. There are many policies, management, and volunteer actions that are possible to maintain these resources, but the correct or optimal actions are not well known, especially with ever-present limited budgets.

Research is a primary vehicle to determine the best course of action that provides the proverbial "biggest bang for the buck" in which optimal benefits may be gained to protect and conserve these resources, but also fulfill our growing demands for food, energy, housing, industry, and roads. Without research, actions are driven by guesswork and emotions, which is suboptimal and not cost effective.

Relationship to existing programs, laws, regulations. The LCCMR has continued to invest in selected research programs, and other state programs within state agencies (e.g., DNR, MPCA, and MDA) have in-house and external research programs. Minnesota state parks and scientific and natural areas provide excellent opportunities for research with minimal external disturbance. However, research budgets are limited. Some research monies can be expected to continue from federal sources, but many federally funded research programs are limited to activity that may not be relevant to state-oriented problems. Some portion of all state budgets that are relevant to conservation and preservation of land and aquatic resources, as well as the implications of development for food resources, energy, urban and industrial development, and transportation systems needs to be directed to research.

Time frame. There is an immediate need for research on these recommendations and for ongoing activity toward implementation of the SCPP.

Geographical coverage. Statewide

Challenges. Because research is often unnoticed and completed early in the process of conservation, the public does not always realize that research is essential. Research over the long term provides cost-effective and efficient answers to prioritization and optimal allocation of resources for the problems of conservation, preservation, and restoration of land and aquatic resources.

Habitat Recommendation 10: Research on near-shore habitat vulnerability **RP**

Description of recommended action. There is a need to increase understanding of near-shore habitat vulnerability. This would be best accomplished through research on the human behaviors that degrade and destroy near-shore habitat, as well as pilot policies or programs that preserve or restore near-shore fish and wildlife habitat. Research can also address historic and cultural resources associated with near-shore habitat. Recommendation details:

- Create a map of aquatic species richness similar to the map of terrestrial species completed by the DNR in its gap analysis program (GAP, an assessment of the status of native wildlife based on natural land-cover types).
- Refine critical aquatic area mapping initiated by this plan by identifying sensitive lakeshore areas across the state.

- Investigate economic benefits of preserving undeveloped shoreline and trails around lakes, and requiring public dedication of riparian areas for parks and public open spaces.
- Conduct research on the barriers and benefits of good near-shore stewardship by lake-home owners.
- Initiate a pilot program to be administered by the state in several areas or on several lakes that attempts to change behavior or limit choices on near-shore habitat alteration by riparian property owners.

Description of impact on natural resources. Shoreland developments are changing Minnesota's lake ecosystems. Development pressure is increasing, with more dwellings and docks per lake each year in Minnesota, leading to a cumulative effect on fish, wildlife habitat, and water quality. Shoreline habitat uses include removal of downed trees, aquatic vegetation, and riparian wetlands. Shoreline alterations include adding riprap, constructing walls, planting sod to the water's edge, and covering public water areas with increasing large in-water structures (e.g., docks, boat lifts). An estimated 20% to 28% of the near-shore emergent and floating-leaf coverage has been lost due to development in bass and walleye lakes. On average, there is a 66% reduction in aquatic vegetation coverage with shoreland development. These declines in aquatic vegetation coincide with lower fish production and reduced water quality in lakes. Woody habitat losses are also occurring in Minnesota lakes but have not been quantified. Many fish depend on aquatic vegetation, woody habitat, and shorelines to provide spawning habitat, cover, and refuge from predators.

Relationship to existing programs, laws, regulations. Pertinent state rules include those on aquatic plant management (M.R. 6280) and structures in public waters and filling into public waters (M.R. 6115).

Time frame. 2 to 20 years, depending on research task.

Geographical coverage. Statewide.

Challenges. Even though much alteration of the near-shore environment is regulated by the state, noncompliance is suspected to be high due to riparian property owner's perception and expansion of riparian rights. There is lack of political will at the state level due to fears of offending well-meaning lakeshore property owners.

Habitat Recommendation 11: Improve understanding of ground water resources

RP

Description of recommended action. Ground water is an indispensable natural resource for human activities and human health. Partly because ground water is a hidden resource, Minnesota has not yet adequately answered critical questions about it. We need to understand how much ground water we have, where we can find it, its quality, how it moves, where it is recharged, where it discharges, and how much we can safely tap, both seasonally and long term.

Figure H37. Degraded shoreline (upper) revegetated to prevent erosion and provide habitat (lower). Credit: DNR Waters.

The state needs to make a major, sustained investment in the collection and assessment of information about ground water and its connection to surface waters. We need to fill information gaps at the site-specific scale and the scale of entire hydrologic systems, including aquifers and watersheds. Given the relatively complex hydrology in our state, Minnesota may be decades away from acquiring sufficient information to inform site-specific decisions about ground-water usage throughout the state. Filling critical information gaps at both scales is essential for achieving sustainable management of ground water that meets the needs of humans and habitats.

The overall goal of this recommendation is to develop a large-scale, hydrologic-system framework for understanding how today's decisions may affect tomorrow's needs. This systems approach will offer insights into the more strategic questions that are beyond the reach of the current site-by-site focus of decision-making for ground-water use. A systems approach will make it possible to answer questions about (1) how much water can be committed to human activities without adversely affecting ecosystems, (2) how much growth a specific region can sustain based upon its water budget, and (3) how land use changes and climate change may shift the whole equation. Specific recommendations to reach this goal are:

- Complete statewide coverage of county geologic atlases or, as appropriate, regional hydrogeologic assessments.
- Build on the information developed in atlases and assessments to understand the amounts of water that can be appropriated on a long-term sustainable basis consistent with ecosystem needs to sustain stream flows, lake levels, and wetland water regimes.
- Upgrade the state's observation well monitoring network by vastly expanding its density; instituting real-time monitoring at critical locations and periodic mass water-level measurements; and routinely assessing the implications of the information for ecosystems and communities.
- Complete the next phase of water sustainability research to understand at a county and watershed scale the amount of water that might be safely withdrawn from the system.
- Investigate the requirements for seasonally variable flows of streams needed to meet the needs of aquatic communities, and assess the significance of the contributions from ground water.
- Study the effects of drainage and other land use practices on rates of recharge and discharge to streams and wetlands, as well as the means to quantify these impacts, and assess the effects of climate change on rates of recharge, discharge, and water demand.
- Construct and implement a comprehensive and GIS-based framework of Minnesota's hydrologic system to answer strategic questions about current and future water demand and annual/seasonal availability at the watershed, county, and subcounty levels, and to assess current effects and future risk of degraded waters on ground-water supplies.
- Use the hydrological system framework to limit state funding for infrastructure and business development to areas with sufficient water resources to meet long-term demands.

Description of impact on natural resources. By making these investments in ground water, decision makers and all Minnesotans will understand the ground-water foundation of ecosystems and how that foundation must be managed to ensure sustainable usage of ground water under future growth and development. Regulatory decisions routinely made by state and local governments require site-specific information about local aquifer boundaries, properties, and recharge and discharge characteristics. The better the available data, the better regulators can estimate the effects of potential withdrawals on aquifers and the surface-water systems they support.

Relationship to existing programs, laws, regulations. The ground-water investment initiative would build on and integrate a number of existing pro-

grams and projects, including several supported by the LCCMR. The Minnesota Legislature has established the legal and institutional framework for managing water supplies to meet today's needs while ensuring that future generations can meet their own needs. The DNR and Metropolitan Council regulate the appropriation of water and operate a number of supporting programs to ensure that water supplies meet economic, social, and ecological purposes. Minnesota Statutes 103G.265 assigns the DNR the task of managing water resources to "ensure an adequate supply to meet long-range seasonal requirements for domestic, agricultural, fish and wildlife, recreational, power, navigation, and quality control purposes." The Minnesota Geological Survey and the U.S. Geological Survey provide the DNR and other state agencies monitor the state's water resources. The Minnesota Department of Agriculture (MDA) checks the state's ground waters for pesticides and nutrients, and regulates these chemicals. MPCA monitors water quality and regulates point sources of contamination. The Minnesota Department of Health (MDH) monitors the state's drinking water systems, much of which tap ground water. Finally, EQB coordinates management and policy development activities among state agencies.

Time frame. Funding priorities should be placed on ground-water initiatives. Work has begun on the hydrologic framework with assistance from LCCMR projects, but will need augmentation as information and knowledge about the resource expands. This should allow initial assessments of the sustainability of new development proposals at a regional scale, with more local scale assessments possible on a case-by-case basis only until the ground-water foundation is better understood.

Geographical coverage. The area of coverage is statewide, with new information collected on a priority basis based upon the threat to the resource and existence of past studies

Challenges. The lack of money is a substantial barrier. However, political, institutional, and cultural barriers also may obstruct efforts to build the complementary regional and site-specific frameworks for managing water, development, and ecosystems on a sustainable basis.

Habitat Recommendation 12: Improve understanding of watersheds' response to multiple drivers of change **R P**

Description of recommended action. Effective water quality protection and restoration will require additional monitoring, research, and evaluation of aquatic and land responses to land use, climate, and other changes. While much is known within various spatial and temporal scales, interactions and responses across scales are not well understood. Research is needed to build the capacity of resource managers to understand and evaluate the multitude of factors that affect these resources across the state.

To accomplish this recommendation, investment is needed for research across many watershed scales to improve understanding of pollutants, pollution sources, movement across the watershed (e.g., hydrology), and physical, chemical, and biological responses. There have been significant advances in monitoring methods and technologies, plus increased funding (e.g., through the Clean Water Legacy Act). The use of biological monitoring has become better integrated with water quality. The next step to achieve a better understanding of watershed systems and an assessment of their health is to gain a more holistic and comprehensive understanding of how a water body and its watershed function. This would result in more effective protection, restoration, and conservation for both land and aquatic habitats.

The UM Water Resources Center hosted an impaired waters research symposium in February 2008 and will provide a list of recommended research activities that could be supported. A report from the symposium is expected in 2008. Additional moni-

toring needs to include the development of selected sentinel watersheds in the state where monitoring will be completed throughout a watershed (e.g., from the mouth up to small subwatersheds). A goal of the sentinel watershed monitoring would be to provide long-term watershed system evaluations and understanding. This would allow the demonstration of the interconnectedness of a watershed and how aquatic life and human recreational uses can be protected as required by the federal Clean Water Act.

A formal physical watershed evaluation monitoring effort is also needed to assess habitat and underlying geomorphic conditions as a component of Clean Water Legacy monitoring and assessment activities. Greater use of geographic information system (GIS) data layers and analysis tools is essential as data layers become more detailed and analytical techniques improve. The DNR Watershed Assessment Tool should be improved to enable the identification of priority habitat investment areas. Use of tools such as the U.S. Environmental Protection Agency (USEPA) Watershed Assessment of River Stability and Sediment Supply (WARSSS) procedures should be supported for developing and completing physical channel, bank, and watershed condition monitoring and evaluation.

The state lacks the basic information needed to understand how multiple drivers of change affect Minnesota's watersheds. The state should conduct a rapid assessment to gather baseline information on the physical, biological, and chemical conditions of streams important to understanding these effects.

Attention is also needed in the evaluation of the potential impacts of climate change on land and aquatic habitats. State-level studies are needed to improve projections of how climate change will alter habitats, the distributions of species, and the stressors that affect both. Studies are also needed to inform strategies that will support adaptation of biodiversity to a changed climate (see Appendix IV).

Description of impact on natural resources. Climate change, in combination with the current and future stressors on these resources (e.g., land use change), has the potential to have massive effects on the quantity and quality of land and aquatic resources. Many of these resources have already been seriously impaired from their presettlement conditions. The effectiveness of conservation, protection, and restoration activities would be greatly enhanced with a more thorough understanding of the factors and processes that affect land and aquatic resources at the watershed scale. Research studies need to be designed to evaluate and predict these effects, and programs need to be established to manage and adapt to these changes.

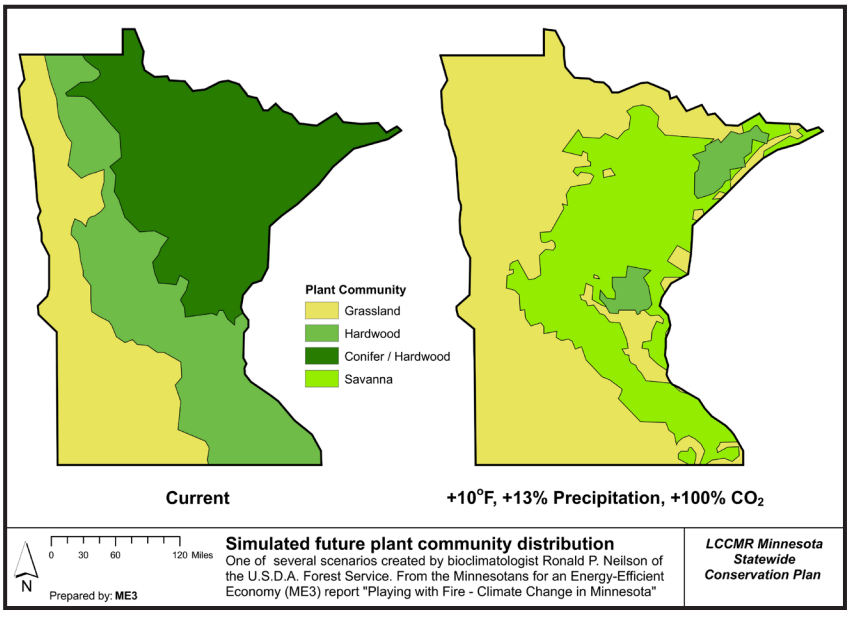


Figure H38: This map projects what Minnesota vegetation cover might look like if average temperatures in the state rise 10 degrees F and precipitation increases 13% at double historical CO_2 levels. This is one of several scenarios created by bioclimatologist Ronald P. Neilson of the USDA Forest Service. Credit: Terry Brown, NRRI.

Relationship to existing programs, laws, or regulations. This recommendation is closely related to several state natural resource programs and would complement or enhance many of these programs. The recommendation focuses on monitoring and research needs for watersheds and would result in an increased understanding of how these systems function. For example, this action would benefit programs and activities for several agencies such as:

- The MPCA's water quality program, including its water assessment monitoring and impaired waters activities
- Programs in the DNR's Divisions of Waters, Fisheries, and Ecological Resources
- BWSR's Clean Water Legacy, water planning, and BMP cost-share programs
- MDA's Clean Water Legacy programs

Time frame. Implementation of this recommendation should start as soon as possible. Incorporation of the recommendation would largely involve adaptations or enhancements to current and ongoing natural resources programs. Initial research activities could be completed in five years, but a vision for long-term strategy of support is essential. The results of the action should be immediate if implemented in a strategy of adaptive management. An understanding of physical and hydrological watershed processes will provide improved resource conservation and restoration strategies.

Geographical coverage. The recommendation would affect the entire state of Minnesota at different levels. Minnesota has a diverse array of watershed ecosystems that vary over the diverse geography of the state. This adds to the complexity of how stressors affect these watersheds. For instance, watershed responses in the agricultural regions are very different in hydrology and geomorphology than those in the forested regions of the north. Understanding how these watersheds function under different stress scenarios will be key to improving conservation and management of Minnesota's resources.

Challenges. Watersheds become increasingly complex as the size of the systems and their variability in topography increases. Fortunately, advancements in computer technology such as GIS and modeling have allowed scientists and resource managers to obtain a stronger grasp on this complexity. Unfortunately, there is a lag time between scientific advancements and actual applications in management. This recommendation can aid in closing this knowledge and application gap, but should be cognizant of the continued reinforcement and interaction between science and management.

Habitat Recommendation 13: Habitat and landscape conservation and training programs for all citizens **R P**

Description of recommended action. The state should invest in education to improve public understanding of the need for better conservation, protection, and restoration of Minnesota's habitats and landscapes. Expanded education, information, and training efforts are needed to bring focus to the complexity of land, water, and land-water interactions in a landscape context. These efforts must be directed to all citizens from K–12 educational levels to higher education, and the general public. A broad range of teaching and information sharing materials has been developed. Means of delivering the materials, goals for communicating them, and ways to measure success need yet to be developed.

As people have migrated to cities over the past 50 years, awareness of natural resources has declined. To attain a more informed constituency, whether as interested citizens or as professionals doing natural resources work, investment is needed. Technical information and transfer of that information is needed for people to grow an awareness of natural resources, and appreciation for monitoring, assessment, and data evaluation.

Examples of approaches for communicating this information include the development of a "master watershed practitioner," patterned after the Minnesota Master Naturalist Program; NRRI's Water on the Web and North Shore Streams Web sites; development of achievement and recognition certificates similar to the River Friendly Farmer; and the possibility of continuing education credits or college credits for those interested in watershed management. MPCA impaired waters staff has researched programs in other states for possible adaptation for Minnesota. The DNR has developed a CD river restoration training program titled "Healthy Rivers: A Water Course," that exemplifies components of a comprehensive education and training effort, and a "Restore Your Shore" CD-ROM that private shoreline owners can use to learn how to better manage vegetation, especially native vegetation, along their waterfront. A primary goal for any effort is to provide an understanding of the many factors that affect land and water resources.

Description of impact on natural resources. A greater awareness and understanding of habitat and landscape science principles (e.g., the importance of watersheds) would help build citizen interest and concern for Minnesota's natural resources. Increased awareness and understanding by resource professionals would help focus the interdisciplinary coordination and cooperation needed to more fully protect, conserve, and restore these resources.

Relationship to existing programs, laws, regulations. State investment in educational materials should meet the environmental education goals the state contained in Minnesota Statutes 115A.073. In particular, development of educational materials can help meet the objective of reaching environmental literacy for all Minnesotans stated in *GreenPrint*, Minnesota's state plan for environmental education. Accomplishing this recommendation would require the coordination, cooperation, and integration of existing activities. It should aid in the development of a better understanding of current programs, laws, and regulations relative to the complexities of natural resources systems. The DNR's Gateway Initiative in Minnesota state parks is an outstanding example of such activity.

Time frame. Development of a coordinated series of information, education, and training efforts could be completed in one to two years; however, the use of the tools will be ongoing. Positive results would be expected to become quickly evident.

Geographical coverage. Statewide

Challenges. The lack of knowledge on the connections between land and water, especially the immediate land-water interface such as our shorelines, shown by the degraded status of many of our land and aquatic resources. Disruption of the soil or degradation of a wetland, whether for agricultural activity, housing development, road construction, or

Figure H39. Wild rice bed in Lake Onamia. Credit: Ducks Unlimited.

other activities, generally results in reduced land and aquatic habitat quality. These activities increase the flow of water, soil, nutrients, and often contaminants to receiving waters. The public does not understand the full consequence of these activities and especially their cumulative effects in the environment as water flows within a watershed across the landscape. Education is essential to improve this understanding among all age groups and professions.

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The following icons are used throughout the plan recommendations by type:

Integrated Planning Recommendations

Critical Land Protection Recommendations

Land and Water Restoration and Protection Recommendations

Sustainable Practices Recommendations

Economic Incentives for Sustainability

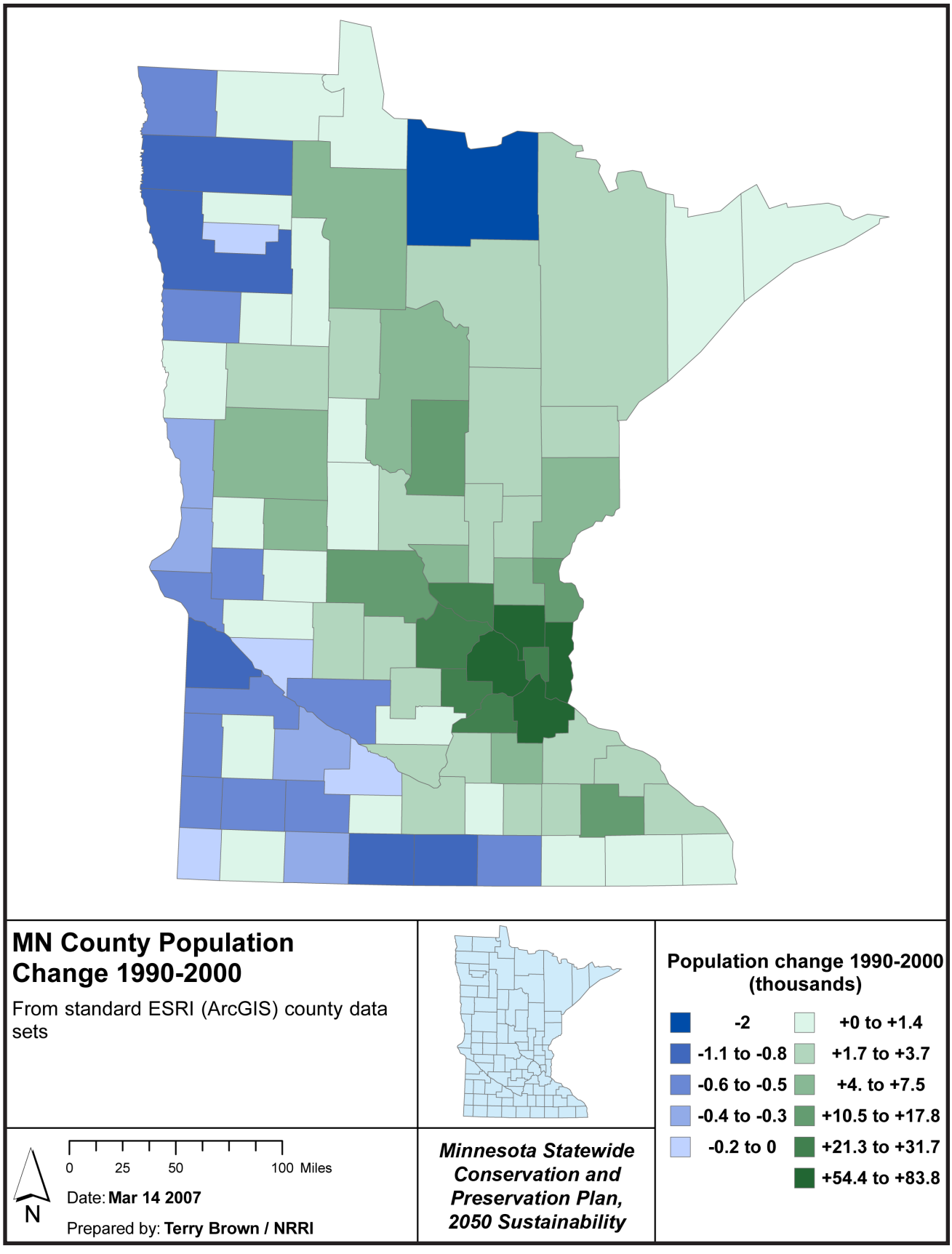

Figure L1. Minnesota county population change, 1990–2000. Credit: Terry Brown, NRRI.

Land Use

Recommendations

Introduction

How land is used to support human activities has both direct and indirect effects on all natural resource systems. The interacting components of land use are complex and diverse, and can have economic as well as environmental consequences. Interrelationships between different uses, patterns and density of development, and agricultural and forestry practices all combine to have major effects not only on land, wildlife, water, and other natural resources, but also on energy consumption and transportation, which in and of themselves have natural resource effects.

The land use team was charged with examining the following questions:

1. What public and private land use choices are needed to improve environmental quality, and to anticipate and adapt to environmental change in Minnesota?

2. What sustainable policy and investment decisions should be made to support these choices?

The team addressed three topics that reflect types of land use in the state—community (development), agriculture, and forestry. Each of these three topics is addressed separately in this report; however, they are clearly interconnected. Community, agricultural, and forested lands are all intertwined on the state landscape, and decisions about one often affect the others. Some trends affect these topics individually, and others, such as climate change, affect natural resources across all land use types.

Community Land Use

One of the greatest threats to Minnesota's natural resources is the expansion of urban and developed areas. Development is the conversion of native land, shoreland, agricultural land, or forestlands into housing, industrial/commercial areas, or transportation corridors. In simple terms, development usually entails three components: removal of what was originally there, such as land cover; alteration of topography; and establishment of new features, such as roads and buildings. These actions impact natural resources on a dramatic level. In addition, the pattern of the new features (e.g., compact versus low-density development) continues to affect natural resources for generations to come.

Key Natural Resource Conditions and Trends in Community Land Use

Over the next 20 years, population in the Twin Cities metropolitan area is expected to increase by more than 1 million people (Figure L1). These people will need places to live, work, and recreate, and transportation to move from place to place. The Twin Cities are not the only location for population growth in the state. Development is occurring all over Minnesota in not only urban and suburban areas, but also in rural areas. This is resulting in rapid and significant changes in land cover. Development has resulted in an increase in impervious surface area such as roads and parking lots, particularly in the Twin Cities metropolitan area (Figures L2 and L3). As urban development has expanded, so has the number of miles driven and commute time.

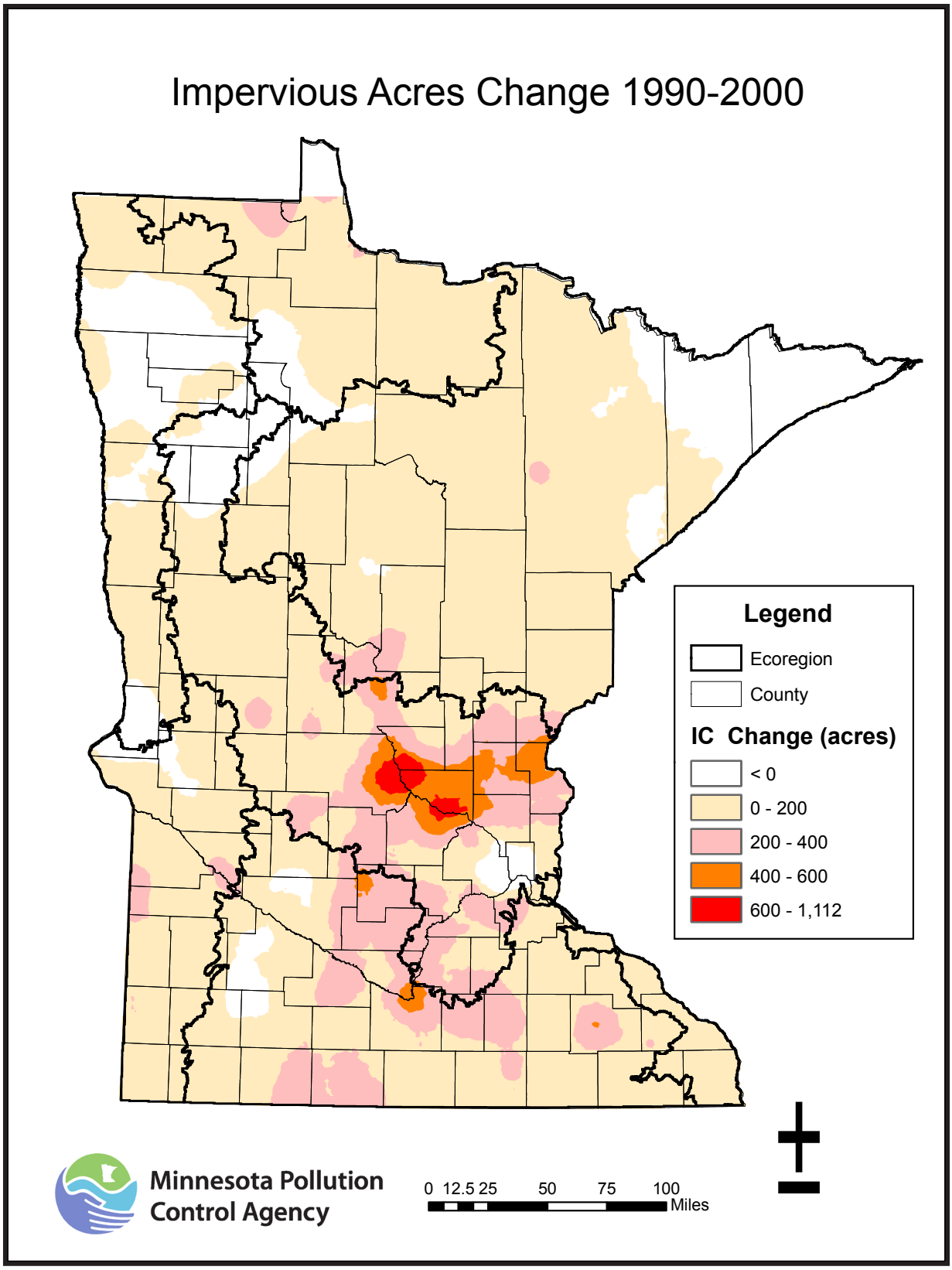

Figure L2. Impervious acres change 1990–2000. Credit: Bruce Wilson and Mike Walerak, MPCA.

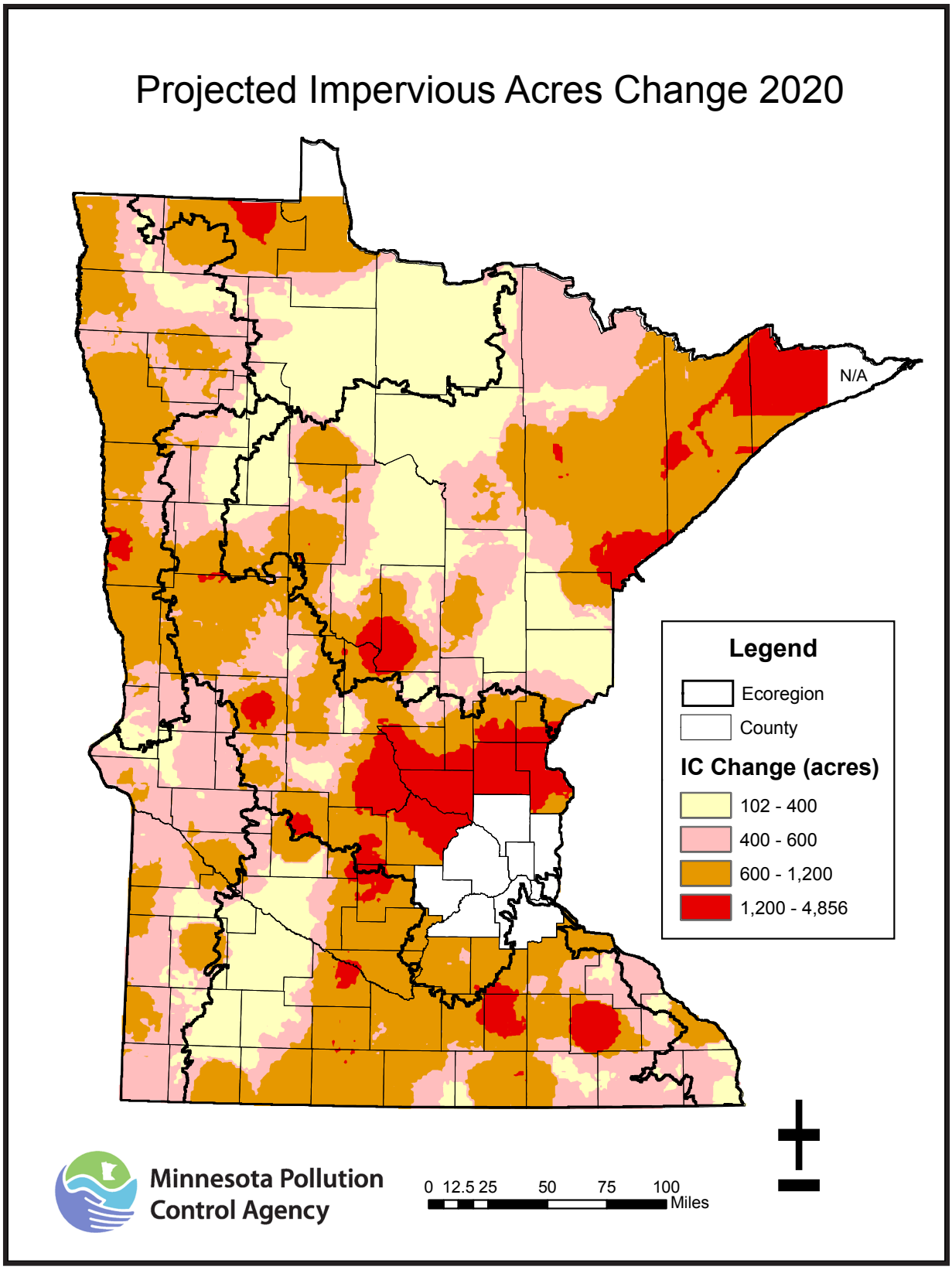

Figure L3. Projected impervious acres change 2020. Credit: Bruce Wilson and Mike Walerak, MPCA.

Drivers of Change for Community Land Use

Development of land resources directly results in many of the most significant drivers of change causing loss and degradation of Minnesota's resources, including the following.

Consumptive Use, Habitat Loss, and Invasive Species

Development leads to the irreversible loss of prime agricultural land, high-quality forests and prairies, pristine shorelines, and open space. In so doing, it depletes wildlife and aquatic habitat and results in habitat fragmentation. In addition, removal of land cover leaves the area more susceptible to invasive species.

Hydrologic Modification and Solids, Nutrient, and Contaminant Loading

Grading and construction of roads and buildings modifies hydrology by interrupting natural watershed drainage. Removal of land cover and increased impervious surface area change the volume, rate, timing, and duration of storm-water runoff. They also increase total runoff of sediment, phosphorus, and contaminants to surface waters.

Air Contaminants and Climate Change

Increased vehicle miles traveled (VMT) and commute times are associated with increased emissions of carbon dioxide (CO_2), a greenhouse gas (GHG) linked to climate change. They also create more carbon monoxide (CO), nitrogen oxides (NO_x), tropospheric ozone, and other transportation-related air pollutants.

Clearly, the fundamental step necessary to alter these trends is to change how we develop and use land across the state. To some extent, all development affects natural resources. However, different patterns of development have different effects. Therefore, supporting conservation-based planning at all levels of government in Minnesota communities underlies all of the land use recommendations. Conservation-based planning puts the identification and conservation of priority natural resources at the center of the land use planning process.

Community Land Use Recommendations

Land Use Recommendation 1: Fund and implement a state land use, development, and investment guide IP

Description of recommended action. The state spends billions of dollars each year on infrastructure, local government and business assistance, and regulation in order to safeguard the environment, help business and communities thrive, and improve the quality of life in Minnesota. However, there is no system or guide in place to provide an overview of how these funds are spent across agencies, to track how these dollars come together on the land and in communities, and to determine whether investments in one sector put those in another at risk.

In addition, while most land use decisions are made at the local level, state-level vision and leadership are needed on many natural resource issues. The state needs to clearly define its interests and use its resources to engage others in securing those interests for the long term. Therefore the preparation and implementation of a state land use, development, and investment guide should be funded. The guide would provide a way to define, quantify, and unify state goals and investment objectives across social, economic and environmental sectors. It would offer the opportunity to reconcile conflicting goals and preserve Minnesota's natural resources. This is more important than ever, given the intense competition for land and resources and the chronic scarcity of state funds coupled with the uncertainties introduced by climate change.

The guide would provide a much-needed framework for aligning activities at multiple levels with statewide natural resource goals. The guide would:

- Identify specific state goals, principles, and policies relating to climate change, land use, development, and investment
- Incorporate the priorities and recommendations of the SCPP
- Define the appropriate connections between transportation, land use, energy use and development, economic development, and natural resources and environmental protection, preservation, and restoration
- Describe how state investments will be coordinated, integrated, and staged to meet the state's goals and respect the connections
- Establish priorities for the allocation of scarce funds and resources
- Ensure that state dollars are not spent in a way that adversely affects state goals
- Identify legislative initiatives key to implementation.

Development of the guide should engage Minnesotans in a continuing dialogue about the future. The guide would be renewed every five years based on updated information on resource management, purchase, research, and data collection and management; the routine evaluation of its implementation; and assessment of its effectiveness. The guide would also be widely distributed to counties, cities, townships, the Metropolitan Council and regional development agencies. Much of the information contained in the guide would be advisory to these regional and local governments, but consistency with its core goals, policies, and principles should be mandatory whenever state funds are involved.

Description of impact on natural resources. Damage to natural resources generally results from efforts to meet other needs, whether for energy, transportation, health care, housing, recreation, or waste management. By making sure that state monies are spent in a way that aligns with state natural resource goals, natural resource interests will get in on the "ground floor" as the solutions to other community needs are contemplated. This has significant implications for protection of high quality natural areas, priority agricultural lands, water quality, outdoor recreation, and the many other aspects of natural resources the SCPP is designed to address.

Relationship to existing programs, laws, regulations. The state has adopted many policies that independently direct consideration of natural resources in decision making. This recommendation would bring those disparate pieces together.

Time frame. With dedicated effort, the first guide could be completed within one year and applied during the following capital budget year.

Geographical coverage. Statewide

Barriers. Preparation and implementation of the guide will be challenging because it requires changing how problems are approached and actions are interpreted. In the context of state government, this means expecting people and programs with limited resources to recognize that broader approaches to different kinds of issues can sometimes achieve far better outcomes for the communities and overall state interests they serve.

State leadership must value, support, and take responsibility for ensuring implementation of guide goals, principles, and recommendations. Challenges will include possible resistance to granting the programmatic discretion necessary to serve broader community goals.

Land Use Recommendation 2: Support local and regional conservation-based community planning

IP

Description of recommended action. The objective of this recommendation is to promote land use planning that advances the permanent protection and restoration of Minnesota's natural resources, important agricultural areas, and open space by supporting conservation-based planning in local and regional communities. The recommendation contains four elements:

- Demonstration (pilot projects)
- Incentives
- Tools and technical assistance
- Investment in base data

This strategy builds on the broader vision, goals, and criteria established under land use recommendation 1—the state land use, development, and investment guide—and refines it for local and regional use. Local governments and conservation organizations can be key agents in implementing the SCPP and local stewardship significantly expands the state's capacity to protect and restore natural areas. Supporting local and regional communities in conservation-based planning will help communities establish long-term goals that are consistent with the state's goals, and allow communities to implement those goals as development occurs.

Conservation-based planning entails proactive and detailed planning for future land use that places preservation of priority natural resources (including priority agricultural lands) at the center of the land use planning process. Conservation-based planning is conducted early in the development or redevelopment process and the community looks at a wide area well beyond where development is currently taking place, considering economic activities dependent on natural resources such as agriculture, forestry and tourism. This allows for coordinated planning of the "green" and "gray" infrastructure such that development of transportation (transit, roadway, and bike/pedestrian) networks can occur while ensuring preservation of natural resources, priority agricultural lands, green space, and planned rural areas.

In the optimal conservation-based planning process, the community identifies its natural resource assets and liabilities through extensive natural resource inventories and assessments using MLCCS cover data or an equivalent mapping system. It develops potential mitigation strategies and uses modeling such as scenario planning and build-out analysis to evaluate the environmental impacts of each. The community then creates a mixture of public policies and funding programs to enable natural resource protection, and links conservation and development so resources are conserved as development takes place. Because natural resources do not stop at political boundaries, as part of the process communities work collaboratively with adjacent counties, cities, towns, and agencies to advance local economic development, housing, social, and environmental objectives.

In order to support conservation-based planning in local and regional communities, four elements are needed: Demonstration, incentives, tools and technical assistance, and base data. The following subrecommendations describe each of these elements.

2A. Demonstrate conservation-based planning through pilot projects

Pilot projects that embody all the elements of good conservation-based planning, as outlined above, would help create an understanding among local and regional communities of the processes involved, identify barriers, and demonstrate benefits. The projects would also generate feedback on adapting strategies for optimal function and effect. Different approaches may be appropriate in different parts of the state, depending on the issues of concern to a particular community or region. Therefore, funding for three types of pilot projects is recommended.

Conservation-based planning in a variety of local communities: These pilot projects would take place in several representative communities from across the spectrum of community types—urban, suburban, rural—that could serve as models for many other communities.

Conservation-based planning along a rapidly developing transportation corridor (involving multiple communities): This process would involve multiple jurisdictions cooperating to develop a detailed area plan for the transportation corridor that would be incorporated into a regional transportation and land use plan guiding future development.

Conservation-based planning resulting in an AUAR-certified comprehensive plan: One pilot project should support a community in conservation-based planning that results in an Alternative Urban Area-wide Review (AUAR)-certified comprehensive plan. This can benefit communities because AUARs are an authorized alternative to traditional environmental impact statements (EISs) and so can streamline the environmental review process.

2B. Provide incentives to local governments and conservation organizations for conservation-based planning

Recent trends in decreasing federal and state natural area grant programs and decreases in general state aid to local governments have undermined local planning and stewardship capacity, even as growth pressures on natural resources have increased. Financial incentives are needed to engage local partners in planning and implementation that meets local and statewide conservation goals.

Provide financial assistance to communities to undertake conservation-based planning: A fund should be established to provide financial support to communities that have a demonstrated commitment to conservation-based planning but that lack the resources and staff to undertake and complete the planning process. Most typically, this will be smaller, exurban communities that are in the early stages of development but that do not yet have the added financial resources that growth can make available to a community.

Provide financial assistance to communities to support implementation of conservation-based plans: A statewide grant program should be created that would provide funds to communities that have completed and adopted a conservation-based plan with the highest standards and have used all available tools for implementation, but that still need financial assistance to "close the gap" so implementation can be fully achieved. Implementation dollars would be available to local units of government (counties, cities, watershed districts, school districts) and nonprofit conservation organizations for implementation activities including acquisition; restoration; alteration of planning, zoning, codes, and other regulations; development review; and installation of conservation measures (e.g., rain gardens). The grants would reflect the state's conservation priorities as identified in conservation-based plans, foster partnerships between local governments and nonprofit organizations with expertise in implementing aspects of the conservation-based plan, and build local capacity to conserve water quality, natural lands, and parks.

2C. Provide tools and technical assistance for conservation-based planning

To develop conservation-based plans, communities must have access to appropriate tools and technical assistance. These include:

Carbon calculator for communities: This recommendation is to develop a simple carbon calculator for communities (rather than for single structures) that would enable Minnesota communities

to readily understand the effects of their land use decisions on greenhouse gas emissions, test alternatives, and make better planning decisions.

Improve agricultural land preservation tools: Existing long-term agricultural land preservation tools are expensive or difficult to successfully implement, and other types of tools offer only short-term protection that cannot withstand strong conversion pressure. Programs and policies from other parts of the country are difficult to adapt to Minnesota's law and culture. To address this, a one-time, multiday congress would be held to bring together Minnesotans with national experts to explore ways Minnesota's agricultural land can be preserved for the long term. Congress topics would include farmland preservation techniques (e.g., purchase of development rights, transfer of development rights, zoning regulations) and agricultural economic development (e.g., development of markets for local food, organics, etc.). At the end of the congress, through a facilitated process, participants would develop reform concepts for future consideration.

Develop and deliver outreach materials: Communities need materials to help them educate themselves, the public, and industry on conservation-based planning processes, tools, and outcomes. Outreach materials should include findings from pilot projects (Land use recommendation 2A); GIS mapping and analysis tools; best practices on building community support, funding identification, and program design; implementation issues, such as land appraisals, easements, and easement compliance; and federal Farm and Ranchland Protection Program (FRPP) requirements.

The state should support work currently underway to build and maintain a comprehensive Web site containing a wide array of best practices. All of the pilot projects should be posted here, along with a detailed description of successful innovations and lessons learned. This resource center should be linked to the pending National Urban Land Institute (ULI) GreenResource Center, and the Minnesota ULI Regional Council of Mayor's Sustainability Committee Web site. All of these best practices and resources should be broadly promoted and distributed through the Association of Counties, the League of Minnesota Cities, the Association of Townships, and others.

Establish a Minnesota natural resources and development partnership: This would be a collaborative, multidisciplinary, intergovernmental partnership that would coordinate support and technical assistance across sectors to help Minnesota communities prepare and implement conservation-based plans. It would address several key challenges, including lack of local capacity, particularly in small communities; fragmented state assistance and investment; federal, state, and local actions that are not always complementary; and assistance that is difficult for communities to access. The partnership would encourage and empower state agencies to combine resources and provide an integrated approach to delivering state assistance. The partnership would operate under the direction of the proposed state land use, development, and investment guide (land use recommendation 1), and ensure that those statewide goals and local conservation-based plans come together for communities "on the ground."

Invest in building state assistance capabilities: In order for state agencies to fulfill their role in the natural resources and development partnership, they need to be more user-friendly community partners that strategically coordinate and integrate the expertise, information, and assistance they offer to better serve local goals and achieve results. This will require additional support for state agencies, both to better connect staff expertise to local communities (through, for example, technical assistance, training workshops, and mentoring opportunities) and to support greater

coordination among the community outreach staff across state agencies. This will begin to reduce the fractured system in place to conserve our state's resources, enable pooling or leveraging of state grant funds, and serve as a model on how to work in an interdisciplinary and interagency fashion.

2D. Invest in generating base data and information necessary to support conservation-based planning

Accurate information about the type and quality of natural resources is essential for making sound planning decisions. Improved planning that uses land cover and other types of natural resources information can identify areas in need of restoration, areas for protection, areas for landscape connectivity, and areas more suitable to development that minimize or avoid environmental degradation and loss. Nearly all of these proposed land use recommendations require accurate, reliable, and standardized information about the type, location, and quality of existing resources as well as an understanding of general land cover type. However, this information is currently severely lacking in the majority of the state, particularly in critical areas.

Develop appropriate MLCCS data in areas vulnerable to near-term development or conversion of land cover: The MLCCS can provide detailed and accurate information that allows great precision and accuracy in conservation and planning. This information allows communities to develop green infrastructure plans that are based on solid data and site-specific conservation strategies. The Minnesota Land Cover Classification System (MLCCS) is particularly useful for planning because it provides a standardized platform for capturing land cover information and is in a format that can be analyzed flexibly, depending on the intended end use. Importantly, it provides broad linkages across multiple categories of recommendations, including water quality, habitat, recreation, urban planning, and open space preservation. Completion of MLCCS data should be funded for select portions of the state, with a priority emphasis on areas vulnerable to near-term land-cover conversion, including growth corridors and areas at high risk for natural resource extraction (timber harvest or mining) where permanent or irretrievable land cover change is likely.

Update statewide land-cover databases and remote sensing capabilities: Conservation-based planning and resource management rely upon land cover and water body characterizations that are up to date and reflect changes from past inventories. Over the next few decades, there will be substantial challenges to preserve our land and water resources in the face of climate change, increasing populations, energy demands, fires, drought, floods, and infestations. Because land and water characteristics can change quickly, statewide land cover and lake quality data should be updated every five years. In order to do this in a cost-effective manner, given Minnesota's geographic area and diversity of land and water forms, continued and expanded use of state-of-the-art remote-sensing techniques will be required. The state should acquire aerial remote-sensing capabilities to obtain near-real-time updating of critical land-cover/land use information for protection and rehabilitation of watersheds.

Description of impact on natural resources. Through the preparation and implementation of strong, conservation-based community plans, we can move toward a future with more compact, efficiently developed communities and supporting transportation networks along with strong, permanent systems of conserved open space (including large blocks of protected agricultural land), with minimal conflicts resulting from incompatible adjacent land uses. With creative, multijurisdictional planning efforts, permanently conserved natural resource systems can be linked into larger contiguous corridors of conserved

natural systems. In addition, with consideration of alternative build-out scenarios and environmental assessment and analysis in planning, environmental impacts can be positively and proactively avoided, minimized, and mitigated.

All of this means less habitat destruction, degradation, and fragmentation through conversion of natural areas and agricultural land into developed areas; less hydrologic modification from impervious surface area and road construction; lower air emissions coming from reduced vehicle miles traveled; and less solids, nutrient, and contaminant loading into waters. In other words, conservation-based planning will improve or reduce degradation of natural resources, including air, land, wildlife, water, fish, and recreation resources.

Relationship to existing programs, laws, regulations. The overall concept of conservation-based planning relates directly to all land use statutes at all levels of government. It also builds on regional planning efforts through the Metropolitan Council and other regional development commissions.

Time frame. As soon as funding is available, all of these recommendations could be started.

Geographical coverage. The recommendations described above have statewide application and coverage. Even when pilot projects are carried out in specific areas, they serve as demonstrations with transferability to communities throughout the state.

Challenges. In several of the recommendations the main challenge would be determining which agency is in the best position to provide administration for the effort. In the Twin Cities metropolitan area, watershed districts, with their regulatory powers and access to financial resources, would often be well positioned to take a leadership role.

Additional challenges include:

- Agency staff are few and lack incentive programs to help guide communities
- Agencies need to change their typical approaches to include working through influence with communities, because state agencies own and manage a very small percentage of Minnesota's urbanized landscape
- Communities vary tremendously in their capacities to plan and act with greater environmental responsibility

Land Use Recommendation 3: Ensure protection of water resources in urban areas by evaluating and improving current programs IP

Description of recommended action. Changes to surface water runoff due to new development and redevelopment have significant impacts on most of the major drivers of change of Minnesota's natural resources. The state of Minnesota has a set of powerful surface water regulatory programs that are largely directed at controlling land use change and development practices to improve and protect water quality. These programs are supported and driven by federal and state statutes and rules, and include:

- Impaired waters and Total Maximum Daily Loads (TMDLs)
- National Pollutant Discharge Elimination System (NPDES) storm-water permitting
  - Municipal separate storm sewer systems (MS4)
  - Construction sites
  - Industrial sites
- Nondegradation for all waters
- Shoreland management

Experience with these regulations over the past several years suggests that a set of tools, monitoring programs, and education efforts would make these regulatory programs significantly more effective. These items, included in this recommendation, com-

prise an integrated set of measures to augment and supplement existing programs to better meet water quality standards and protect existing high water quality.

Four subrecommendations include:

- Credit system for storm-water and LID BMPs
- "Simple" modeling protocols for TMDL compliance
- TMDL BMP implementation monitoring
- Water quality media campaign

Land use practices for new development and redevelopment can protect and improve water quality. With appropriate augmentation and support, the existing regulatory framework can provide a level playing field that will promote and mandate the implementation of these practices as urban land uses expand. These measures will also support water-quality improvement when redevelopment provides opportunities for correcting past practices. This integrated set of measures will:

- Provide analytic tools for regulated parties, such as cities and developers
- Produce incentives to support development practices that protect and improve water quality
- Support better understanding of the effectiveness of a wide range of storm-water BMPs
- Provide a system of accountability for the various sectors and parties expected to implement BMPs to meet water-quality standards and improve water quality
- Establish educational programs that will reach the general public and raise the level of understanding and support for issues related to land use and regulations, and their relationship to water quality.

New development and redevelopment have, in the past, resulted in new impervious land cover and subsequent water-quality degradation. Maps included in this section indicate the extent of past and projected changes in impervious acres in Minnesota (Figures L2 and L3). The measures included in this recommendation are intended to improve the effectiveness of the existing regulatory framework so that expected land use changes can occur and water quality can still be protected and improved.

3A. Credit system for storm-water and LID BMPs

For a limited number of storm-water BMPs, such as storm-water National Urban Runoff Program (NURP) ponds, a strong system of credits is integrated into the storm-water regulatory framework at multiple levels. This system of credits needs to be extended to a much wider range of BMPs, including low-impact development (LID) practices, conservation design, and nonstructural BMPs.

NURP developed a system that was very effective in supporting the design and installation of storm-water ponds. This system has four major components:

- Good scientific and research support
- Specific and detailed design guidelines enabling any engineer or designer to size and design an effective storm-water pond
- Quantification of the benefits of correct design and implementation—specific removal rates for phosphorus and total suspended solids
- Integration into all levels of storm-water regulations (state, city, watershed, etc.)

The result of this effort was the universal adoption and acceptance of storm-water ponds across all sectors. Designers working on projects could use the design guidelines to include storm-water ponds in their projects in order to meet permit and design standards from multiple reviewing and approving government entities.

This system needs to be extended to a wide range of relatively new BMPs. Many of the design standards are currently incorporated into the Minnesota Stormwater Manual. What is missing is a credit system for implementing the BMPs. A well-defined and strongly-supported credit system is needed to moti-

vate developers, builders, and local government units (LGUs) to include these practices in their projects.

This credit system must apply to multiple levels of the landscape. In a manner similar to NURP ponds, the credit system should apply to individual sites and construction projects. The credit system should also function at the regional and statewide levels. The Lake Pepin TMDL, for example, will probably call for a significant phosphorus reduction across the 60% of the lake's watershed in Minnesota. An effective credit system should function at this level to enable cities to determine whether their storm-water BMP programs are sufficient to meet the waste load allocation from the TMDL.

Steps to achieve this are:

- Develop a comprehensive list of BMPs (structural and nonstructural) currently in use by developers, builders, and LGUs
- Develop a comprehensive list of additional desirable BMPs
- Perform an extensive literature review to collect information on total load reduction, including pollutant removal rates and volume reduction.
- Based on the information from the literature review, develop a credit system for each BMP system; include guidelines on design standards with variation depending on the type of design and construction used
- Develop a system to address overlap and redundancy among BMP systems and instructions on how to address situations where multiple BMPs are applied to the same land area
- Prepare a report on the level of research and support for deriving the credit for each type of BMP system, identify and list strengths and weaknesses, develop a strategic framework to address BMP systems for which research support should be strengthened
- Incorporate the BMP credit system into the Minnesota Stormwater Manual and NPDES storm-water regulatory programs

3B. Simple modeling protocols for TMDL compliance

TMDL studies produce waste-load allocations and load allocations for pollutants. These allocations result in a responsibility for implementation of restoration measures by cities, other LGUs, and other landowners. In the case of municipal wastewater treatment plants and cities covered under the NPDES MS4 storm-water program, these responsibilities take the form of permit requirements.

Cities need a relatively simple storm-water modeling system to estimate current loading for a range of pollutants and changes to loading if various BMP systems are implemented on portions of the land in their jurisdiction. This type of modeling system would enable them to gauge their current loading compared to the allocation set in a TMDL. It would also enable them to design an appropriate mix of new BMPs that would constitute the most cost-effective approach to meet the TMDL load allocation in the future.

This simple modeling system would consist of a load estimating model based on land use and loading rates combined with a total load reduction model based on load removal rates and volume reduction rates appropriate for a wide range of BMP systems. This simple model could be used by all cities and other landowners with relatively low technical knowledge and manageable input requirements.

Steps to achieve this are:

- Review the current simple model used for nondegradation analysis by MS4 cities, and determine sufficiency for this purpose
- Integrate this project with the credit system for storm-water and LID BMPs, using the estimated total load reductions as the basis for the total load reduction model component of this system
- Develop an integrated loading rate and total load reduction model for use by cities and other landowners

- Prepare guidance documents and user instructions
- Integrate this model into protocols for TMDL studies and implementation plans
- Develop and implement outreach and training to support the wide usage of this model

3C. TMDL BMP implementation monitoring

Draft and implement a program of detailed BMP monitoring in selected representative watersheds with TMDL studies and implementation plans. In addition to monitoring the water body itself, this program would involve monitoring throughout the watershed to determine the effectiveness of BMP systems implemented by various entities and types of entities (agriculture, silviculture, cities, storm-water, wastewater, etc). It would also involve detailed in-stream or in-lake monitoring to better understand processes in the water bodies themselves, as well as contributions from the landscape and municipal infrastructure.

This monitoring program may include some BMP implementation monitoring – simply counting and documenting the extent of the implementation of BMP systems across the landscape. The main focus, though, will be water-quality monitoring to directly measure the impact and effectiveness of BMPs by measuring water-quality parameters at discharge points and in water bodies near or adjacent to the BMP systems.

This scale of monitoring would provide an important accountability framework for all parties involved in implementing BMPs and meeting water-quality standards (cities, watershed organizations, agriculture, etc.). This type of monitoring program has also been referred to as "sentinel watershed" or "representative watershed" monitoring.

Steps to achieve this are:

- Prepare a program workplan (goals, techniques, equipment, protocols, budget, entities and personnel to be involved, stakeholder group, technical advisory committee, etc.)
- Integrate with appropriate state agencies and entities (MPCA, DNR, Environmental Quality Board [EQB], Clean Water Council, etc.)
- Integrate with the statewide science and research strategic framework
- Integrate with existing and proposed research projects (e.g., stream-bank stability, bacteria fingerprinting)
- Select representative watersheds
- Implement water-quality monitoring program
- Review data and prepare reports

The first one or two watersheds should be pilot projects. The selected watersheds should be small and the implementation BMPs to be monitored should be relatively simple with rapid results. These watersheds should be worked through as completely as possible with the goal of learning important lessons before proceeding to larger and more complex watersheds.

The equipment to perform this monitoring, if purchased using state funds, should be owned by the state. This will significantly expand the state's monitoring capacity.

3D. Water quality media campaign

Further develop and expand the reach of Minnesota Water—Let's Keep It Clean!, a storm-water pollution prevention campaign produced by a coalition of cities, nonprofits, agencies, watersheds, and others working to develop pollution prevention resources for the Twin Cities metropolitan area.

This campaign is designed to enhance public education and awareness of storm-water pollution prevention strategies by disseminating messages in mass

media and providing educational materials for educators and municipal staff through the www.cleanwatermn.org Web site.

By expanding to reach a statewide audience, the campaign can reduce stormwater pollution discharges to receiving waters through the dissemination of effective and innovative storm-water pollution prevention public education materials and messages across the state.

Effective storm-water programs can improve water quality only when there is an appropriate level of understanding among and support from the general public. A broad-based multimedia campaign is an essential element to achieving these results. There must be large, statewide constituent groups to support:

- State regulatory programs
- Statewide legislative initiatives (e.g., the Clean Water Legacy Act)
- Local actions (e.g., cities' MS4 permit compliance)
- Market-driven efforts (e.g., LID and conservation design developments)

The Minnesota Water—Let's Keep It Clean! campaign's existing program development model would serve as the primary template for this activity. Steps are:

- Prepare a program workplan (audience, goals, techniques, protocols, budget, entities and personnel to be involved, stakeholder groups, steering committee, etc.)
- Integrate with appropriate agencies and other entities (MPCA, DNR, EQB, Clean Water Council, Metro Watershed Partners, Minnesota Cities Stormwater Coalition, Minnesota Stormwater Steering Committee, etc.)
- Integrate with the statewide storm-water pollution prevention public education strategic framework
- Integrate with existing and proposed research on maximizing the effectiveness of public education campaigns relating to water quality and storm-water pollution prevention
- Select public outreach materials, activities, and products
- Implement a storm-water pollution prevention education program
- Review program effectiveness and prepare reports

Relationship to existing programs, laws, regulations. The elements of this recommendation are intended to augment and supplement existing regulatory programs to better meet water-quality standards and protect existing high water quality. This integrated set of measures is beyond the current technical capacity or regulatory responsibility of the MPCA, DNR, BWSR, and other state agencies with storm-water and water quality regulatory roles.

These elements are designed to provide incentive systems, analytic tools, effectiveness and accountability monitoring, and educational support to significantly and cost-efficiently increase the effectiveness of the existing storm-water and water-quality regulations.

Time frame. The credit system and the simple TMDL modeling protocols should be developed as soon as possible. Both projects could be completed within two years.

The TMDL BMP implementation monitoring and water quality media campaign should be started as soon as possible but will extend over a longer period. Both should be viewed as 5- to 10-year efforts. These elements should yield some short-term results, but most of the positive outcomes will be seen in the longer term.

Geographical coverage. The storm-water and water-quality regulations extend statewide. The benefits of the elements of this recommendation will be seen in all these regulatory programs and will effectively supplement the efforts of all parties throughout Minnesota working to comply with these regulatory programs.

These regulatory programs cover a large number of cities, townships, counties, watersheds, construction sites, and industrial facilities throughout Minnesota. Improving the effectiveness of these programs will have a dramatic impact on the landscape and water quality statewide.

Challenges. There are no major challenges implementing all the elements of this recommendation. The scientific research and technical literature needed to develop and support these elements exists currently.

The participation of a significant number of stakeholder groups would be needed for the development and implementation of these elements. These groups are currently participating in the Minnesota Stormwater Steering Committee, the Clean Water Council, and other organizations and initiatives.

Costs. Costs of meeting this recommendation are:

- Credit system for storm-water and LID BMPs—approximately $100,000
- Simple modeling protocols for TMDL compliance—approximately $100,000
- TMDL BMP implementation monitoring—$500,000 to $2 million (over time)
- Water quality media campaign—$500,000 to $2 million (over time)

Agricultural Land Use

Agricultural production is highly dependent on and also has a large impact on natural resources, especially soil, water, and climate. The increasing demand for food, feed, fiber, and now fuel is resulting in more pressure on these natural resources. Access to productive land for agricultural use is also under pressure, affected by nonagricultural land uses including urban development. Protection of both the natural resource base and access to productive lands for agriculture will require improved planning and management in this rapidly evolving economic and technological environment.

Minnesota's agriculture and agro-ecoregions vary considerably across the state. It is not possible to address the wide range of products, production practices, and natural resources of the whole state in a limited set of recommendations. Appropriate production practices are described already in publications of University of Minnesota Extension, the Minnesota Department of Agriculture (MDA), the USDA Natural Resources Conservation Service (NRCS), the MPCA, and others. The focus here is rather on a very few key natural resource indicator conditions and trends, and some strategies to address them.

Key Natural Resource Conditions and Trends for Agricultural Land Use

Impaired Waters

Many of Minnesota's rivers, streams, and lakes in agricultural regions are impaired by sediment and nutrients and don't meet water quality standards for designated uses (Figure L4 and Table L1). Many more water bodies have yet to be tested and evaluated, so the list is incomplete.

Approximately half of the area of the state and most of Minnesota's agricultural production is in the Mississippi River watershed, which includes the Minnesota River. Lake Pepin, a natural lake formed by a constriction of the Mississippi River, is impaired by excess nutrients and turbidity. Major segments of the Minnesota River are also impaired by turbidity. Currently, a large group of scientists and modelers is conducting a multiyear TMDL study of these impairments, including interaction with a large stakeholder advisory committee. The results so far provide the following information.

Stream-bank erosion is a major and increasing source of sediment delivered to Lake Pepin, primarily from the Minnesota River and its tributaries. Estimates from several different methods and researchers indicate that streambank and other near-channel sources account for well over half of the sediment coming from the Minnesota River. The increasing proportion from this source indicates an increase in peak and bankfull flows over time. This would indicate a need to reduce peak flows and bankfull durations if this source is to be reduced. The contribution from upland field and gully erosion is still significant and needs attention, especially on sloping land near streams (Figure L5). See also the sections on erosion in the energy recommendations introduction and the preliminary plan of the SCPP.

Climate Change

GHG emissions continue to increase and are insufficiently mitigated with current practices (Figure L6). The introduction to the energy recommendations section of this report addresses this issue more fully and the reader is referred to that section. Biofuel sources and production methods have large effects on soil and water, so they are addressed in the recommendations for agricultural lands as well as the energy and mercury recommendations.

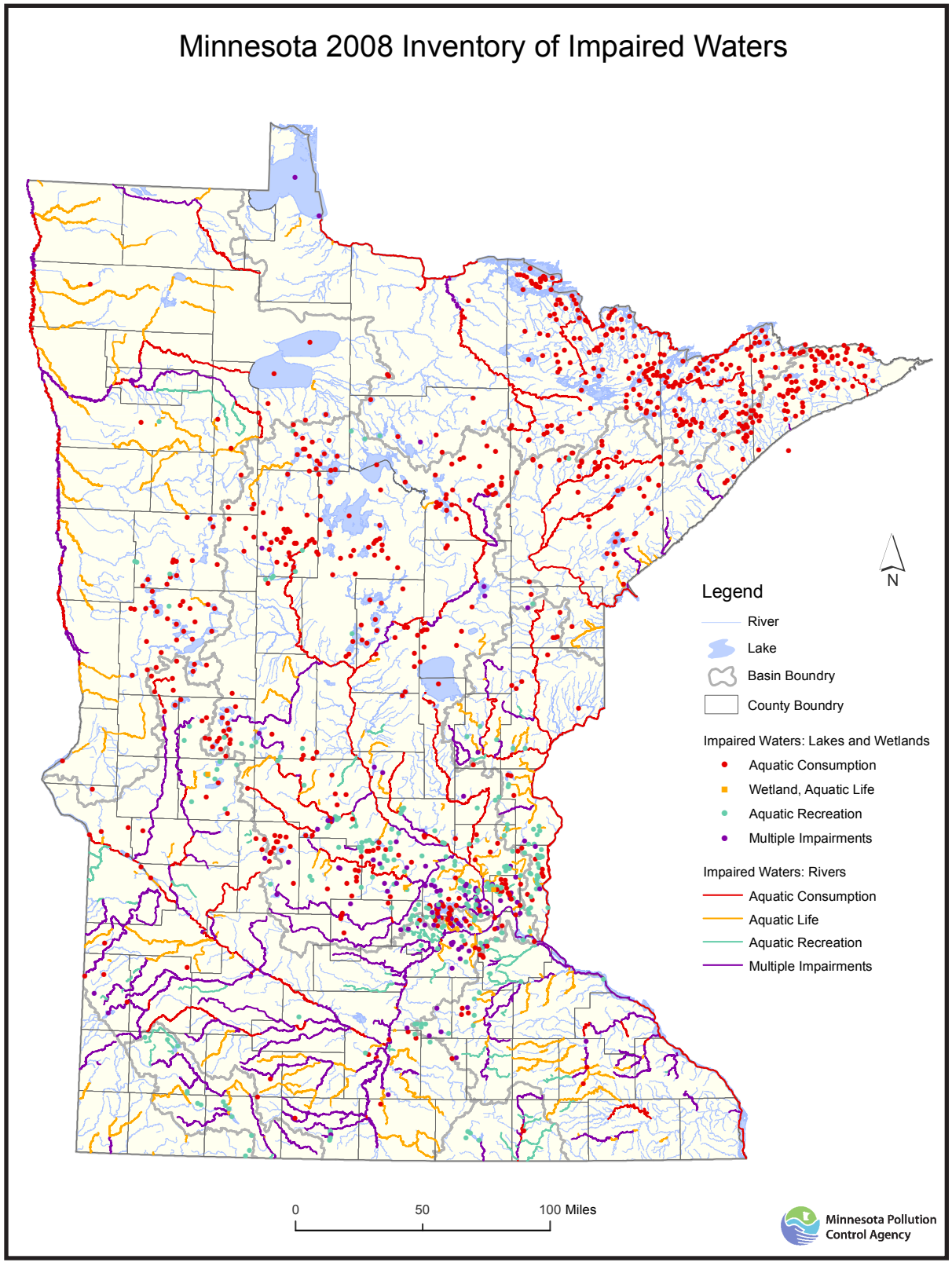

Figure L4. Minnesota inventory of impaired waters. Credit: Thomas Pearson, MPCA.

Pollutant or stressor	Affected designated use
Arsenic	Aquatic consumption
DDT	Aquatic consumption
Dieldrin	Aquatic consumption
Dioxin (including 2,3,7,8-TCDD)	Aquatic consumption
Mercury in fish tissue	Aquatic consumption
Mercury Water Column	Aquatic consumption
PCB in Fish Tissue	Aquatic consumption
PCB in Water Column	Aquatic consumption
Perfluorooctane Sulfonate (PFOS) in Fish Tissue	Aquatic consumption
Toxaphene	Aquatic consumption
Acetochlor	Aquatic life
Ammonia (Un-ionized)	Aquatic life
Aquatic macroinvertebrate bioassessments	Aquatic life
Aquatic Plant Bioassessments	Aquatic life
Chloride	Aquatic life
Fish bioassessments	Aquatic life
Lack of a coldwater assemblage	Aquatic life
Oxygen, Dissolved	Aquatic life
pH	Aquatic life
Temperature, water	Aquatic life
Turbidity	Aquatic life
Fecal Coliform	Aquatic recreation
Nutrient/Eutrophication Biological Indicators	Aquatic recreation

Table L1. Pollutants grouped by affected designated use category. Credit: Thomas Pearson, MPCA.

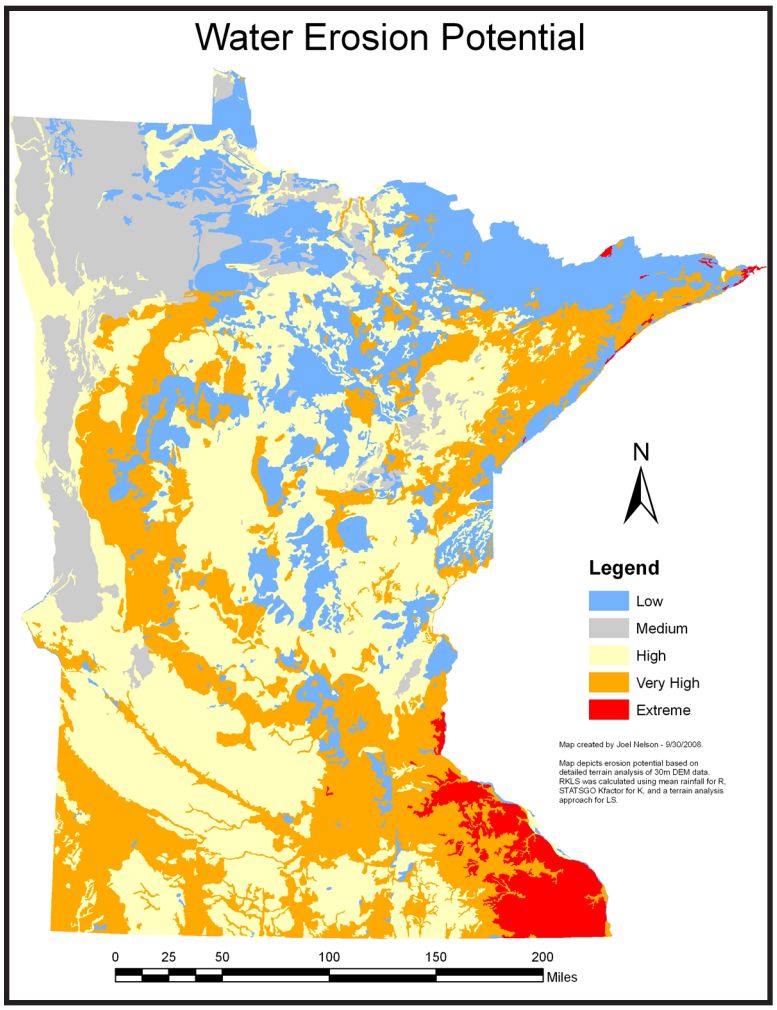

Figure L5. Potential soil erosion by water. Credit: David Mulla, UM.

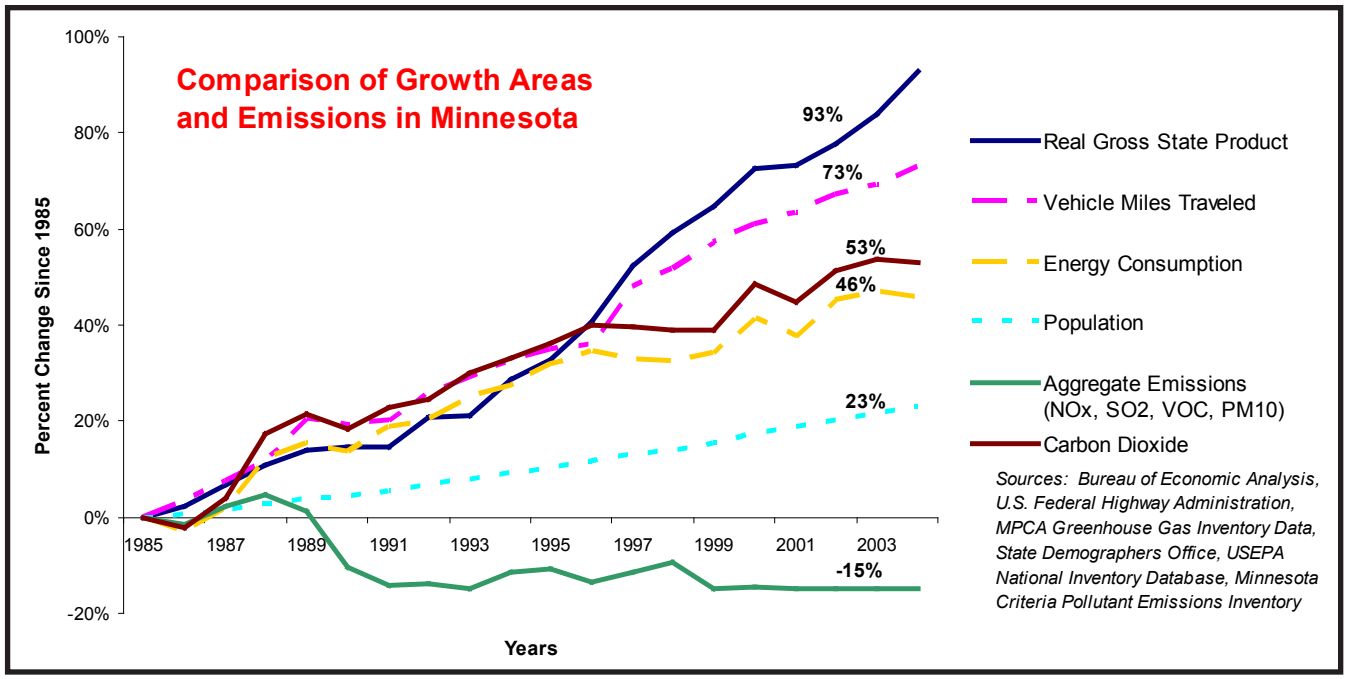

Figure L6. Comparison of economic and emission growth factors in Minnesota from 1985 to 2005. Credit: MPCA.

Loss of Agricultural Lands

Agricultural lands are being permanently lost to urban and residential development (Figure L7). This loss results from both the direct conversion of agricultural land to development and the fragmentation of agricultural areas by suburban and exurban sprawl, increasing conflicts with agriculture and reducing the availability of agricultural product and service providers in those areas.

Drivers of Change for Agricultural Land Use

The drivers of change affecting the condition of natural resources addressed by the agricultural recommendations include:

Land-Cover Changes on Agricultural Lands

Land in annual row crops has been steadily increasing while land in perennial crops, pasture, and nonrow annual crops has been decreasing (Figure L8). The lack of early-season ground cover in annual row crops decreases protection from soil erosion and nutrient loss and increases the volume of runoff due to lower early and late season transpiration. See Randall et al. (1997) for a comparison of drainage volume under various crops.

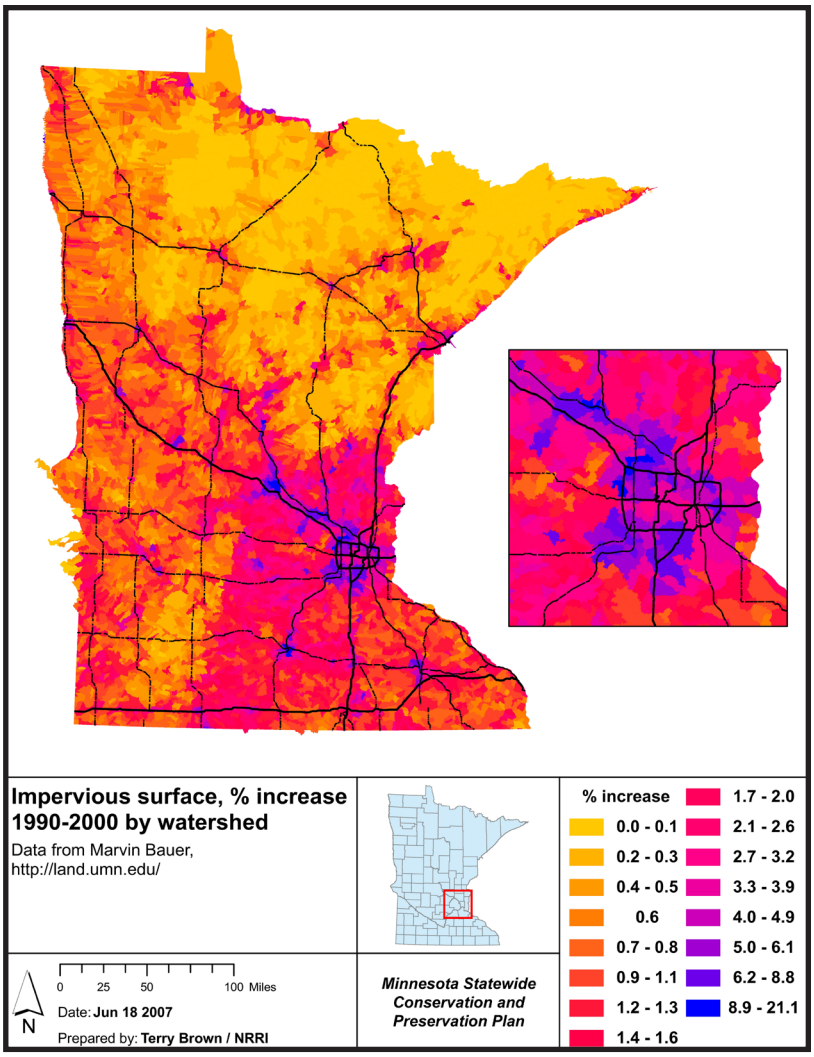

Figure L7. Impervious surface increase by watershed 1990–2000. Credit: Marvin Bauer, UM. Funded by LCCMR. Figure prepared by Terry Brown, NRRI.

Altered Hydrology

Annual row-crop production is often accompanied by surface and subsurface drainage systems designed to quickly remove water from the field, enabling early-season field operations and improving plant growth in wet years. This altered hydrology affects peak stream flows and total volumes, and, in conjunction with recent increases in annual rainfall, can increase the potential for streambank erosion. Subsurface drainage systems also increase the delivery of nitrates to river systems.

Ethanol Mandates

Ethanol mandates are increasing the demand for corn, providing pressure for conversion of additional land to row-crop production, including land currently enrolled in the Conservation Reserve Program (CRP). See the introduction to the energy recommendations for graphs of expiring CRP (Figures E13, E14 and E15). Congressional agriculture committee leadership has indicated that there will be no attempt to keep CRP rental rates competitive with

the rapid increases in land rental rates for corn production.

Land Development

Rapid expansion of urban and residential land use is reducing the area available for agricultural production.

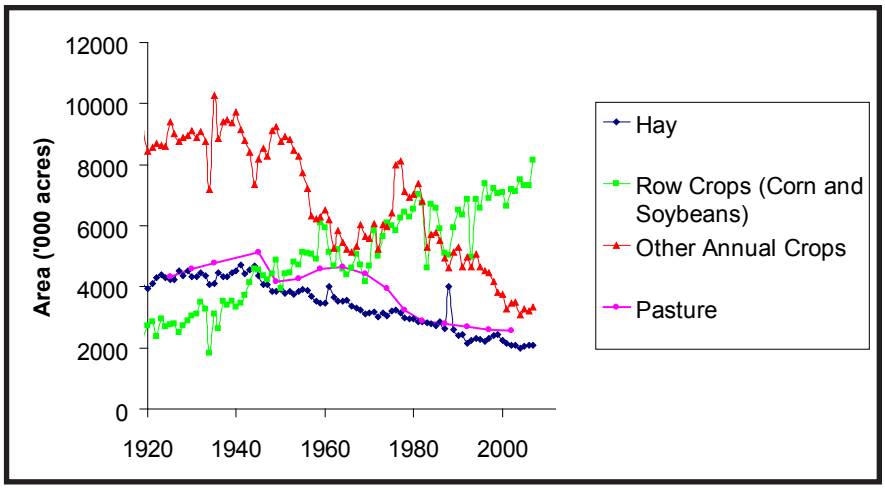

Figure L8. Acreages planted to hay, row crops, pasture and other annual crops. Credit: Laura Schmitt, UM.

Agricultural Land Use Recommendations

Land Use Recommendation 4: As much as possible, transition renewable fuel feedstocks to perennial crops

SP

Perennial species protect the soil from erosion throughout the year and reduce the volume of early-season water runoff (related to stream-bank erosion) because of a longer annual duration of evapotranspiration and increased infiltration. Additionally, the use of perennial cellulosic crops as feedstock for biofuels can significantly reduce life-cycle GHG emissions relative to grain-based ethanol production systems. Because an appropriate selection of perennials is less sensitive to risks such as temporary flooding and drought, and presents less risk of erosion and nutrient runoff, it can complement annual food and feed crops by occupying the more vulnerable land areas, stabilizing incomes and protecting the environment.

Conservation and protection of water quality and soils are strongly influenced by land cover. Perennial species protect the soil from erosion throughout the year and reduce the volume of water runoff (related to stream-bank erosion) because of a longer annual duration of evapotranspiration and increased infiltration. Additionally, the use of perennial crops as feedstock for biofuels can significantly reduce life-cycle GHG emissions relative to grain-based ethanol production systems.

This strategy directly addresses two of the key drivers of change: land use practices and energy production and use. Current trends in energy production and use are changing land use practices by increasing the land area in corn, replacing other annual crops and perennial cover. This strategy will facilitate a transition to use of perennial crops as feedstock for biofuels and other products, thereby improving protection of soil and water as well as affording a greater reduction in net GHG emissions.

4A. Invest in research on parameters that control successful perennial feedstocks

Description of recommended action. Invest in research to determine ecoregion and site-specific suitability and management of perennial species for use as feedstock for biofuels and other products. Minnesota agro-ecoregions (Figure L9) differ significantly in suitability for perennial species that can serve as feedstocks for biofuels and other products. Growing season length and temperature, precipitation, and soil characteristics are important determinants of species suitability. Research is necessary to help producers select site-specific perennial species for use as cellulosic feedstocks.

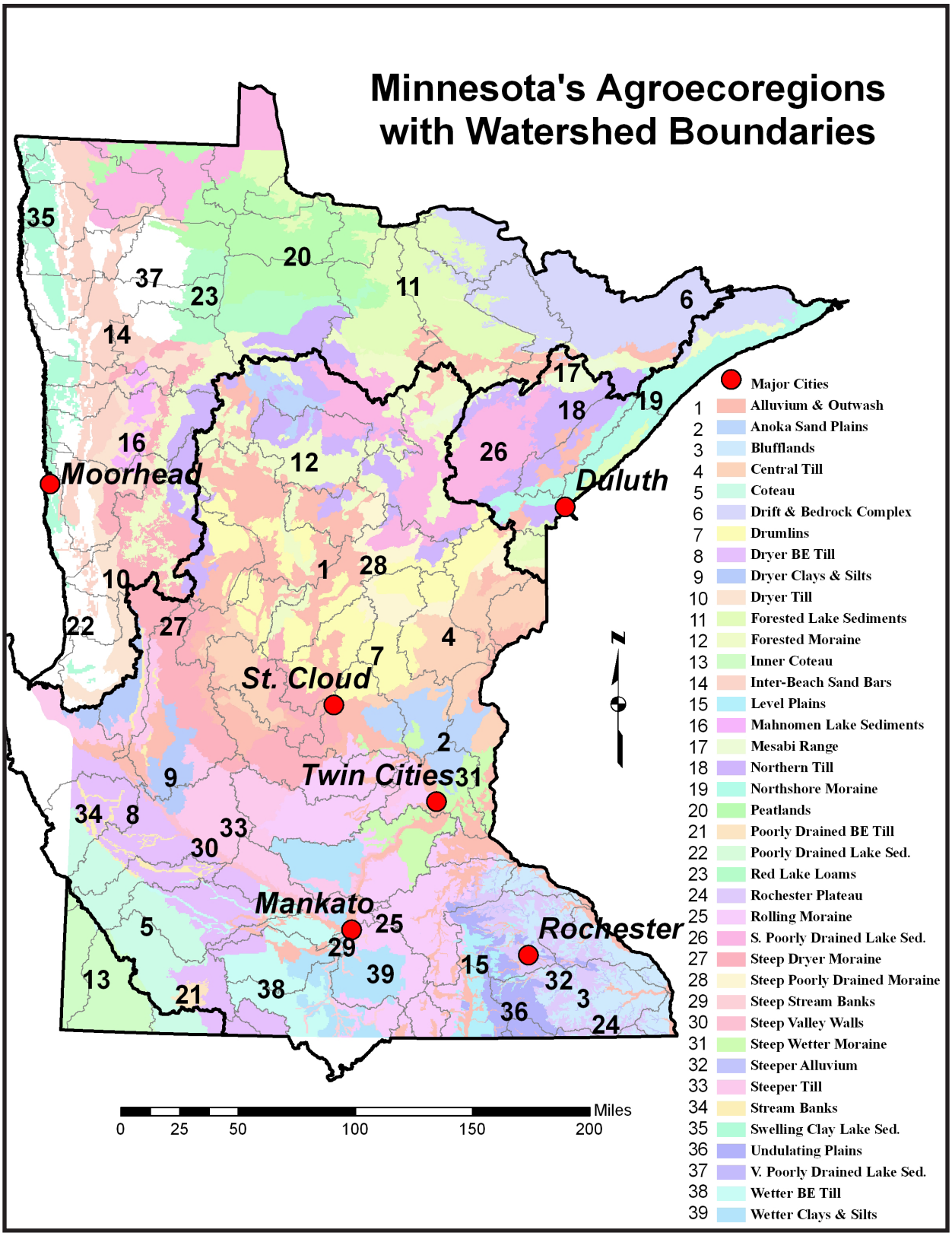

Figure L9. Minnesota agro-ecoregions differ significantly in suitability for perennial species that can serve as feedstocks for biofuels and other products. Growing season length and temperature, precipitation, and soil characteristics are important determinants of species suitability. Credit: David Mulla, UM.

Description of impact on natural resources. Research will:

- Optimize yields by matching appropriate species to agro-ecoregion and sites
- Optimize yields by developing management recommendations for individual species
- Minimize loss of nutrients and sediment through appropriate plant management

Relationship to existing programs, laws, regulations. Existing research funding, both public and private, is focused primarily on annual crops traditionally used for food or feed, with some adaptive research, primarily in the private sector, on corn grain as an ethanol feedstock. There is very little research on site-specific suitability of perennial crops targeted for use as biofuel and bioproduct feedstock.

Time frame. This investment needs to begin now, and continue as a significant and ongoing component of agricultural and energy research. Initial investments should be higher because of the extensive species screening that will be necessary.

Geographical coverage. Agricultural areas statewide

Challenges. Availability of funds for research, along with as-yet undetermined processing qualities needed for feedstocks for biofuels and other products

Costs. An example of the cost of perennial crop research is the $1.5 million annual budget of the USDA Agricultural Research Service (ARS) Plant Science Research Unit at the University of Minnesota (UM), which conducts forage research.

A second cost is the opportunity cost created by the competition of energy crops with food crops for research time and funds.

4B. Investigate policy changes on fuel feedstock transition

Description of recommended action. Investigate, analyze, and adopt policy that will gradually transition biofuel feedstocks produced for the Minnesota ethanol mandate to perennial crops. The transition should be matched to availability of processing technology and requirements for infrastructure development.

Description of impact on natural resources. This policy will:

- Reduce the volume of water runoff (surface and tile) because of a longer annual duration of evapotranspiration and increased infiltration (Randall et al. 1997)
- Reduce soil erosion
- Reduce net GHG emissions relative to current ethanol production systems (Farrell et al., 2006; Hill et al., 2006; Tilman et al., 2006)

Relationship to existing programs, laws, regulations. Current Farm Bill commodity programs provide strong incentives for annual row-crop production, primarily corn, as feedstock for ethanol. Direct payments for corn in the 2002–07 Farm Bill are $0.28/bushel. Price-dependent payments are not currently being paid since corn prices are high; however, they provide a floor-price guarantee not available to non-program crops.

As technology improves for use of perennial plants as feedstock for ethanol, incentives should change to encourage their use. The existing state mandate for ethanol blends in gasoline could be amended to gradually decrease the GHG equivalent of the ethanol produced to fulfill the mandate, which would strongly encourage a shift to perennial plant feedstock sources. California is implementing similar legislation aimed at reducing the life-cycle fossil carbon content of transportation fuels (http://www.arb.ca.gov/fuels/lcfs/lcfs.htm).

Time frame. Policy evaluation could begin immediately, with the objective of setting goals for the timing of transition to perennial feedstocks for ethanol.

Geographical coverage. Agricultural areas statewide

Challenges. Determination of the GHG equivalent of ethanol from various production systems will be needed, and will eventually include expected changes in soil organic carbon from production of various feedstocks. Initially this might be limited to a few classes (e.g., corn grain vs perennial crop biomass). In that case the ethanol source tracking is solely by type of ethanol production facility (grain or cellulosic).

Timing the transition policy to availability of appropriate technology and infrastructure development will require careful preparation.

Costs. Costs include:

- Determining the GHG equivalent of ethanol from various production systems
- Tracking ethanol sources (perennial crop cellulosic ethanol vs. other sources)
- Converting current ethanol infrastructure to cellulosic processing

Other costs will depend on the nature and efficiency of processing technology used and on the choice, productivity, and markets for biomass crops. This will affect economic returns to farmers and processors, and the ethanol price to users.

Land Use Recommendation 5: Reduce stream-bank erosion through reductions in peak flows **R P**

Reductions in peak and total flows by modification of drainage systems, and constructing and restoring wetlands and riparian areas in strategic locations, will reduce attendant stream-bank and near-channel erosion, a major source of sediment in the Minnesota River basin. While agricultural drainage is necessary, research-based modifications such as shallower tile placement can reduce downstream impacts. With placement guided by more accurate digital elevation data, strategically located water storage would lessen the impact of both surface and subsurface drainage systems on stream channels and reduce nutrients in water. Some water storage areas could be occupied by biomass crops not sensitive to temporary flooding.

Research in development of the Lake Pepin and Minnesota River turbidity TMDLs has revealed that greater than 50% of the sediment coming from the Minnesota River is originating from near-channel sources, including stream-bank, gulley, and bluff erosion. Furthermore, the contribution of these sources has increased substantially over the past century, indicating a gradual and major change in stream and river flows. This is due in part to an increase in annual precipitation since the 1930s, and also to the extensive artificial ditch-and-tile drainage network that continues to be installed, and that connects previously isolated landscapes to the river system. Research-based goals for peak-flow reductions will, if adopted and achieved, reduce the contributions of sediment from streambank erosion.

The principal drivers related to this recommendation are climate change and land use practices. Land use change began with European settlement, which resulted in extensive land drainage to enable agricultural production. A gradual shift away from mixed livestock and grain production systems, including perennial forage and pasture, to more cash-grain and grain-based livestock production has also contributed to changes in hydrologic regimes with a reduction in early- and late-season evapotranspiration.

5A. Invest in research that quantifies the relationship between artificial drainage and stream flows

Description of recommended action. Invest in research to determine the quantitative relationship among trends in precipitation, artificial drainage systems, and stream hydrology.

Determination of the quantitative relationship among trends in precipitation, artificial drainage systems, land cover, and stream hydrology would allow more precise targeting of mitigation strategies, since the relationships are complex and strategies will be site specific.

Description of impact on natural resources. The research investment would promote efficient selection and targeting of mitigation strategies.

Relationship to existing programs, laws, regulations. There is little research in Minnesota quantifying the relationship between artificial drainage and stream flows. The proportion of river-borne sediment from stream-bank and other near-channel sources has only recently been determined to be higher than previously estimated and rising over time. Studies to quantitatively partition the effects of changing precipitation, artificial drainage, and changes in land cover have not yet been initiated.

Time frame. These investments should begin immediately and continue until hydrologic peak-flow goals are attained.

Geographical coverage. Agricultural areas statewide

Challenges. Funds for research and modeling, elevation data acquisition, and monitoring data are limiting factors.

Costs. Financial cost of the research $300,000 to $500,000 for modeling, plus an undetermined amount for additional field research as needed

5B. Investigate policy changes for goals for peak flow reductions

Description of recommended action. Set research-based goals for peak-flow reductions through hydrologic detention, wetland and riparian zone restoration, and other measures.

Description of impact on natural resources. Research-based goals would provide quantitative requirements for the extent of mitigation measures.

Relationship to existing programs, laws, regulations. There are currently no explicit goals for peak flows or flow reductions. Existing programs in wetland restoration provide upland storage, but are not specifically targeted for maximum hydrologic effect.

Time frame. Goals for peak flow reductions should be prepared as part of the Lake Pepin and Minnesota River TMDL implementation plans, with other river systems to follow. Timing depends on availability of results of research determining the quantitative relationship among trends in precipitation, artificial drainage systems, and stream hydrology.

Geographical coverage. Agricultural and urban areas statewide

Challenges. Determination of necessary and achievable reductions in peak flows will require funding for modeling and research.

Costs.

- Financial costs for modeling
- Personnel costs for expert and stakeholder participation in goal setting

5C. Invest in targeted water detention

Description of recommended action. Invest in strategically targeted programs for reduction of peak flows through increased water detention in agricultural drainage systems, including wetland construction and restoration, in-ditch storage, and conservation drainage.

Targeted drainage water detention will reduce peak flows and attendant stream-bank erosion. It will also reduce sediment and nutrient contributions from uplands through sediment deposition and denitrification. Hydrologic detention measures should

complement programs and policies to reduce flows through more perennial crops and buffers.

Description of impact on natural resources. Targeted mitigation programs will:

- Reduce peak flows and attendant stream-bank erosion
- Reduce sediment and phosphorus contributions from uplands through sediment deposition
- Increase denitrification of drainage water

Relationship to existing programs, laws, regulations. Existing wetland restoration programs are not targeted specifically at modifying drainage systems to reduce peak flows. Programs must be coupled with peak flow reduction targets to make them effective for this objective.

Time frame. These investments should begin immediately and continue until hydrologic peak flow reduction goals are attained.

Geographical coverage. Agricultural and urban areas statewide

Challenges. Funds for mitigation programs are limited.

Costs.

- Funds for structures, land, and practices for drainage water detention
- Funds for technical services to select sites and design/install structures and practices

5D. Investigate policy changes for peak flow reduction

Description of recommended action. Investigate, analyze, and adopt science-based policy that strengthens mitigation of peak flows from artificial drainage systems.

Description of impact on natural resources. Analyzing and adopting policy for mitigation of peak flows will ensure a baseline of peak-flow mitigation for reduction of streambank erosion.

Relationship to existing programs, laws, regulations. There is currently no effective policy regarding mitigation of peak runoff flows originating in rural areas. Minnesota Statutes 103E governs "public drainage authorities," defined as "the board or joint county drainage authority having jurisdiction over a drainage system or project." The statute requires drainage authorities to "give proper consideration" to downstream effects in establishing or modifying a public drainage project, but establishes no standards for mitigation, and applies only to public systems in construction or modification.

Time frame. A deliberative process should begin to review existing data and policies that would result in policy for peak-flow reductions. Timing depends on availability of results of research quantifying the relationship among trends in precipitation, artificial drainage systems, and stream hydrology.

Geographical coverage. Agricultural and urban areas statewide

Challenges. Determination of how much peak-flow reduction should be achieved through regulatory adjustment and how much through purchase of easements for constructed wetlands and other storage will require research, negotiation, and funds.

Costs.

- Personnel costs for expert and stakeholder participation in policy analysis and selection
- Personnel costs for policy implementation

Land Use Recommendation 6: Reduce upland and gully erosion through soil conservation practices **R P**

Education, targeted incentives, and practice-flexible, outcome-based soil and water conservation plans where needed would reduce soil erosion from fields

and areas of concentrated flows. The result would be reduced sediment and phosphorus delivery to water and protection of soil productivity. Certified crop consultants already deliver conservation-related services (nutrient and pest management) and can provide other field-based services in support of soil conservation to augment services provided by the USDA, NRCS and Soil and Water Conservation Districts (SWCDs).

Soil erosion from sloping fields, especially those near unbuffered streams, is a significant source of sediment and associated phosphorus. Current federal Farm Bill and energy policies and incentives are increasing row-crop production (Figure L8), especially on the sloping soils of southeastern Minnesota, where a high proportion of land has been in pasture and perennial crops. The increased width of tillage, planting, and spraying implements makes maintenance of erosion-control structures such as terraces and grassed waterways more difficult and less likely. The increased prevalence of corn following corn for ethanol production increases the prevalence of intense tillage to reduce crop-residue effects on corn early growth and yields. The percentage of cropland operated by renters, many of them with short-term leases and cash rents, exceeds 40% (2002 Census of Agriculture), lessening the incentive for long-term soil stewardship. Reductions in upland and gully erosion will require stronger incentives and standards for soil conservation if the trends above continue.

The principal drivers of change related to this recommendation are land use practices and energy production and use, resulting in more intensive row-crop production with less incentive for soil protection.

6A. Invest in soil conservation practices

Description of recommended action. Invest in education and incentive programs, leveraging federal, state, and local resources when possible, that target landowners in critical sediment source areas.

Landscape areas differ in potential to deliver sediment and nutrients to water, based on proximity, slope, and other factors. Education and incentive programs that target high-contributing areas will achieve more mitigation per dollar invested than nontargeted programs (Figure L5).

Relationship to existing programs, laws, regulations. The four largest programs related to water protection in rural landscapes are funded by the federal Farm Bill conservation title. They are the CRP, the continuous sign-up CRP (CCRP) for buffers, the Wetlands Reserve Program, and the Environmental Quality Incentives Program (EQIP) for practices on working lands. None of these is specifically targeted to mitigation of listed impaired waters; however, the CCRP for buffers is targeted to areas near streams statewide. In the near term, the area in CRP will significantly decrease due to CRP rental rates that are too low to compete with returns from crop production. EQIP is likely to remain steady but not expand in the new Farm Bill. The smaller Wetlands Reserve Program, based on permanent easements, is likely to not lose ground but not gain much in the current environment. The state has been able to leverage the CRP through the Conservation Reserve Enhancement Program (CREP), adding sign-up incentives and contract duration for buffer areas. The two past CREP sign-ups were able to target buffers to specific large river basins, but not to specific lands identified as sediment and nutrient source areas. Wetland restoration is also part of CREP, providing matching funding from the state Reinvest in Minnesota (RIM) program and ensuring permanent easements on those restored wetlands.

Description of impact on natural resources. Benefits of funding targeted upland sediment reduction education and incentive programs include reductions in sediment delivery to waters with improvement of water quality. Sediment reductions are obtained with more economic efficiency than nontargeted programs.

Time frame. Targeted programs should be initiated as soon as possible.

Geographical coverage. Results of critical-area analyses determine the geographical targeting of programs.

Challenges. Funding for outreach programs and incentive programs is limited. Also, targeting federal programs is not under state control.

Costs.

- Funds for education and incentive programs
- Technical assistance for conservation practice implementation
- Personnel costs for determination of sediment source areas and targeting of programs

6B. Investigate policy changes to reduce upland and gulley erosion

Description of recommended action. Investigate the feasibility of developing or amending policy, such as water quality rules, to phase in outcome-driven, practice-flexible soil and water conservation plans for all farms with potential to deliver sediment and nutrients to water bodies. The phase-in priority could begin with farms in watersheds with sediment and phosphorus-related impairments.

Description of impact on natural resources. This policy would:

- Reduce sediment and nutrients delivered to water bodies, improving water quality if policy is adopted
- Maintain the productivity of agricultural soils

Relationship to existing programs, laws, regulations. The only current policy addressing erosion and sediment from agricultural fields is the conservation compliance provision of the federal Farm Bill. That provision only addresses fields classified in the bill as Highly Erodible Land (HEL). The conservation compliance requirements set in the 1985 Farm Bill were later relaxed, and were never designed to address sediment delivery in an impaired waters framework. Many fields not in the HEL category deliver sediment via concentrated flow, and are not addressed by the conservation compliance provision. Current yield-based federal commodity subsidies, as well as ethanol mandates and subsidies, are strong incentives for maximizing both area and yield of annual row crops with no constraint on sediment and nutrient delivery to waters, except for the HEL provisions listed above. While flexibility is needed in how erosion will be controlled, standards are needed for reducing sediment delivery. A soil and water conservation plan allows the necessary flexibility in management while ensuring that goals for sediment and nutrient delivery reductions are met. One possible policy framework to consider would be state water-quality rules. (Note: The soil and water conservation plan referenced here is more limited in scope than the NRCS Conservation Plan, which addresses additional resources.)

Time frame. Policy alternatives should be investigated with recommendations available by 2011.

Geographical coverage. Statewide

Challenges. Water-quality rules are administered by MPCA, while expertise on conservation planning resides with the SWCDs and NRCS. Precedents exist for cross-agency program administration: for example, feedlot rules are administered by a combination of MPCA, county feedlot officer, and DNR staff. The rules would need to be carefully written to achieve the necessary reductions in soil erosion and sediment delivery to waters without excessive paperwork and intrusion. The focus would need to be guided by soil and nutrient loss predictive tools like RUSLE2 and the Phosphorus Index, as well as locating and treating concentrated flows. Technical assistance could be provided by the producer's current crop consultant.

One challenge would be to define the erosion and sediment loss standards for designing the level of treatment necessary.

Costs.

- Personnel costs for policy analysis
- Technical assistance for preparation of soil and water conservation plans if policy is adopted
- Cost of erosion control structures where necessary if policy is adopted

Land Use Recommendation 7: Enable improved design and targeting of conservation through improved and timely data collection and distribution

Determination of sediment source areas, targeting of conservation practices, determination of effectiveness of practices, and installation of conservation structures all require adequate resource data. These include high-resolution digital elevation data, land cover, crop residue coverage, and conservation practice effectiveness monitoring.

Planning, targeting, and implementation of conservation practices to protect soil and water require adequate and current data. Few data are currently available, and the lack thereof significantly impedes selection, siting, and installation of conservation practices to mitigate impaired waters.

The principal driver of change related to this recommendation is land use practices. The data specified below assist in tracking land use practices and predicting their effects on natural resources.

7A. Invest in data collection

Description of recommended action. Invest in the following basic information to support soil and water protection:

- Statewide high-resolution digital elevation data (LIDAR) and associated high-resolution watershed delineation
- Statewide updated land-cover data
- Maps of the artificial drainage network
- A long-term program monitoring the effectiveness of BMPs on critical source areas
- An annual crop residue survey (following planting) of sloping lands near streams
- A periodic detailed survey of benchmark sampling sites to determine trends in soil erosion, as was carried out previously by the NRCS for the National Resources Inventory
- Periodic remote sensing by aircraft and/or satellite for land cover and other attributes

Description of impact on natural resources. This recommendation would provide:

- Information that enables identification, quantification, and characterization of sediment source areas, resulting in more efficient targeting of mitigation investments
- Information that enables prediction of hydrologic responses and selection of cost-effective mitigation investments
- Information on effectiveness of mitigation strategies that improves design and selection

Relationship to existing programs, laws, regulations. The above-listed data are not currently available.

Time frame. The above data should be acquired as soon as possible.

Geographical coverage. Statewide

Challenges. Funds to obtain and maintain the data

Costs. Funds would be needed for:

- Statewide LIDAR: $7 million, reducible by negotiation with counties that have already acquired the data
- Statewide updated land-cover data (see land use recommendation 2)
- Monitoring of BMP effectiveness: $600,000 to $800,000 annually from multiple sources
- An annual crop residue survey of sloping lands near streams: $180,000 annually

- A periodic detailed survey of benchmark sampling sites to determine trends in soil erosion, as was carried out previously by the NRCS for the National Resources Inventory
- Periodic remote sensing by aircraft and/or satellite for land cover and other attributes (see land use recommendation 2)

Forestry Land Use

The forests that cover nearly a third of Minnesota's land area play an important role in the ecological, economic, and social fabric of the state. The conifer forests of the northeastern part of the state and the hardwood forests of the central and southeastern parts provide substantial ecosystem services, including providing wildlife habitat, intercepting precipitation, filtering out water pollution, and sequestering carbon. These working forests also support a large forest-products industry and provide opportunities for outdoor recreation.

These recommendations provide strategies to improve the long-term health, productivity, and sustainability of Minnesota's forest resources in the face of key drivers of change, including forest parcelization, climate change, invasive species, and development pressures. These strategies build upon the important work of the Minnesota Forest Resources Council (MFRC) in its *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines*. These recommended sustainable practices have transformed forest management in Minnesota, and have been widely accepted by resource managers and landowners. Since the publication of the guidelines, however, climate change, invasive species, and parcelization have become distinct challenges that threaten the health of forests and require specific policy and management responses.

Key Natural Resource Conditions and Trends in Forestry Land Use

Northeastern Minnesota has approximately 23 million acres of broad areas of conifer forest, mixed hardwood and conifer forests, and conifer bogs and swamps. These forests are composed of a patchwork of private, state, country, federal, and tribal blocks of land. There are numerous large privately held parcels that are 500 acres or more, and several parcels over 1 million acres owned by corporations. In contrast,

the hardwood forests of the central and southeastern parts of the state, which cover about 12 million acres, have been more substantially fragmented and reduced to smaller patches. Approximately 85 percent of the remaining forestland in these areas is privately owned, and few of these parcels are larger than 500 acres. Only 0.2 percent of southern Minnesota forestlands are owned by industry (Minnesota Department of Natural Resources 2008).

Timber Industry Restructuring

Due to changes in international forest product industries, the timber industry is undergoing major restructuring, affecting forest management and forest holdings in northern Minnesota. From 1989 to 2003, individuals accounted for 94% of all forest acreage purchased and 89% of all acreage sold, indicating a slight but gradual shift in forestland ownership out of corporations and to individuals.

Forest Ownership Changes/Parcelization

Parcelization is a trend in the northeastern forests where land holdings have traditionally been large. Parcelization is the division of larger blocks of forested land into smaller blocks with multiple owners. A recent study in Itasca County in northern Minnesota found that from 1989 to 2003, the average tract size of forest land sold decreased from 72 to 59 acres (18%); from 1991 to 2003 it decreased by 30% (Kilgore and MacKay, 2007). The MFRC recently identified parcelization as the single most important policy issue affecting the economic and ecological health of the state's forests.

Development and Forest Conversion

Development and forest conversion, the changing of forestland to any nonforest use such as commercial or residential development or agriculture, is a trend in all forested areas of the state. Forest parcelization is also linked to forestland conversion. In a study of land parcelization in Itasca County, 54% of the land splits (parcelization) from 1999 to 2006 occurred on previously undeveloped land, and 68% of the splits had building value added within seven years after division (Kilgore et al. 2007).

Drivers of Change for Forestry Land Use

Forest systems in Minnesota are vulnerable to many global environmental change factors, including fragmentation, invasive species, climate change, and increased atmospheric carbon and nitrogen. They affect hydrologic function. These drivers interact in ways that can escalate their individual and aggregate impacts. For example, climate change and nonnative biological invasions have the potential to dramatically impact community composition and ecosystem structure and function. These impacts range from species diversity to nutrient cycling and hydrology.

Habitat Fragmentation

Forest conversion from development and parcelization can lead to forest fragmentation, or the creation of many small forest "islands" separated by nonforested areas. Fragmentation erodes the functioning of the remaining natural system, reducing the forest's resilience to disturbance and change including climate change and invasive species. Fragmentation also endangers habitat for native wildlife species, especially for larger mammals such as bears and wolves, which require large tracts of undeveloped land.

Invasive Species

Minnesota now has several invasive species that are harmful to forests, such as the gypsy moth, buckthorn, and earthworms. Fragmentation and conversion contribute to the spread of invasive species and can lead to uneven growth as edge species are favored over interior species.

Climate Change

Forests are directly affected by increased CO_2, including changes in plant productivity and response to insects and diseases. They are also affected by climate change, including changes in species composition of native communities. Other factors such as fragmentation and invasive species exacerbate this effect.

Hydrologic Modification and Solids, Nutrient, and Contaminant Loading

Conversion of forestlands is a significant hydrologic modification that can negatively affect water quality. A forested landscape will infiltrate at least 90% of the volume of water from rain events in an area, preventing runoff. After conversion only 10% of the volume may be infiltrated, resulting in significant runoff.

Forestry Land Use Recommendations

The overall strategy of these recommendations is to increase forest ecosystem resilience through maintenance of large blocks of forested land and forest resource health. This requires protection of forestlands against conversion to other uses, and conservation of working forestland resources through sustainable management.

Land Use Recommendation 8: Protect large blocks of forested land **LP**

Description of recommended action. The objective of this recommendation is to identify, prioritize, and promote protection of large blocks of forested land, focused on areas that are adjacent to large publicly held blocks and that are at risk of parcelization, conversion, and fragmentation.

8A. Identify forestlands for protection

Research is needed to indicate the location and characteristics of land that should be targeted for protection. Specifically, research is needed to:

- Provide a detailed map of land parcelization trends in Minnesota
- Identify targeted blocks of threatened land near large blocks of publicly held land

8B. Prioritize forest lands for protection

Prioritization should be based on proximity to large blocks of already protected land (both public and private) to maximize the resiliency of the forests, and should include a specific focus on protecting working forests so that forest products can continue to support regional economies of Minnesota. Protection should focus on at-risk and high-priority lands (generally 100 acres or more) in both the Laurentian mixed forests and eastern broadleaf forests.

8C. Support and promote permanent protection of forest lands

Permanent protection of forestlands through fee title acquisition or conservation easements will need to be supported and promoted to landowners through financial incentives, education, and technical assistance, including:

- Increase financial incentives for conservation easements, including conservation tax credits, income tax deductions, and/or reductions in estate taxes
- Advocate for statewide or regional funding for land acquisition and tax incentive programs (tax breaks) for landowners who take appropriate steps to protect their forestland
- Provide information and technical assistance (on- and off-site) to interested landowners on easement practices and funding sources
- Establish and maintain partnerships to aid in identifying and protecting priority forestland through conservation easements (Minnesota Department of Natural Resources, 2008)

- Ensure that all easements meet statutory requirements and DNR policies, including those regarding legal description, appraisals, environmental review, easements drafting, record keeping, and title review (Minnesota Department of Natural Resources, 2008)

Land Use Recommendation 9: Assess tools for forest land protection LP

Description of recommended action. This recommendation is focused on identifying, examining, and monitoring the impacts of diverse tools in order to assess their effectiveness for forest land protection.

The state can make a spectrum of investments to protect forestland. Some directly support permanent protection of forestland, such as fee title acquisitions, conservation easements, and tax policies. Others, such as cost share, forest certification, and forest stewardship planning, support forestland protection indirectly by supporting sustainable management practices.

Each tool has a role in protecting Minnesota's forests, and the choice of tools depends on many factors, including site-specific conditions and cost effectiveness. Protection tools have been successful in protecting critical forest lands in Minnesota, but a comprehensive assessment of their appropriateness in various settings is lacking.

Research is needed to assess and compare the effectiveness of these diverse tools at protecting forestland under different site-specific conditions so that tools are best matched with the forestlands that they aim to protect. Additionally, given the limited resources available to the state and private land-protection organizations, it is important to determine which tool provides the greatest benefits at the least cost. Specifically, research is needed to assess:

- The effectiveness of diverse forest protection tools, including the cost effectiveness, particularly comparing conservation easements to fee title acquisition
- The role that agencies and nonprofits should play in developing and implementing forest protection tools
- Management restrictions that are required to encourage compliance with BMPs on forestlands
- Funding levels that are required to encourage landowner participation in BMPs

This research should then be used to create a toolbox of protection tools that can be adapted to address regional or site-specific pressures, and to the goals of specific forest owners.

Land Use Recommendation10: Support and expand sustainable practices on working forested lands SP

Description of recommended action. The objective of this recommendation is to promote and implement sustainable forest practices in working forests in Minnesota. This strategy builds on the accomplishments of the MFRC voluntary guidelines. Strategies include education, financial incentives to landowners, research and demonstration, and direct investment in specific management strategies.

10A. Educate consumers on benefits of certified wood to increase the demand for sustainably raised timber in Minnesota

- Build networks of retailers, private industry, and educators to increase public awareness of forest certification standards.
- Educate retailers and consumers about environmental and economic benefits of sustainable harvest and growing practices.

10B. Educate landowners and forest managers on best management practices to protect working forests

- Increase funding for BMP education for both the public and forest products industry.
- Expand impact of voluntary management practices as described in the MFRC's management guidelines.

- Educate landowners, loggers, and forest managers on biomass harvesting BMPs (e.g., master logger certification program).
- Improve peer-to-peer networks to increase BMP information sharing among private landowners.

10C. Promote collective/cooperative management of forestlands at a landscape level in order to increase the multiple benefits of forests (timber, air quality, carbon sinks, water quality, etc.)

- Promote landscape-level cooperation and collaboration between public and private sectors to increase management.
- Support MFRC ongoing efforts in this regard.
- Develop multistakeholder statewide networks to facilitate implementation of BMPs on private and public land.

10D. Provide incentives for sustainable forestry practices

- Encourage cost sharing on forests and private timber sales (to obtain adequate regeneration, especially of oak).
- Emphasize state cost-share programs based upon soil erosion and water quality impacts.
- Identify and mobilize programs to compensate landowners for land taken out of production.
- Provide incentives to landowners who practice BMPs on private land.
- Inform and assist landowners on cost-share practices and funding sources.
- Provide professional assistance to forest owners to assist in forest management in order to optimize forest resources and fulfill specific forest owner goals without jeopardizing sustainability and biodiversity.

10E. Develop and test new management practices to improve ecosystem resilience

Invest in research and demonstration areas that identify, examine, and monitor the impact of management scenarios on ecosystem resilience and increase understanding of the impact of climate change and other key drivers on forested ecosystems.

- Focus on innovative management practices that enhance the resilience of the forested ecosystem, forest management as a carbon sequestration tool, and effectiveness of BMPs, and develop effective monitoring protocols that help inform management decisions.
- Create areas large enough to encompass some landscape-level functions (300-3,000 hectares) to help expand understanding of the impact of climate change, invasive species, and other system drivers on the state's forested ecosystems.
- Undertake research to broaden understanding of the interplay between climate change, nonnative species invasion and other global environmental changes, the primary and secondary impacts of invasive species from a local and landscape level, and the potential for controlling these species.
- Use these areas for educational opportunities. Examples of sustainably managed sites, comparisons between sites impacted and not impacted by nonnative invasive species, and examples of services healthy functioning forest can provide, can help increase public understanding of the impacts global change can have on the landscape and land.

10F. Support the use of fire to increase forest health and biodiversity

Use of fire is supported by management strategies currently being developed by DNR for newly updated Ecological Classification System (ECS) plant community classifications.

- Use fire in pine and oak forests to encourage regeneration that would result in overall improvement in habitat quality benefiting multiple species.
- Fire as a BMP could be used in conjunction with biomass harvested for energy production.
- Support development of infrastructure necessary to conduct prescribed burns. This may include staff, training, and trucks.

Impacts on natural resources. The protection of large blocks of forestland is a fundamental action to increase resilience of forest ecosystems. It prevents parcelization, conversion, and fragmentation, allowing for the movement and migration of species in the face of climate change; creates buffers to nonnative species invasion; and supports resilient forested systems that continue to function properly and provide services to the surrounding landscape. The implementation of sustainable management practices on public and private forested lands will also help increase the resiliency of forests to climate change and other drivers and to restore connections between forest fragments.

Relationship to existing programs, laws, regulations. These recommendations support, update, and expand on activities currently underway at the UM, the MFRC, the Minnesota Forest Legacy Program/ Partnership, and the DNR. For example:

- *Minnesota Forest for the Future* (Minnesota Department of Natural Resources, 2008) stated as a primary goal "[t]o promote strategic conservation of private forests." Key strategies recommended to reach this goal include: preferentially protect the largest, and most intact blocks of forest; preferentially pursue projects that will result in the greatest amount of linkage between forested land; and preferentially encourage projects that are linked to regional and statewide conservation efforts and that create a cumulative conservation effect.
- The Forest Legacy Program promotes the use of permanent working conservation easements. The Forest Legacy Partnership successfully completed the most successful forest protection effort in more than 10 years when it protected 51,163 acres in state forests in Koochiching and Itasca state counties. The forested land is a key link to connect more than 500,000 acres of critical habitat.
- The MFRC provides management guidelines in *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers* (MFRC, 2005).
- The UM and DNR provide research, demonstration, and educational projects:
  - UM Minnesota Futures Phase II project
  - UM Integrative Graduate Education and Research Traineeship (IGERT) Invasive Species Program
  - DNR Forest Certification Program
  - University of Minnesota Forest and Climate Change Project
  - DNR Forest Legacy Partnership

Time frame. Work could begin as soon as funding is available.

Geographical coverage. In general, attention should be given to the north, north-central, and southeastern portions of the state to areas where the drivers are currently impacting the landscape.

Challenges. To ensure acceptable outcomes, all three recommendations require the cooperation of diverse stakeholders with differing goals and strategies for protecting Minnesota's forests (e.g., landowners, researchers, forest managers, forest product industry representatives, wildlife and water quality professionals, governmental and nongovernmental organizations). It may be a challenge to maintain coordination and cooperation among these diverse stakeholders. This will require transparency, with open and constructive dialogue regarding goal setting, acquisition processes, and monitoring. Public and private hearings and meetings to determine needs/goals of various stakeholders would help to facilitate open communication and trust.

Costs. According to *Minnesota Forests for the Future* (Minnesota Department of Natural Resources, 2008) the estimated costs to protect forestland in Minnesota vary from $125 to $250 million to meet Laurentian mixed forest protection targets, to $40 to $60 million for eastern broadleaf protection targets.

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The following icons are used throughout the plan to quickly identify recommendations by type:

Integrated Planning Recommendations

Critical Land Protection Recommendations

Land and Water Restoration and Protection Recommendations

Sustainable Practices Recommendations

Economic Incentives for Sustainability

Transportation

Recommendations

Summary

This section of the Minnesota Statewide Conservation and Preservation Plan (SCPP) makes recommendations on transportation and related policies that examine the impacts of surface transportation development on the critical resources of the state.

Roads and their use have negative impacts on natural resources. They fragment habitat, disturb hydrological regimes, and damage vegetative land cover and soils. Roads can also make barriers to nonmotorized recreation. Cars and trucks cause air, water, and noise pollution. Nevertheless, the roadway system of Minnesota also provides necessary access and mobility to the state's 5 million residents. The economic health of the state (agriculture and industry drivers) and nearly the entire array of development drivers of changes identified in the SCPP preliminary plan are indirectly or directly associated with the surface transportation system that provides these services.

The conservation planning and policy rationale for these three transportation-related recommendations is to provide an integrated approach to address some of the fundamental fragmentation of planning, design, and decision-making processes across transportation, land use, and conservation objectives. The recommendations target development drivers identified in the preliminary plan with potential approaches to integration of research-based resource conservation planning, assessment, and protection with efficient transportation system planning and land use decisionmaking processes. These recommendations suggest ways in which natural resource impacts resulting from the development of surface transportation can be minimized, mitigated or adapted through combinations of planning, design, regulation, and incentives across geographic scales, modes of surface transportation, and related government jurisdictions and community stakeholders.

The three recommendations presented below outline an immediate to near-term strategy with long-term effects to integrate transportation system development more effectively with other statewide and local planning and decision-making and to bolster its effectiveness with increased use of data analysis and research-based performance standards and practices. This integration is initially achieved through recommendations to align statewide planning and enhance cross-consultative environmental review of projects in early stages of planning and design. By adopting performance standards, best practices, and other protective conservation strategies across jurisdictions, transportation projects can also coordinate with county and metropolitan land use and environmental comprehensive planning and land use decision-making to reduce growth in per capita vehicle miles traveled (VMT). This performance standards–based approach also generates incentives for research, analysis, monitoring, and education to protect habitat and water resources.

The three recommendations presented in this section are:

- Transportation Recommendation 1—Align transportation planning across state agencies and integrate transportation project development and review across state, regional, metropolitan, and county/local transportation, land use, and conservation programs.
- Transportation Recommendation 2—Reduce per capita VMT through compact mixed-use development and multi- and intermodal transportation systems.
- Transportation Recommendation 3—Develop and implement sustainable transportation re-

search, design, planning, and construction practices, regulations, and competitive incentive funding that minimize impacts on natural resources, especially habitat fragmentation and nonpoint source water pollution.

Introduction

Sustainable Surface Transportation and the Minnesota Balance Statement

The provision of transportation is critical to the economic health of the state. Surface transportation is largely a public value, constituting the largest connective public space in the state. On the other hand, the conservation of natural resources is also fundamental to the state's well-being, economic and otherwise. On a vast spectrum of monetary and nonmonetary values, the state's air, land, water, aquatic species, and recreational values underpin the very character of Minnesota. These values must be brought into balance. The connective, mixed, and hierarchical character of surface transportation provides mobility over long distances and access to various destinations. As a necessarily pervasive system it interrupts, transforms, or replaces natural systems connectivity and functions and challenges or erodes biodiversity and ecosystems services provision.

The overlay of surface transportation on the land occurs at multiple scales. Responsibility for the provision of surface transportation in this state lies with the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), and the Minnesota Department of Transportation (MnDOT) in collaboration with counties and metropolitan planning organizations. Larger projects and systems especially have a footprint that is state-, region-, and ecosystem-wide, and all projects have immediate, or site-scaled, impacts (Figure T1). Impacts can be minimized, mitigated, or adapted from a conventional transportation policy, planning, and design perspective basically in three ways: loca-

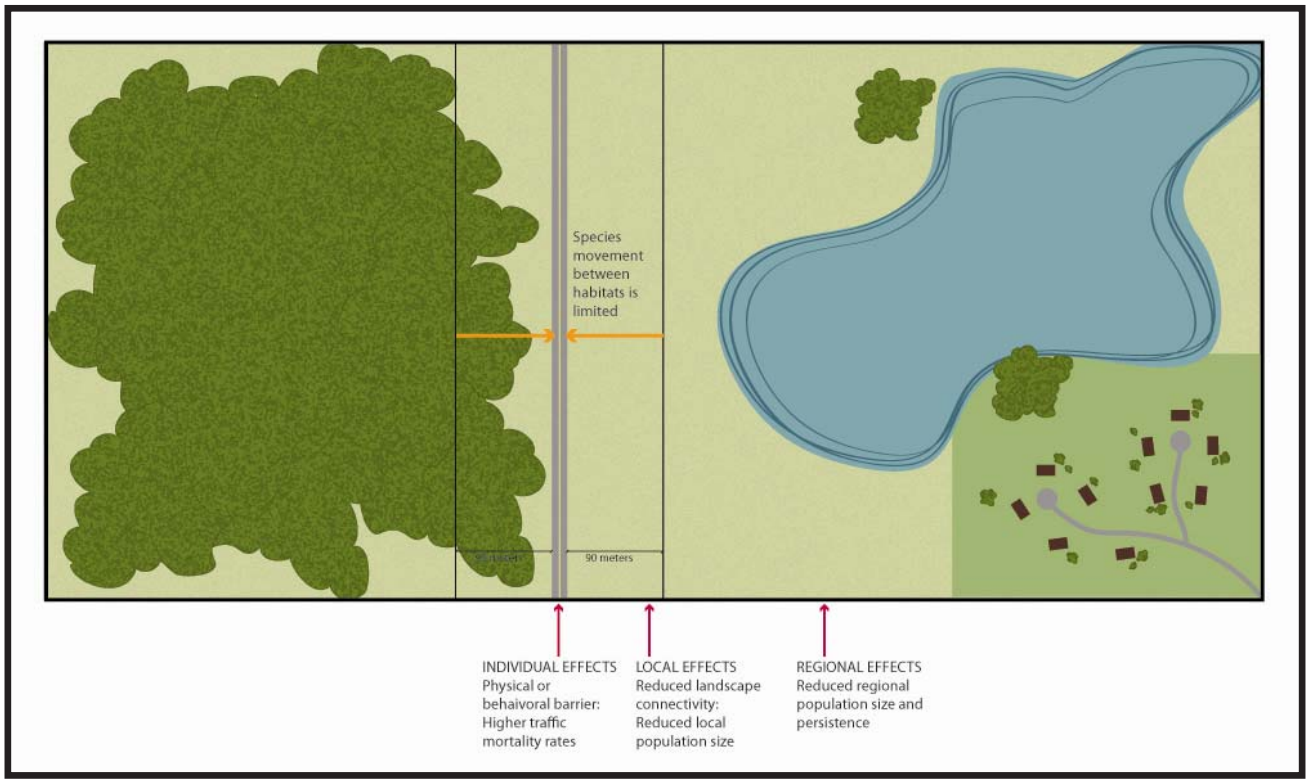

Figure T1. Fragmentation effects of transportation infrastructure. Credit: KatherineThering, UM Metropolitan Design Center.

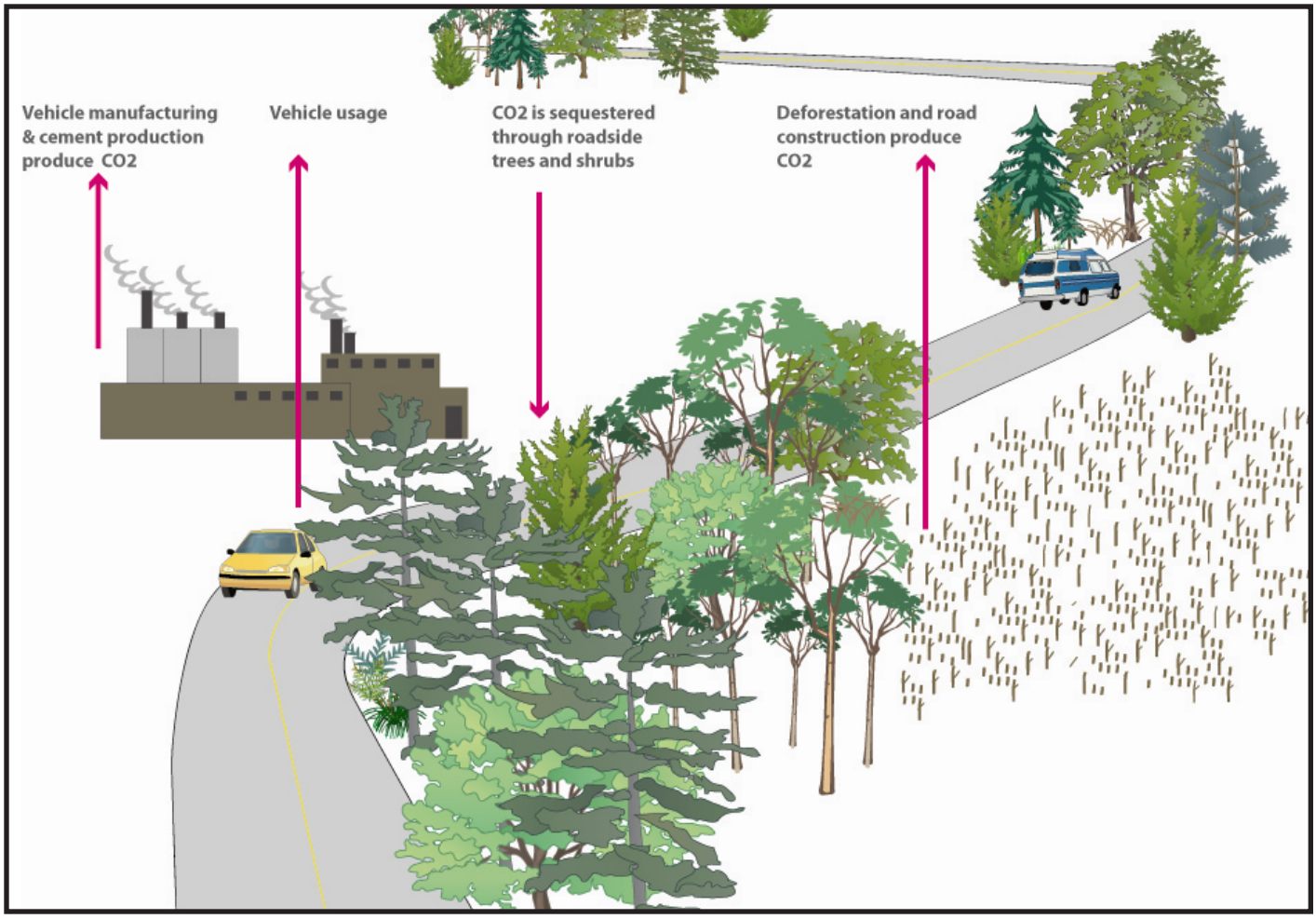

Figure T2. An overview of some of the elements of the "carbon footprint" of vehicular transportation. Credit: KatherineThering, UM Metropolitan Design Center.

tion of roadways away and buffered from resources; provision of multiple and connected nonmotorized modes and transit service in support of compact development; and careful policy making and integrative planning and design in relation to resources, all supported by balanced planning, regulatory, and incentive frameworks and enhanced cross-consultation in governance, planning, and project development.

Climate Change, VMT, Fuels, and the Road

The challenges of climate change converge to sharpen the particular challenges to the goal of sustainable surface transportation in Minnesota. Most notable is the composite environmental impact on air, land, and water of rapidly expanding automobile use related to dispersed settlement patterns, as measured in VMT (See Figures T3 and T4).

VMT can be correlated to the production greenhouse gases, especially carbon dioxide (CO_2) and carbon monoxide (CO). Between 1990 and 2003, greenhouse gas (GHG) emission from transportation increased by 43% and VMT increased by 42% in Minnesota (compared with 15% population growth, Figure T2).

VMT per capita increased by 23%, with much of the increase occurring in the Twin Cities metropolitan and collar county area. VMT growth statewide is projected to plateau at 0.9% (e.g., http://www.cts.umn.edu/Research/Featured/GreenhouseGas/index.html).

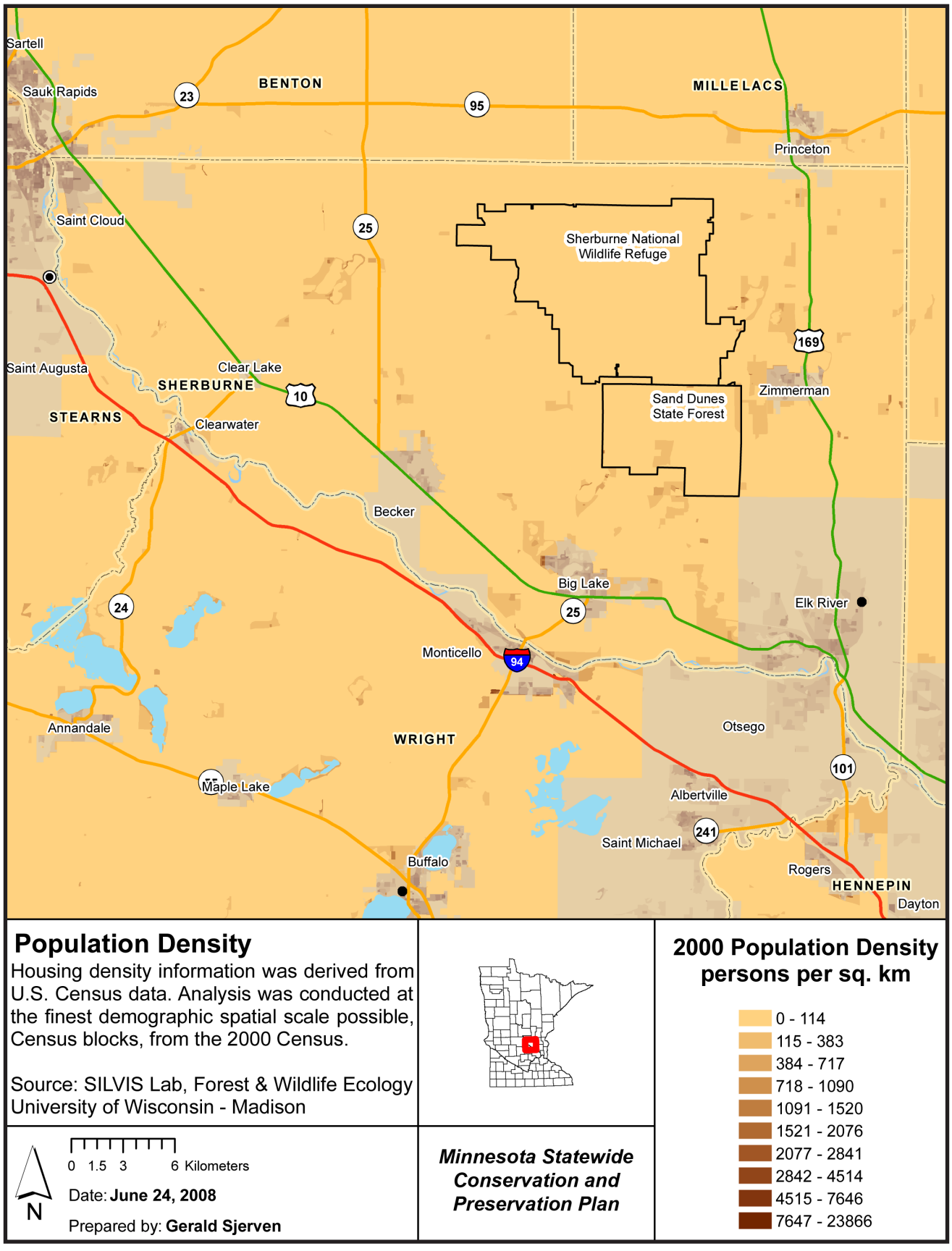

Figure T3. Population density. Credit: Gerald Sjerven, NRRI.

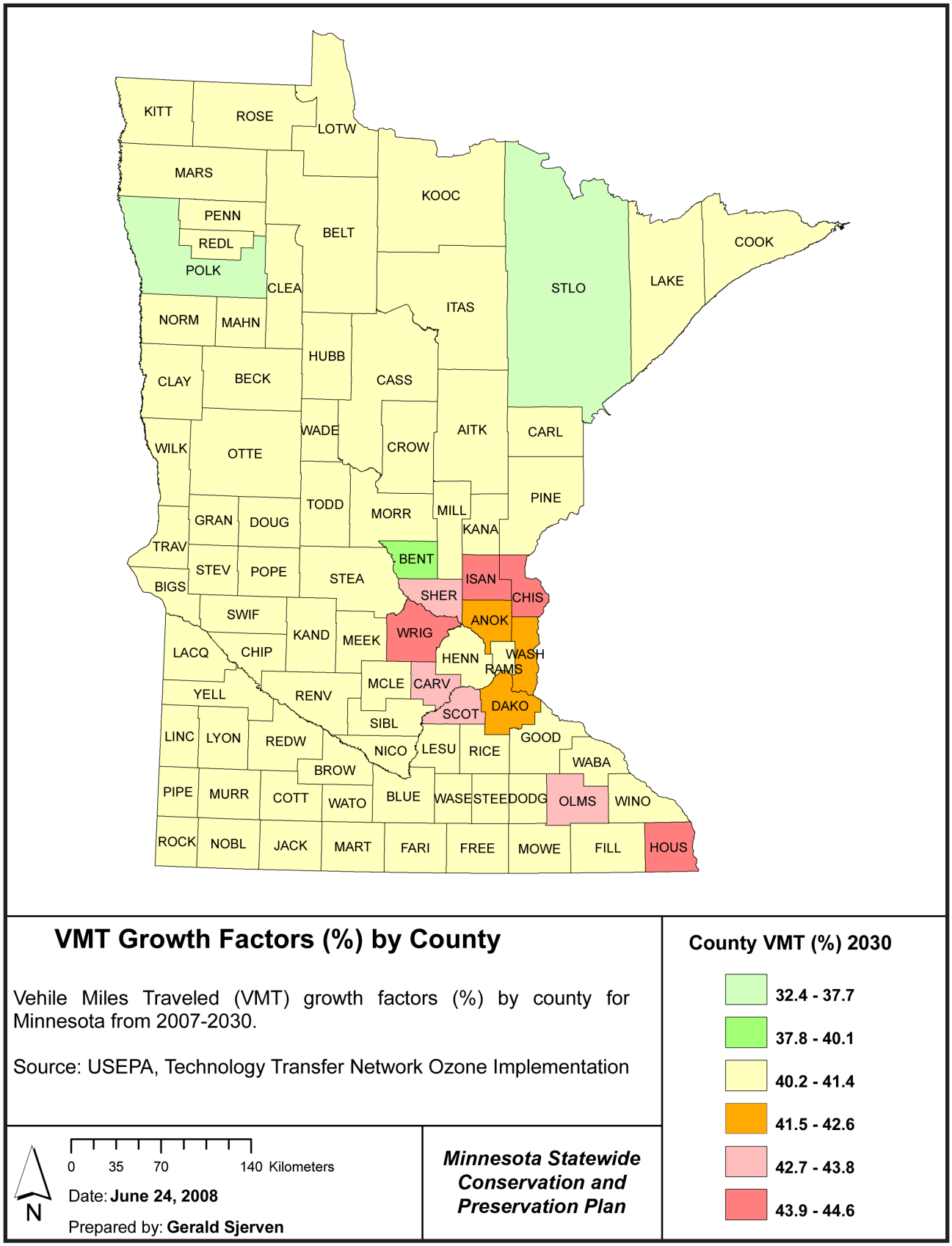

Figure T4. VMT growth factors by county. Credit: Gerald Sjerven, NRRI.

Nevertheless, the projected population growth, specifically in metropolitan areas, especially the Twin Cities, suggests clearly the need for an immediate strategic shift that would more closely integrate transportation with land use changes and environmental review.

Minnesota Transportation, Land Use, and Environmental Linkages and Disconnections

While land use, land-cover, design, and resource implications are cast by the imprints of the transportation network, these issues often run in parallel to (i.e., are not integrated into) transportation planning and design processes. Yet transportation planning and design might perform the important role of interconnecting land use and conservation planning processes.

Transportation directly affects the location and configurations of land use patterns. Conversely, land use patterns affect travel demand, the types and design of transportation facilities, and their performance, including their impacts on environmental resources.

In large part the disconnections stem from the different levels of jurisdiction, and therefore scales of impact, and the order in which decisions on transportation, resource conservation, and land use are made.

In light of these and other challenges, the future of the state depends upon a balanced and integrative approach to transportation, land use, and related infrastructure and environmental resource conservation planning and decision-making. A balanced approach requires thinking more strategically about the land use, transportation, and natural resources relationships that can reduce VMT, improve air quality, promote economic and community vitality, and reduce energy consumption while conserving natural resources.

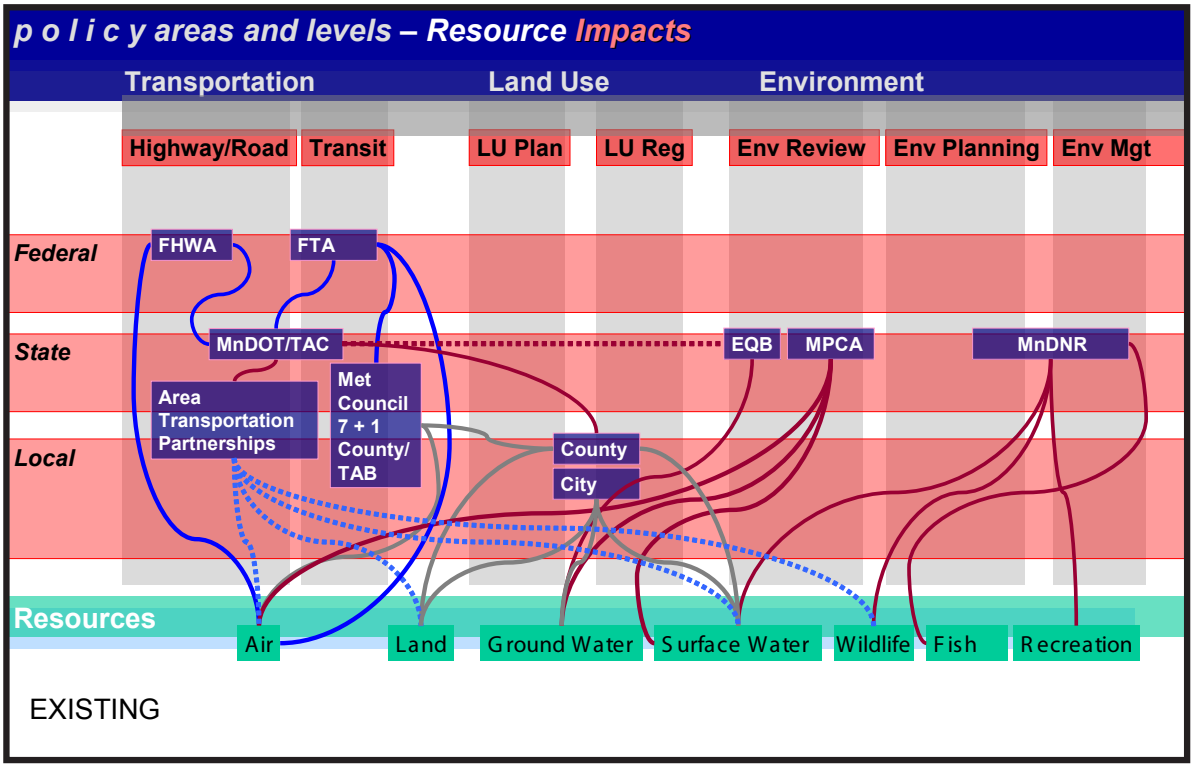

Figure T5. Policy areas and levels—resource impacts. Credit: Lance Neckar, UM.

Differences in Land Use, Transportation, and Environmental Planning Approaches

The existing process can be seen as a range of activities in transportation land use and environment across levels and jurisdictions of government having variously connected and disconnected (dotted lines) roles in resource conservation (Figure T5).

The intent of these recommendations is to strengthen existing elements of the process. Specifically the recommendations would enhance planning and review coordination across state agencies to create early opportunities for mitigation, adaptive planning, and land acquisition; and would make more effective the MnDOT Area Transportation Partnership (ATP) with the added potential of the Environmental Technical Advisory Team (ETAT) to make a comprehensive conservation approach to all resources affected by a transportation project (solid lines to resources, Figure T5).

Drivers and Trends

The preliminary plan of the SCPP identified major and proximal drivers of change and their impacts on four resources land, water, wildlife, and fish.

Habitat Loss

Development of roadways is a significant contributor to habitat fragmentation and degradation. In fact, road development is the leading cause of forest fragmentation in the state. Paved roads affect aquatic habitat integrity by physical alterations of drainage patterns that increase peak volumes of runoff, usually at higher temperatures and contaminant loads. Current trends in plant and wildlife populations show the direct effects of habitat fragmentation such as roadway construction (including widening and infrastructure upgrades). For example, 16% of the state's native plant species are listed as special concern, threatened, or endangered, and 32% of mammal, bird, and reptile species are recognized as species of greatest conservation need (SGCN) by the Minnesota Department of Natural Resources (DNR) .

These negative land-cover and wildlife trends will be minimized through integrated roadway planning and design. By leaving high-priority natural areas intact with connecting terrestrial natural resource corridors between them and reducing the number of unnecessary roads, habitat fragmentation and degradation will be minimized. Thus, integrated roadway and land use planning and design will help neutralize one of the major drivers of change for land cover and wildlife resources.

Hydrologic Modification

Hydrologic modification such as roadways is a major driver of change in water quality. Impervious surfaces such as roads affect surface waters through increased runoff of water (in extreme cases causing increased flooding and "flash flood effect"), sediment, phosphorus, and contaminants; decreased seasonal wetland persistence; and exacerbated drought impacts. Impervious surfaces affect ground water by preventing infiltration of precipitation and diverting the water to storm-water systems, which can reduce groundwater recharge. From 1990 to 2000, impervious surface area increased in all areas of the state, with a 20% increase in some areas.

Through careful and integrated planning of transportation systems, and resource-focused project planning and design processes for highways and bridges and local streets, the number, location, scale, and detailed design of projects can minimize inefficient roadway networks. These processes can (by planning) minimize the growth and scale of impervious networks and (by planning and design) minimize, mitigate, or adapt to negative impacts to surface waters and ground water of increased impervious surface.

Toxic contaminants and pollution

Fuel-burning by vehicles results in emissions of CO_2, the primary GHG responsible for global climate change; and air pollutants such as CO, particulate matter (PM), nitrous oxide (NOx), sulfur oxides (SOx) from diesel, and hydrocarbons (HCs) or volatile organic compounds (VOCs). All of these emissions negatively impact air quality.

Air quality trends reflect the negative impacts of fuel-burning by roadway vehicles. The last 20-some years have seen significant increases in VMT (73% between 1985 and 2005), average commute times, traffic congestion, and vehicle idling times, which all contribute to increased emissions. The impacts can be seen in a 53% increase in CO_2 emissions from 1985 to 2005, with transportation contributing 34% of total CO_2 emissions. With its high vehicle traffic, the Twin Cities had the worst air quality in the state in 2005, with more "moderate" air quality days than "good," five "unhealthy for sensitive group" days, and three days that were considered "unhealthy for all" .

Still, the most serious contamination from surface transportation may be the least understood: the addition of toxins and other contaminants either in solution or as sediments that run off of paved surfaces, sometimes directly into surface waters. This uncertainty will require well-focused research and monitoring efforts.

Recommendations

Transportation Recommendation 1: Align transportation planning across state agencies and integrate development and review across state, regional, metropolitan and county/local transportation, land use and conservation programs

IP

1A. Institute interagency alignment of planning to coordinate transportation with other state planning cycles

The state should coordinate cyclical statewide plans across state agencies (e.g., MnDOT, Minnesota Pollution Control Agency [MPCA], DNR) and provide environmental data coordination and analysis, including determination of vulnerable ecological areas by resource, cumulative impact analysis and projection, performance standards and best practices research, and recommendations for land acquisition. MnDOT would continue to have the role of responsible governing unit (RGU) for surface transportation projects.

There are two overarching rationales of this recommendation.

The first is to bring MnDOT statewide surface transportation planning cycles into a more integrative alignment with natural resource planning cycles and related capital budget directions across state agencies by providing an integrated organizational structure, staff capacity and shared tools. Transportation and metropolitan planning organizational planning cycles include the MnDOT 10-Year Capital and Service Improvement Programming Process, the State Transportation Improvement Program (STIP), and the Metropolitan Council's Transportation Improvement Program (TIP).

The second rationale is to fuse enhancements in the integrative planning and environmental assessment processes with the design and implementa-

tion of projects. This recommendation provides a cross-consultative forum and analytical capacity to minimize impacts via integration of cyclical planning with project development. It sets a cross-agency and cross-jurisdictional context for project planning where the environmental assessment forum could be focused on the MnDOT Interregional Corridor District, Area Transportation Partnership (ATP) stakeholders, tribal governments, and the freight planners, with guidance of the statewide Technical Advisory Committee (TAC), the Metropolitan Council Technical Advisory Board (TAB), and other local and regional stakeholders. This cross-consultation may allow for more robust integration of housing and employment development planning into these considerations of resource conservation (http://www.dot.state.mn.us/metro/tsp/pdfs/chapter1.pdf).

This process would foreground project design with database development, analysis, resource assessment, and monitoring across scales and land cover morphologies. An integrative alignment could occur on the research/planning/assessment front. Strategic targeted joint MnDOT/DNR research projects on key resources at risk would build a common geographic information systems (GIS) and other monitoring-based database. Integration would also give the fullest consideration of alternatives, costs of minimization, mitigation, and adaptation; and best practices for projects.

If implemented, integration would provide incentive for feedback systems through monitoring and strategic research programs, organize and align early review of projects, and promote nonstructural and structural practices and performance measures.

Below, for example, are nine steps in an integrated project approach that foregrounds resource conservation (adapted from the Florida and Maine DOT processes):

1. Improve statewide transportation cyclical planning processes alignment with other state agencies; incorporate environmental minimization/mitigation costs in MnDOT STIP.
2. Provide district coordination for project scoping via ATP process and (new) Environmental and Technical Advisory Team (ETAT) and EQB alignment of environmental review across appropriate jurisdictions.
3. Develop purpose and need statement and environmental minimization and mitigation strategies across jurisdictions.
4. Develop alternatives to mitigate resource impacts (MnDOT/EQB with state agency, county, and metro planning cross-consultation).
5. Prepare detailed alternatives analysis and draft National Environmental Policy Act/ Environmental Assessment Worksheet (NEPA/ EAW) document (MnDOT/EQB).
6. Identify preferred alternative and conceptual minimization and mitigation plan (MnDOT).
7. Prepare final NEPA document finding of no significant impact or record of decision of mitigation processes and proposed outcomes (MnDOT).
8. Complete final project design, minimization, and mitigation coordination and permit decision (MnDOT).
9. Implement project and environmental monitoring (MnDOT and EQB).

1B. Integrate streamlined statewide environmental transportation project review with other statewide and cross-jurisdictional planning, design, budgeting, and review programs

Adopt environmental interagency stakeholder involvement (streamlining) project planning protocols through coordination across state, metropolitan, and county/local transportation, land use, and conservation decision-making responsibilities.

Modify the highway project development process (HPDP) to create a cross-consultative regional and local forum and an environmental team to lead federal- and state-mandated impact assessment. MnDOT and the EQB would create the forum and teams with participation of other review agencies, including MPCA, DNR, the Minnesota State Historic Preservation Office (SHPO), and metropolitan and county units.

Description of recommended action. A coordinated statewide interagency planning process around transportation and other statewide initiatives will enhance efficiencies and coherence of funding and other efforts with resource conservation objectives.

At the project scale, environmental interagency (streamlined) project development protocols (through MnDOT and EQB collaboration) will integrate resource protection into a more balanced and cost-effective project planning and design process. The effectiveness of this process will necessitate coordination across state, metropolitan, and county/local transportation, land use and conservation decision-making responsibilities. The central change to the project institutional process would be to modify the HPDP process to incorporate early ETAT processes and impact minimization and mitigation with local coordination and roadway project initiation through the ATP program administered through the district offices of MnDOT. (http://www.dot.state.mn.us/tecsup/xyz/plu/hpdp/).

The overarching rationale of this recommendation is to bring environmental planning into a scheduled and aligned interagency focus on conservation and to connect this planning into integrative project design and assessment. Project streamlining is intended to increase knowledge about and transparency on project planning and design and to provide a cross-consultative forum and analytical capacity to reduce impacts and to give fullest hearing of best practices and costs of minimization, mitigation, and adaptation.

In interagency planning, EQB could serve as a cross-consultative forum and environmental data gathering and analysis lead jointly with MnDOT. In projects, for example, MnDOT would lead as RGU, but should coordinate with EQB for data analysis and cross-agency review. The integrated efforts may, for example, occur as an expansion of MnDOT processes to meet FHWA/FTA environmental mandates or as extensions of context-sensitive design/solutions process approaches. As RGU for transportation projects MnDOT would mobilize environmental responsibilities to streamline review with other agencies for federal- and state-mandated impact assessment (e.g., MPCA, DNR, and SHPO). EQB and MnDOT will also work with metropolitan and county units on technical team-based adoption of project environmental performance standards-driven and other environmental practices in project planning, budgeting, and design.

Once a project is approved in the annual review process associated with the STIP, the purpose and need statements that formed their environmental assessment parameters will have been set. Since these projects have already been prioritized at the MnDOT district level through the regional ATP using the STIP projection of costs of minimization/mitigation, they would be potential candidates for streamlined environmental review. When streamlined environmental assessment occurs, EQB and MnDOT (and in the cases of transit corridors, the Metropolitan Council and/or the counties that are the joint RGUs for the project) are responsible to align all interagency environmental processes and to set and coordinate project performance standards and best practices and develop monitoring. This process will have local coordination based on analysis and cross-consultation via a new ETAT process.

The ETAT is a proposed facet of this approach. Each project would have an ETAT. The ETAT idea adapts the Florida DOT's district-level interagency planning coordination process. The ETAT would have primary responsibility to document, plan, and

design for transportation impacts by correlation of impacts to/on resources at scale through scenario modeling and overlay analysis. For example, at the ecosystem scale, corridor route alternatives would consider broader impacts over time and space, communities and species, and physical resource (air, land, water). Each ETAT would be composed of 12 to 20 members that represent federal, state, and local transportation, environmental, regulatory, and resource agencies. ETAT representatives would provide agency responses to the respective transportation planning entities—MnDOT and the affected metropolitan planning organization (MPO), MPOs, or counties through the ATP. During the early phases of programming screen, ETAT input would provide "agency scoping" to help satisfy the requirements of NEPA and other pertinent laws addressed during the NEPA process. At this stage, ETAT members would be offered the opportunity to accept or comment on the purpose and need statement, update the environmental reviews, identify required technical studies, and opt out of further involvement. (Additional information on this aspect of the recommendation may be obtained at http://www.dot.state.fl.us/emo/.)

A key tool needed here is an Internet-accessible GIS application that links ETAT members and the Minnesota Land Cover Classification Systems (MLCCS). Standardized GIS analyses (as prescribed by each environmental, regulatory, or resource agency) would be performed to identify potential impacts to environmental resources. ETAT members would need only an Internet connection to view and comment on results. These reports also would be available to the public through a read-only Web site.

Another decision-support tool needed for community response is visualization software such as Community VIZ that could be linked to the same database. The database system would house responses from ETAT members as well as MnDOT summaries of public comments.

State projects, including bridges, bottleneck and other corridor improvement projects, have the potential to direct the position, guide the processes and set the scales and types of land use development of a corridor. In the ATP/ETAT process these project-specific issues could be integrated across jurisdictions with appropriate guidance from MnDOT and EQB. Some example project types and models include:

- Corridor planning: coalitions plus Regional Rail Authority, community/private partnership joint land use planning, and urban design (Arlington, Va., model);
- Bridges: Woodrow Wilson Bridge (Virginia, Maryland) project model of engagement and flexibility of scope
- Bottlenecks and bypasses: multimodal and access-oriented planning and design and congestion pricing

At the local level, design decisions relative to passenger multi- and intermodal access and compact development are made. Decision support (e.g., community visualization exercises) helps to place issues in systemic resource context. Resources are often mapped, and could be understood in terms that would indicate transportation minimization/mitigation. For example, regulations on protection of streams that follow the statewide shoreland protection requirements for subdivision ordinances could result in best practices and performance standards for road construction across the functional classification.

Some typical kinds of transportation and land use decisions that require integration with statewide and regional planning and design on projects:

- Roadway design standards and geometrics: flexible (ecoregion standards) for arterial, local street right-of-way design
- Transit-oriented design: density bonuses for development in serviceshed
- Stream corridor/watershed subdivision ordinances: storm water–sensitive designs for street network/linked open space lot-size bonuses
- Zoning ordinances: mixed use, density bonuses for conservation

Description of impact on natural resources. Potential statewide advantages of integrated statewide cyclical plans would be integration of conservation with transportation and land use–related planning and data analyses (e.g., GIS, monitoring data). Issues to be considered include:

- VMT reduction toward legislated emissions and energy 2020 targets
- Transit use, nonmotorized travel, and other alternatives to VMT generation
- Greater and better targeted funding for mitigation (e.g., in the STIP process) including reversal of terrestrial and aquatic habitat loss and fragmentation; reversal of surface- and ground-water quality degradation; improved statewide storm-water performance standards for sediments and contaminants—total maximum daily load (TMDL); research on fate to ground and surface waters by land cover, land use, and soil type; and improved statewide multimodal recreational connectivity/access and integrated multifunctional land use and landscape management.

The principal objectives of the integration of performance- and practice-based project streamlining would be to reverse, stabilize, mitigate, or adapt to:

- Air: pollution by VMT reduction (emissions) through multi/intermodal planning and design
- Land: vegetative land-cover loss, drainage modification, erosion, habitat fragmentation
- Water: surface- and ground-water quality degradation through transportation projects
- Habitat: land and aquatic habitat fragmentation
- Fish: heating effects; contaminant, nutrient and sediment loading associated with storm-water runoff; invasive species and zoonotic disease transport
- Recreation: multiple modes of access

There is embedded potential for MnDOT development, for example, of new design and project performance standards for roadways that incorporates expanded transportation demand modeling, functional classification flexibility and ecoregion informants of environmental problems or constraints. These standards could have the following project impacts:

- Design standards on bioregional and hydrological criteria (e.g., roadside vegetation, culverts, pavement porosity) and related land use adjacencies
- Management practices, including right-of-way vegetation and bridge maintenance and painting
- Noise, vibration standards by key species of greatest conservation need (SGCN)
- Improved standards and practices for invasive species mitigation
- Chemical storage performance standards

Relationship to existing programs, laws, regulations. The complex array of programs, laws, and regulations illustrates the relative disconnect of transportation system development from land use development and environmental conservation. Today the long-range transportation planning process is embodied in the document, *Minnesota Statewide Transportation Plan: Moving Minnesota from 2000 to 2020* and there is a 2008–30 transportation system plan (TSP) for the eight-county Twin Cities metropolitan area. There is, however, currently no integrated statewide environmental or land use planning. More effective and efficient statewide environmental planning and assessment processes could be more closely aligned to transportation planning and funding processes. This alignment potential represents an important opportunity to provide a fuller environmental cost accounting as part of an aligned planning and budgeting process. MnDOT, for example, is audited by the Office of the Legislative Auditor (http://www.auditor.leg.state.mn.us/PED/2008/trunkhwysum.htm).

One connection between general long-term transportation planning and the development of projects is the three-year STIP cycle. The STIP is coordinated through the MnDOT Office of Investment Management (OIM). MnDOT statewide planning

for the STIP programming process sits within long-range planning processes currently in place. The STIP must adhere to certain requirements of project type and location. For example, there are these overall guidelines on statewide apportionment:

- 10 percent for enhancement activities (a potential source of environmental mitigation)
- 10 percent for safety activities
- 24 percent for transportation management areas (Twin Cities area)
- 26 percent for other areas of the state (includes 110 percent of 1991 secondary funding for rural areas under 5,000 population)
- 30 percent for any area of the state

Local coordination and project initiation is sought (and encouraged in the STIP guidance process) through the ATP program that is administered through the district offices of MnDOT (http://www.oim.dot.state.mn.us/pdpa/STIPGMar01.pdf). The ATP process is given guidance on target formulas for funding of certain types and settings of projects. For example, statewide 30% to 40% of funding should be used for preservation of existing infrastructure. This is a competitive process and is subject to yearly updates. The process by which localities bring forward priority projects (usually through the district offices of MnDOT and the ATP) is also the start of a capital project process.

Funding is distributed on a prorated target basis by ATP (http://www.oim.dot.state.mn.us/targetformula/Talking%20Points%20for%20Web%202-22-06.doc). Then, within each ATP, certain thresholds and caps are required by project type according to fiscal constraints allocation proportions (http://www.oim.dot.state.mn.us/districtplans/d-4/Chapter%206%20%20Fiscally%20Constrained%20Investment%20Plan.pdf).

By the time a project has been listed in the STIP, all environmental assessment has been completed, although this process should be more clearly elucidated in the STIP guidance document (http://www.oim.dot.state.mn.us/pdpa/STIPGMar01.pdf). The processes that accomplish the Federal mandates on environmental assessment and mitigation of individual projects are delegated through the NEPA. Again, these processes reflect the relatively disjointed—yet paradoxically connected—processes by which the agencies accomplish both the assessment and construction of surface transportation projects. Currently MnDOT operates by the letter of the environmental review laws embodied in the NEPA and the Safe Accountable Flexible Efficient Transportation Equity Act (SAFETEA-LU).

The environmental worksheet process begins in the EQB. There are two routes to a full environmental impact statement (EIS): either it is mandated or it is determined to be necessary because of size, location, and magnitude of potential environmental impact. Determination of the level of project assessment occurs as a process between MnDOT, MPCA, DNR, and SHPO. Normally highway and infrastructure distribution projects require an EIS. These types of projects and those deemed subject to an alternate urban area review (AUAR) have the scope that could be appropriately fitted to this recommendation (http://www.eqb.state.mn.us/documents/EnvironmentalReviewProcess.1.06.pdf).

Among the several existing elements or project reviews are:

- NEPA, EQB processes

  An environmental assessment (EA) is prepared for federal projects to determine if a full EIS is needed. An EIS is prepared for mandated projects. State EAW or AUAR processes are used for state or nonmandated transportation corridor, bridge and bridge replacement, and bypass and bottleneck projects (http://www.dot.state.mn.us/tecsup/xyz/plu/hpdp/book1/2cpr/class3/ea/ea.html).

  The EIS process currently contains the following steps:

  1. The RGU (MnDOT) determines if an EIS is needed.

2. An EA or EAW form is completed by the RGU and the project proposer as an aid in scoping the EIS. The EAW is distributed to reviewing agencies and noticed in the *EQB Monitor*. A press release is provided to a local newspaper.

3. A 30-day scoping period follows the notice, allowing for public review of the EAW and input into a decision on the issues to be analyzed. A public meeting is held during this period to receive verbal comments. The purpose of the scoping is to focus the EIS analysis on the pertinent issues and to determine what reasonable alternatives will be compared to the project.

4. The RGU makes an official scoping decision which outlines the contents of the EIS.

5. A summary of the scoping decision (EIS preparation notice) is published in the *EQB Monitor* and a press release is supplied to a local newspaper.

6. The scoped issues are analyzed with economic and sociological impacts being considered in addition to environmental impacts. The results of the analysis are compiled into a draft EIS document. Frequently, a consulting firm is hired to assist the RGU with the analysis and the document.

7. Any person can review and comment on the draft EIS for a period of at least 25 working days after a notice of the draft EIS is published in the *EQB Monitor*. A press release is sent to a local newspaper. A public meeting must be held to receive verbal comments.

8. The EIS is revised into final form based on the comments received.

9. The RGU makes an official decision on the adequacy of the EIS. A notice of the impending decision is published in the *Monitor* at least 10 working days in advance. The adequacy decision is based on three criteria: (1) Were all issues for which information was reasonably available addressed? (2) Were all legitimate comments on the draft responded to? and (3) Were proper procedures followed? In exceptional circumstances, this decision may be made by the EQB instead of the RGU (http://www.eqb.state.mn.us/documents/EnvironmentalReviewProcess.1.06.pdf).

- MnDOT ATP processes

  MnDOT regional districts prepare transportation plans in consultation with the counties and in the case of the Twin Cities, the Metropolitan Council. Some road, bridge, and transit projects in these plans go to the STIP. Mapping and planning protocols observed by county and local planning and engineering officials follow the target formulas for existing maintenance and other project types and the functional classification set out in this formula. Some projects remain local. Regardless of funding sources, the plans set forth mobility and access improvements to the network, and the roadway improvements that are codified by their functional classification. The functional classification system sets roadway design standards that are closely followed by district and county engineers as these standards are tied to safety and related capacity design standards as well as to state and county aid compliance. The connected pattern of standards means that generally all roadway widths and edge treatments are physically similar, described by their functional classification, regardless of where they are in the state. Very often these determinations are related to land use planning and to population projections. When land use changes by local subdivision, the roadway classifications set by county-level planning decisions (e.g., arterial improvements) generally also guide the design of collector and local streets. This design could in turn, along with other related roadway improvements have regional impacts on natural resources. Such develop-

ment-scaled decisions are also framed by city- and county-level land use planning and zoning decisions which tend to mirror the transportation hierarchy although strictly speaking occur separately from larger-order transportation decisions.

- MnDOT context-sensitive design and context-sensitive solutions (CSD/CSS)

  Primarily oriented to visual, aesthetic and recreational environmental enhancements, this program could have a broader and deeper scientific role.

- National Pollutant Discharge Elimination System (NPDES)

  The federal Environmental Protection Agency (EPA) and by delegation, the MPCA, are responsible for setting standards for impairment and for enforcing the Clean Water Act and the associated NPDES permits to industries, cities (and other larger public corporate entities classified as MS4 entities), and other point sources of contamination. The transportation network is not subject to permitting since it is not defined as a point source.

The potential for increased transparency, cross-consultation, and overall efficiency and effectiveness of streamlined processes has shaped updated federal guidance documents issued by FHWA and FTA on mandated roles in environmental assessment and planning integration:

"The development of the revised integrated environmental review process gives participants an opportunity to share past experiences and to strengthen the interagency relationships that were established during the development of the Highway Methodology NEPA/404 process. These stronger interagency relationships will help to improve understanding and ultimately reduce project delays in the future. Trust relationships, coupled with the changes noted below, are the keys to fulfilling the goals of TEA-21 (now SAFETEA-LU and the Cooperative Agreement). This process is recommended as beneficial and applicable to transportation development projects, regardless of the source of funding" (http://www.environment.fhwa.dot.gov/strmlng/linkingtrans.aspIn).

Time frame. An expanded time frame (years) will be needed to implement the alignment and project review processes recommended and assemble and create tools, and decades will be needed to evaluate transportation impacts.

Geographical coverage. Aligned planning will have a statewide effect. What Richard Forman (2003)calls the "virtual" catalytic effects of transportation system changes and the potential uncertainty built into complexity and/or lag are especially complex in the three-biome, multi-ecoregion, multiwatershed configuration of the state. Shifting land uses at edges of metropolitan areas and in biofuels production and distribution areas make transportation planning, design, monitoring, and management even more difficult. Changing patterns of land use and transportation, even economic development attendant upon increased energy costs add further uncertainty.

One focus in this document is on suburban expansion since population forecasts seem to place the greatest emphasis on this growth, particularly in the outer metropolitan areas surrounding the Twin Cities. From a transportation and land use perspective, that focus is a linchpin of environmental conservation for all of the state's resources. This fact is due in part to the patterns of urban settlement and their close relationship to these resources, especially water and land-based resources and agriculture.

While projections made prior to the current fuel and food cost rises and mortgage crises have not been precisely accounted for in this writing, population growth and related VMT projections have historically been closely tied:

"The target formula includes the state demographer's forecast of population for the year 2025 to represent future system usage.… Analysis of the state demog-

rapher's 1995 projected population and 1995 VMT as reported by MnDOT showed a 99 percent correlation between population and VMT" (http://www.oim.dot.state.mn.us/pdpa/STIPGMar01.pdf).

Surface transportation projects such as bottlenecks and bypasses, corridor improvement, and bridges have both site-specific and corridor- and ecoregion-wide impacts because of the scale-setting effect they have on land uses, systems of transportation, and ecosystems services production.

Challenges. Two administrative challenges are to align interagency and cross-jurisdictional environmental assessment with statewide transportation planning, and to insert environmental minimization, mitigation, and adaptation into the transportation investment planning process that frames project location, purpose and need statements, planning, design, and implementation. Another challenge is to link project planning and design more integrally with land use planning to achieve a more comprehensive statewide strategy to balance growth with resource conservation.

Other challenges, among many, include:

- Political: Metro and outstate funding formulas and the related project-type formulas may not fit with plans to conserve resources. Agency silos and legal silos may be obstacles.
- Research and Data: Environmental conservation will eventually be evaluated according to performance outcomes both statewide and on projects. A principal challenge is the research gap, especially relative to rapidly changing interrelated environmental conditions and impacts (e.g. research on fate of contaminants to ground and surface waters). This gap frustrates the cause of making a case for integration of modeling, environmental assessment, monitoring, and evaluation with planning and design.
- Modeling and Scenario Building: More precise measures might be modeled (e.g., projected VMT based on actual transportation data and multimodal data from other projects, not just projected population) in order to model more comprehensive and multimodal scenarios such as are created in the metropolitan planning areas and some counties. However, at this writing, a forecast of VMT is not necessarily available by county.
- Creation of new statewide roadway design, management practices, and standards (e.g., noise, vibration standards by key SGCN, improved standards for invasive species mitigation, roadside vegetation, culverts, pavement porosity, chemical storage performance standards, statewide storm-water performance standards for sediments and contaminants, bridge maintenance and painting standards) will affect bioregional and hydrological criteria.

At the project scale, there is the scientific gap in understanding of cumulative and virtual impacts of transportation projects. The complexity and specificity of resources, indeterminate temporal and spatial impacts drivers, and cumulative impact assessment are among the several scientific and technical challenges that underlie the considerable administrative challenges.

Other project administrative challenges include the cost justification for cross-governmental coordination: What are the costs, mitigation responsibilities and benefits of environmental streamlining/sustainability? Can they be monetized? What are the institutional culture challenges, especially relative to shared project control? In technical terms, there is the coordination challenge across mapping and other data-resolution issues (e.g., SGCN at township scale vs. point scale data in the county biological surveys and scales of attribute mapping in Data Deli sources and transportation project planning and design).

See 2005 Florida DOT data on efficient transportation decision making (ETDM) evaluation and the ETAT integration (http://www.dot.state.fl.us/emo/pubs/Final%20PMP%20Report_April%202005.pdf).

Costs. Cyclical planning alignment could be achieved cost-effectively by reassigning tasks or moving or creating two to five environmental assessment process team staff positions, probably in EQB. Data sharing (especially GIS) and these added staff would minimize costs across agencies and may support streamlining. Other project recommendations, especially the formation of ETAT-supported processes and changes in ATP workloads, might incur initial staffing costs within MnDOT (http://www.environment.fhwa.dot.gov/strmlng/newsletters/nov03nl.asp).

Transportation Recommendation 2: Reduce per capita vehicle miles of travel (VMT), through compact mixed-use development and multi- and intermodal transportation systems

Description of recommended action. The principal means by which VMT can currently be reduced are through reducing growth in lane miles and increasing intermodal and multimodal (including nonmotorized) transportation access and use. In the context of an automobile and truck fleet that cannot turn over (i.e. be replaced by more efficient vehicles and new fuels) in less than a decade regardless of other conditions, current efforts should concentrate on supporting planning and design of compact, mixed-use urban and suburban development and corresponding intermodal and multimodal transportation networks. Existing and proposed MnDOT plans and processes (e.g., interregional corridor plan, ATP, ETAT) should be used as foundations for support of compact urban and suburban development.

2A. Use alternative transportation planning and design processes and tools to support compact mixed-use development

Incorporate expanded transportation demand modeling (TDM) and Access Management modeling and other related strategies in statewide and local planning and project design to enhance local multimodal and passenger intermodal access that supports compact mixed-use development and resource conservation. For example, expanded Transportation Demand Management (TDM) analysis of MnDOT interregional corridor commutesheds, (i.e., areas of service at peak across modes) could suggest alternatives to usual applications of the functional classification standards. It is also important to have uniformity among expanded TDM requirements across neighboring communities so cities that implement expanded transit and nonmotorized TDM are not penalized budgetarily for their efforts by placing themselves at a disadvantage compared to civil divisions that do not implement TDM.

2B. Provide incentives for compact mixed-use development

Encourage and prioritize qualified transit and nonmotorized system fiscal investments in the STIP for regions that integrate local resource planning and performance-standard based design for compact development (Figure T6). Incorporate economic and employment development into resource protection. For example, focus these approaches on the Twin Cities metropolitan area and other employment and service centers.

2C. Augment and communicate information on practices and performance of compact mixed-use development and transportation

Conduct interdisciplinary research (e.g., case studies) to correlate VMT changes with types, locations and scales of development in relation to transportation demand and planning for systems and modes. Establish databases on VMT-related statistics for resource-sensitive roadway network design and for patterns, intensities and combinations of land uses in multimodal and passenger intermodal development. EQB could provide research coordination of state agencies (e.g., MnDOT, MPCA); counties and localities (including minor civil divisions), educational institutions, and nonprofit stakeholders and

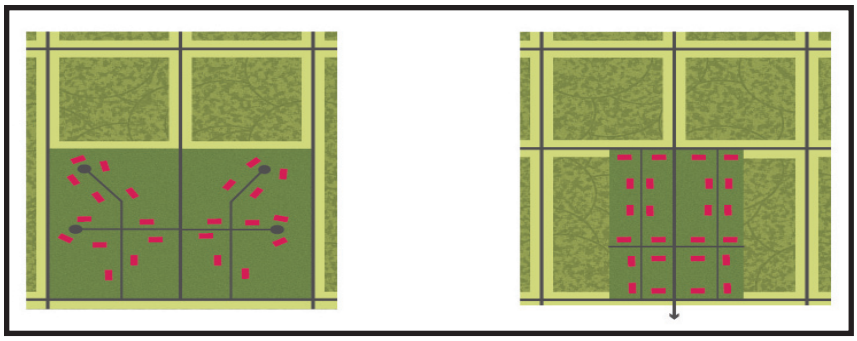

Figure T6. Left: conventional cul-de-sac low, density development in context of road networks and land cover. Right: Right: same number of dwellings in compact, connective street system. Credit: KatherineThering, UM Metropolitan Design Center.

foundations. Use this information to develop planning and design toolkits for the state, counties, metropolitan and local communities, developers, and citizens that include performance standards scorecards of structural and nonstructural approaches to VMT minimization/mitigation (e.g., based on models of per capita/per household VMT by land use configuration).

Description of impact on natural resources. The primary direct impact on natural resources of reducing VMT would be reduced emission of GHGs and other pollutants into the air. All internal combustion engines emit GHGs (including CO_2, CO, and NOx), HC (also known as VOCs), PM, and SOx (http://www.ec.gc.ca/cleanair-airpur/CAOL/transport/publications/trucks/truck3.htm).

By supporting compact, mixed-use development, reduced VMT would also directly or indirectly reduce other resource impacts. For example, reduced growth in lane miles would result in reduced:

- vegetative land-cover loss, hydrologic modification, soil erosion (land)
- surface- and ground-water quality degradation from transportation projects (water)
- terrestrial and aquatic habitat fragmentation (wildlife and fish)
- heating effects and contaminant, nutrient, and solids loading associated with storm-water runoff (fish)

Relationship to existing programs, laws, regulations. This recommendation is targeted to provide one approach to meeting the state legislative mandate to reduce carbon emissions by 20% by 2020.

The EQB has a number of "smart growth" resources on its Web site, including the memo *Growing Smart in Minnesota* (1999) and Smart Growth Bonding Criteria. The state Department of Administration also published in 2002 *Under Construction: Tools and Techniques for Local Planning.* In 2000 Minnesota Planning published a handbook on model ordinances (http://www.mnplan.state.mn.us/pdf/2000/eqb/ModelOrdWhole.pdf).

While Minnesota communities have a variety of density bonus and conservation ordinances, there is little consensus on the nature of the resource protection they offer. This and other potential positive effects of altering local practices are otherwise largely not regulated through subdivision or zoning.

Time frame. Years to implement processes, decades to develop data, modeling, scenario building and to monitor conservation effects

Geographical coverage. Statewide but with special attention to the metropolitan edge, where the conversion of agricultural lands present this and other challenges to the natural resources of the state

Challenges. The relationship of land use, transportation planning and design and conservation is poorly understood from scientific, governance, political, and cultural perspectives. There is not enough research to demonstrate interdependencies of decisions and to forefront natural resource protection. Data resolution issues make it difficult to quantify conservation performance standards that might be written into transportation planning and design standards at the statewide level or into local subdivision or zon-

ing ordinances. Government support of transportation occurs generally at statewide and regional levels largely disconnected from local, incremental governmental decision making that makes subdivisions of and assigns use to land via zoning. The mismatch of the landscape scale of resource protection and local land use processes and personal practices is a fundamental challenge. Ultimately land is largely configured according to private decisions, based in property rights—potentially a fundamental political and cultural challenge to conservation-based land use practices and processes.

Costs. Programmatic costs, development of research and coordinative support through EQB and MnDOT, local costs of ordinance revision.

Transportation Recommendation 3: Develop and implement sustainable transportation research, design, planning, construction practices, regulations, and competitive incentive funding that minimize impacts on natural resources, especially habitat fragmentation and nonpoint source water pollution

IP

LP

Description of recommended action. This recommendation seeks to minimize, adapt, and mitigate habitat fragmentation and nonpoint source pollution from surface transportation (and related land uses) through research and design linkages via EQB, MPCA, and other stakeholders with MnDOT, and through expanded regulation and funding incentives for innovative project approaches and increased environmental innovation on roadway design standards.

3A. Develop research programs on habitat fragmentation and planning, design, and construction techniques for adaptation, minimization, mitigation, and restoration

Roads fragment habitat. Some species are more or less impacted by road network configuration, width, pavement and shoulder treatments, bridging, and sizes and types of culverts. Species are generally also benefited by vegetated edge design and management and grade-separated crossings such as bridges or culverts. While there is a body of existing research around the academic efforts of Richard Forman, Daniel Sperling, and others, the main foci of environmental mitigation of habitat loss are still largely practice-based. See, for example, the FHWA CSS Web site (http://www.fhwa.dot.gov/context/index.cfm). For cases, see http://www.contextsensitivesolutions.org/.

Research is needed to explain land-cover and species relationships to local and regional impacts of road functional classification changes (widening and/or curbing), new routes, bridges, culverts, and other projects. Further research is needed to document effectiveness of innovative techniques including hybridizations of the functional classification, CSD/CSS, and innovative crossings of water.

Research specific to best conservation practices for Minnesota's prime terrestrial and aquatic habitats and SGCN would be embedded into EQB/MnDOT statewide and district office planning in the form of ecoregional GIS coverages at increased resolution. These would be used to make determinations of pending impacts and as planning, design and construction practice and incentive grant guidelines.

3B. Develop research and design linkages of nonpoint source pollution to surface and ground waters from right-of-way and adjacent land uses that would improve performance of roadway-based infrastructure in relation to hydrological resource resilience and overall stability

In this state, water is always close, whether on the surface or in the ground. The cumulative and spatial impacts of transportation and associated land use development on water quality and aquatic habitat are only beginning to be understood (Figure T7). Research is needed to develop a finer understanding of the spatial and biophysical dynamics and metrics

of transportation-induced contamination of water, especially surface water, but in areas of high permeability, also ground water. Research on fate to ground and surface waters by land cover, land use, and soil types is needed to improve statewide storm-water performance standards for sediments and contaminants TMDLs. These standards could inform review of all transportation projects for NPDES permits as recommended here. The research would identify issues and model and test hypothetical conservation planning, design, implementation, and management practices across scales. For example, research could:

- Develop data analysis and research in support of new MnDOT design performance standards and local standards and practices.
- Establish state watershed databases on nonpoint source pollutant fate by land use/land-cover types and establish design, planning, and management practices by contaminant, land cover, slope, soils, stream segment, overland distances (buffers) to surface waters, and relationship to ground water and to biotic resources (especially aquatic habitat).
- Relate project planning and design goals, incentives, and best practices to long-term (cumulative impact) models of performance on watershed bases.

3C. Implement a standard baseline of habitat fragmentation and nonpoint discharge review for all projects that increase impervious highway roadway or drainage infrastructure surface in Minnesota

Require all new roadway projects or functional classification upgrade projects on existing roads to secure NPDES permits.

This recommendation could link project development more closely to comprehensive habitat data and impact analysis via the connection between the MnDOT statement of project purpose and need and environmental review. The statement of purpose and need provides the basis for developing a range of reasonable alternatives and, ultimately, identification of the preferred alternative. It also sets budgetary frameworks. If properly described, it also limits the range of alternatives that may be considered

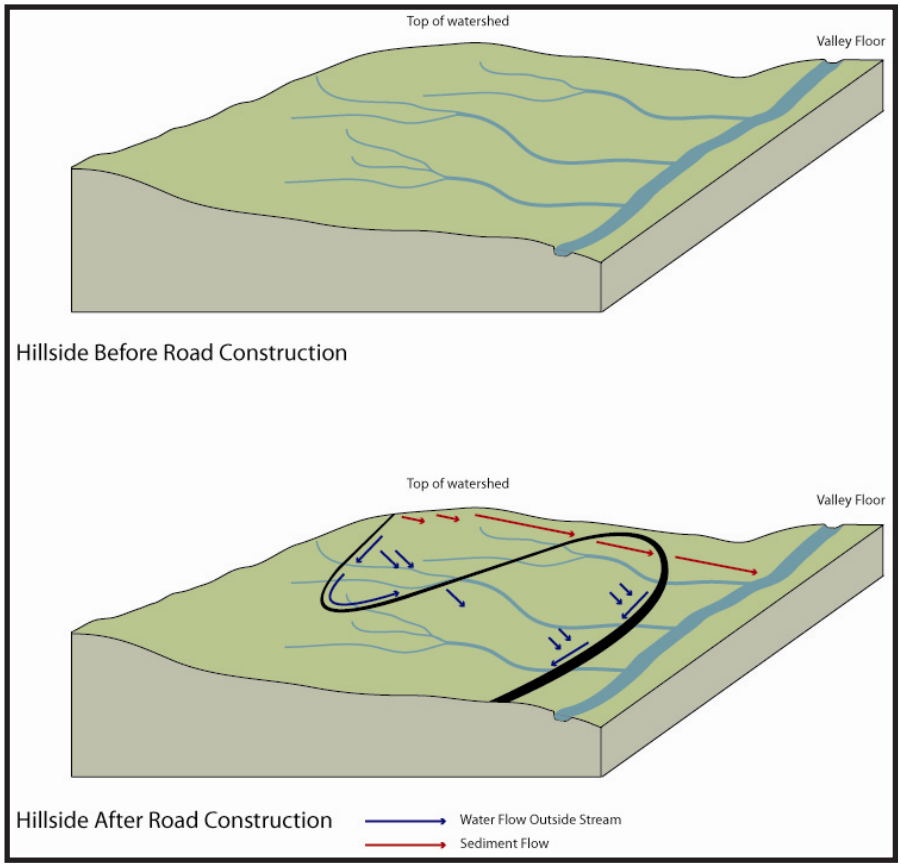

Figure T7. Road construction alters runoff speed, patterns, and volumes, and directs sediments and associated contaminants rapidly to the valley floor of a stream system. Credit: Katherine Thering, UM Metropolitan Design Center.

reasonable, prudent, and practicable in compliance with Council on Environmental Quality (CEQ) regulations, Section 4(f) of the Executive Order on Wetlands and Floodplains, and the Section 404(b)(1) guidelines. Further, it demonstrates the problems that will result if the no-build alternative is selected (http://www.dot.state.mn.us/tecsup/xyz/plu/hpdp/book1/2b/class1/purpose-need.html).

3D. Pilot incentive program grants for habitat and water-quality conservation design and construction innovations in transportation projects

The state should consider creating a grant program which would offer grants to MnDOT, counties, and local governments for transportation projects that demonstrate new or catalytic conservation approaches to road and related drainage design, development or (re)construction (Figure T8).

Description of impact on natural resources. The principal objectives of research programs would be to strengthen planning, design and implementation practices to reverse, stabilize, minimize, mitigate or adapt to:

- Vegetative landcover loss via increase in impervious cover and other drainage modifications related to transportation development associated with new routes, functional classification changes, and/or land subdivision
- Habitat disconnection
- Surface- and ground-water quality degradation through erosion and sedimentation during and after transportation project construction
- Construction impacts of bridges and culverts, including noise, vibration, and sedimentation
- Flow constriction and aquatic habitat fragmentation of roadway and bridge design
- Heating effects, contaminant, nutrient and sediment loading associated with stormwater runoff from pavement

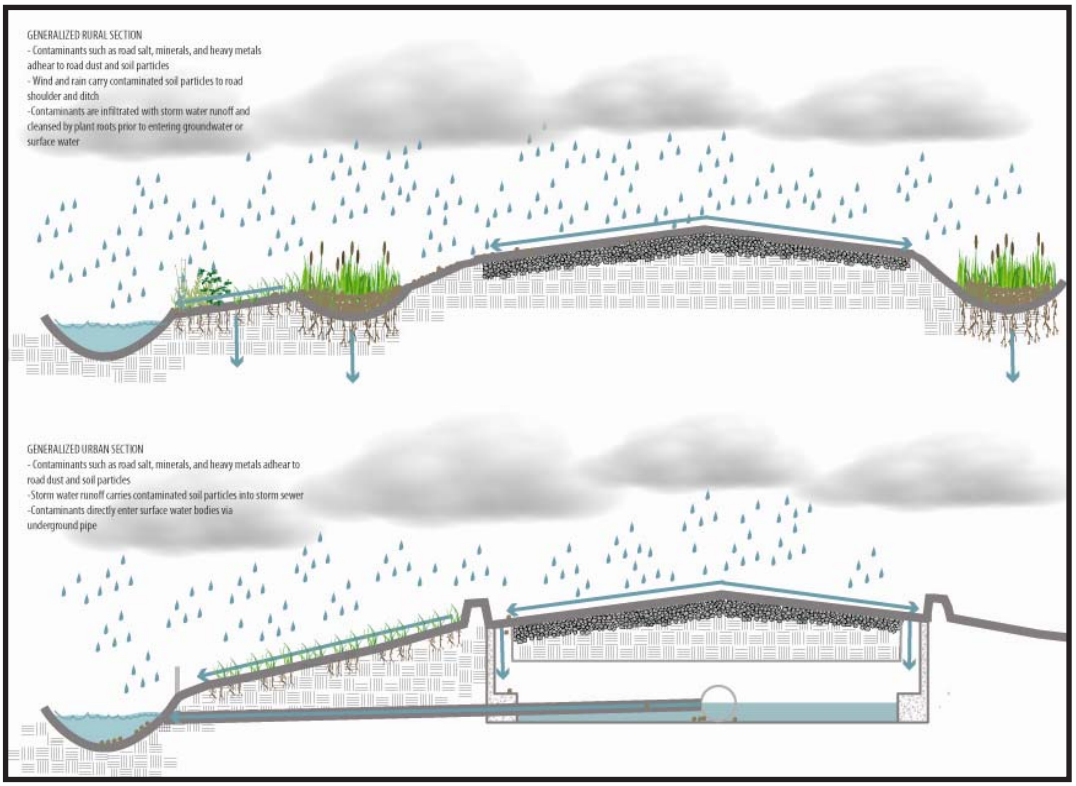

Figure T8. One current practice in road design is to provide vegetative infiltration areas in roadside swales to filter and slow runoff from paved surfaces. Curb and gutter additions to roads that accompany the changes in functional classification (e.g., to urban arterial) are especially detrimental near water bodies. Credit: KatherineThering, UM Metropolitan Design Center.

Relationship to existing programs, laws, regulations. NPDES review is used for some transportation projects (see http://www.dot.state.mn.us/tecsup/xyz/plu/hpdp/forms/forms_erosion.html). In the Twin Cities metropolitan area the Metropolitan Council has created the Livable Cities Demonstration Account program to provide competitive grants to communities to encourage environmental innovation in site planning and design. This program could be a model.

Time frame. Years

Geographical coverage. Statewide, with particular research focus on metropolitan edges, forest interiors, key watersheds, lake-to-lake movement, and water crossings in stream and river corridors.

Challenges. Data and mapping at appropriate resolution to assess impacts of transportation changes; jurisdictional implementation.

Costs. Programmatic costs include funding for development of research, innovative grants and coordinative support through EQB, MnDOT, MPCA, and DNR.

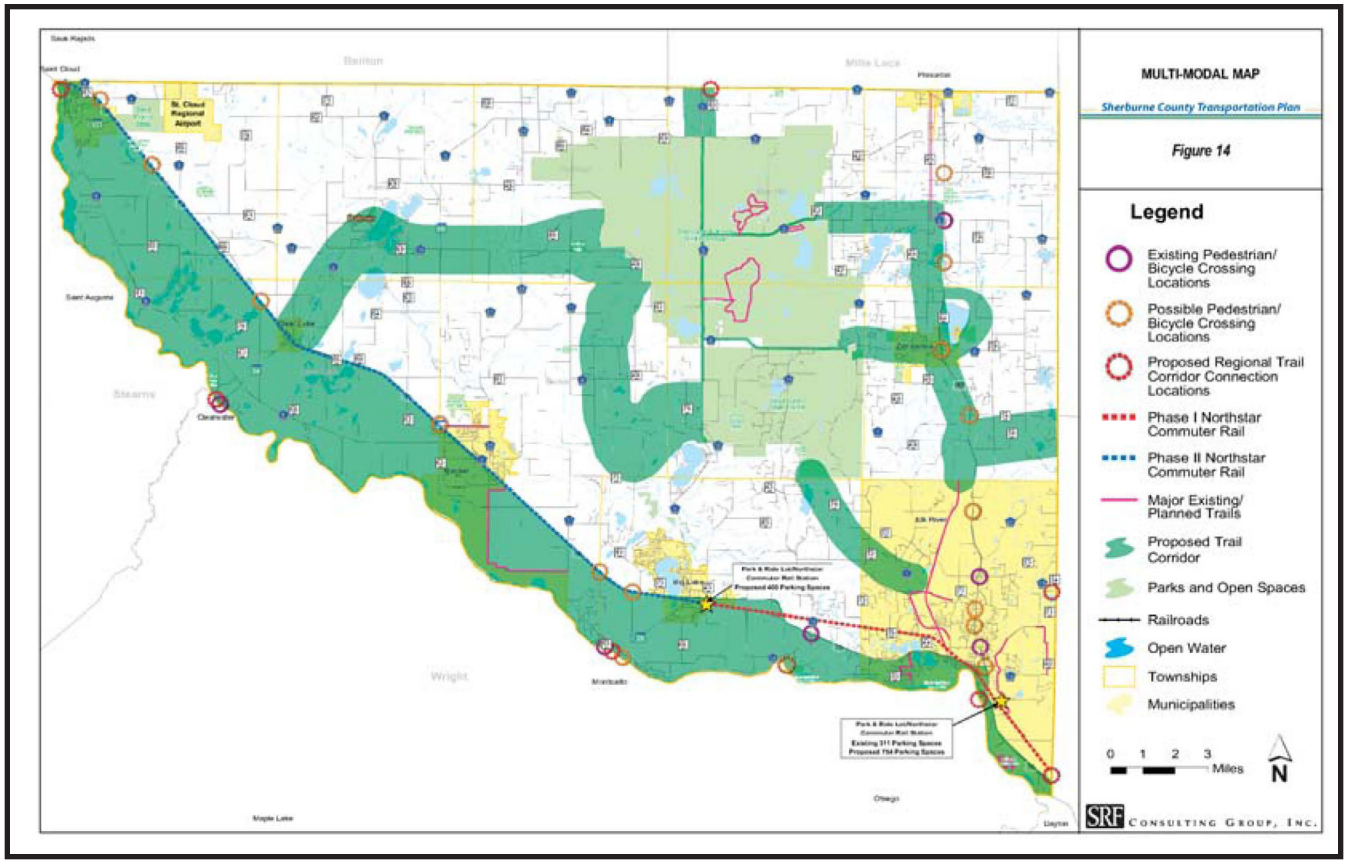

Figure T9. The several conservation green corridors in the Sherburne County Multimodal Plan (2007) represent a good beginning point to suggest the tradeoffs in resource conservation and the locations and types of roadway functional classification change and related bridging proposals that require more thorough analysis and design. In the eastern part of the county (shown in the box) functional classification upgrades are proposed for County Hwy 4 in the Sherburne National Wildlife Refuge and for County Hwy 5 between the Refuge Area and the Sand Dunes State Forest. Credit: KatherineThering, UM Metropolitan Design Center.

Road Impacts on Critical Habitat: A Case Study Analysis Based on the Sherburne County Transportation Plan

Sherburne County is predominately rural, but is undergoing rapid development. The county contains several important natural habitat areas, including Sherburne National Wildlife Refuge, Sand Dunes State Forest, and a border with the Mississippi River.

The Sherburne County Long-Range Transportation Plan (2007), in which the "green corridor" multimodal map (Figure T9) was used, begins to suggest how to assess the amount and quality of critical habitat changes with respect to planned changes in road functional classes. The intent of the transportation plan is to accommodate anticipated growth over the next 20 years (to 2030), including moving goods related to farming, mining and agricultural activity, as well as increased commuter use.

This analysis was based on the terrestrial critical habitat map created in the SCPP (Figures H2 through H7). The habitat map was formed by integrating a number of natural resource data layers, including sites of biodiversity significance, SGCN, game species, terrestrial vertebrates, and a number of other factors. The habitat analysis also incorporated key stressors and drivers of change, including road density, housing density, and connectivity at the wildland/urban interface. The present analysis expands on the SCPP habitat analysis in that it assesses changes in habitat as they relate to specific transitions in road function classes projected in the Sherburne County transportation plan (Figures T11 through T17).

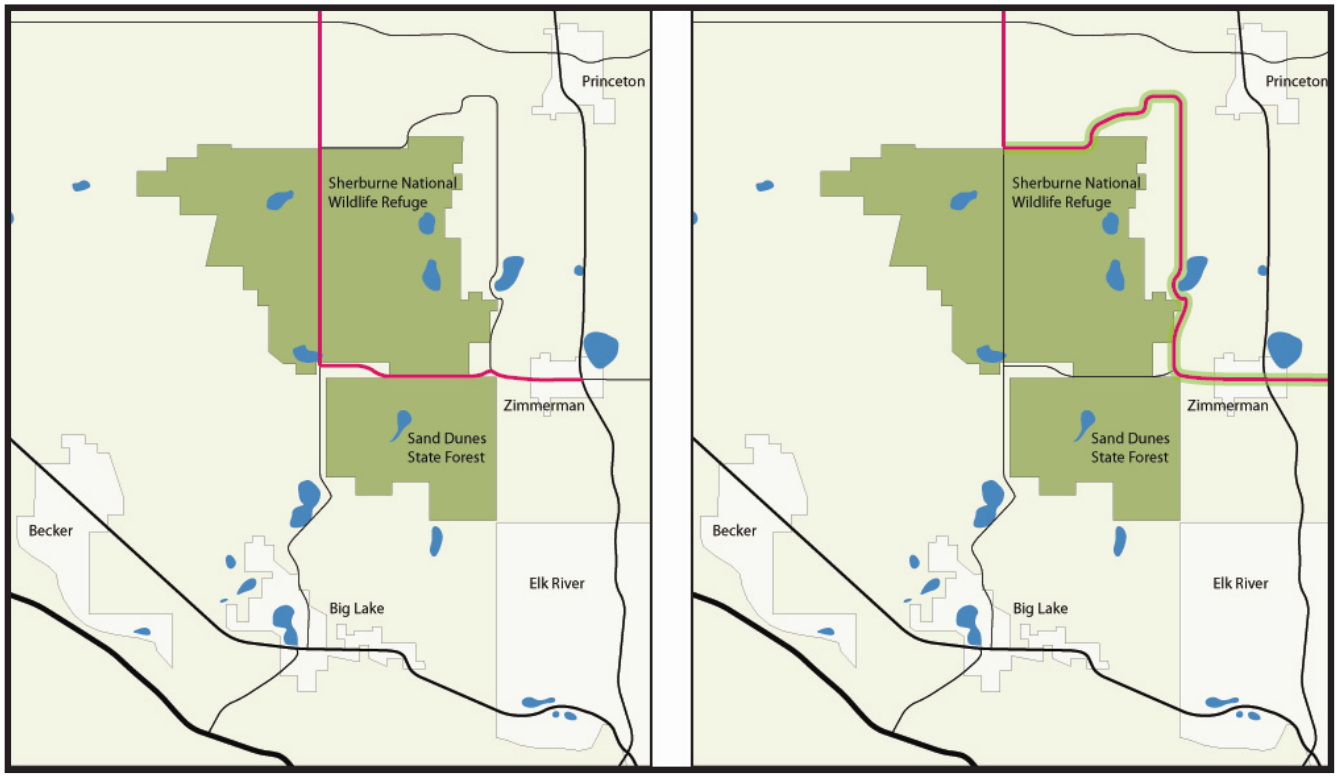

Figure T10. One alternative, right, to minimize the impacts of proposed upgrades in and at the southern edge of the Sherburne National Wildlife Refuge (County 5 and County 4) near Zimmerman would be to shift these "green corridor" projects around the habitat in the refuge and to design a location-specific roadway type to buffer impacts at the edges of the refuge and Sand Dunes State Forest.
Credit: KatherineThering, UM Metropolitan Design Center.

The proportion and quality of critical habitat was assessed along all roadways in the county, both existing (2007) and projected (2030) (Figures T12 through T15). Roads were analyzed by functional class: major, minor, and urban collectors and major and minor arterials. The buffer distance for the analysis varied with road functional class, as shown in Table T1. A change analysis was used to determine the degree of habitat change association with transitions in road classes.

The plan adds 7.5 miles of road to the existing transportation network (Table T2). There are strong differences in functional class, however, with 58 miles of road becoming minor arterials, predominately from the minor and major collector class of roads.

The direct and indirect influence of roads varies with road size (Forman, 2003), so the transition to minor arterials from small classes of roads has a significant potential on habitat quality. This is particularly true in areas where major collectors traverse significant natural areas. The north-south corridor along the western edge of Sand Dunes State Forest and the east-west arterial that bisects the large area between the state forest and Sherburne National Wildlife Refuge have both direct effects on local habitat and broader effects related to landscape connectivity within the region (Figure T16).

Functional Class	**Buffer Distance (m)**
Urban Collector	90
Minor Collector	90
Major Collector	180
Minor Arterial	270
Major Arterial	360

Table T1. Buffer distances for road functional classes.

Functional Class	2007	2030	Change
PRINCIPAL ARTERIAL	61.8	52.1	-9.6
MINOR ARTERIAL	35.6	93.7	58.1
MAJOR COLLECTOR	169.4	135.1	-34.2
URBAN COLLECTOR	14.8	20.3	5.5
MINOR COLLECTOR	76	63.8	-12.2
Total	357.6	365.1	7.5

Table T2. Road lengths (mi) in current and future functional classes.

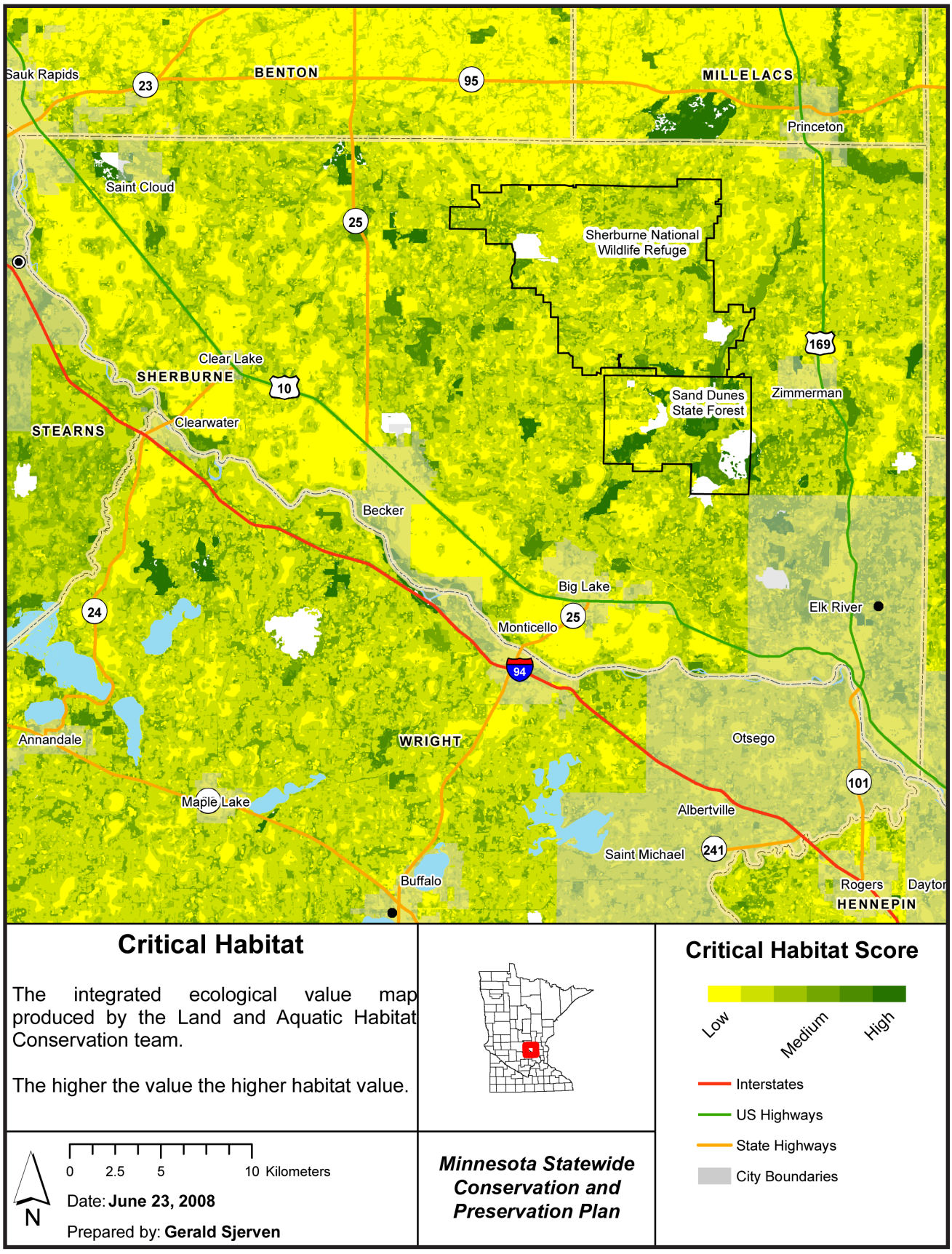

Figure T11. Critical habitat. Credit: Gerald Sjerven, NRRI.

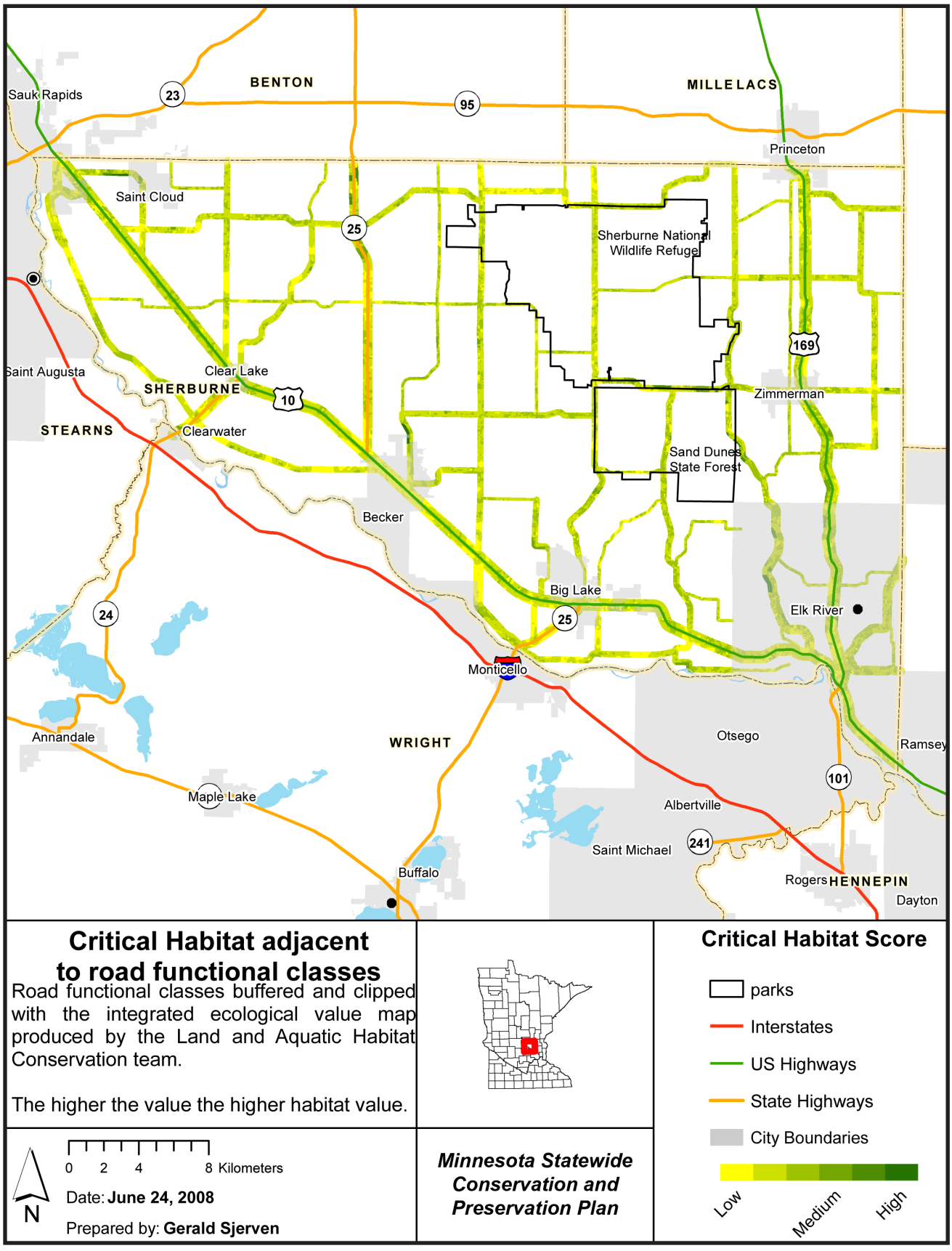

Figure T12. Critical habitat adjacent to road functional classes. Credit: Gerald Sjerven, NRRI.

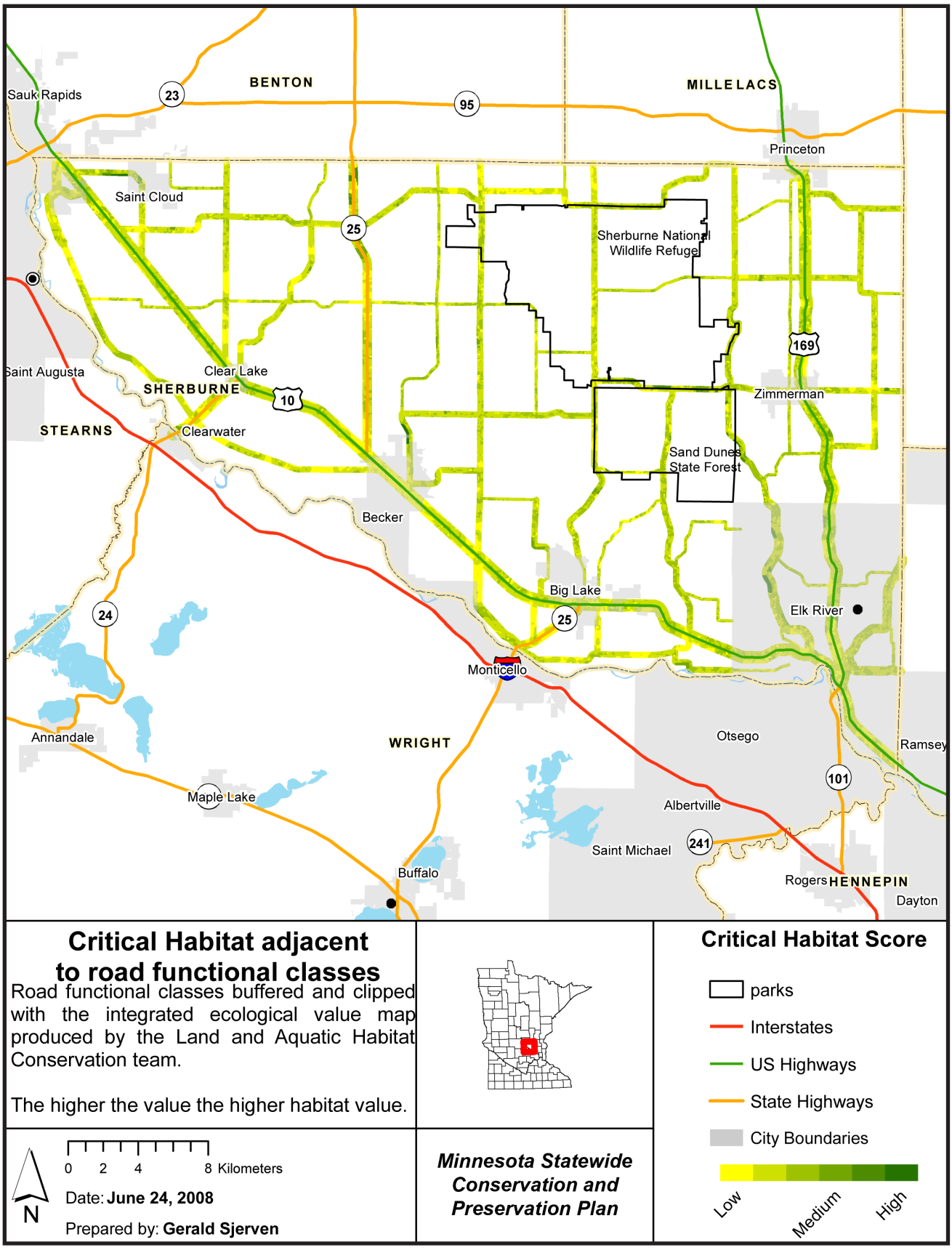

Figure T13. Critical habitat adjacent to future road functional classes. Credit: Gerald Sjerven, NRRI.

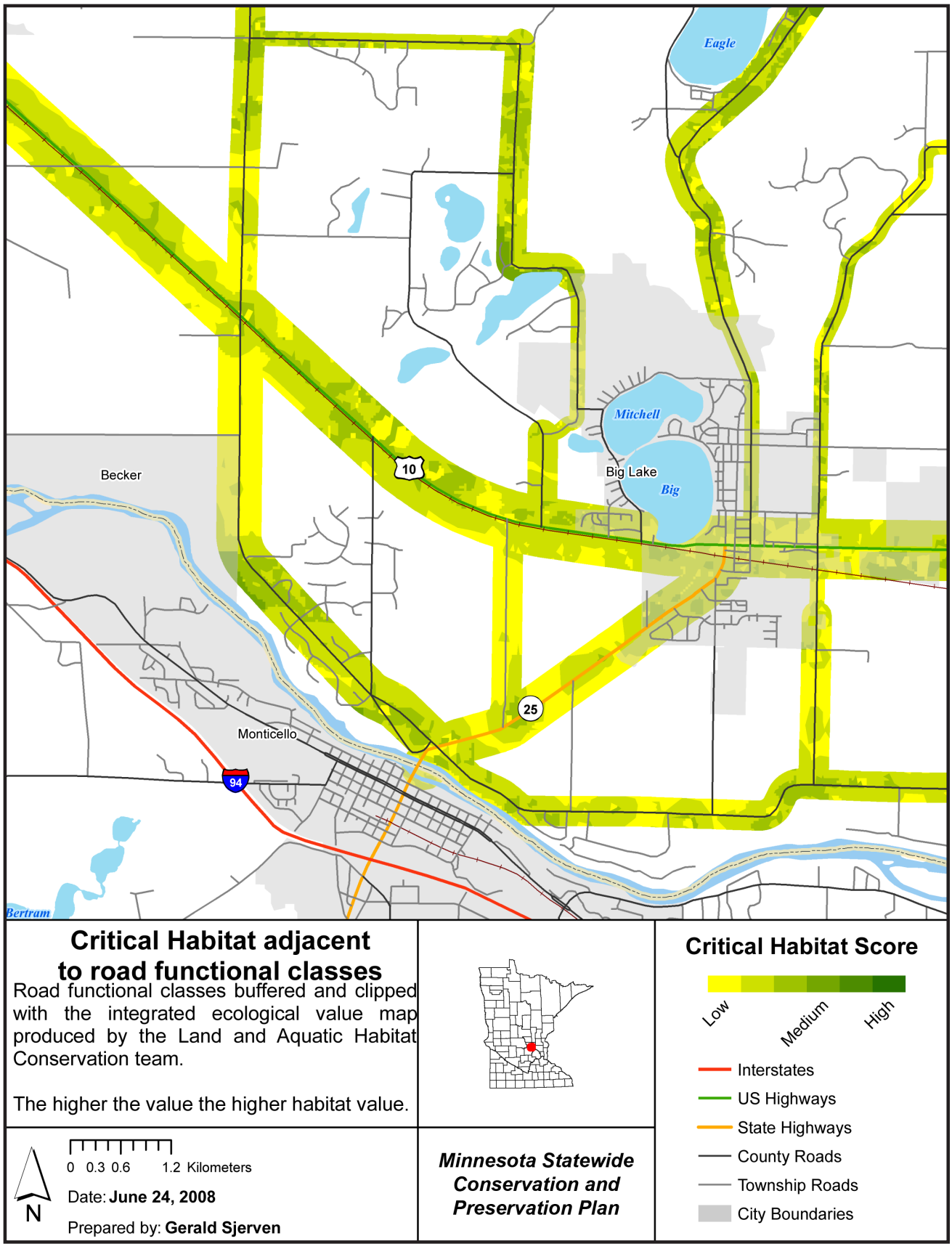

Figure T14. Critical habitat adjacent to road functional classes. Credit: Gerald Sjerven, NRRI.

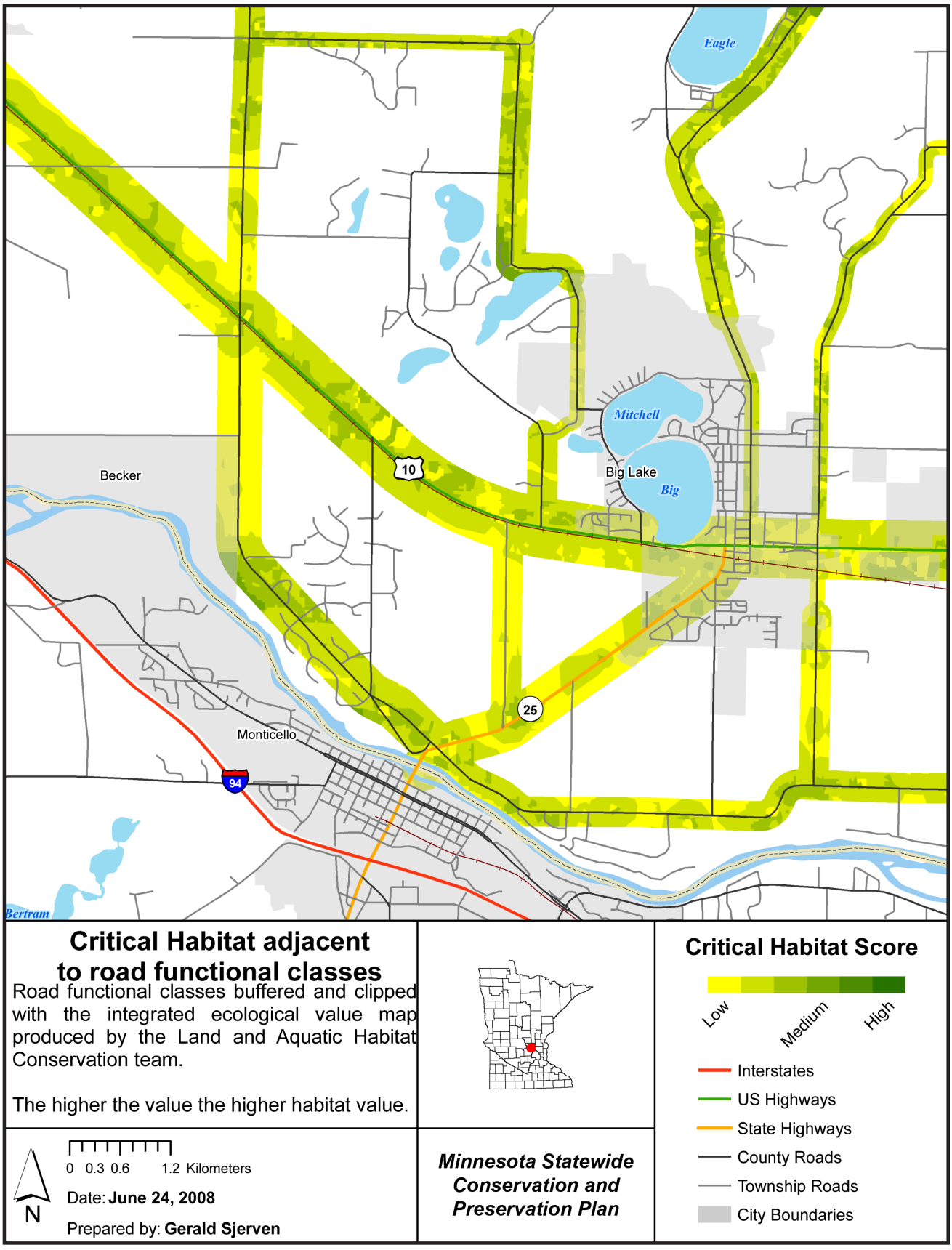

Figure T15. Critical habitat adjacent to future road functional classes. Credit: Gerald Sjerven, NRRI.

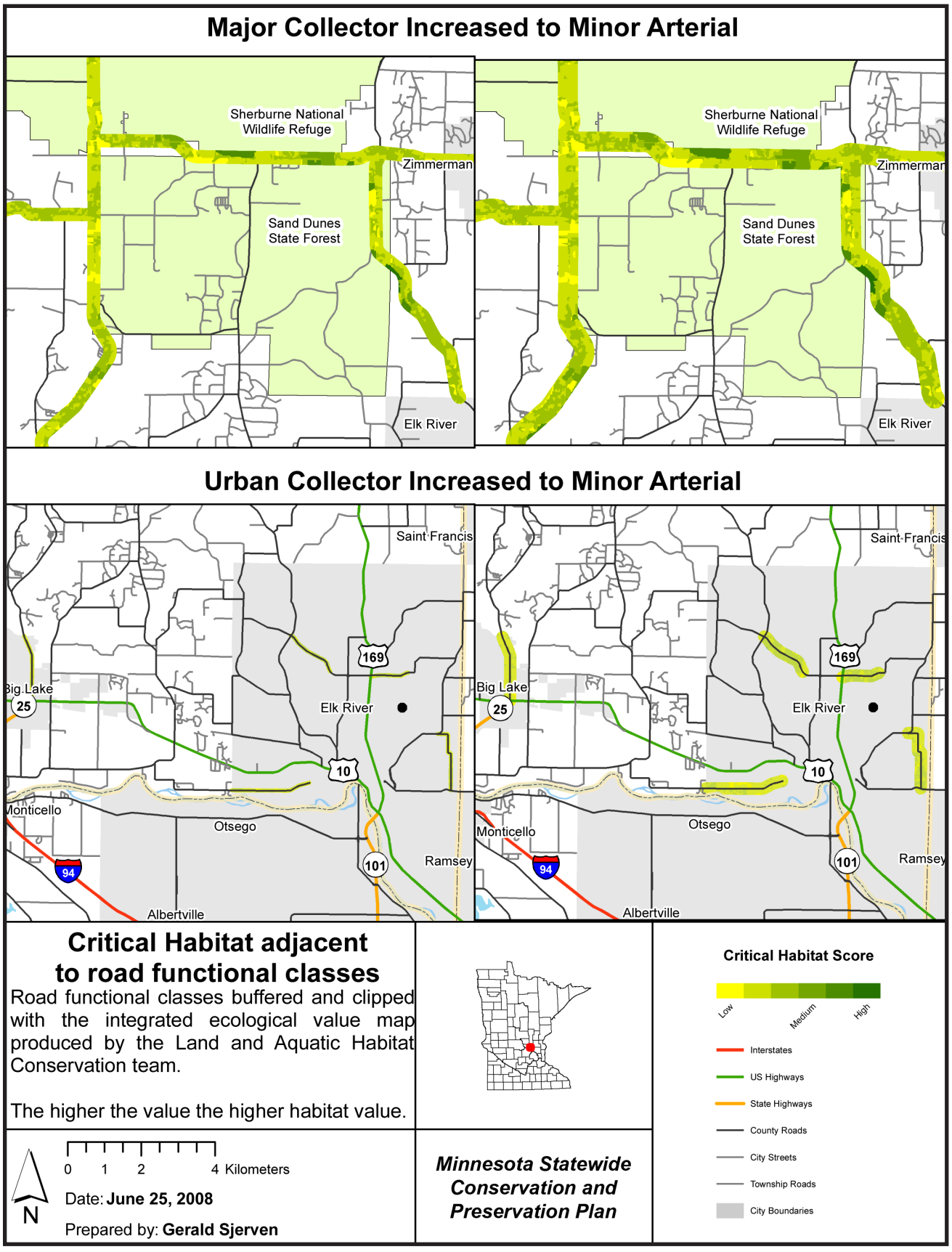

Figure T16. Critical habitat adjacent to road functional classes. Credit: Gerald Sjerven, NRRI.

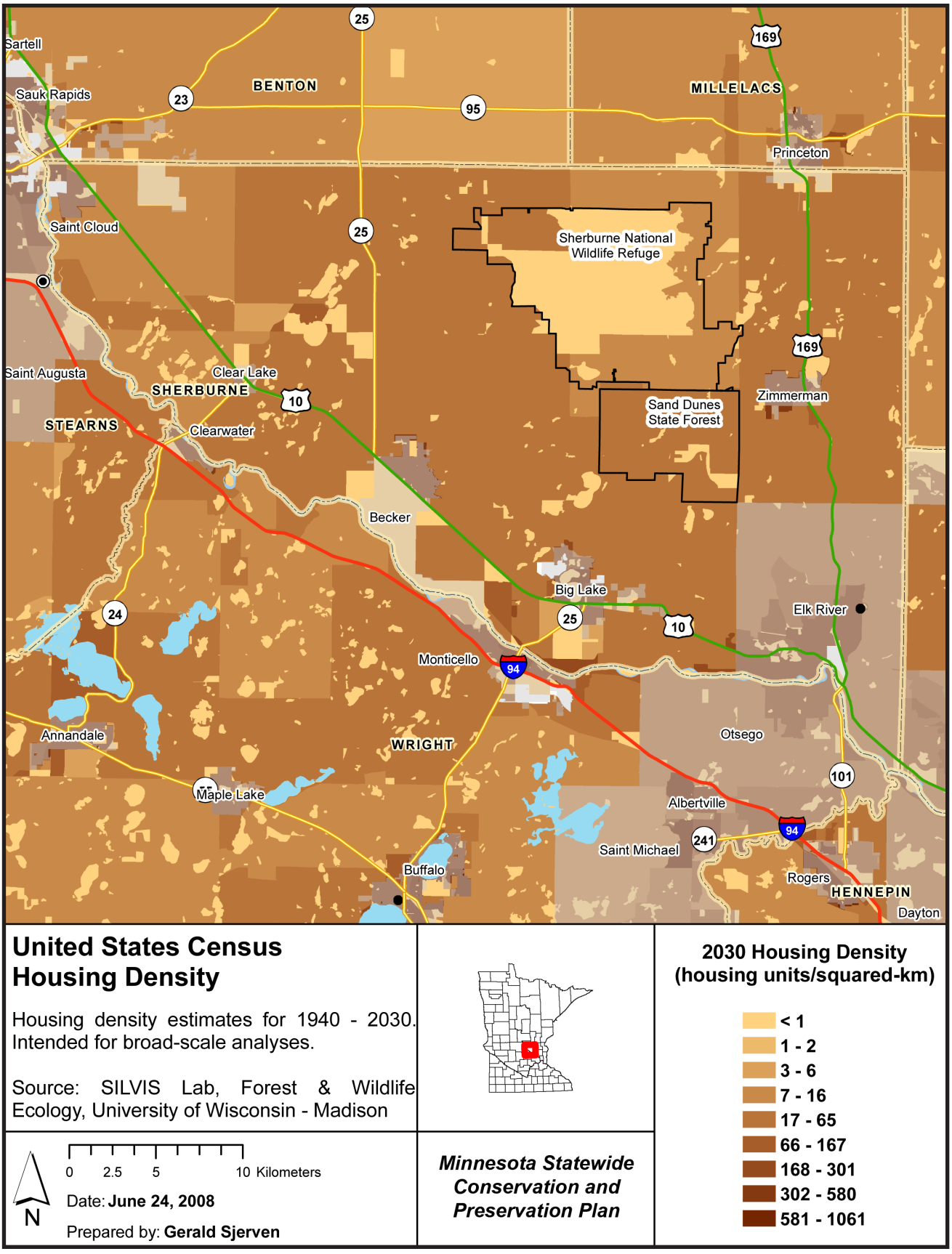

Figure T17. U.S. Census housing density. Credit: Gerald Sjerven, NRRI.

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The following icons are used throughout the plan to quickly identify recommendations by type:

IP **Integrated Planning Recommendations**

LP **Critical Land Protection Recommendations**

RP **Land and Water Restoration and Protection Recommendations**

SP **Sustainable Practices Recommendations**

ES **Economic Incentives for Sustainability**

Introduction

General Context

The United States is one of the largest consumers of energy in the world, consuming roughly 100 quadrillion Btu of energy each year (Energy Information Administration, 2006). Fossil fuels, including petroleum (40% of supply), coal (22% of supply), and natural gas (23% of supply), account for 86 quadrillion Btu. U.S. consumption of oil in 2006 reached 7.6 billion barrels, with just under half of this amount coming from foreign sources.

Motor vehicles in the Unites States consume nearly 3.4 billion barrels of oil each year. In Minnesota, gasoline consumption is slightly higher than the U.S. average. Vehicles driven in Minnesota consumed nearly 2.6 billion gallons of gasoline in 2006. U.S. demand for coal reached 1.1 billion tons in 2007, over 90% of which was burned to generate electricity. Minnesota currently obtains 65% of its electricity from coal, 25% from nuclear power, 5% from natural gas and petroleum, and 5% from renewable sources, including solid waste, wood, wind, hydroelectric, and landfill gas.

There is increasing awareness of the adverse consequences of relying on fossil fuels. Petroleum supply is expected to decline within the next decade or two as the world reaches peak oil. Burning fossil fuels, including coal, produces large amounts of greenhouse gases (GHGs), which contribute to global climate change. Coal burning also produces mercury emissions, which pollute land and water, and accumulate in aquatic organisms. Minnesota burned 20.9 million tons of coal in 2006. Minnesota carbon dioxide (CO_2) emissions arise mainly from electrical production (35%) and transportation fuels (34%). Minnesota emissions of CO_2 now exceed 140 million metric tons.

Federal and state policies now actively promote renewable energy production in order to supplement and potentially replace a portion of the energy supplied from fossil fuels. Renewable energy now accounts for 7% of the U.S. energy supply. Major renewable sources of energy in the United States include hydroelectric power (36% of renewable supply), biomass (53%), wind energy (5%), geothermal energy (5%), and solar energy (1%). There is a significant desire and potential for future expansion of the energy supplied from biomass, wind, geothermal, and solar energy sources.

The Federal Energy Policy Act of 2007 mandates 36 billion gallons of ethanol from renewable sources, with 21 billion gallons from cellulosic feedstocks such as corn stover or perennial energy crops. Minnesota's Next Generation Energy Act of 2007 mandates an 80% reduction in GHG emissions by 2050. Minnesota also requires that all gasoline sold for motor vehicles include a 10% blend of ethanol, increasing to a 20% blend beginning in 2012. Xcel Energy will be required by law to generate 30% of its electricity using renewable sources by 2020, which could include biofuels used to generate electricity. These policies mean that agricultural and forest lands in Minnesota will increasingly be used to produce biomass-based fuels, leading to competition with other types of production and uses that occur on these lands, including food, fiber, animal feed, wildlife habitat (e.g., pheasants and waterfowl), and recreation. At the same time, it is unrealistic to expect that biofuel energy production practices alone can supply Minnesota's growing demand for energy. Thus, it is important to develop policies and

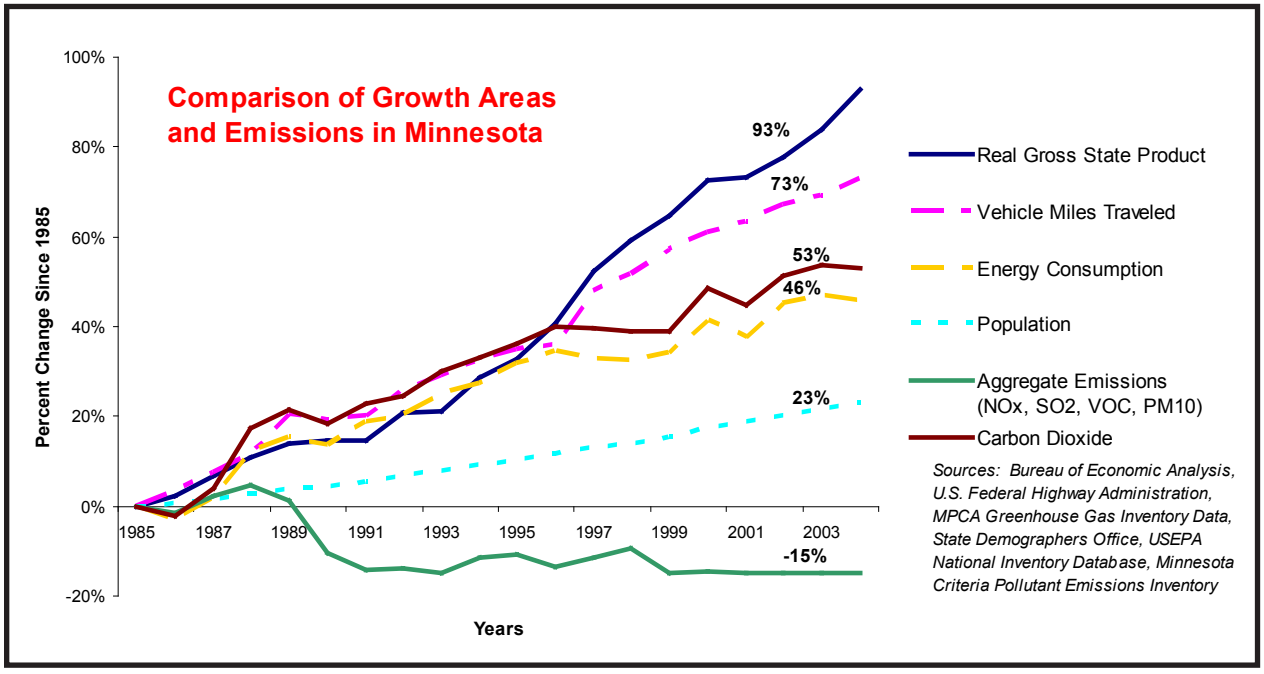

Figure E1. Trends in Minnesota population growth, energy consumption, vehicle miles traveled, and greenhouse gas emissions. Credit: Laura Schmitt Olabisi, UM Sustainability Initiative; MPCA.

strategies for significant conservation of fossil fuel sources in parallel with increased renewable energy production.

Minnesota has been very proactive in trying to develop strategies to combat climate change and promote renewable energy resources for electricity and transportation. Governor Pawlenty signed the Next Generation Energy Act in May 2007 to promote energy conservation, community-based energy development, and GHG reduction. Another outcome of this act was the establishment of a NextGen Board to develop bioenergy and biofuel policies and recommendations. Recommendations of the NextGen Board (MDA, 2008) were reviewed by the SCPP energy and mercury team. Some of the recommendations here are nearly identical with the NextGen Energy Board recommendations (e.g., improving energy and water-use efficiency in biofuel production). Most are complementary, and focus on mitigating impacts of renewable energy production on the environment.

Associated as well with the Next Generation Energy Act was the formation of a Minnesota Climate Change Advisory Group (MCCAG). MCCAG was asked to develop policy recommendations to reduce or sequester GHGs. MCCAG developed recommendations to reduce GHG emissions by 470 million tons by 2025 through changes in agricultural, forestry, and waste management; through residential, commercial, and industrial nonelectricity supply; through energy supply; through transportation and land use; and through cross-cutting or integrated strategies. Again, the SCPP energy and mercury team reviewed the MCCAG recommendations (Center for Climate Strategies, 2008). Some of our recommendations are nearly identical with MCCAG's recommendations (e.g., expanded use of biomass feedstocks for electricity), while others are complementary.

In 2003 the Minnesota Legislature asked the Legislative Electric Energy Task Force (LEETF) to develop recommendations (LEETF, 2005) concerning potential wind electric energy resources. Some energy and mercury team recommendations are very consistent with LEETF's recommendations, (e.g., develop

mechanisms for better coordination of government efforts on renewable energy impacts). In contrast to the LEETF recommendations, the energy and mercury team's recommendations are less focused on wind energy sources, and more focused on biomass energy sources.

Given this context, the energy and mercury team has developed 25 recommendations for the SCPP that embody the following goals:

- Promote renewable energy production strategies that reduce reliance on fossil fuel consumption and create environmental cobenefits
- Promote a healthy economy based on renewable energy production strategies and environmental protection
- Promote efforts to conserve energy and improve energy use efficiency
- Promote strategies for significant reductions in mercury deposition

Trends

Energy Consumption

Over the last decade, Minnesota's population has increased by 23% (see Figure E1). The Twin Cities metropolitan area has expanded rapidly during this period, and people now commonly commute 20 or more minutes from home to work. Vehicle miles traveled (VMT) have increased 73%, leading to greater consumption of gasoline in motor vehicles. Overall, energy consumption in Minnesota has increased 46%, while CO_2 emissions have increased 53%.

Electricity Consumption

Electricity demand in Minnesota will climb exponentially in the coming decades if current growth continues (see Figure E1). Under the Renewable Energy Standards, an increasing portion of this electricity will come from renewable sources. Wind, solar, and deep geothermal energy would be best able to meet this growing demand with minimal impacts on the state's land resources. Wind is already deployed on a widespread basis in Minnesota, but further research and technological development are needed to overcome storage and intermittency concerns as a greater percentage of the state's electricity is generated with wind. More research is required on solar and deep geothermal energy sources to determine their potential for implementation and to overcome technological constraints. In some regions of Minnesota, municipal solid waste or waste streams from paper production, timber processing, or animal husbandry may play a role in renewable electricity production. Exclusive reliance on perennial crops to produce electricity would strain the state's land resources and would compete with agricultural land for the production of food, feed, and ethanol.

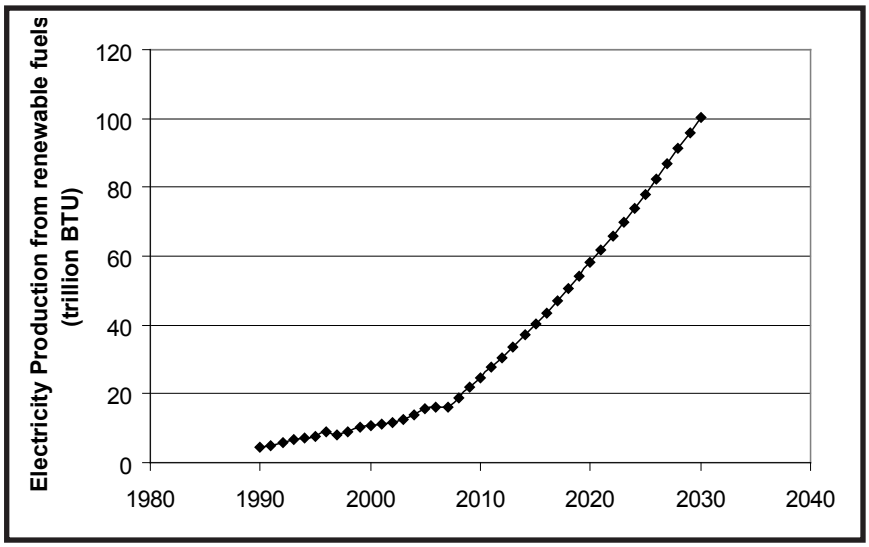

Figure E2. Historical and projected electricity production from renewable sources. Historical data from MPCA/Electric Power annual; future projections based on projected Minnesota electricity consumption and Minnesota Renewable Energy Standards. Credit: Laura Schmitt Olabisi, UM Sustainability Initiative.

Country	Consumption (MBtu/p)
Canada	436
Denmark	153
Finland	241.5
France	181.5
Germany	176
Italy	138.9
Japan	177
Norway	455.7
Russia	212
Spain	163.3
Sweden	259.9
United States	340.5

Table E1. Per capita energy consumption by country for 2005. Credit: EIA (www.eia.doe.gov/emeu/international/energyconsumption.html).

Energy Conservation

There is significant potential to reduce the energy consumption of the state by taking actions on industrial, commercial, and consumer levels. Study of usage patterns abroad indicates that the energy consumption per capita is very high in the United States compared to other industrial nations. In 2006, the U.S. per capita energy consumption was estimated to be 334 million HBtu per person, a slight improvement from 2005. The comparative consumption numbers for various industrialized countries is shown in Table E1. For Minnesota, the comparable number was 362.2 MBtu per capita.

Many industrialized countries have been significantly more aggressive in reducing the energy used by all sectors of their economy by establishing reuse and recycling practices for municipal waste that recaptures a significant portion of the energy content of this material for production of energy or for conversion into new manufactured products. Japan and Germany have established policies that try to maximize the benefit waste capture and have sound conservation practices. Germany's other European neighbors have also focused on improved conservation as a key energy policy. Additional conservation policies encourage the use of optimized architectural design practices for building construction that incorporate energy use optimization for both commercial and residential construction. Extensive use of shallow geothermal heating practices is being practiced in Germany for both commercial and new residential construction and in retrofitting existing commercial buildings where possible. In Japan and Germany, there is also a key emphasis on recovering the energy from waste heat sources from industrial operations in order to produce power and steam. Some cities also have instituted district steam heating practices to take advantage of combined heat and power situations.

On a consumer scale, energy can be conserved through adoption of energy efficient lighting, heating, and building materials. One notable example for building materials is the incorporation of encapsulated paraffin wax nodules in wallboard. The capsules soak up inside heat during the day and release it at night to help reduce air conditioning and heating requirements.

Waste recycling is also extensively used in Japan and Germany, as well as other European Union countries. Recycling programs maximize the reuse of materials in manufacturing products, reducing the need for new material. Alternatively, the materials energy value may be extracted from waste materials before they are landfilled. Some key recommendations are made for Minnesota to help the state reduce its energy consumption through improved conservation practices.

The capture and reuse of waste heat from the state's power and industrial sector should be encouraged. Technologies now exist (e.g., organic rankine cycle [ORC] engines and Kalina engines) for using low-temperature heat and directly converting this energy source to electrical power. The adoption of these recapture technologies could facilitate the amount of

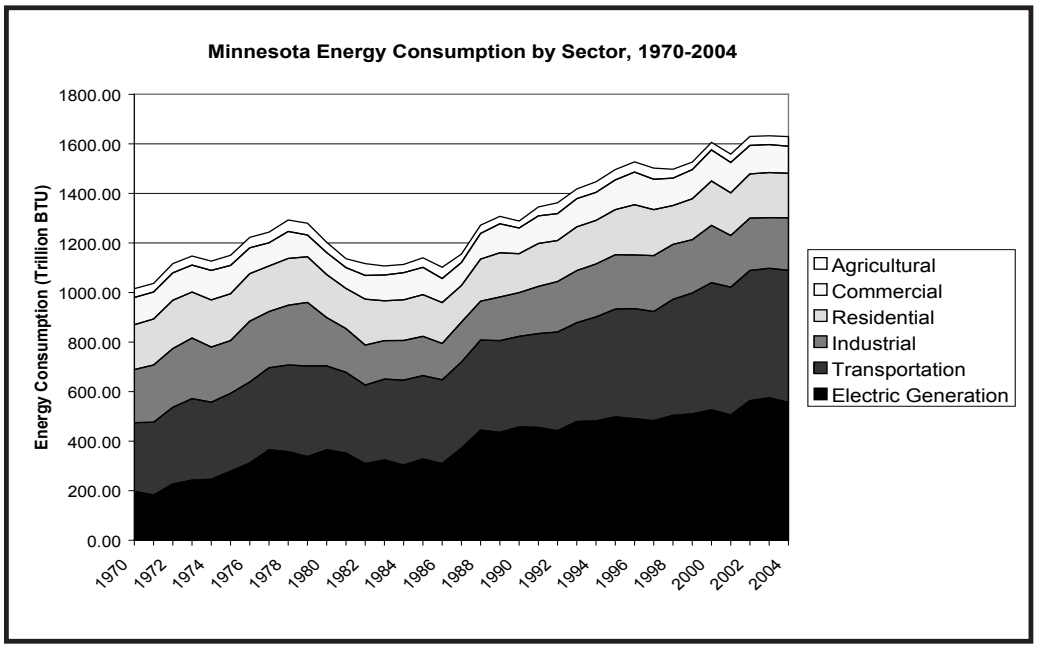

Figure E3. Energy consumption in Minnesota by economic sector, 1970–2004.
Credit: Laura Schmitt Olabisi, UM Sustainability Initiative; MPCA and Minnesota Utility Data Book.

electrical energy generation that could be attained from alternative, low GHG energy sources and also help meet the conservation mandates for industrial consumers that are outlined in existing Minnesota statutes on future electrical power generation.

Vehicle travel is responsible for one-third of Minnesota's energy consumption and GHG emissions (See Figure E3). Individuals can make choices to reduce energy demand for transportation by driving at lower highway speeds; commuting to work by bicycle, foot, or mass transit; and choosing to live close to where they work and shop. Programs designed to educate and raise awareness of carbon footprint, as described in one of the recommendations below, can help to inform individual choices.

Wind Potential

Wind energy potential in Minnesota is greatest in the southwestern portion of the state (see Figure E4). The south, southeast, west, and northwest regions also show high wind energy potential. Central, eastern, and northeastern Minnesota (except Minnesota areas of Lake Superior) show much lower wind speeds resulting in the lowest potential. It is also important to note that wind speed and energy potential increase with turbine height. Minnesota currently produces 1,300 MW of wind energy, with another 47 MW anticipated from current construction projects.

Of all the renewable energy sources in the state, wind generation potentially has the lowest overall impact on natural resources. No water is required for cooling in wind production, no GHGs are generated during the operations phase, and land requirements are relatively small. The largest barriers to increased wind produc-

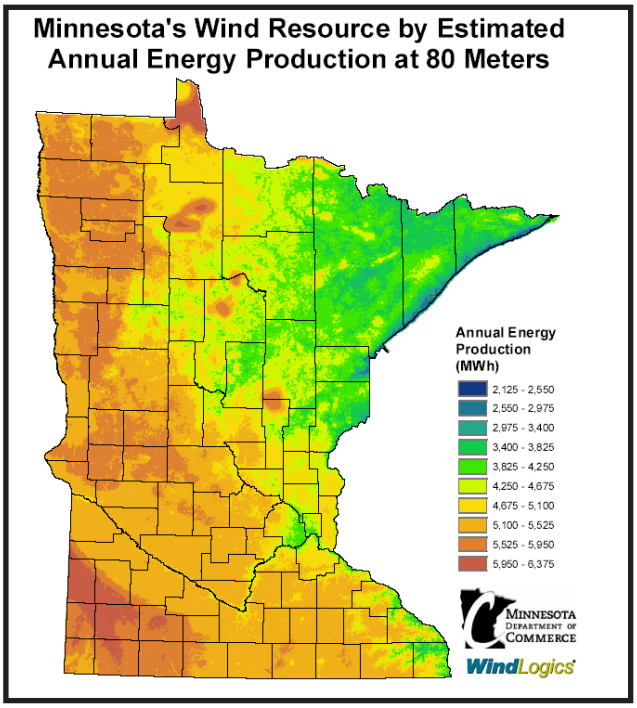

Figure E4. Minnesota's wind resource potential.
Credit: Minnesota Department of Commerce and WindLogics.

tion include storage needs (storage technologies, including various battery designs, currently exist but may be prohibitively expensive) and transmission.

Wind turbine design and layout are important aspects of wind farm planning due to the differential impacts of the various designs on wind power and avian mortality. Wind power is affected by factors such as location, tower height, lattice or tubular tower, and tower alignment. The tubular tower design is most commonly used for today's wind farms; this design is simple and reduces areas where birds can perch and nest. It is also important to correctly determine where the wind farm will be located. There is a consensus in the literature that a preconstruction study should be done to determine if there are any important avian considerations near the construction site that would call for different design and construction techniques. For example, if the project is near a large nesting habitat for a certain bird species, construction should be put on hold during important breeding periods.

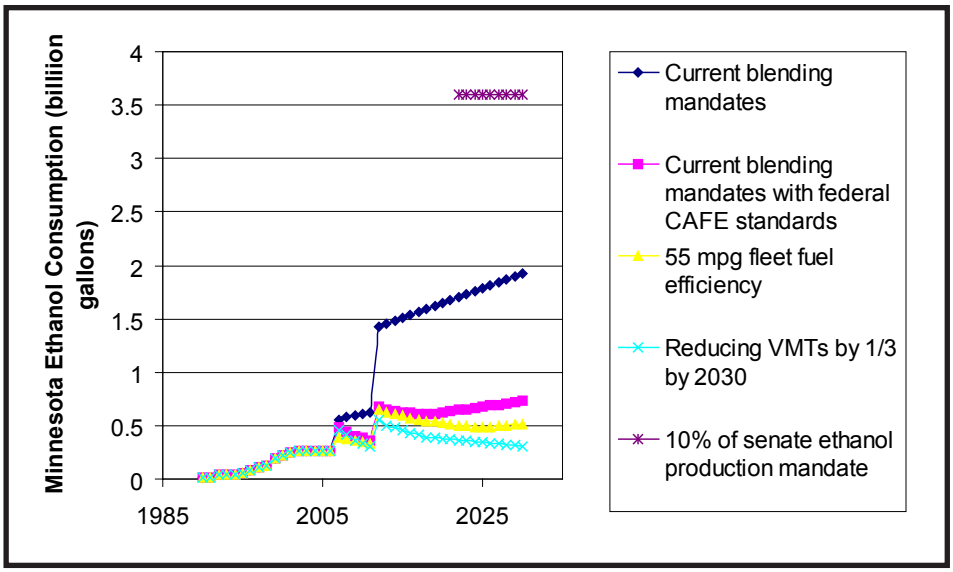

Figure E5. Historical and projected Minnesota ethanol production under a variety of future scenarios. Most of Minnesota's future ethanol production is likely to be exported. Future projections based on Minnesota vehicle miles traveled, current and future blending mandates, and recently enacted CAFE standards. Credit: Laura Schmitt Olabisi, UM Sustainability Initiative; MDA.

There is also a potential for using small wind turbine generation systems to help reduce local power requirements on a distributed basis where local wind conditions are favorable. The County Building in Duluth has installed six small turbines on the roof of the building that will provide a substantial amount of the electrical energy required for the building operation. The use of distributed, smaller-scale systems should be explored for locations that have good wind conditions. Many tall municipal structures may be good candidates for this type of application.

Another important consideration for wind and other renewable energy sources is the role they might play in the transportation sector. One of the recommendations in this section is to encourage a partial transition of Minnesota's vehicle fleet to electric power generated from wind, solar, or geothermal sources. This will have the benefit of reducing state GHG emissions, while alleviating pressure on the land resource to produce both food and fuel.

Biofuel Potential

Minnesota's population is expected to grow by an additional million people in the next two decades. A number of different policy options are available to mitigate the impact of this population growth on consumption of fossil fuels for transportation. Minnesota's demand for ethanol currently is 263 million gallons per year. With current ethanol blending mandates (10%, increasing to 20% by 2012) and anticipated increases in population and VMT, Minnesota vehicles will consume roughly 2 billion gallons of ethanol by 2025 (Figure E5). If corporate average fuel efficiency (CAFE) standards of 35 mpg are fully implemented by 2020, Minnesota's ethanol

consumption will rise to roughly 750 million gallons. If fleet fuel efficiencies of 55 mpg are reached, ethanol consumption in 2030 would increase only slightly above current consumption. If VMT are reduced by one-third, ethanol consumption by Minnesota vehicles would be stabilized at roughly 300 million gallons per year. Regardless of changes in fuel efficiencies or vehicle miles traveled in Minnesota, Minnesota's ethanol production is likely to be strongly influenced by national trends, since Minnesota is a net ethanol exporter. The Federal Energy Policy Act of 2007 mandates 36 billion gallons of ethanol production. Minnesota currently produces roughly 10% of the nation's ethanol. Assuming that this trend continues, by 2025 Minnesota will produce roughly 3.6 billion gallons of ethanol, most of which will be exported from the state.

Minnesota has significant potential to produce ethanol from renewable resources. At present, these resources include corn grain, sugar beets, aspen trees, softwood timber, and smaller amounts of other resources. Future resources for ethanol production on agricultural cropland include high- input monocultures of row crops, monocultures of perennial crops, and low-input polycultures of perennial crops.

High-input monocultures of row crops would be based primarily on corn grain and corn stover in a corn-soybean or corn-corn-soybean rotation. Minnesota currently produces 2.2 billion bushels of corn grain and over 5 million tons of corn stover. If cellulosic ethanol production techniques become economically feasible, this stover could potentially produce 3.8 billion gallons of ethanol, compared to a potential ethanol production from corn grain of 6.3 billion gallons. These estimates assume that all of the corn grain and stover production in Minnesota would be used for ethanol, an extremely unlikely scenario.

Monocultures of perennial crops could include plantings of alfalfa, switchgrass, miscanthus, hybrid poplar, or willow. Research at the University of Minnesota (UM) Southern Research and Outreach Center across a wide range of soils and landscapes has shown that alfalfa produced 7.2 tons/ac, and switchgrass produced 2.7 tons/ac. In comparison, 3.3 tons/ac of corn stover were produced in the same experiment. More research is needed to optimize all aspects of production management for these crops.

Research at the UM Natural Resources Research Institute (NRRI) has shown a large potential for producing cellulosic ethanol from forest biomass (See Table E2). Hybrid poplar plantations have the potential to produce approximately 5 tons/ac based on the current best clone materials. Potential sources of forest biomass for

Biomass Source	**Current (t/yr)**	**Near Term Achievable (t/yr)**	**Future Potential (t/yr)**	**Notes**
Roundwood	0	1,495,000	1,495,000	Current: 3.7 M cord harvest; future: 5.5 M cord harvest
Harvest Residues	750,000	1,155,000	1,155,000	
Red Pine	184,000	310,500	409,400	
Aspen Thinning	0	0	1,000,000	100,000 acres@ 10t/ac
Brushlands	0	400,000	400,000	
Energy Crops	0	0	5,600,000	3.5 t/ac/t yield, 1.6 M ac
Total	***934,000***	***3,360,500***	***10,059,400***	

Table E2. Summary of woody biomass resources. Credit: William Berguson, NRRI.

ethanol production include thinning of aspens and red pines, roundwood, harvest residue from logging operations, brushlands harvesting, and energy crop development based on woody biomass (e.g., hybrid poplar). The estimated biomass availability for the future from these sources is 10 million dry tons. These sources have the potential to produce 0.5 to 1 billion gallons of ethanol.

Polycultures of perennial crops are most commonly assumed to be represented by mixtures of native prairie grasses and legumes. These crops have the advantage of not requiring heavy inputs of fertilizer or pesticides, but they have the disadvantage of not producing as much biomass as monocultures of perennial crops that receive fertilizer and pesticides.

The use of biomass for commercial and residential heating applications is a growth industry in Europe and is starting to take off in various parts of the United States. In this case, pelletized wood and other biomass products are being converted to pellets and used in specially designed wood burner systems to provide the heat for the structure using the technology. In Europe, the logistics of pellet movement are handled by bulk trucks that move the pellets from the pellet plant to the consumer on a contract basis. In Minnesota, pellet production and furnace sales have already begun and in some situations, Minnesota wood is being pelletized and shipped to Europe for use in this type of heating system. The current costs for propane and fuel oil are high enough to allow conversion to a pellet fuel system with a reasonable payback for the consumer. As the price for other fuels continues to escalate, the biomass pellet heating systems may become even more attractive for other heating situations as well.

Biomass fuels are also finding increasing use as a natural gas and coal substitute in industrial applications. The Minnesota taconite industry now routinely substitutes various biomass materials for the natural gas commonly used in pellet induration kilns. In addition, Laurentian Energy in Hibbing and Virginia, Minnesota, is now routinely using biomass in combination with coal to generate significant amounts of electricity in northern St. Louis County. Minnesota Power at its Hibbard plant is fully fueled by biomass from a variety of sources. This plant produces the steam used by the local paper plant located in Duluth. Other examples of using biomass to produce electricity and fossil-fuel substitutes can be found throughout the state.

Other Renewable Sources

The potential for using solar and geothermal energy in Minnesota has not yet been thoroughly explored. Geothermal energy may be divided into two types: shallow and deep. Shallow geothermal applications already exist in Minnesota, and are typically used to mitigate heating needs in winter and cooling needs in summer. Deep geothermal power can potentially supply both electricity and heat, but more research is needed to determine whether this is a viable option in Minnesota. Passive solar systems (which use the sun's energy without mechanical devices) also seem to have significant potential for use in Minnesota for heating and cooling of both residential and commercial structures. While photovoltaic solar panels remain prohibitively expensive compared to wind turbines and are not likely to generate a significant portion of Minnesota's electricity in the coming decade, they may be appropriate for rooftop use. Shallow geothermal and passive solar heating systems for heating and cooling should be encouraged due to their low environmental and GHG footprints. Specific recommendations on the use of these technologies as well as the potential for establishing the utility of deep geothermal heat recovery are contained in this report.

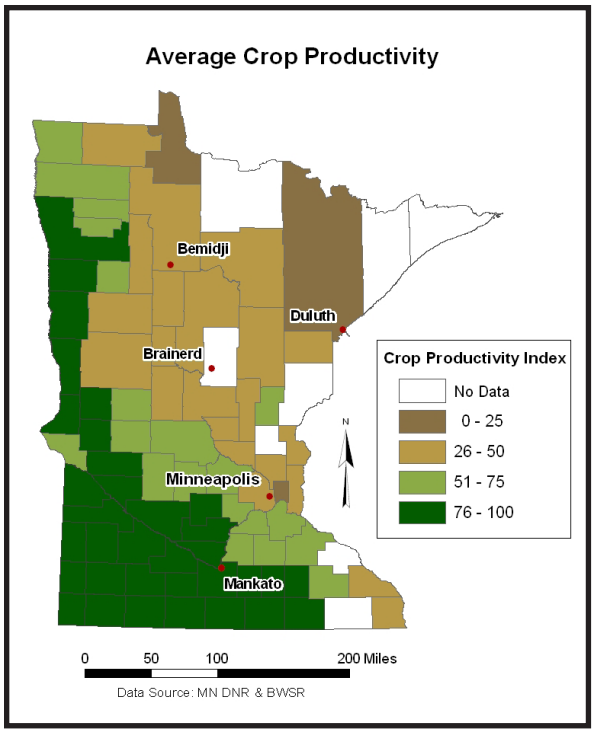

Figure E6. Average soil-based crop productivity index values for Minnesota counties. Crop biomass production potential increases as the value of the index increases. Credit: Aaron Spence, BWSR; Joel Nelson, David Mulla, UM; data from USDA-NRCS and BWSR.

Soil Productivity

Minnesota has a wide array of soil types. Seven soil orders occur, including Mollisols (32% of land area), Alfisols (27%) and Entisols (18%). Mollisols are the most productive, with deep topsoil and high organic matter content formed under prairie grassland. Alfisols are shallower, less productive soils formed under forest. Entisols are sandy soils without well-formed soil horizons.

The suitability of Minnesota soils for crop and biofuel production depends on a number of factors including available water capacity, bulk density, and pH. These factors have been used by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) and the Board of Water and Soil Resources (BWSR) to develop a soil crop productivity index for Minnesota. Soil productivity (Figure E6) ranges from 0 to 100, with 100 being the most productive soils in the state and 0 being the least productive soils (bedrock). The most productive soils are located in the southern and southwestern portions of the state. The effects of these differences in soil productivity across Minnesota's diverse landscapes have not yet been accounted for in estimating biofuel production potentials for different regions of the state.

Commodity Prices and Crop Acreage Changes

From 2005 to 2007, the price of corn doubled from $2 to $4 per bushel. Wheat increased from $3.42 to $6.65 per bushel. Soybeans increased from $5.66 to $10.40 per bushel. Increasing prices for commodities are due to a combination of factors, including speculation, prices of oil, drought, decreasing power of the U.S. dollar, and increasing demand for corn-based ethanol. Over the same time frame, oil prices increased from $50 to $64 per barrel, and prices surpassed $130 per barrel in 2008.

In response to steep increases in the price of corn, Minnesota producers planted nearly 1.1 million more acres of corn in 2007 than in 2006 (Figure E7). This is a 15% increase in corn acreage, which was accompanied by increases in the application of fossil fuel–based fertilizer and crop protection products. Nearly all of this corn planting occurred on land that was planted to soybeans in 2006. Despite the large increases in corn acreage, corn production only increased by 3% between 2006 and 2007. This was largely due to an extensive drought that affected central Minnesota in 2007; of lesser importance is that some of the areas with the largest increases in corn planting are also lower productivity soils. Increases in corn-planting acreage were not uniformly distributed across the state. The largest increases in acreage occurred in the west-central, central, south-central, and northwestern portions of the

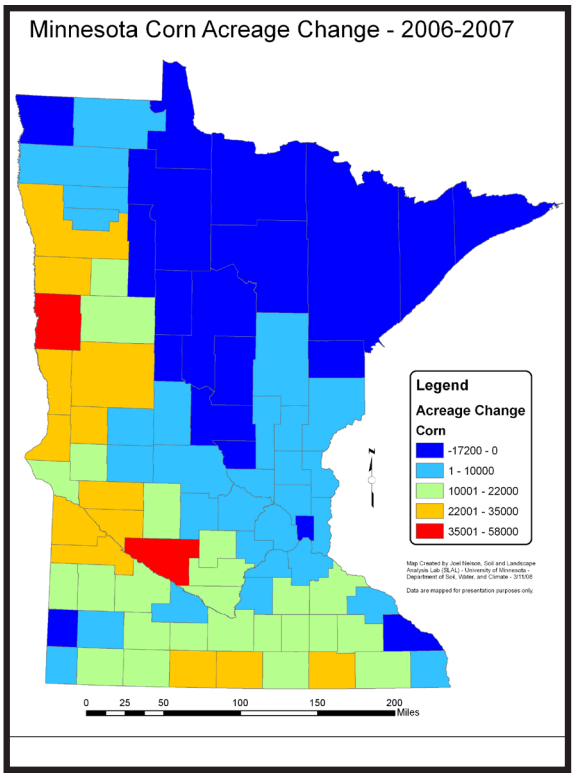

Figure E7. Change in Minnesota corn acreage between 2006 and 2007. Credit: Joel Nelson, David Mulla, UM, from USDA-NASS data.

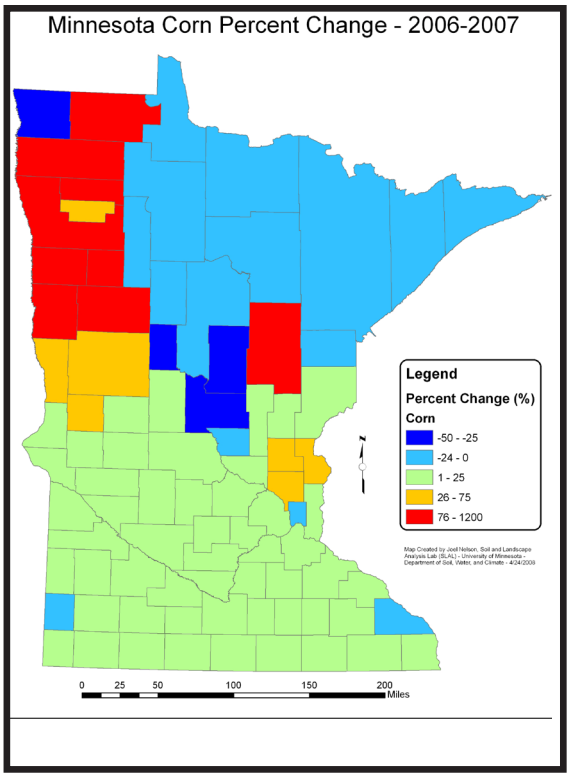

Figure E8. Percent change in Minnesota corn acreage between 2006 and 2007. Credit: Joel Nelson, David Mulla, UM, from USDA-NASS data.

state. The largest increases as a percent of corn acreage in 2006 occurred in the Red River of the North basin (Figure E8).

Environmental Impacts of Renewable Energy Production

Erosion Rates for Different Land Use Practices

Minnesota has a variety of climatic regions, soil types, cropping systems and agricultural management practices. All of these factors affect rates of wind and water erosion. Based on USDA Natural Resources Inventory (NRI) data, rates of wind and water erosion are greatest on cultivated cropland. Water erosion on cultivated cropland averages 2.1 tons per acre per year (See Figure E9), while wind erosion averages 4.3 tons per acre per year (See Figure E10). Rates of water erosion on pasture and Conservation Reserve Program (CRP) land average 0.25 and 0.22 tons per acre per year, respectively, much lower than rates of water erosion on cultivated cropland. Rates of wind erosion on pasture and CRP land average 0.15 and 0.08 tons per acre per year, respectively, much lower than rates of wind erosion on cultivated cropland. These results suggest that biofuel production strategies that favor perennial grasses rather than cultivated row crops will lead to large reductions in rates of wind and water erosion.

One of the concerns over use of corn stover for ethanol production is that removing corn stover increases the potential for soil erosion. Erosion rates by water are strongly affected by the percent of soil surface that is protected by living or dead (residue) vegetation. As rates of erosion increase, there is an increased potential for polluting nearby streams, rivers, and lakes with sediment and associated nutrients and

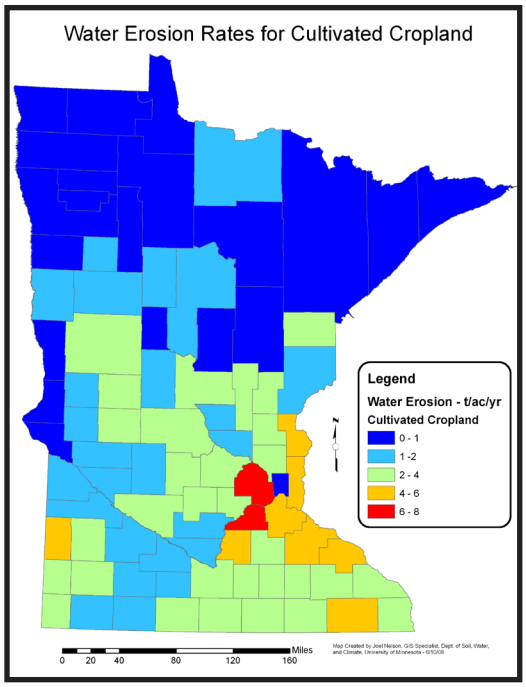

Figure E9. Water erosion rates for cultivated cropland in Minnesota. Credit: Joel Nelson, David Mulla, UM, from USDA-NRI data.

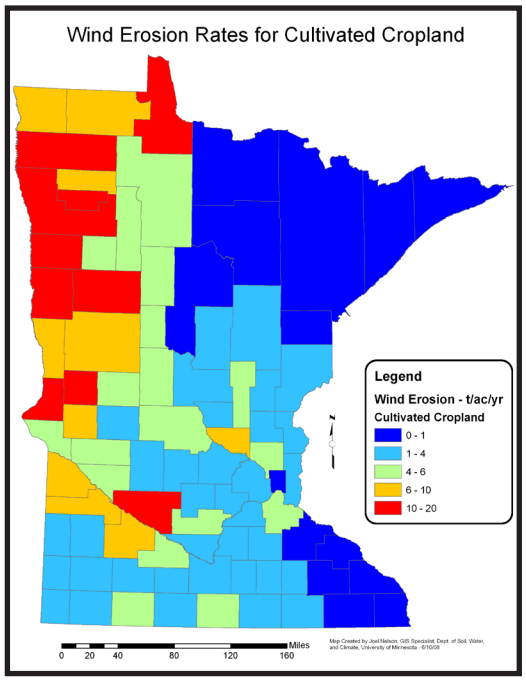

Figure E10. Wind erosion rates for cultivated cropland in Minnesota. Credit: Joel Nelson, David Mulla, UM, from USDA-NRI data.

pesticides that are bound to sediment. A modeling study currently being conducted by the University of Minnesota in the Le Sueur River watershed in the Minnesota River basin was used to evaluate the impacts of various rates of corn stover removal on delivery of sediment to streams by water erosion. The Le Sueur River is classified as an impaired water body for sediment, and roughly 30% of the sediment arises from upland agricultural sources. Results showed that with no corn residue removal and a corn-soybean rotation, the average amount of sediment delivered to the Le Sueur River was about 1 tons per acre per year. In contrast, if 60% of the corn residue was removed for cellulosic ethanol production, roughly 1.6 tons per acre per year of sediment was delivered to the river. These results clearly show the need for additional erosion control practices (such as riparian buffer strips or cover crops) under situations where corn residue is removed for ethanol production.

Carbon Sequestration

Another concern with removal of corn stover is the potential impact on soil organic carbon content. Stover contains carbon and nutrients that are returned to the soil over time by natural decomposition. These inputs of carbon and nutrients help maintain soil organic carbon and fertility. Research is underway at many locations in the Midwestern United States to estimate how much crop residue should be retained on the soil in order to maintain soil organic carbon. Results indicate that more crop residue has to be retained in order to maintain soil organic carbon than the amount that needs to be retained to control water erosion (Wilhelm et al., 2007). Roughly twice as much residue can be removed in a no-till continuous corn cropping system without affecting soil organic carbon than in a moldboard-plowed corn-soybean rotation.

Global climate change is partially driven by increasing amounts of CO_2 emitted to the atmosphere by burning fossil fuels. One of the reasons given for

promoting energy production from biomass sources is the increased potential for sequestering CO_2 from the atmosphere. Perennial crops sequester more carbon than annual row crops. A recent report by the UM for the DNR (UM, 2008) suggests that converting row crops to short rotation woody tree crops (such as hybrid poplar) would sequester nearly 2 tons of carbon per year. In contrast, converting row crops to perennial grasses would only sequester about 0.4 tons carbon per year. Adding cover crops to annual row crop systems would sequester 0.2 tons carbon per year, while converting conventional row crops to conservation tillage row cropping would sequester only 0.1 tons carbon per year. These results suggest that producing cellulosic ethanol from perennial tree crops would sequester more atmospheric carbon than any other production technique.

Pesticides

Any expansion of corn acreage for ethanol production increases the risk of polluting surface and ground water resources with pesticides. The two pesticides most commonly applied to corn for control of weeds are acetochlor and atrazine. Some counties in southern Minnesota receive as much as 145,000 pounds of acetochlor and 70,000 pounds of atrazine applications annually, although per area rates of application are typically 2 pounds per acre or less.

The UM, working in partnership with the Minnesota Department of Agriculture, recently conducted a study to evaluate the risk of ground- water contamination in Minnesota from acetochlor and atrazine. Small regions throughout the state of coarse-textured soil and sediments were identified as having a high leaching potential. These regions were superimposed on maps showing the areas of the state that experienced large increases in the acreage of corn plantings between 2006 and 2007. An evaluation of the resulting maps indicate that for acetochlor (Figure E11), the areas of increased corn plantings did not generally occur in regions with a high risk for ground-water contamination by acetochlor. For atrazine, however, many areas of increased corn plantings were highly susceptible to ground-water

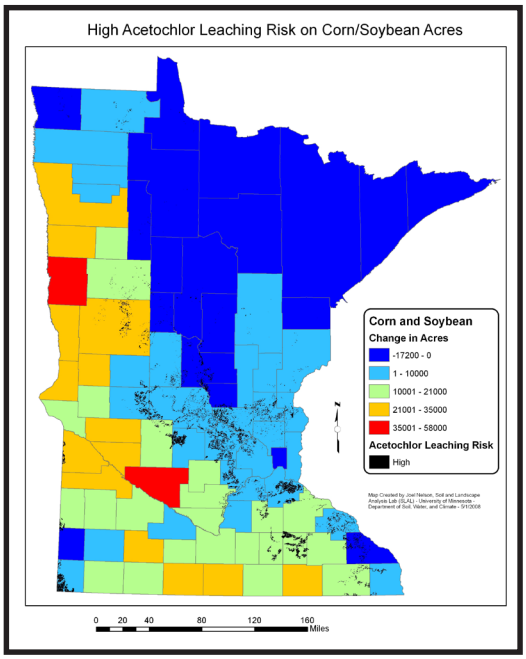

Figure E11. Areas of high acetochlor leaching risk on Minnesota corn-soybean land. Credit: Soloman Folle, Joel Nelson, David Mulla, UM.

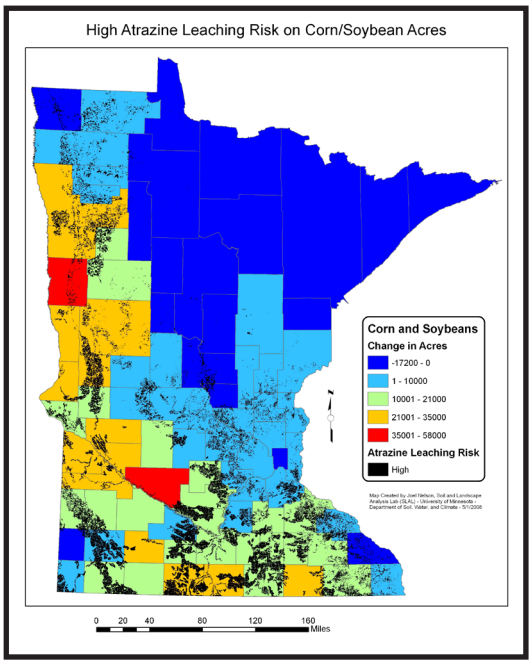

Figure E12. Areas of high atrazine leaching risk on Minnesota corn-soybean land. Credit: Soloman Folle, Joel Nelson, David Mulla, UM.

contamination (Figure E12). Thus, the increased corn plantings in 2007 had a much higher risk for contaminating ground water with atrazine than with acetochlor.

Conservation Reserve Program Land

Rising commodity prices have increased the likelihood that Minnesota producers will expand crop production into areas that have been protected by federal and state conservation programs such as CRP. CRP pays farmers to enroll their least productive and most environmentally sensitive land in practices that reduce erosion and improve wildlife habitat. Minnesota currently has roughly 1.7 million acres of land enrolled in CRP. CRP acreage is heavily concentrated in the Red River of the North basin and other portions of western Minnesota (Figure E13). These are areas that experienced large increases in corn planting between 2006 and 2007. Thus, there is a risk that as commodity prices increase, producers in the Red River basin and other portions of western Minnesota will plant their CRP land to agricultural crops when their contracts expire.

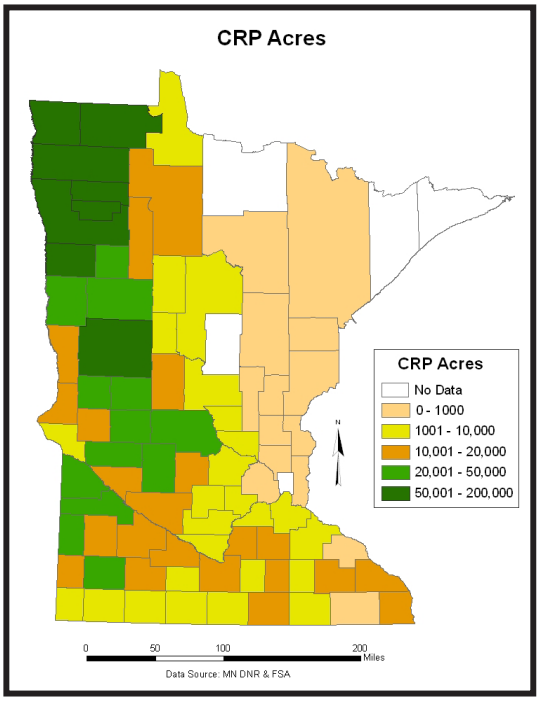

Figure E13. CRP acres in Minnesota. Credit: Joel Nelson, David Mulla, UM, using data from USDA.

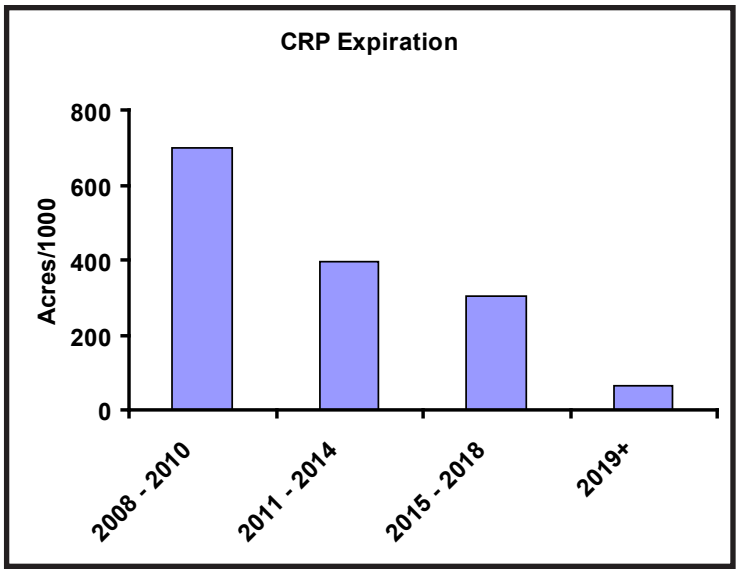

Figure E14. Acres of Minnesota CRP land with contracts expiring in different time intervals. Credit: Joel Nelson, David Mulla, UM, using data from USDA.

Contracts on large amounts of CRP land are going to expire in the next 10 years (Figure E14). From 2008 to 2010, nearly 700,000 acres of CRP land will retire. From 2011 to 2014, 400,000 acres will expire. From 2015 to 2018, 300,000 acres will expire. These lands are environmentally sensitive and provide valuable wildlife habitat. Measures are needed to ensure that expiring CRP lands are either re-enrolled or are used for perennial crop production to the greatest extent possible.

There is a significant potential for production of biofuel crops on Minnesota's expiring CRP lands. If all of Minnesota's CRP land were planted with switchgrass or hybrid poplar, and these crops produced 3 tons/ac of biomass, roughly 3.5 billion gallons of ethanol could be produced using cellulosic technology. However, it is not realistic to project that all of Minnesota's CRP land will be planted with biofuel crops, because some of the CRP lands may be re-enrolled after they expire. It is likely that only the most productive CRP lands will be taken out of retire-

ment and planted with economic crops. Analysis of CRP lands (Figure E15) shows that 51% (900,000 acres) have a soil crop productivity index between 75 and 100 (average 86). A significant proportion of these lands have a high likelihood of being planted with economic crops after their contracts expire. Roughly 23% (400,000 acres) of CRP land has a soil crop productivity index between 50 and 75 (average 64). It would not make economic sense for producers to plant most of this land with economic crops. The remaining CRP acreage (25%, 440,000 acres) has a soil crop productivity index lower than 50, and is very likely to be re-enrolled when it expires.

Consumptive Use of Water

Minnesota cities and industries use roughly 339 billion gallons of ground water (Suh, 200X). In contrast, Minnesota's ethanol industry currently uses 2.9 billion gallons of water in the production process. Ground water supplies 96% of this consumptive use. There is concern that this rate of groundwater pumping will deplete aquifers that are used for public drinking supplies or will dry up streams fed by ground-water discharge. Research is underway to evaluate these potential problems, and more research is warranted to understand how regional ground-water supply and demand are related. Research is also needed to improve the water use efficiency of ethanol plants. Current ethanol plants use roughly 4 gallons of water for every gallon of ethanol produced. It is projected that cellulosic ethanol plants may use as much as 6 gallons of water per gallon of ethanol produced. As cellulosic ethanol production expands, ground- water supplies must be adequate to support the increased demand without affecting other uses and demands.

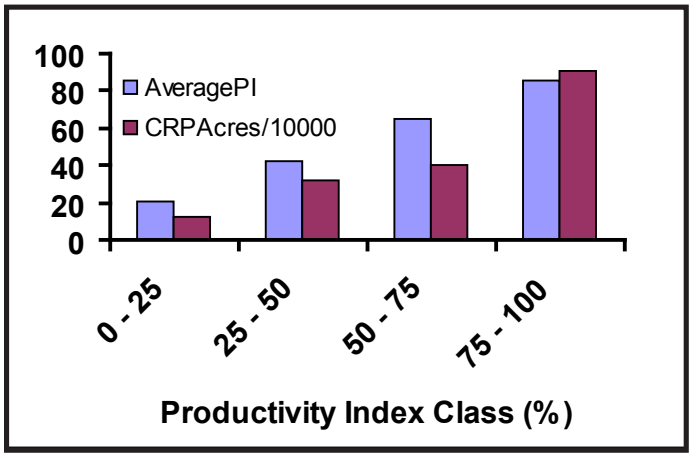

Figure E15. Average soil-based crop productivity index and acres of expiring CRP land for four crop productivity index classes. Crop biomass production potential increases as the crop productivity index increases. Credit: Joel Nelson, David Mulla, UM.

Mercury Pollution

Mercury deposition in Minnesota is responsible for extensive pollution of streams, rivers, and lakes, leading to widespread fish consumption advisories. In a state that values water and fish, mercury is a leading cause of impaired waters. Roughly 1,892 reaches of water are classified as impaired in Minnesota, and 66% of these are for mercury.

According to the Minnesota Pollution Control Agency (MPCA), mercury deposition in Minnesota was over 11,000 pounds per year in 1990. By 2005, mercury deposition in Minnesota decreased to 3,300 pounds per year. Mercury arises primarily (70%) from anthropogenic sources, and 90% of the mercury deposition in Minnesota arises from sources outside Minnesota. Minnesota's 10% share of mercury deposition arises mostly (56%) from electrical production plants that burn coal, while 22% is from processing of taconite ore.

In 1999, Minnesota's electrical utility plants voluntarily agreed to reduce annual mercury emissions by 275 pounds per year. In 2006, the Mercury Reduction Act was signed to obtain a 90% reduction in emissions of mercury from Minnesota's electrical production plants. The goal of this act is to cap mercury emissions from Minnesota coal-burning plants at 789 pounds per year by 2018. Taconite-processing plants are considering a proposal to reduce their mercury emissions by 50% in 2025. There is also the

potential to substitute biomass for fossil fuel in both coal-burning and taconite- processing plants in order to reduce emissions of mercury.

The impacts of these mercury reduction strategies on concentration of mercury in fish are negligible. For example, the average mercury concentration in northern pike during 1990 was 0.248 parts per million (ppm). The projected concentration of mercury in northern pike after full implementation of the Mercury Reduction Act in 2018 is expected to be 0.228 ppm. If mercury emissions from outside Minnesota were reduced by 50%, mercury concentrations in northern pike would drop to 0.190 ppm. These projections show the importance of promoting policies that reduce mercury emissions from coal-burning plants in regions that border Minnesota.

Drivers of Change

The 25 recommendations from the energy and mercury team are intended to promote:

- Renewable energy production strategies that reduce reliance on fossil-fuel consumption and protect the environment
- A healthy economy based on renewable energy production strategies and environmental protection
- Efforts to conserve energy and improve energy use efficiency
- Strategies for significant reductions in mercury deposition

Each recommendation addresses a different driver of environmental change. Figure 4 in the introduction summarizes the potential impact of each recommendation.

Recommendations

Goal A

Promote alternative energy production strategies that balance or optimize production of food, feed, fiber, energy and other products with protection or improvement of environmental quality, including:

- water quality and water resource supply
- wildlife habitat
- greenhouse gas emissions
- soil quality and critical landscapes

Energy Recommendation 1: Develop coordinated laws, policies, and procedures for governmental entities to assess renewable energy production impacts on the environment

IP

Develop laws, policies, and procedures for governmental entities to assess and manage the cumulative impacts on the environment of proposed and established energy production facilities, focusing on both individual and combined impacts. Information from this effort should be used to develop a biennial report to the legislature that informs the direction of the statewide conservation planning strategy.

Description of recommended action. Minnesota Statutes 116D.10-.11, require state agencies and the governor to prepare a biennial report to the legislature on efforts to address Minnesota's energy and environmental policies, programs, and needs. This requirement provides an ongoing vehicle within state government for internalizing, integrating, and tracking implementation of recommendations developed by the SCPP. Further, while the SCPP lays much of the foundation for future strategy reports, these reports will need to address other issues and describe how SCPP recommendations fit with them. For example, biofuel production initiatives are one component of a proposed package for meeting state greenhouse gas

emission reduction goals. In addition, they are potentially a significant vehicle for addressing impaired waters. The biennial strategy report must ensure that these efforts complement one another (along with other state goals, such as enhancement of wildlife habitat) and that they are kept on track. This report would integrate information coming out of the permitting process for individual biofuel plants to paint a statewide picture of how energy production in Minnesota impacts state resources.

Two actions are needed. First, the law should be amended to explicitly reference the SCPP and to streamline requirements. Second, strategic investments are required to build state capability to develop biennial assessments and track progress across issues. A third package of actions, those investments needed to follow up on other conservation strategy recommendations, will contribute to the foundation upon which biennial assessments will be based.

Description of impact on natural resources. A vast and diverse array of interrelated initiatives is required to protect Minnesota's environment and meet society's energy demands. Despite the law, no one has taken the initiative to make certain these efforts pull in the same direction and are adequately supported. Progress is not routinely monitored, nor are adjustments considered in a comprehensive manner. By ensuring that the state aggressively follows through on SCPP recommendations, potentially huge benefits should accrue for Minnesota's natural resources. In turn, failure to do so will likely mean spotty, inefficient, and, ultimately, ineffective resource management and protection.

Relationship to existing programs, laws, regulations. This recommendation is consistent with LEETF's recommendation for better government coordination on energy issues. The law governing the biennial energy and environmental strategy report is in place, but needs renewed focus and attention.

Time frame. The state and its conservation plan partners should complete an energy and environmental strategy by October 1, 2009.

Geographical coverage. The strategy is statewide in scope.

Challenges. Funding and staffing may become a barrier if additional support cannot be acquired. Single issue advocacy, politics, and interorganizational competition also pose challenges to successful strategy development.

Energy Recommendation 2: Invest in farm and forest preservation efforts to prevent fragmentation due to development guided by productivity and environmental vulnerability research

L P

Description of recommended action. Farm and forest fragmentation is a serious threat to wildlife habitat and ecosystem biodiversity. Expansion of urban and agricultural areas often produces fragmentation of forests, and urban expansion reduces the land resource available for producing food, feed, fiber, and fuel. Strategies and policies are needed to protect farms and forests, and prevent fragmentation. The 2008 legislature provided a $53,000 grant to the Minnesota Forest Resources Council (MFRC) to match $150,000 in funding from the Blandin Foundation and Iron Range Resources for a study of forest parcelization and development, an assessment of available policy responses, and policy recommendations to the 2010 legislature. The 2007 legislature provided a $40,000 grant to the UM Institute on the Environment that built on earlier MFRC research to assess potential impacts of parcelization and development on wildlife habitat and biodiversity in northern Minnesota. The state should consider recommendations from these studies relative to potential changes in policy or law, and relative to potentially funding specific proposals to prevent forest and farmland fragmentation due to development.

Description of impact on natural resources. Parcelization and development of forests and farmland continues to occur statewide, despite the recent downturn in the housing market and the economy in general. Investments in appropriate policy approaches to reduce adverse impacts of parcelization and subsequent development and habitat fragmentation would result in protection of wildlife habitat, water quality, recreational access, timber availability, and land resources critical to producing food and, increasingly, renewable energy crops.

Relationship to existing programs, laws, regulations. This recommendation is consistent with MCCAG's recommendations AFW-6 and AF-5. The study mentioned above will assess diverse existing programs, laws, and regulations (e.g., fee title ownership of public lands, public land acquisition and exchange, land use planning and zoning, conservation easements, tax policy, technical and financial assistance, education/information/awareness). Policy recommendations will recommend potential changes to some of these programs and laws to reduce adverse impacts of parcelization and subsequent development and fragmentation.

Time frame. Policy recommendations will be made to the 2010 legislature relative to forestland.

Geographical coverage. The area affected by the recommended action is statewide, with particular focus on forested regions of northern, central, and southeastern Minnesota.

Challenges. Continuing development of forestland and farmland is inevitable, and there will be numerous political, institutional, financial, and other barriers to implementing recommended actions to protect these lands. The most significant barriers may be cultural resistance to rural land use planning and financial constraints on public fee title land acquisition and conservation easements.

Energy Recommendation 3: Invest in perennial biofuel and energy crop research and demonstration projects on a landscape scale **S P**

Invest in research and demonstration projects on a landscape scale to evaluate management and harvest techniques and yield potentials for various perennial biofuel crops (including monocultures of perennial grasses or woody biomass and polycultures) on different soils and agroecoregions throughout the state. These research and demonstration projects should accomplish the following goals:

- Improve yields through genetic, fertility, or pest management trials
- Develop best management practices (BMPs) for perennial crops that maximize environmental and wildlife benefits (including water and soil quality, fire and pest reduction, wildlife habitat, and decreased flooding)
- Determine which soils, landscapes, and agroecoregions of the state are best suited to various biofuel crops and are most resilient to climate change
- Study the economic costs, benefits, and barriers and develop strategies for minimizing the economic costs for growers pertaining to the time lag between perennial crop establishment and maturity, and maximizing the economic benefits of biofuel production
- Evaluate biomass resource availability and sustainable production rates by agroecoregion and landscape characteristics under various climate change scenarios

Description of recommended action. Based on nationwide analyses of potential biomass resources done by the U.S. Department of Energy (DOE) and USDA, energy crops are expected to play a major role in development of biomass resources for next-generation biofuels or carbon-neutral electrical generation. Coordinated research and policy experimentation should be carried out to develop and refine renewable energy production systems based on diversified biomass farming that emphasizes perennial

biomass crops. This initiative has great potential to improve environmental quality and support economic revitalization in rural Minnesota, while providing large amounts of biomass for renewable energy and bio-products. Developed properly, diversified biomass farming can help support current production agriculture while enhancing rural economic opportunities, producing locally grown renewable energy, and addressing important statewide water quality and environmental issues. In order to make energy crops a practical reality in the state, work is needed to improve yields through genetics and through identification of the optimal sites and BMPs for these crops. The state should support demonstration projects that bracket the various parts of the state so both yield and environmental questions associated with perennial crop production for given state locations can be ascertained in a timely manner. Existing data generated by the MFRC on forestry issues and county-based agricultural production data developed by the Center for Energy and Environment may be used to determine biomass availability. Opportunities and limitations associated with use of these resources should be identified. The effects of various assumptions about environmental impacts and biomass availability should be analyzed.

To move forward on commercial-scale pilot renewable-energy projects based on diversified biomass farming, it will be necessary to take a comprehensive approach to establish a bio-refining system that integrates production, processing, feedstock conversion/refining, and end-use market applications including but not restricted to energy production. In particular, development of these projects will need to integrate the following elements:

- Public investment to overcome technical and economic risk and establish appropriate infrastructure
- Applied research to troubleshoot technical barriers
- Private investment and development, community support, and shared ownership
- A progressive local and state policy/regulatory framework that provides incentives to reward innovation

Description of impact on natural resources. Diversified biomass farming has potential to be highly multifunctional. This form of farming can function in two ways: first, to produce biomass for energy and other bio-industrial purposes, and also to provide other valuable goods and services, such as control of agricultural pests, improved recreation, hunting and fishing, cleaner water, protection of biodiversity, and protection against destructive flooding. In essence, multiple benefits come from putting the right plants in the right places in farm landscapes. In Minnesota, biomass can be produced from a range of perennial crops that are adapted to many regions of the state and to many different areas in farm landscapes. Biomass cropping options include mixtures of native prairie grasses, fast-growing trees and shrubs such as willows and poplars, and wetland species. The information developed as part of this project is central to planning the development of a renewable energy industry in the state. The research and demonstration projects would identify sources of feedstock available for production of renewable, low-carbon energy and determine the costs and environmental considerations related to using these resources.

Relationship to existing programs, laws, regulations. This recommendation is consistent with MCCAG's recommendation AFW-3 and with NextGen Board's recommendation to conduct technical analysis on the environmental impacts of biofuel production. Energy crop development is ongoing in the state through the work of the NRRI on woody crops (native poplar and hybrids), UM on prairie polymixes, and the USDA and UM on switchgrass. For the most part, these crops have been tested on a limited scale in specific locations in the state and work has not been widespread enough to make recommendations for their widespread application. Research on wildlife impacts of these crops has been done in the

past but not on large plantings and over a sufficient time frame to fully understand potential benefits and impacts. The UM has performed research related to biomass production in forested zones. Also, this project will build on information developed by the Center for Energy and Environment on potential biomass availability across the state.

Time frame. This work would be done over a 10- to 15-year time frame. Development of new genotypes and adequate testing of new genetic material requires a relatively long time. Work on environmental benefits and impacts can be done over 5 years on preexisting sites.

Geographical coverage. The geographic range of this project would include all of Minnesota, including agricultural and forested regions.

Challenges. For farmers, biomass farming must be profitable and economically efficient, and profitability and efficiency will likely depend critically on augmenting income from biomass with payments for a variety of ecological services produced by multifunctional biomass farms (e.g., carbon and nutrient credits).

To meet needs of rural communities and regions, renewable energy production based on agricultural biomass must neither increase nor continue unacceptable economic, environmental, or social effects of current agricultural land use. It is clear that diversified biomass farming has excellent potential to reduce such unacceptable effects, but landscape-scale planning, efforts to retain value in rural communities, and other new management and policy initiatives will be needed to ensure these outcomes. The DNR's Working Lands Initiative is a very promising example of such policy innovation.

More broadly, renewable energy production based on diversified biomass farming has the potential to create significant economic value for many different community and regional stakeholders. These opportunities include production of goods and services such as water-quality protection, wildlife habitat, and carbon storage at relatively low cost; community-based production and use of sustainable renewable energy; development of local value-added supply chains for agricultural products; and creation of new industries that retain wealth in communities through living-wage jobs and local ownership. To build support for development of diversified biomass farming, new policy initiatives will be needed that capitalize on at least some of these opportunities for value creation.

Moreover, development of commercial-scale pilot renewable energy projects based on diversified biomass farming must be well coordinated. A number of lines of work must be pursued in a concurrent and highly interdependent manner. The bottlenecks to implementation of diversified biomass projects are strongly interrelated and mutually reinforcing. For example, local and regional planning to promote land use shifts to diversified biomass farming will likely be highly sensitive to market demand for ecological goods and services provided by these production systems. Conversely, a multifunctional landscape must meet the needs of multiple stakeholders and therefore actual production of any particular ecological service will be affected by the interests and concerns of multiple stakeholders. Consequently, planning and market development efforts cannot be undertaken independently or sequentially. Thus, it will be important to begin implementation by forming and facilitating the work of a multistakeholder implementation team.

Energy Recommendation 4: Develop policies and incentives to encourage perennial crop production for biofuels in critical environmental areas SP

Invest in research and develop policies and financial incentives to encourage perennial crop production for biofuels on expiring CRP lands and other environmentally sensitive or low-productivity lands.

These research efforts, policies, and incentives should result in a balance between profitability and productivity on one hand, and benefits to the environment and wildlife habitat on the other hand.

Description of recommended action. The state should develop firm policies that would encourage the growth of energy crops on conservation lands and marginal farmlands and also reflect environmental and ecological needs for animal habitat and water resource conservation. There is currently an economic incentive for producers to plant productive expiring CRP land with row crops and small grains. Currently, there do not appear to be economic incentives for farmers or growers to grow perennial energy crops on these expiring environmentally sensitive lands. Policies and incentives are needed to encourage perennial biofuel crops on the most productive expiring CRP lands. Managers of low-productivity CRP lands should be encouraged to re-enroll them in conservation programs.

Description of impact on natural resources. Multiple environmental benefits would result from implementation of this recommendation. These benefits would be similar to those detailed under energy recommendation 3, more specifically applied to CRP lands and adjacent waterways.

Relationship to existing programs, laws, regulations. This recommendation is consistent with MCCAG's AFW-4 recommendation and with the NextGen Board's recommendation to increase the supply of biomass through farm incentive programs. Various laws govern the use of conservation lands under different jurisdictions. New policies are needed to allow prudent use of these lands for energy crop production while maintaining their other beneficial attributes.

Time frame. This is a high priority area. In order to meet future raw material needs for biomass material production, guidance is required on what practices will be permitted on the land in question. In addition, the establishment of energy crops is predicted to take from three to five years before the crop is available for its first harvest.

Geographical coverage. This impacts CRP lands across the state.

Challenges. The financial barrier to energy crop production is substantial, whereas other crop types have known federal subsidies to encourage their production. In addition, restrictions on conservation lands currently limit what can be done with these lands.

Energy Recommendation 5: Invest in data collection to support the assessment process **S P**

Invest in data collection to support the assessment process described in energy and mercury recommendation 1.

Data collection is needed in the following areas:

- Water quality
- Water resource sustainability (surface and ground water)
- Wildlife habitat and biodiversity
- Invasive species
- Land use changes
- Soil compaction, cover, and residue levels
- Infrastructure and storage needs for alternative fuel strategies
- GHG emissions

Description of recommended action. Minnesota needs a comprehensive approach to monitoring the cumulative impact of its energy production on the state environment. Data collection to support the monitoring and assessment of energy production should cover every step of the production process, and has the potential to inform the biennial report described in energy recommendation 1. Currently, many of the data needs listed above are incomplete or lacking entirely. Minnesota should fund data collection in these categories in locations around the state.

Description of impact on natural resources. Data collection to inform a biennial report on Minnesota's energy production will help direct the state towards an energy infrastructure that is less harmful to the state's natural resources. Ongoing monitoring efforts will catch potential problems before they become too large, and will allow the state to adapt its energy production strategy to changing environmental conditions (e.g., climate change). This will have a beneficial effect on all natural resource categories.

Relationship to existing programs, laws, regulations. Current data collection efforts should be assessed for their ability to inform the biennial energy report, and new collection efforts should be targeted at the gaps in current collection schemes. The MPCA is currently monitoring water quality in some locations. The DNR and Metropolitan Council are monitoring deep and shallow ground water in wells at various locations in the state, and two research projects at UM are working on methodologies to assess Minnesota's ground- water sustainability. The DNR keeps geographical databases of many wildlife species and invasive plant and animal species. The UM is monitoring some land use changes using satellite imagery. Some research groups at the UM (e.g., the Industrial Ecology Lab) are analyzing the infrastructure and transportation needs of biofuel production facilities. The MPCA keeps a database of greenhouse gas emissions in the state, but new data on non-fossil fuel–related emissions (e.g., GHG flux from agricultural soils) is needed.

Time frame. This is part of an ongoing monitoring effort, with no end date.

Geographical coverage. These data are needed statewide.

Challenges. Coordination of current and future data collection efforts is a challenge. Finding appropriately qualified persons to carry out the data collection, and allocating time and money to these efforts, may also be barriers.

Energy Recommendation 6: Invest in research to determine sustainable removal rates of corn stover and to establish incentives and Best Management Practices (BMPs)

SP

Invest in research to determine sustainable removal rates of corn stover for animal feed and biofuel production, and to establish incentives and BMPs for mitigating the adverse impacts of corn stover removal on soil carbon and erosion.

Description of recommended action. There is currently a debate among researchers and practitioners regarding how much corn stover may be removed from a field for biofuel or animal feed processing without significant negative impacts on soil carbon and erosion rates. Since the corn stover biofuel industry is close to being operational, the answer to this question in the Minnesota context is needed as soon as possible. If negative impacts of corn stover removal may be mitigated through farmer-installed BMPs (riparian buffer strips or cover crops), the state should encourage adoption of these BMPs.

Description of impact on natural resources. Understanding and mitigating the negative ecological impacts of corn stover removal could have positive effects on land, water, air, and fish resources. Water quality and fish populations are impacted when eroded soil enters waterways. Air quality is negatively affected by wind erosion. The integrity of the agricultural land base is threatened if soil carbon declines or erosion increases.

Relationship to existing programs, laws, regulations. Comprehensive environmental impact reviews are currently being required for biofuel plants, but these reviews do not include the impacts of corn stover removal. Researchers at the USDA Agricultural Research Service (ARS) in Morris and at Iowa State University have done some research on stover removal rates and soil carbon effects. These research projects are limited in geographic scope.

Time frame. Two to three years for data collection and analysis

Geographical coverage. Research plots should be located wherever corn is being grown as an energy crop or for animal feed in the state. A diverse range of state climates should be represented, since temperature and precipitation can affect soil carbon and erosion processes.

Challenges. Research that could lead to limits on corn stover removal may be met with push-back from the biofuel industry, the livestock industry, and corn farmers. The challenge of selecting appropriate research sites that will inform biofuel production in all major climate regions of the state is another barrier.

Energy Recommendation 7: Invest in research to review thermal flow maps for Minnesota **S P**

Invest in research to review current thermal flow maps for Minnesota to assess their validity/accuracy, and if necessary develop improved thermal flow maps, with the goal of informing geothermal power development in Minnesota

Description of recommended action. As a first step, the existing heat flow map for the state that was produced some years ago should be critiqued by experts from the Minnesota Geological Survey and their counterparts at the NRRI. Recent investigations of the current map seem to indicate that the existing projections for heat flow may be significantly underestimated due to the sampling technique used in the original data collection effort. Other countries at similar or higher latitudes, most notably Germany and Denmark, are adopting deep geothermal energy systems in order to produce necessary electrical power while reducing GHG emissions. A critical tool for assessing the viability of deploying this environmentally friendly energy technology is a thermal flow map for the state that relates the depth of the resource to the expected energy capture that may be possible.

In addition, organic rankine cycle (ORC) engines are often used in conjunction with deep geothermal mining to extract the heat for energy generation. These same engines can be used to recover waste heat from industrial facilities and power generation stations in order to generate supplemental electrical energy. The adoption of this technology on a broad basis should reduce the need for fossil fuel-based electrical energy production and also lower the energy footprint of many industrial plants in the state. Once the geothermal power development potential in Minnesota is assessed, funding should be made available to study the potential adoption of ORC engines for various industrial applications in the state (including taconite mines, corn-based alcohol plants, steam boiler plants, paper mills and chemical plants that have waste heat as a by product of operations).

Description of impact on natural resources. The use of geothermal energy will tap the energy lost every day as natural heat moves from the interior of the earth to the earth surface and then to space. Others are capturing this energy and using it to generate steam and power. The use of this renewable resource will decrease the need for coal- and nuclear- generated electric power, and decrease the amount of GHG generated in meeting the state's electrical energy requirements.

The recovery of waste heat from industrial plants and electrical energy power stations is another way to conserve energy and reduce GHG generation. The wide adoption of energy capture through newly installed heat exchange technology coupled with the ORC electrical generation technologies (or equivalent) will help the state meet its power generation targets as noted in existing statutes. It will also distribute electricty-generation capacity and help reduce the need for significant power transmission infrastructure improvements by allowing electrical energy to be used at the source of power generation.

Relationship to existing programs, laws, regulations. Current laws mandate significant renewable electrical generation capacity increases by the year 2025. Both approaches if proven to be viable could become a significant part of the energy solution if the heat flow characteristics prove favorable for the sources noted.

Time frame. This work should be done as soon as possible so that effective energy planning can incorporate this technology if the results of the assessment show significant potential.

Geographical coverage. Deep geothermal energy can be captured statewide. The recovery of waste heat from industrial operations and the subsequent conversion of the waste heat to electricity can be done throughout the state.

Challenges. Poor heat-flow data for various regions of the state exist at the present time. This limits our understanding of how this technology now adopted elsewhere in the world could be used here. A better database for expected heat flow from deep geothermal sources is needed to overcome this barrier. A complete understanding of the ORC technology and its applicability to our industrial and power generation facilities must be developed.

Energy Recommendation 8: Invest in applied research to reduce energy and water consumption and green house gas emissions in present and future ethanol plants, and enact policies to encourage implementation of these conservation technologies

S P

Description of recommended action. Minnesota should invest in applied research and demonstration projects that reduce water consumption, energy use, and CO_2 emissions at corn-based ethanol plants.

Description of impact on natural resources. A chief criticism of Minnesota corn-based ethanol plants is the small net gain of energy output from the energy expended to produce ethanol from current operations. At the same time, criticism has also focused on the high water-resource needs that accompany current production techniques in these plants. Current ethanol processing technology consumes from 4 to 5 gallons of water per gallon of ethanol, while future cellulosic technologies are expected to consume 6 gallons of water per gallon of ethanol. Finally, current production methods lead to significant generation of CO_2 in addition to ethanol and dried distillers grains.

Relationship to existing programs, laws, regulations. There are 17 ethanol plants operating in the state and more are being planned and implemented. The state and our rural communities have large investments in the existing plants and it is important to determine ways that overall plant efficiency in terms of both water use and energy consumption can be reduced through introduction of new technologies that can be integrated into existing plant structures. In addition, there is current development effort going on to demonstrate the potential use of CO_2 sources as a feedstock for alcohol production using both biological and thermochemical conversion. If the CO_2emissions from the plants can be converted into additional useful chemical and fuel agents, then the criticisms in terms of net GHG emissions impacts from existing operations will also be lessened.

Time frame. This recommendation is consistent with NextGen Board's recommendation to improve the efficiency of ethanol plants. This work would be done over five years. Development of engineering improvements for existing plants based on applied research and design for water and energy consumption reduction should be conducted as soon as possible. It is important to then test promising approaches at the pilot and demonstration level so that the best approaches can be adopted quickly by our existing industry and the approaches can be made part of the engineering design for new plants.

Geographical coverage. All areas of the state where ethanol plants exist and/or are contemplated for future installation.

Challenges. Technical approaches need to be brought out of the laboratory and tested at the pilot level and beyond. Specific applied research and development funding needs to be focused on taking proven laboratory concepts to the next level as soon as possible.

Energy Recommendation 9: Invest in research to determine the life cycle impacts of renewable energy production systems

Invest in research to determine the life-cycle impacts of renewable energy production systems on the rural economy, greenhouse gas emissions, water sustainability, water quality, carbon sequestration, gene flow risks, and wildlife populations at landscape and regional scales while building on previous studies. This research should be used to direct the development of the renewable energy industry in Minnesota, including the storage and infrastructure needs associated with alternative fuels.

Description of recommended action. This recommendation is compatible with energy recommendations 1 and 5 in that it aims to estimate the cumulative impact of Minnesota's renewable energy development through data collection and analysis. Basically, the recommendation is that energy policy and incentives at the state level take a systems view, accounting for the resource benefits and impacts associated with each stage of energy production, transport, consumption, and associated waste processing. Research will be needed for legislators, citizens, and industry to make informed decisions about these benefits and impacts. Language to this effect should be added to legislation relevant to alternative energy development.

Description of impact on natural resources. If this recommendation is adopted, particularly with energy recommendations 1 and 5, Minnesota will position itself as a national leader in structuring its renewable energy economy for the benefit of both the economy and the natural resource base. Directing energy development toward beneficial activities and away from activities that significantly harm natural resources will have positive effects on all natural resource categories in the state.

Relationship to existing programs, laws, regulations. There is a large body of literature on the life cycle impacts of renewable energy strategies, including ongoing research efforts by UM faculty. This literature should be used as a guide to framing the issues in the Minnesota context. Current data collection efforts by various state agencies and researchers are described under Energy and Mercury Recommendation 4. The state has a goal of reducing its GHG emissions 80% by 2050, which may be informed by this research.

Time frame. This is an ongoing monitoring and assessment effort, with no endpoint.

Geographical coverage. The entire state should be considered.

Challenges. Perhaps the most challenging aspect of life- cycle analysis is drawing the system boundary. For example, energy production for out-of-state markets may have negative impacts on Minnesota's natural resources; alternatively, Minnesota might export its energy production and the associated resource impacts. These dynamics and their implications for renewable energy development should be considered in consultations involving scientists, policy makers and citizen stakeholders. Another barrier concerns' directing the state's energy production according to a life-cycle systems point of view, which is not currently being done.

Energy Recommendation 10: Invest in research and demonstration projects to develop, and incentives to promote, combined wind power/biomass, wind power/ natural gas, and biomass/coal co-firing electricity projects SP

Description of recommended action. Integration of various energy production techniques that can help optimize the energy production system is an important opportunity for local communities, medium-size commercial and industrial users, and institutions in the state. As shown with the energy modeling work at the UM Morris, campus, a combined wind and biomass energy system allows overall optimization of energy production and the potential of almost complete energy self-sufficiency for the institution. The adoption of combined systems allows energy storage, peak loading, and stable energy generation issues to be addressed in a holistic fashion. For rural applications where biomass availability is high and wind conditions are favorable, systems can be envisioned where a wind turbine system is coupled with a biomass gasification system to enhance the storage of off-peak power through generation of hydrogen and oxygen using water electrolysis. The produced gases then can be utilized to help facilitate improved gasifier operations. The stored oxygen can be used to displace air in the gasifier combustion process, and the hydrogen can be added to the producer gas to enhance its chemical potential to produce a syngas for natural gas replacement or additional power generation. The enhanced syngas can also be utilized to produce liquid fuels for use locally. Additionally, wind power/natural gas and biomass/coal electrical generation projects should be demonstrated that will allow GHG reductions while stabilizing electrical generation capacity in the state.

Description of impact on natural resources. The combined use of biomass with wind resources allows a significant stabilization of alternative energy products that can be utilized to reduce GHG production and the need for coal in electrical power generation. Additionally, the potential enhancement of the syngas from the combination gives more use options for the producer gas than from a gasifier implemented alone. The placement of gasification facilities in rural areas near wind power generation sites also helps minimize transportation logistics for the biomass material and should aid in overall system economics. The use of wind/natural gas–based power generation systems allows stabilization of electrical generation from the turbine sites through incorporation of smaller natural gas turbine electrical power generation systems that can be brought up and down when wind conditions are insufficient to meet load demands. The use of biomass in coal-based power systems allows displacement of coal and incrementally reduces GHG generation from these facilities.

Relationship to existing programs, laws, regulations. The various combinations noted will directly help Minnesota meet its statutory targets for energy production from renewable resources and its GHG reduction targets. In addition, the combination of wind/biomass gasification and water electrolysis for hydrogen and oxygen generation and storage should facilitate production of syngas that can be converted to liquid fuels or used as a replacement for natural gas.

Time frame. This recommendation should be implemented on a short-term basis in order to allow demonstration of the combined systems in the near future. The experience generated from the combined systems should then be shared broadly in order to facilitate widespread adoption throughout the state.

Geographical coverage. The technology combinations should be demonstrated throughout the state where conditions for biomass supply and/or wind conditions are suitable.

Challenges. The technologies noted have been developed on an individual basis to a high degree. The key to future success is the integration of the facilities, which has not been done on a commercial scale. The

technical risk of implementation of the technology combinations is a key barrier. Financial incentives that will help mitigate risk should be provided in order to demonstrate these potentially valuable technology systems.

Energy Recommendation 11: Invest in research and enact policies to protect existing native prairies from genetic contamination by buffering them with neighboring plantings of perennial energy crops **R P**

Description of recommended action. In developing Minnesota's perennial biofuel industry (see energy recommendation 3), varieties may be selected for widespread planting that are not native to Minnesota, or that have been genetically modified from native plants. These biofuel plantings have the potential to genetically contaminate the state's native prairie remnants if they are close to these ecosystems. Research should be undertaken on the potential for this contamination, and policies should be developed to prevent it through mandated buffer plantings.

Description of impact on natural resources. Preservation of remnant native prairie is an important conservation goal in Minnesota, and the genetic integrity of native plants is necessary for the persistence of prairie remnants. Native prairie has significant cultural and ecological significance in Minnesota, providing habitat for a variety of plant and animal species.

Relationship to existing programs, laws, regulations. A number of prairie restoration projects are ongoing throughout the state. While these projects have not explicitly addressed genetic contamination from nonnative biofuel feedstocks, BMPs for native prairie will inform the work performed under this recommendation.

Time frame. The research could take place over two to three years, concurrent with the development of perennial bio-feedstocks. Policy would be developed based on the research findings.

Geographical coverage. Regions of the state with native prairie remnants.

Challenges. Aside from the cost of the research, there is a risk that implementing this recommendation will not prevent genetic contamination of native prairie remnants. This risk should be carefully assessed using appropriate methodologies, and weighed against the benefits of developing a perennial biofuel industry in Minnesota.

Energy Recommendation 12: Invest in efforts to develop sufficient seed or seedling stocks for large-scale plantings of native prairie grasses and other perennial crops **R P**

Description of recommended action. If perennial crops are to become a significant component of biofuel production in Minnesota, sufficient genetic stock for large-scale plantings will be necessary.

Description of impact on natural resources. Implementing this recommendation will be necessary for the implementation phase of energy recommendations 3 and 4, including all of their positive effects on natural resources. These would include biodiversity preservation, watershed protection/flood prevention, and low-carbon fuel provision.

Relationship to existing programs, laws, regulations. This recommendation is consistent with the NextGen Board's recommendation to establish a biomass production infrastructure. Agronomic research on native plant breeding is ongoing at the UM.

Time frame. Seed and seedling stocks would be built up over three to five years and maintained while perennial biofuels are grown in Minnesota.

Geographical coverage. All regions of the state, including agricultural and forest regions

Challenges. Expert personnel and facilities for these seed/seedling banks must be provided. Also, the question of which plants should be grown in which part of the state (see energy recommendations 17 and 18) must be answered at least in part before seed banks are developed. However, widescale plantings of perennial biofuels cannot proceed without seed-bank development. This recommendation is therefore intimately connected with energy recommendations 3 and 4, and they should be funded and implemented together.

Goal B

Promote a healthy economy, including strategies that promote local ownership of alternative energy production and processing infrastructure, where appropriate.

Energy Recommendation 13: Invest in research and policies regarding "green payments" **S P**

Invest in research and policies on implementation strategies and optimal pricing schemes for green payments. These payments may be applied to perennial energy crop production on expiring CRP land, in impaired watersheds, on environmentally sensitive or low-productivity land, on DNR working lands, and on annual cropland. Multiple tiered payments for water quality, carbon, wildlife, fuel production, and other benefits may be considered, and special attention should be paid to helping producers through the transition period for perennial energy crop production. Knowledge and insights gained from previous multifunctional fuelshed experiments (at Waseca, Madelia, and UM Morris, for example) should be applied.

Description of recommended action. This recommendation fits well with energy recommendation 2. If adopted together, these two recommendations would strengthen the state's efforts to protect environmentally sensitive land from intensive production, while providing benefits to farmers, local communities, natural resources, and wildlife. A green payment program should be informed by the most up-to-date scientific information on how biofuel production strategies impact natural resources. Farmers should be encouraged to plant perennial energy crops appropriate to their region (see energy recommendation 1).

Description of the impact on natural resources. An effective green payment program could have positive impacts on land, water, air, fish, wildlife, and recreation resources by reducing erosion, creating habitat, improving soil quality, sequestering carbon, and creating recreational opportunities.

Relationship to existing programs, laws, regulations. This recommendation is consistent with NextGen Board's recommendation to create a supply of biomass through farm incentive programs. The Reinvest in Minnesota (RIM) program currently pays farmers to enroll their land in conservation easements. However, this program may be less effective when high commodity prices dissuade farmers from renewing their contracts. A green payment program, on the other hand, would allow farmers to leverage the multiple environmental benefits of removing their land from intensive production. Ongoing research efforts at the UM are exploring how farmers might take advantage of Chicago Climate Exchange payments for sequestering carbon.

Time frame. This would be an ongoing program with no end date.

Geographical coverage. These actions should be focused on areas of the state with high amounts of expiring CRP or other environmentally sensitive land.

Barriers. Adopting this recommendation could have unintended negative consequences, such as driving up land costs or encouraging more intensive production on some agricultural lands. Periodic monitoring and assessment of the program could identify these problems and mitigate them to some extent. Public opinion regarding the production energy crops on environmentally sensitive lands may not be entirely positive.

Energy Recommendation 14: Investigate opportunities to provide tax incentives for individual investors in renewable energy (e.g., individuals who wish to install solar panels)

Description of recommended action. The state should make it easy and cost effective for individual homeowners or businesses to get their electricity from solar, geothermal, or wind power sources they install themselves. The specific financial mechanism needed to accomplish this goal should be developed in consultations between economists, policy makers, and citizen stakeholders. Other states (such as Massachusetts) have programs that might serve as an example.

Description of impact on natural resources. Assisting interested individuals to invest in renewable energy technologies could have a snowball effect that would lead to widespread adoption of these technologies in Minnesota. This would reduce emissions of GHG, mercury, and other harmful air pollutants from coal-fired plants. It would also reduce water consumption in the electricity-generation sector, and could reduce the pressure on Minnesota's land resources to provide biofuels for electricity generation.

Relationship to existing programs, laws, regulations. This recommendation is consistent with the Minnesota Climate Change Advisory Group (MCCAG)'s RCI-4 recommendation. Minnesota already encourages community-based wind electricity through the community-based energy development (C-BED) program. Another state model may be seen in Massachusetts, which has developed a state rebate program which allows homeowners to pay off the cost of solar panel installation within five years, and targets extra assistance at low-income households.

Time frame. This program would continue until a given renewable energy option (for example, solar panel installation) becomes economically competitive on the open market.

Geographical coverage. Entire state.

Challenges. Finding the funds for such a program could be a challenge. Massachusetts has financed its program through electric bill taxes. In addition, increasing demand for individual renewable energy technologies (solar panels, wind turbines) could outpace supply, driving up costs in the short term.

Energy Recommendation 15: Invest in efforts to develop, and research to support, community-based energy platforms for producing electricity, transportation fuels, fertilizer, and other products that are locally/cooperatively owned

Description of recommended action. Many renewable energy sources (e.g., wind, biomass, and solar power) are located in the rural parts of the state. The localized development of alternative energy systems that can be placed at the source or nearby the source of the biomass materials will reduce the problems associated with logistical movement of unconsolidated biomass and reduce the transportation costs for biomass energy conversion. At the same time, the production and use of energy and energy products on a local basis will reduce infrastructure costs associated with power and fuels distribution. Both factors should allow localized development of smaller scale alternative energy systems that will benefit the local rural communities and add valued products to their economies. The state should encourage the development of these localized alternative energy systems by

adoption of policies and incentives to facilitate their adoption. In addition, research and demonstration for systems that can facilitate the implementation of this localized energy solution should be supported. Part of this support will involve transferring the lessons learned from successful community-based energy platforms (e.g., at UM, Morris; and Madelia, Coleraine Minerals Laboratory) to other communities interested in developing their own renewable energy platforms. The integration of local waste streams into energy production mechanisms is a key part of this recommendation.

Description of impact on natural resources. The primary effect of this recommendation is economic, in promoting community renewable energy over corporate ownership and shielding local communities from the rising costs of fossil fuels. Direct benefits for the air resource will result from decreased fossil-fuel burning. Indirect benefits for natural resources may result from communities being able to observe the impacts of their energy production and consumption patterns in their immediate surroundings. This may lead to more responsible energy and natural resource practices on a local scale. For example, capturing and reusing waste streams for energy may be easier on a local scale than statewide. In addition, the availability of new power and fuel sources generated at the local level will avoid substantial investments in new infrastructure that could delay adoption of useful technologies that can be implemented in the short and medium term and lessen the current energy issues facing Minnesota.

Relationship to existing programs, laws, regulations. Minnesota's C-BED establishes a tariff to promote community-based wind power.

Time frame. Ongoing

Geographical coverage. Entire state

Barriers. Community-owned energy may be difficult to integrate into the existing electricity grid, although this problem may be overcome through targeted investments. Start-up costs are likely to be great compared to corporate owned power operations. Distributing electricity and other energy generation throughout the state may also lead to some citizen discontent, since more people would be living near an energy plant.

Goal C

Promote efforts to improve energy conservation and energy efficiency among individuals, businesses, communities, and institutions.

Energy Recommendation 16: Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power, while simultaneously increasing renewable electricity production for transportation

ES

Description of recommended action. Powering Minnesota's current transportation fleet solely with biofuels or fossil fuels is not feasible in the long term. Fueling our vehicles predominantly with ethanol would place enormous pressure on the state's land resources, and would take land out of food production and conservation. Gasoline -powered vehicles contribute substantially to global climate change, and the rising price of gasoline creates an economic burden for Minnesota residents and businesses. Therefore, a state goal should be to transition the vehicle fleet away from dependence on both fossil fuels and biofuels. Powering vehicles with electricity derived from renewable sources makes sense from an ecological and sustainability standpoint, but is not yet economically viable. Several automakers have announced plans to sell electric vehicles within the next two years. However, the up-front cost for these vehicles will likely be more than for a conventional gas-powered vehicle. Minnesota should therefore provide appropriate incentives to encourage state residents and businesses to purchase electric vehicles, with the goal of creating a robust electric vehicle sector in the

state. The use of electric vehicles for commuting to work and while shopping locally in metropolitan environments where the commuting distances are relatively short should especially be encouraged.

These vehicles will require more capacity in the electricity sector, which should be provided with renewable sources (wind, solar, and geothermal). Some of this excess capacity may be mitigated by encouraging electric vehicle owners to charge their vehicles during off-peak hours (i.e., at night).

Description of impact on natural resources. Transitioning a substantial fraction of Minnesota's vehicle fleet to renewable electricity would have a beneficial impact on the state's air quality, and would help to reduce GHG emissions and stabilize food prices (by removing competition for land between food and fuel needs).

Relationship to existing programs, laws, regulations. Minnesota's renewable energy standards require state utilities to produce progressively higher fractions of state electricity from renewable fuels. Some of this renewable electricity could be directed to the state's transportation needs. This recommendation would also help the state accomplish its GHG reduction goal of 80% below 2005 levels by 2050.

Time frame. Electric vehicle phase-in would occur over 10 to 20 years.

Geographical coverage. Entire state

Barriers. Electricity production will need to be ramped up to accommodate a growing electric vehicle fleet. This may present capital investment and infrastructure constraints. Financing and public support for an incentive program are also an issue. Current technology does not allow electric vehicles to travel more than 40 miles on electric charge only (beyond that point, a gasoline motor charges the battery), so for long trips electric vehicle owners will still have to use a small amount of gasoline.

Energy Recommendation 17: Promote policies and incentives that encourage carbon-neutral businesses, homes, communities, and other institutions with an emphasis on learning from institutions already working toward this goal (e.g., UM, Morris) S P

Description of recommended action. Energy conservation and renewable fuel goals should be advanced simultaneously in Minnesota. Much more could be done to encourage businesses, homes, communities, and other institutions in Minnesota to dramatically reduce their carbon footprint through energy conservation and low-carbon fuel use. This recommendation fits well with energy recommendation 14—providing incentives for individuals to take advantage of solar, wind, and geothermal technologies would help them to become carbon neutral. Most likely, achieving carbon neutrality will require a portfolio of energy technologies and lowered energy consumption like that seen at UM, Morris (wind, biomass, etc.). Policies and incentives should be targeted to help individuals, businesses, communities, and institutions develop renewable energy portfolios appropriate for their situation.

Description of the impact on natural resources. Policies and incentives aimed at reducing the carbon footprint of individuals, businesses, and communities would have beneficial impacts on state land, air, and water resources. Reduction in energy consumption would lower water needs for electricity generation. Carbon-neutral businesses, homes, and communities would reduce state GHG emissions and would have secondary benefits for air quality. Reduced energy consumption could lower pressure on land resources to provide fuels.

Relationship to existing programs, laws, regulations. This recommendation is consistent with MCCAG's RCI-4 recommendation. Minnesota building codes are some of the country's most stringent in terms of energy conservation, and state-funded construction of affordable housing and new state buildings

must incorporate green materials and construction. Assisting businesses, homes, and communities with further progress toward carbon neutrality would help the state achieve its GHG reduction goals.

Time frame. 10 to 20 years

Geographical coverage. Entire state

Barriers. Educating individuals, businesses, and communities about the need to reduce carbon footprint is one barrier (see energy recommendation 22). Improving individual and community access to renewable energy technologies and tools for carbon planning is another (see energy recommendation 14).

Energy Recommendation 18: Implement policies and incentives to lower energy use of housing stock while monitoring the performance of improvements and calling on the utility industry to join in the effort **S P**

Description of recommended action. The envisioned housing improvements should consist of locally manufactured building material resources, especially those that use industry byproducts as their primary production feedstock. It is further recommended that the state develop specific policies and incentives to greatly improve construction practices for new residential homes. This can be accomplished by employing regional, sustainable building materials, and promoting the application of breakthrough systems approaches to new housing construction in an effort to drive down residential energy consumption. The UM has developed new technologies that present alternative means and methods for achieving vastly improved energy code compliance; these technologies should be further investigated to overcome implementation barriers.

Description of impact on natural resources. Execution of the recommended actions will markedly reduce the energy consumption of homes in the state. Creating a call-to-action to improve the existing housing stock will reduce energy consumption, thereby reducing our dependence on all fuel sources. Promoting continuous improvement and best practices in systems building will ultimately lead toward the goal of net-zero-energy new homes. Improvements in energy conservation at the micro-level of every household will reduce dependence on all fuel sources. In addition to energy savings for the homeowner, as local building material supply chains develop there will be a dramatic reduction in transportation energy related to building materials distribution. Greatly improving the energy efficiency and long-term durability of existing and new housing stock reduces the load on Minnesota's highly prized forest resources.

Relationship to existing programs, laws, regulations. The conservation improvement program of the past has faded away. The current state energy code is in place, but less than 30% of existing homes meet this code. The home-remodeling and home- building industry needs the know-how to improve the performance of residential housing on an ongoing basis.

Time frame. The recommendations should be acted on immediately. The result will begin reducing the state residential energy demand on all fuels within the first year of implementation. Our action is not short term; the solution should become a long-term initiative that results in standardized housing performance expectations.

Geographical coverage. Putting these actions into practice will impact all regions of the state. The actions will especially improve the economic conditions for those who live in older housing.

Challenges. The greatest challenge is to train the remodeling and new construction contracting industry. State-of-the-art methods, materials, and technology are never easy to implement in a standardized fashion. These industries are already stressed, so creating interest in the early stages is critical. It will be

most helpful to demonstrate the benefits so these industries are aware of the important role they play in improving housing. Demonstration projects that showcase what can be done should be funded to allow potential practitioners to see what can be done on a firsthand basis.

Energy Recommendation 19: Promote policies and strategies to implement smart meter and smart grid technologies S P

Description of recommended action. Smart meter and smart grid technology is the next generation of electrical distribution technology. It provides for more local management and control of the energy used in the region and on site.

- The use of both smart meter and grid technology requires a series of advancements and changes in the current distribution practices. On a national level, there should be a uniform interconnection standard that would allow for a more robust mix of distributed and central-based power generation.
- At a state level, guidelines should be established for purchase of backup and supplemental power so that distributed combined heat and power (CHP) plants are not put at an economic disadvantage when negotiating with investor-owned utilities.
- At a state level, investor-owned and electric cooperatives should be encouraged to move to smart grid technology and economic studies should be carried out to determine the benefit of incorporating distributed generation into the state's transmission grid.

Description of impact on natural resources. The best outcome for distributed smart grid smart meters is a more efficient use of generated power. With conventional central-based power generation, the conversion of energy to power is as low as 30% at the end user site. Any gains at the end of the grid will have significant impacts on the amount of energy used to produce the power at the plant. Thus, fewer natural resources will be consumed, and less pollution will be generated. Distributed generation could provide economic incentives for local energy producers.

Relationship to existing programs, laws, regulations. Smart meter/smart grid implementation depend on changes in both the national and state regulations.

Time frame. Fiscal incentives or cost avoidance will be the driver of the implementation of this technology.

Geographical coverage. This technology would affect the entire state, but would have the greatest benefit in the southwest, where transmission infrastructure is already congested and impeding the development of additional wind resources.

Challenges. Challenges include costs to both power generators and power users, because both will be impacted to install an integrated technology distribution system that has two-way communications, next-day pricing, and digital control networks with in the building operations; standard interconnection regulations and reasonable charges and actual costs of accommodating the use of distributed generation on the grid; and regional studies to understand the best opportunities for advancement of this technology.

Energy Recommendation 20: Develop incentives to encourage the widespread adoption of passive solar and shallow geothermal heat pump systems in new residential and commercial building construction; invest in research to develop improved technology for storing renewable energy S P

Description of recommended action. It is recommended that policies be adopted to encourage the widespread adoption of passive solar and shallow geothermal heat pump systems in new residential and commercial construction. Furthermore, it is recommended that incentives be developed to allow more widespread adoption of these technologies in existing structures where it is deemed to be a practical method for reducing water and habitat heating

and cooling requirements. Utilities should be asked to incorporate specific programs to encourage structure owners to adopt these technologies in order to help meet the state's conservation goal as noted in existing Minnesota statutes.

Description of impact on natural resources. Beneficial resource and economic impacts include: (1) avoids need for expanding coal based electricity to provide electric power for vehicles, (2) reduces GHG emissions, (3) improves water quality and quantity, (4) opens up new labor markets and business opportunities, (5) reduces in mercury emissions, (6) offers health benefits to people who consume fish, and (7) reduces fuel bills for consumers.

Relationship to existing programs, laws, regulations. This recommendation is tied directly to Minnesota Statutes 216B.241, "Energy Conservation Improvement." The goal of this statute is to drive energy conservation improvements in the state. Specific targets have been set for various utilities, depending on the service provided. The incorporation of the adoption of alternative heating technologies on a distributed basis will help reduce the demand for the utilities' products and satisfy the targets noted in this statute.

Time frame. The recommended actions should be taken over the next biennium in order to achieve results in a timely manner. Discussions with architectural and engineering experts to develop recommended practices for wide-scale adoption should be undertaken as a first step.

Geographical coverage. These actions can be done statewide.

Challenges. Incentives must be created to facilitate conversion to these technologies by existing structure owners. Policies that allow routine adoption of these passive energy technologies into new structures need to be defined and codified in order to have reliable adoption of the technologies on a broad basis.

Potential disadvantages of these incentives include: (1) cost of research, (2) cost of technology, (3) cost of technology implementation, (4) cost of fuel, and (5) cost of permitting and code development.

Relationship to Preliminary Plan drivers. This fits in with the need to use non-GHG-generating and renewable energy sources as a principal vehicle to reduce overall fossil fuel energy reduction.

Energy Recommendation 21: Develop standards and incentives for energy capture from municipal sanitary and solid waste, and minimize landfill options for MSW

ES

Description of recommended action. A state mandate should be established that requires the capture of energy units from municipal solid waste (MSW) or municipal sanitary waste generated in the state. Appropriate statutory actions should be taken to establish targets for MSW use and minimization of landfill options for this waste material.

Description of impact on natural resources. A significant and underutilized source of energy exists in most communities today that, if utilized, could reduce the need for new energy production. This is municipal sanitary waste or MSW products that remain after recycling and reuse options are exhausted. Municipal sanitary waste is potentially useful for growing algae that can generate bio-oils for energy. MSW contains many paper, wood, gas by-products, and other biomass waste that could be used for energy production. The reduction of material volumes that need to be processed in sanitary landfills and certified disposal facilities should be a priority both at the state and local level. Other states and countries are now routinely implementing waste-to-energy programs that are highly beneficial to the reduction in GHG emissions while also resulting in valuable energy production.

Relationship to existing programs, laws, regulations. This recommendation is consistent with the NextGen Board's recommendation to promote the installation of methane digestors. MSW is a consequence of our collective use of a variety of commercial products in everyday life. It is very important to extract as much use as possible out of the material goods produced for human consumption. Others have recognized MSW as a valuable product that can be tapped for energy production. The use of this material on a regular basis is a fundamental conservation technique that should allow the state to meet its renewable energy targets.

Time frame. Current environmentally acceptable technologies have been developed and implemented in other localities for capturing energy products from MSW. Policies in statutory form should be implemented to encourage the adoption of these technologies in Minnesota.

Geographic coverage: All areas of the state

Challenges. Challenges include lack of knowledge of available options, current disposal methods that center around landfill practices, and challenges related to transportation and storage.

Energy Recommendation 22: Invest in public education focusing on benefits and strategies for energy conservation targeted toward individual Minnesota residents and businesses

Description of recommended action. Individual action is critical in reducing state energy demand, which will lower GHG emissions and reduce pressure on the land resource to provide alternative fuels. Specific examples of actions that should be encouraged may be found in the MCCAG recommendations. These include bicycle/pedestrian/public transit commuting, slower highway driving speeds, and purchasing energy-efficient appliances. There is a need to educate the public about lifestyle choices to reduce their energy consumption, particularly related to homes and transportation. Advertising and communications experts should be brought into this effort to disseminate the carbon reduction message in a creative way that reaches the broadest segment of the population possible.

Description of impact on natural resources. If individuals reduce their energy use, it will have beneficial effects on air and land resources, through reducing emissions associated with fossil-fuel burning and lowering pressure on land resources to provide ethanol and other biofuels. Secondary benefits might include reduction in urban sprawl as individuals choose to live closer to their workplaces/city centers (this would benefit land, water, fish, recreation and wildlife resources).

Relationship to existing programs, laws, regulations. This recommendation is consistent with the NextGen Energy Board's recommendation to promote education and training programs on renewable energy. Some public education efforts are targeted at the Twin Cities metropolitan area (for example, ads for Metro Transit transportation). Energy audits are available for individual homeowners through the RES, and information about this program has been advertised. These efforts should be greatly expanded and directed toward a broader state audience.

Time frame. 5 to 10 years

Geographical coverage. Entire state

Challenges. There may be some pushback against this effort from some industrial sectors. Any public education effort runs the risk of being ineffective.

Goal D (see related Appendix III)

Promote regulations, policies, incentives, and strategies to achieve significant reductions in mercury deposition in Minnesota.

Energy Recommendation 23: Develop mercury reduction strategies for out-of-state sources IP

Minnesota state agencies should work closely with the U.S. Environmental Protection Agency (USEPA) to develop mercury reduction strategies and assessment tools for the state, with the goal of meeting federal Clean Air Act and Clean Water Act standards. A mercury-reduction strategy should be developed that includes reduction of in-state demand for coal-powered electricity, and addresses mercury deposited in Minnesota from out-of-state sources.

Description of recommended action. Development of the national program that regulates mercury emissions from existing and future sources is very important in addressing the overwhelming contribution by sources from outside of Minnesota to the Minnesota environment (e.g., Minnesota water bodies). A federal mercury emissions program would minimize competitive disadvantage that regulations on the state levels potentially could create. Coordinated and joint efforts between the state agencies and the EPA would strengthen existing laws and reduce environmental loads of mercury.

Description of impact on natural resources. Mercury cycles through the air, water, land, and biota as a result of natural and human activities. It accumulates in the aquatic food web. Predatory fish species usually have the highest mercury concentrations. Most mercury that accumulates in the fish muscle tissue is in the form of methylmercury, a potential neurotoxin. Humans who eat contaminated fish may be exposed to dangerous concentrations of methylmercury. A national reductions program would greatly reduce mercury deposition in the state, and its concentrations in the environment.

Relationship to existing programs, laws, regulations. Currently there is no federal mercury emissions program. This recommendation supports the creation of a new federal policy that deals with mercury emissions.

Time frame. It may take up to several years to establish and create a national mercury emissions program. It may take several more years to enforce/bring into compliance mercury emissions because some plants may need to be retrofitted with new control technologies.

Geographical coverage. Regional and/or national mercury emission reductions would have a great impact on the deposition rates in Minnesota; because about 90% of mercury deposition comes from sources outside of Minnesota.

Barriers. Development of the national program would require cooperation and coordination with a number of state and federal government institutions. It may prove to be very timely and costly to establish this program. It may also take a lot of time, money, and effort to bring polluters into compliance.

Energy Recommendation 24: Continue state enforcement programs to reduce mercury loads IP

The MPCA should be provided with adequate resources to continue to enforce/support existing mercury regulations and programs that lead to reduced emissions of mercury in Minnesota through market restrictions, pollution control techniques, and disposal requirements.

Description of recommended action. Existing regulations reduce product-sector emissions. The MPCA works closely with and provides education to the industry sectors on mercury reduction strategies and new control technologies. The voluntary/enforcement programs have been successful in reducing mercury air and water emissions.

Description of impact on natural resources. Mercury cycles through the air, water, land, and biota as a result of natural and human activities. It accumulates in the aquatic food web. Predatory fish species usually have the highest mercury concentrations. Most mercury that accumulates in the fish muscle tissue

is in the form of methylmercury, a potential neurotoxin. Humans who eat contaminated fish may be exposed to dangerous concentrations of methylmercury. Reduced mercury loads into the environment would positively impact air and water quality and human health.

Relationship to existing programs, laws, regulations. This recommendation is a continuation of existing policies.

Time frame. This is an ongoing effort to reduce mercury pollution and emissions in the environment.

Geographical coverage. Mercury reductions will benefit Minnesota, neighboring states, and Canada, where up to 50% of Minnesota emissions are deposited.

Challenges. None

Energy Recommendation 25: Develop public education on actions that individuals and communities can take to reduce mercury loads **S P**

Minnesota should develop a strong public education and outreach effort focusing on the health risks associated with mercury pollution and on techniques for reducing mercury loads (including energy conservation and proper disposal of light bulbs) in the environment.

Description of recommended action. Currently there are a number of state-sponsored and community-based public education and outreach programs addressing mercury emissions. They are specific to certain industries (e.g., energy producing facilities), activities (e.g., disposal of light bulbs) or public health advisories (e.g., mercury fish concentrations). Although beneficial, the programs are often inaccessible by many Minnesota citizens because they are not greatly publicized. Creation of a single, large, well-coordinated interagency public-outreach and education program could potentially address many issues more effectively and efficiently. Promotion and recognition of a single program may be easier to achieve.

Description of impact on natural resources. Mercury cycles through the air, water, land and biota as a result of natural and human activities. It accumulates in the aquatic food web. Predatory fish species usually have the highest mercury concentrations. Most mercury that accumulates in the fish muscle tissue is in the form of methylmercury, a potential neurotoxin. Humans who eat contaminated fish may be exposed to dangerous concentrations of methylmercury. Greater awareness of dangers posed by mercury will reduce human health risks and environmental emissions.

Relationship to existing programs, laws, regulations. A number of government agencies and community-based organizations already have public education and outreach programs in place. They usually address specific industry sectors, activities, or communities and rarely reach all levels of population. It may be more beneficial to develop a strong interagency/community outreach program. This would contribute to better organization and communication of the information.

Time frame. It may take up to a couple of years to identify, coordinate, and unify existing mercury public outreach and educational programs.

Geographical coverage. The citizens of Minnesota and the state environment would benefit from reduced mercury risks and lower concentrations in the environment.

Challenges. Coordination and unification of a number of interagency and community-based programs may be timely and costly to achieve. It may prove impossible to unify different types of outreach programs without losing some valuable participants and partners.

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II. Participant List

III. Mercury Report

IV. Climate Change Report

V. Assessment of Costs and Environmental Benefits

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VII. Public Outreach Efforts and Summary of Public Outreach Comments

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Statewide Conservation and Preservation Plan
Final Plan June 30, 2008

Revised November 1, 2008

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Recommendations from Preliminary Plan

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Preliminary Recommendations for LCCMR Funding Priorities

This appendix contains preliminary recommendations delivered to the LCCMR on June 20, 2007, by the Minnesota Statewide Conservation and Preservation Plan (SCPP) project team. Immediately below are top preliminary recommendations that provide benefits to multiple resources; a list of the most pressing issues facing Minnesota's natural resources; and details on key drivers of change for each resource area.

Recommendations that would provide benefits to multiple natural resources

- Identify, protect and manage strategic land areas that contribute relatively more to conservation
- Establish statewide habitat corridors using consistent methodology and criteria
- Acquire important data on a regular basis (e.g., LIDAR, parcel and land cover)
- Manage development to decrease effects on resources
- Increase understanding of potential effects of climate change on resources
- Increase understanding of effects of contaminants on resources

List of most pressing issues

- Land use change/development/land disturbance
- Habitat fragmentation/loss/erosion
- Climate change
- Contaminants
- Consumptive use
- Invasive species
- Energy production
- Transportation
- Demographics
- Human health

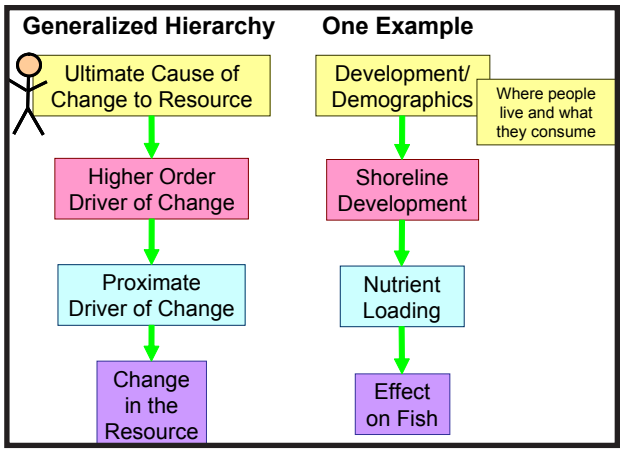

Figure 1. Conceptual hierarchy of drivers. Proximate drivers directly impact the resource. Higher order drivers are often where policy/investment choices operate.
Credit: Jean Coleman, CR Planning

Primary Drivers of Change

A major focus of the first phase of the project was identifying the key drivers of change affecting each of six natural resource areas (air, land, wildlife, water, fish, outdoor recreation). Each research team began by identifying proximal drivers, those acting most closely upon the resource, and then mapping them to higher order drivers (see Figure 1). The teams, with the assistance of outside experts from relevant state agencies, then ranked these drivers by their relative impact on a common set of "elements of sustainability". These elements were: air quality; water quality; habitat quality; soil/land quality; fish and wildlife health; human health; biodiversity; abundance of resource; economic health; aesthetics; and recreational/cultural/spiritual values. As an example, for the Fish resource, the proximal driver Nutrient Loading affects sustainability elements Water Quality (medium), Fish Health (high), and Human Health (low), among others.

The rankings were mathematically analyzed to rank the proximal drivers in order of total impact (integrated across elements of sustainability) on the resource. The resulting list of top-ranked drivers (i.e. those with the most overall impact on the resource) forms the backbone of the recommendations listed below.

Following is a list of primary drivers of change for each resource area, and below each driver are the recommendations related to each driver.

Air – Drivers of Change/Recommendations:

Climate Change

- Invest in projects similar to projects traded on the Chicago Climate Exchange
- Study effects of biofuels on greenhouse gases

Energy Production

- Assess the effects on air of changing from coal to natural gas
- Study effects of biofuels on air pollution

Transportation

- Encourage greater use of natural gas, hybrids, biodiesel and electric vehicles
- Increase the use of public transportation and make it less polluting
- Assess barriers to the use of public transportation
- Increase bike paths for commuting

Land – Drivers of Change/Recommendations:

Strategic Land Areas

- Identify land areas that contribute disproportionately to conservation
- Protect and manage these lands

Soil Erosion

- Acquire high resolution elevation data (using LIDAR) to gain accurate slope information and measure erosion rates
- Develop better estimates of erosion from gullies, ravines, and streambanks
- Evaluate watershed scale impacts of erosion control practices
- Restore annual surveys of crop residue cover after planting

Land Use Change

- Establish habitat corridors statewide using consistent methodology and criteria
- Obtain and regularly update GIS land parcel data – make it comprehensive and broadly available, and establish a method for consistent updating
- Obtain and regularly update current land cover data – ensure consistent and frequent updating, and include all native plant communities
- Improve updating of soil surveys
- Create a GIS portal interface integrating land cover, soils, and bedrock geological information

Habitat Fragmentation

- Research the effects of fragmentation on species and genetic diversity
- Conserve native genetic material
- Understand GMO effects on native plants – literature review

- Integrate and assess information on contaminated sites and contaminant sources (landfills, brownfields, pesticide spills, pollutant sources, etc.)
- Expand scope of monitoring for contaminants in the landscape

Wildlife – Drivers of Change/Recommendations:

Land Use Change and Fragmentation

- Perform land cover mapping at regular intervals to understand changes in wildlife habitat
- Identify priority natural areas and corridors (hubs and connections) to preserve for wildlife - statewide
- Identify how to make all aspects of the land network (urban to agricultural to natural) more supportive for wildlife

Development

- Determine how to build urban and exurban areas and retain the highest possible species diversity

Disease and Invasive Species

- Research the (currently unknown) effects of diseases and invasive species and human structures on wildlife

Water – Drivers of Change/Recommendations:

Land Use Change

- Invest in management and protection of Strategic Land Areas that affect water
- Manage development to reduce erosion and pollutant loading
  - Focus on shoreland development
  - Focus on fast-growing urban areas
  - Promote shoreline buffers
  - Promote urban and construction Best Management Practices (BMPs)
    - Support research to quantify the benefits of BMPs and Low Impact Development (LID)
    - Support water quality monitoring and assessment

Contaminants

- Assess the impacts of emerging contaminants discharged to surface waters (pharmaceuticals, perfluoro-chemicals, pesticides, endocrine disruptors)
- Assess the impacts of contaminants from urban activities (construction, transportation, impervious areas)
- Support research on how to reduce, minimize, remove, or remediate contaminants

Consumptive Use and Energy

- Measure the impact of water withdrawals on ground water – focus on the relationship between withdrawal vs. recharge
- Determine the impacts of different renewable energy options on water quantity and quality

Fish – Drivers of Change/Recommendations:

Aquatic Invasive Species

- Develop effective ways to stop or reduce spread of harmful invaders – urgently needed for VHS!
- Develop more effective methods of controlling aquatic invasive species
- Improve risk assessments for potentially harmful new invaders
- Create solutions to restore native communities after invasive species are under control

Land Disturbance

- Invest in protection of Strategic Land Areas to reduce nutrients and solids loading to surface waters
- Create tools to predict when cumulative land disturbances will alter fish communities
- Evaluate consequences of land use policies for fish communities

Aquatic Habitat Loss

- Create tools to predict reductions in fisheries productivity due to lake habitat losses
- Evaluate effectiveness of BMPs for shoreline habitat restoration
- Create tools to predict effects of shoreline development with and without BMPs on fish communities

Climate Change

- Fill crucial data gaps to predict and monitor effects of climate change, including effects on lake and stream water and nutrient budgets, temperatures linked to other climate data, and on-game fish, aquatic invertebrates, and aquatic plants
- Develop methods to predict the effects of climate change combined with other stressors on fish communities

Fish Stocking

- Develop guidance on environmentally appropriate source populations and species for stocking to:
  - Restore fish communities
  - Adapt to climate change
  - Support fishing

- Evaluate effects of stocked fish on:
  - Genetic diversity and fitness of wild fish (same species)
  - Entire aquatic communities (other species)
- Evaluate effects of current fish stocking on anglers' experience – quality and quantity of fish caught

Contaminants

- Monitor endocrine disruptors and pharmaceuticals:
  - Distribution in surface waters
  - Effect on fish health
  - Biological response in fish in contaminated waters

Outdoor Recreation – Drivers of Change/Recommendations:

Land Use Change

- Assess how changing land use patterns affect demand for, and supply of, the recreation resource

Human Health

- Measure physical and mental health benefits of outdoor recreation:
  - Perceived and attained benefits
  - Measure actual activity via biophysical data

Demographics

- Assess preferences for, and constraints to, recreation among racially/ethnically diverse population segments and inter-generational groups

Climate Change

- Research how the effects of climate change will affect recreation users and recreation providers in Minnesota, including:
  - Lack of snow and ice
  - Lower water levels
  - Change in land cover and water quality/quantity
  - Higher summer temperatures
  - Longer spring and fall seasons

Appendix II

Participant List

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Project Participants - Preliminary and Final Plan Phases

The Minnesota Statewide Conservation and Preservation Plan (SCPP) project team is composed of many leading experts in science, natural resources, data analysis and modeling, planning, land use, policy implementation, and facilitation of large, complex projects.

Many of the University of Minnesota faculty involved are recognized locally, regionally, nationally, and internationally for their scientific expertise. In addition to holding prominent leadership and research positions at the University of Minnesota, they have served on advisory committees to the U.S. government, in joint Canadian-U.S. scientific and policy groups, and have contributed their time and experience to advisory groups to the United Nations. They sit on the editorial panels for leading scientific journals, and several hold highly prestigious international fellowships.

The private consultant team members are widely recognized within the industry for their experience and applied knowledge, and all bring a strong regional, and in some cases national, reputation for skill and excellence. Two are current or past owners of their own planning firms, and several are widely published. Many have been members or board members of regional, local, and national professional organizations, and have served leadership roles in those organizations. Members of the project team and project advisors are listed below.

In the following list, University of Minnesota refers to faculty or staff from the UM-Twin Cities; UM Duluth NRRI refers to faculty or staff from the UM at Duluth's Natural Resources Research Institute.

Project Team Members

Deborah Swackhamer	Principal Investigator	University of Minnesota
Jean Coleman	Project Coordinator	CR Planning
Ira Adelman	Fish Team	University of Minnesota
Dorothy Anderson	Recreation Team	University of Minnesota
James L. Anderson	Water Team	University of Minnesota
Todd Arnold	Wildlife/Habitat Team	University of Minnesota
Richard Axler	Water Team	UM Duluth NRRI
John Baker	Energy and Mercury Team	University of Minnesota
Marv Bauer	Information Systems	University of Minnesota
James Barton	Transportation Team	Barton Consulting
Michelle Beaman	Support Staff	University of Minnesota
Bill Berguson	Energy and Mercury Team	UM Duluth NRRI
Robert Blair	Wildlife Team	University of Minnesota
Paul Bockenstedt	Land/Habitat Team	Bonestroo
Terry Brown	Support Staff-GIS/Habitat Team	University of Minnesota
John Cannon	Student Support Staff	University of Minnesota
Amy Carolan	Student Support Staff	Bonestroo
Alex Conzemius	Student Support Staff	CR Planning
Amy Cowell	Cost Benefit Analysis Team	University of Minnesota
Francesca Cuthbert	Wildlife/Habitat Team	University of Minnesota
Nick Danz	Support Staff/Habitat Team	University of Minnesota
Kathryn Draeger	Outreach/Energy and Mercury Team	University of Minnesota
William Easter	Cost Evaluation Workshop	University of Minnesota
Alan Ek	Land Team	University of Minnesota
Debra Elias Morse	Support Staff/Editor	CR Planning
Les Everett	Land Use Team Lead	University of Minnesota
Don Fosnacht	Energy and Mercury Team Lead	UM Duluth NRRI
Sue Galatowitsch	Climate Change/Habitat Team	University of Minnesota
Elizabeth Gould	Land/Land Use Team	Bonestroo
Cindy Hagley	Outreach Team Lead	University of Minnesota
Mirja Hanson	Outreach Team	Mirja P. Hanson Associates
Joel Haskard	Energy and Mercury Team	University of Minnesota
Alex Helling	Student Support Staff	University of Minnesota
David Hendrickson	Energy and Mercury Team	University of Minnesota

Kurt Hinz	Support Staff	Bonestroo
Mary Hoff	Science Writer/Editor	Independent Consultant
George Host	Habitat Team Lead	UM Duluth NRRI
Mark Hove	Water Team	University of Minnesota
Annalisa Hultberg	Land Use Team	University of Minnesota
Gregg Johnson	Energy and Mercury Team	University of Minnesota
Kris Johnson	Outreach Team	University of Minnesota
Lucinda Johnson	Water/Land Use Team	UM Duluth NRRI
Wendell Johnson	Energy and Mercury Team	University of Minnesota
Nick Jordan	Land Team	University of Minnesota
Anne Kapuscinski	Fish/Habitat Team Lead	University of Minnesota
Michael Kelberer	Support Staff	University of Minnesota
Steve Kelley	Cost Evaluation Workshop	University of Minnesota
Mike Kilgore	Land/Habitat Team	University of Minnesota
Kathy Klink	Air Team	University of Minnesota
Azra Kovacevik	Energy and Mercury Team-Mercury	University of Minnesota
Dana Kraus	Support Staff	CR Planning
Holly Lahd	Student Support Staff	University of Minnesota
Emily Levine	Student Support Staff	University of Minnesota
Maia Mahowold	Support Staff	CR Planning
Dave Mech	Wildlife Team	University of Minnesota
Ben Meyer	Water Team	Bonestroo
Loren Miller	Fish Team	University of Minnesota
David Mulla	Land Use/Energy and Mercury Team Lead	University of Minnesota
Lance Neckar	Land/Transportation Team	University of Minnesota
Joel Nelson	Energy and Mercury Team	University of Minnesota
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Randy Neprash	Water/Land Use Team	Bonestroo
Ray Newman	Fish Team	University of Minnesota
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Steve Polasky	Cost Benefit Analysis Team	University of Minnesota
Lowell C. Rasmussen	Energy and Mercury Team	University of Minnesota Morris
Peter Reich	Land/Land Use Team	University of Minnesota
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Ciara Schlichting	Recreation Team	Bonestroo
Laura Schmitt-Olabisi	Energy and Mercury Team	University of Minnesota

Ingrid Schneider	Recreation Team	University of Minnesota
Mark Seeley	Air Team	University of Minnesota
Dale Setterholm	Water Team	University of Minnesota
John Shardlow	Land Use Team Lead	Bonestroo
Matt Simcik	Air Team	University of Minnesota
George Spangler	Fish Team	University of Minnesota
Sangwon Suh	Cost Benefit Analysis Team	University of Minnesota
Ashley Tabery	Student Support Staff	University of Minnesota
Steve Taff	Land Use Team	University of Minnesota
Katherine Thering	Transportation Team	University of Minnesota
Mary Vogel	Recreation Team	University of Minnesota
Bruce Vondracek	Fish/Habitat Team	University of Minnesota
Mark Wallis	Water Team	Bonestroo
Bruce N. Wilson	Water Team	University of Minnesota
Dave Zumeta	Energy and Mercury Team	University of Minnesota
Winnie Zwick	Support Staff	CR Planning

Project Advisors – The following individuals provided valuable advice to project teams or participated as advisors on project teams. The recommendations in this report are the sole product of the project team listed above. Project Advisors do not necessarily endorse the recommendations and did not participate in the selection of the final set of recommendations.

Charles Anderson	Fish Team	Minnesota Department of Natural Resources
John Bailey	Land Use Team	Greater Minnesota Housing Fund
Tom Bakritges	Land Use Team	Builders Association of the Twin Cities
Wayne Barstad	Habitat Team	Minnesota Department of Natural Resources
Steve Benson	Wildlife/Habitat Team	Minnesota Department of Natural Resources
Don Berger	Land Use Team	Minnesota Pollution Control Agency
Lyn Bergquist	Land Team	Minnesota Department of Natural Resources
Kristen Blann	Habitat Team	The Nature Conservancy
Daren Carlson	Wildlife/Habitat Team	Minnesota Department of Natural Resources
Steve Chaplin	Habitat Team	The Nature Conservancy
Ian Chisholm	Habitat Team	Minnesota Department of Natural Resources
Clay Cottingim	Water Team	Minnesota Department of Natural Resources
John Curry	Habitat Team	Minnesota Campaign for Conservation
David DeVault	Water Team	United States Fish and Wildlife Service
Bob Engstrom	Land Use Team	Robert Engstrom Company
Anne Gelbmann	Land Use Team	Minnesota Pollution Control Agency
Dianne Granfors	Habitat Team	United States Fish and Wildlife Service
Jim Hafner	Land Use Team	City of Blaine/League of Minnesota Cities
Eric Hedtke	Land Use Team	Minnesota Association of Townships
Ryan Heiniger	Habitat Team	Ducks Unlimited
Carrol Henderson	Wildlife Team	Minnesota Department of Natural Resources
Don Hickman	Land Use Team	Initiative Foundation
Steve Hobbs	Land Use Team	Belwin Foundation
Andrew Holdsworth	Land Use Team	Minnesota Department of Natural Resources
Roy Johnannes	Fish Team	Minnesota Department of Natural Resources
Greg Johnson	Habitat Team	Minnesota Pollution Control Agency
Tim Kelly	Recreation Team	Minnesota Department of Natural Resources
Beth Knudsen	Habitat Team	Minnesota Department of Natural Resources
Thomas Landwehr	Habitat Team	The Nature Conservancy
Bill Lee	Energy and Mercury Team	Chippewa Valley Ethanol Company
Mark Lindquist	Energy and Mercury Team	Minnesota Department of Natural Resources
Kevin Lines	Habitat Team	Water and Soil Resources Board
Jill Mazullo	Land Use Team	1000 Friends of Minnesota

Steve Merchant	Wildlife/Habitat Team	Minnesota Department of Natural Resources
Paul Merwin	Land Use Team	League of Minnesota Cities
Jason Moeckel	Habitat Team	Minnesota Department of Natural Resources
Jim Mulder	Land Use Team	Association of Minnesota Counties
Michael Noonan	Land Use Team	Rottlund Homes
Max Norris	Energy and Mercury Team	Agricultural Utilization Research Institute
Bob Patton	Land Use Team	Minnesota Department of Agriculture
Don Pereira	Water Team	Minnesota Department of Natural Resources
Sharon Pfeifer	Land Use Team	Minnesota Department of Natural Resources
Anne Pierce	Land Use Team	Minnesota Department of Natural Resources
Cordelia Pierson	Land Use Team	The Trust for Public Land
Jane Prohaska	Habitat Team	Minnesota Land
Paul Radomski	Water/Habitat Team	Minnesota Department of Natural Resources
Bart Richardson	Habitat Team	Minnesota Department of Natural Resources
Marty Rye	Habitat Team	United States Forest Service
Dave Schad	Wildlife Team	Minnesota Department of Natural Resources
Susan Schmidt	Habitat Team	The Trust for Public Land
Jon Schneider	Habitat Team	Ducks Unlimited
Don Schreiner	Fish Team	Minnesota Department of Natural Resources
Barb Senness	Land Use Team	City of Plymouth/Assoc. of Metro Municipalities
Luke Skinner	Fish Team	Minnesota Department of Natural Resources
Brian Stenquist	Energy and Mercury Team	Minnesota Department of Natural Resources
Hannah Texler	Wildlife Team	Minnesota Department of Natural Resources
Ray Valley	Habitat Team	Minnesota Department of Natural Resources
Tom Weaver	Land Use Team	Metropolitan Council
Dave Weirens	Land Use Team	Board of Water and Soil Resources
John Wells	Habitat/Energy/Land Use Team	Minnesota Environmental Quality Board
Keith Wendt	Habitat/Land Team	Minnesota Department of Natural Resources
Bruce C. Wilson	Water/Habitat Team	Minnesota Pollution Control Agency
Dave Wright	Fish Team	Minnesota Department of Natural Resources

Key Participant Credentials - Preliminary and Final Plan

Deborah Swackhamer, PhD, University of Minnesota

Dr. Swackhamer is professor of environmental chemistry in the Division of Environmental Health Sciences, School of Public Health. Dr. Swackhamer is an international expert in the chemical and biological processes that control the fate of toxic organic contaminants in the aquatic environment, particularly bioaccumulation of persistent compounds in fish in the Great Lakes; the processes that control exposure to environmental estrogenic compounds; and the development of contaminant indicators of ecosystem health. Dr. Swackhamer served as interim director of the Institute on the Environment (2006–08), and is co-director of the Water Resources Center. She currently sits on the science advisory boards of the U.S. EPA and the International Joint Commission of the U.S. and Canada. She also serves on the advisory board for the National Undersea Research Program of NOAA for the North Atlantic-Great Lakes region, and the Board of Scientific Councilors of the U.S. EPA. She was appointed by Governor Pawlenty to serve in the Clean Water Council in 2007. Dr. Swackhamer is a member of the editorial advisory boards for the journals *Environmental Science & Technology and JEM: Journal of Environmental Monitoring*.

Jean Coleman, JD, MA, CR Planning, Inc.

Ms. Coleman has proven skills in managing complex teams over tight time frames and extensive knowledge of using natural resource information in land use planning and zoning. In addition to serving on the core management team, Ms. Coleman served as the consultant team project coordinator. Her primary role was to manage internal communication and document creation and supervise project support personnel. Ms. Coleman has extensive experience in natural resource and farmland protection, preparing comprehensive land use plans and zoning ordinances, group process facilitation, and growth management. Her work combines her interests in planning and law by using public participation and conflict resolution techniques to develop policies, ordinances, and programs. She enjoys working in a variety of landscapes and has managed multiple projects at the neighborhood, township, county, and regional scale.

Todd Arnold, PhD, University of Minnesota

Dr. Arnold is associate professor of fisheries, wildlife, and conservation biology. He has also worked extensively with environmental NGOs, including stints as senior scientist for Ducks Unlimited Canada and scientific director for Delta Waterfowl Foundation. His research focuses on prairie- and wetland-dependent wildlife, especially waterfowl. He has worked on numerous regional issues in waterfowl management, including development of a decision support system for conservation planning in the Canadian prairie pothole region.

Paul Bockenstedt, MA, Bonestroo

Mr. Bockenstedt has over 23 years of experience in the natural resources field, including 13 years of experience with state and county agencies in Iowa and Minnesota, and most recently nine years working throughout the Upper Midwest at Bonestroo. He has been involved with natural resources inventory, conservation, management, and planning at the local, county, regional, watershed and state levels in Minnesota and Iowa since 1992. He has served as the project manager and/or lead ecologist for over 100 natural resource and recreation/parks planning projects and botanical inventories. and written over 125 ecological restoration plans during his career. In addition, he has numerous publications and presentations to his credit.

Les Everett, PhD, University of Minnesota

Dr. Everett is an agronomist and program coordinator at the Water Resources Center, University of Minnesota, where since 1995 he has managed grant-based Extension education and on-farm research/demonstration programs related to water quality. He works closely with Extension and research faculty as well as state and federal agencies to deliver programs on manure, crop nutrient, and tillage management. He was raised on a crop and livestock farm in Iowa, obtained a BS in farm operation at Iowa State University, an MS in agronomy at Cornell University, and a PhD from the Department of Agronomy and Plant Genetics at the University of Minnesota. Prior to his current position, Dr. Everett was a scientist for the International Institute of Tropical Agriculture in Nigeria and Cameroon for 10 years, and prior to graduate training was a U.S. Army officer and a Peace Corps agricultural advisor.

Don Fosnacht, PhD, University of Minnesota

Dr. Fosnacht is director of the Center for Applied Research and Technology Development based at the University of Minnesota Duluth's Natural Resources Research Institute. He oversees the research and development program of over 65 researchers dedicated to fostering economic development of Minnesota natural resources in an environmentally acceptable manner. In addition, he serves as principal investigator on projects related to value added iron creation, aggregate utilization, bioenergy generation, and environmental remediation using mineral processing techniques. He has worked in the metals and mining industry in various capacities concerning technology development and resource utilization. His work has included particle technology characterization, process evaluation, process design, and manufacturing efficiency development. In addition to various professional memberships, Dr. Fosnacht has served on the Governor's Committee on Minnesota Mining's Future and the Tax Policy Advisory Committee. He also led development of the mining roadmap for Minnesota that was funded by the U.S. Department of Energy. He currently is a member of the State of Minnesota Minerals Diversification Committee. Dr. Fosnacht is also co-leader for the Energy Use and Production Subcommittee, for the LCCMR effort concerning development of a statewide conservation and preservation plan. He has authored or co-authored numerous publications, patents and presentations.

George Host, PhD, University of Minnesota

Dr. Host is a senior research associate and landscape ecologist with the Natural Resources Research Institute at the University of Minnesota Duluth and director of the Natural Resources Geographic Information System laboratory at UMD. He currently is principal or co-principal investigator on 15+ research projects distributed across the fields of forest ecology, ecological assessment and indicator development, plant response to atmospheric pollutants, linkages between terrestrial and aquatic systems (particularly with respect to stormwater issues), and data visualization and spatial analyses for land use planning. Dr. Host has over 50 refereed publications, and has served on advisory panels for the Minnesota Department of Natural Resources, the Minnesota Forest Resources Council, and numerous county and municipal groups. Dr. Host managed a GIS analysis to identify lands of high conservation value for the development of conservation easements through the Forest Legacy Program.

Anne R. Kapuscinski, PhD, University of Minnesota

Dr. Kapuscinski is professor of fisheries, wildlife and conservation biology, Sea Grant Extension specialist, and founding fellow of the Institute on the Environment. She also directs the Institute for Social, Economic and Ecological Sustainability (ISEES) and currently co-leads the Ecosystem Science and Sustainability Initiative funded by the Bush Foundation. She is a global leader in conservation of aquatic biodiversity, sustainability science, and biotechnology environmental policy. Her biodiversity research addresses effects of technologies from dams to fish hatcheries, aquaculture and genetic engineering on fish conservation. Her sustainability science research asks how to make our society more resilient to environmental and socioeconomic change, currently through the Minnesota 2050 Project, bringing together citizens and researchers to develop plausible future scenarios and compare them to quantitative trends. She holds a Pew Marine Conservation Fellowship, the world's preeminent marine conservation award, and a USDA Honor Award for Environmental Protection. In 2008, the international Society for Conservation Biology awarded her a Distinguished Service Award for devoting her career to practicing science for the public good. For the U.S. National Academy of Science, Kapuscinski has co-authored three reports on endangered salmon and on genetically engineered organisms, and chaired a committee on genetically modified organisms, wildlife and habitats. She is a frequent scientific advisor to international organizations - UN Food and Agriculture Organization, World Health Organization, World Animal Health Organization, Global Environment Facility, Convention on Biological Diversity; the U.S. government – U.S. Secretary of Agriculture, Food and Drug Administration, congressional hearings; and the state of Minnesota - state agencies and Legislature. She served on the board of trustees of the WorldFish Center of the Consultative Group on International Agriculture Research and is currently on the board of directors of the Union of Concerned Scientists, the Seafood Watch Advisory Board, and WorldFish Center Science Advisory Committee.

David Mulla, PhD, University of Minnesota

Dr. Mulla is the W.E. Larson Chair for Soil & Water Resources in the Department of Soil, Water, and Climate, a fellow in the Institute on Environment, and director of the Precision Agriculture Center at the Univ. of Minnesota. His research focuses on nonpoint source water quality pollution and spatial statistics in agriculture and the environment. He and his colleagues have produced over 160 publications, and their research has been funded at over $10 million. Dr. Mulla is an internationally recognized researcher and scholar. His research has taken him to Brazil, Canada, England, France, Holland, Germany, Greece, India, Italy, Japan, Jordan, Lebanon, Mexico, Morocco, Niger, Sri Lanka, Sweden, and Switzerland. His scientific peers elected him as a fellow in the Soil Science Society of America (SSSA), and as a fellow in the Agronomy Society of America. In 2000, he received the Minnesota Governor's Commendation for the Lake Pepin Phosphorus Study. In 2002, he received the Visiting Distinguished Faculty Award from the Univ. Kentucky, and the Best Research Paper Award from *J. Soil Water Conservation*. In 2005 the USDA featured his paired watershed study among all integrated water quality research project funded by CSREES in the USA. The same year he was selected to serve on the scientific advisory panel for the Lake Pepin (Mississippi River) sediment and phosphorus TMDLs. In 2007 he was appointed as a founding fellow to the University of Minnesota's new Institute on Environment.

Lance Neckar, MLA, University of Minnesota

Professor Neckar is professor of landscape architecture and serving currently as department chair. Dr. Neckar conducts applied research on the relationships between urban development and the sustainability of water and other resources. His current teaching focuses on sustainable infrastructure. He also brings over 20 years of experience as a registered landscape architect with several award-winning urban design projects. He is acting Director of the Metropolitan Design Center.

Randy Neprash, BS, Bonestroo

Mr. Neprash is a stormwater regulatory specialist and engineer with the Water and Natural Resources Group at Bonestroo. He has served as the technical/administrative consultant for the coalition of more than 100 cities regulated under the NPDES MS4 Stormwater Permit program for more than four years. In this capacity, he has represented cities on the Minnesota Stormwater Steering Committee (MnSSC) and its Operations Subcommittee since its conception. The MnSSC is charged with informing, advising, and coordinating stormwater management efforts across the state. It also provides support for other programs that include stormwater components such as: impaired waters, shoreland management, drinking water source water, wetland management, Minnesota Nonpoint Source Management Plan, federal funding programs, groundwater recharge, watershed organizations, surface water management plans.

Gerald Niemi, PhD, University of Minnesota

Dr. Gerald Niemi is professor of biology and director of the Center for Water and the Environment at the Natural Resources Research Institute at the University of Minnesota Duluth. He also was a Fulbright-Hays scholar to Finland. His primary research interests include birds, Great Lakes ecosystems, conservation biology, and sustainability of natural resources. He has written over 200 articles, publications, book chapters, and technical reports. He has received more than $18 million in research funding. Dr. Niemi regularly teaches Ornithology and Conservation Biology.

Ingrid Schneider, PhD, University of Minnesota

Dr. Schneider is an associate professor in forest resources and director of the University's Tourism Center. She has broad experience in visitor behavior in outdoor recreation management and sustainable tourism with particular emphasis in visitor attitudes, conflict and constraints. She is a member of the Governor's Council on Tourism.

John Shardlow, AICP, Bonestroo

Mr. Shardlow directs urban planning services for Bonestroo. He has extensive and wide-ranging experience serving clients in both the public and private sectors, and has led many multidisciplinary teams of consultants in large, complex planning projects. His skills include comprehensive and community planning, project planning, redevelopment planning, regulations, and environmental assessments. He is a faculty member of the Government Training Service, and is a member of the America Institute of Certified Planners, the American Planning Association, and Minnesota Planning association, and past president of the Minnesota chapter of the Community Association Institute. He is a past president of the Sensible Land Use coalition, and currently serves on the executive Committee of the Twin Cities Chapter of the Urban Land Institute (ULI).

Matt F. Simcik, PhD, University of Minnesota

Dr. Simcik is an associate professor of environmental health sciences in the School of Public Health. He has broad expertise on air toxins and their interactions with aquatic and terrestrial systems. He is currently president of the International Association of Great Lakes Research.

Sangwon Suh, PhD, University of Minnesota

Dr. Suh is an assistant professor focusing his research on environmental and economic systems analysis in the interface between engineering, economics, ecology and public policy. His expertise lies on building and management of databases, mathematical modeling, and systems analysis. For the last five years he authored or co-authored around 30 peer reviewed journal articles, two books and two commercial databases. He is an associate editor of the *International Journal of Life Cycle Assessment* and serves on the editorial boards of economics and engineering journals. He advises the Eco-Industrial Development Council (EIDC) and the European Commission's Directorate General, the Environment on its Integrated Product Policy (IPP).

Appendix III

Mercury Emissions and Their Relationship to Energy Use

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Introduction

Mercury is a naturally occurring element in the environment. It is also used or produced in a variety of industries, and can enter the environment as a result of ore smelting, agricultural practices, production of chlorine and caustic soda and other human activities.

Mercury is a toxic pollutant; it can cause defects in the central nervous system. During the 1950s, industrial discharges of methyl-mercury into Minamata Bay in Japan resulted in the contamination of fish with methyl-mercury; and consequently the poisoning of thousands and deaths of hundreds of individuals.

Mercury has a complex biogeochemical cycle (Figure 1). It can transfer between different ecosystem reservoirs and exhibit chemical transformations that control its behavior and toxicity.

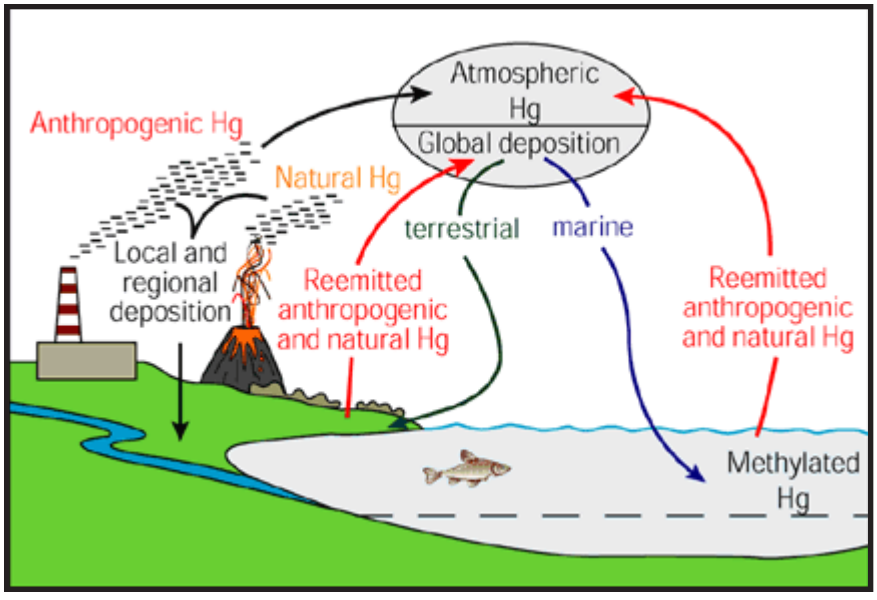


Figure 1. Biogeochemical cycle of mercury in the environment. Credit: USGS, 2008.

In the environment it occurs in various forms, including inorganic mercury ion (Hg^{2+}) , methyl-mercury (CH_3Hg^+) or dimethyl-mercury [$(CH3)_2Hg$]. Methylated mercury compounds are much more toxic then the inorganic mercury. The methylation of mercury results in increased solubility and volatility (of Hg) and increases its movement into the food chain. Methylated compounds are rapidly taken up by aquatic organisms where they bioaccumulate in the fatty tissue, and can become very harmful to that organism or others that consume it.

Mercury in the Environment

When mercury is released in to the atmosphere it falls on earth and runs into lakes, rivers and streams. Bacteria in the water transform the mercury into toxic methyl-mercury. When fish consume these bacteria they become contaminated. As this cycle moves up the food-chain the larger fish end up with higher concentrations of toxic mercury in their flesh. Humans are also exposed to methyl-mercury by eating contaminated fish.

Atmospheric deposition is the primary source of mercury to the water bodies in Minnesota. According to the Minnesota Pollution Control Agency (MPCA, 2005) about 99 percent of mercury that is deposited in Minnesota comes from atmospheric deposition.

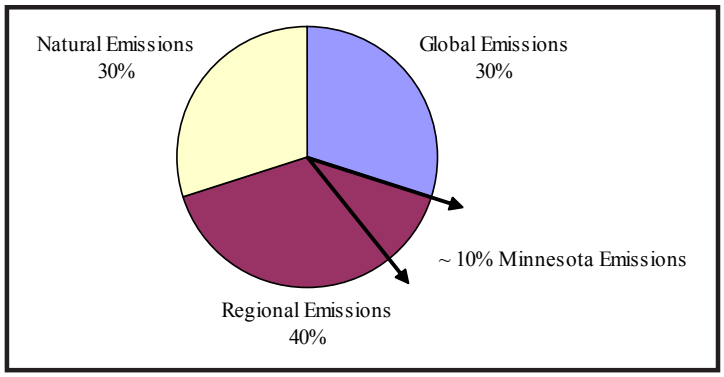


Figure 2. Sources of atmospheric mercury deposition to Minnesota. Credit: MPCA TMDL, 2007; Engstrom and Swain, 1997

Various modeling studies of global mercury cycling have concluded that natural emissions (e.g. volcanoes) contribute 30% to mercury deposition, while the other 70% is a result of human activities (MPCA Total Maximum Daily Loads (TMDL), 2007). Similarly, a recent scientific study in Minnesota (Engstrom and Swain, 1997) indicated that anthropogenic emissions account for 70% of mercury deposition in the state. The authors further stated that 30% of mercury deposition comes from global pollution and 40% comes from regional pollution.

According to the MPCA TMDL (2007) about 10% of total mercury deposition in Minnesota is due to emissions in the state. The sources of atmospheric mercury deposition in Minnesota are summarized and illustrated in Figure 2. Sector specific mercury emissions in the state are discussed in the following section.

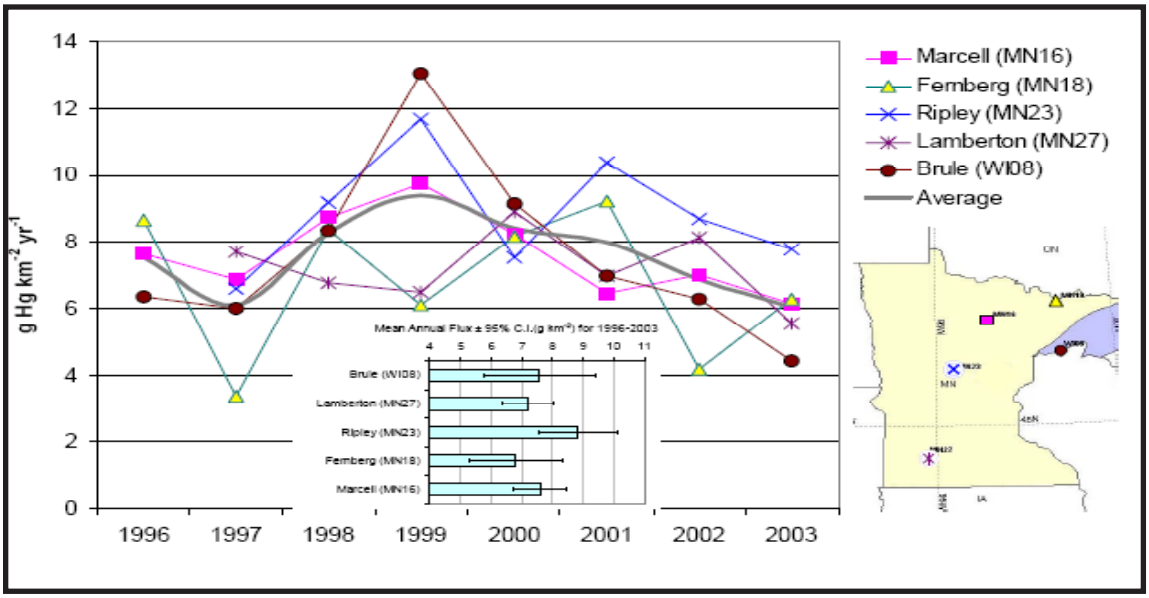


Figure 3. Annual mercury flux at mercury deposition network (MDN) sites in Minnesota. Credit: MPCA TMDL, 2007.

According to the MPCA TMDL (2007) wet deposition rates in Minnesota have not changed significantly since the mid 1990s. This information is presented in Figure 3 which shows an overlap in annual mercury deposition fluxes from fixed monitoring stations in Minnesota and Brule, Wisconsin. The figure also shows that the station mean annual fluxes are not significantly different in the ('96 to '03) period (MPCA TMDL, 2007).

Region	Eco-region	Wetlands (%)	Cultivated (%)	Hay/ Pasture (%)	Lake TP (µg/L)	Stream TP (µg/L)	Lake Chl *a* (µg/L)	Stream Chl *a* (µg/L)
NE	NMW	58.9	8.3	4.6	14 – 27	40 – 90	2-10	3.2
	NLF	26.9	3.6	6.5	14 – 27	20 – 50	2-10	2.1
SW	NCHF	14.9	35.0	23.4	23 – 50	60 – 150	5 – 22	15.8
	RRV	7.3	78.8	6.6	23 – 50	110 – 300	5 – 22	22.1
	NGP	4.6	73.5	16.5	130 – 250	90 – 250	30 – 55	27.1
	DA	4.5	23.8	27.1	N/A	60 – 150	N/A	N/A
	WCBP	2.9	76.8	12.2	65 – 150	160 – 330	30 – 80	23.6

NMW: Northern Minnesota Wetlands RRV: Red River Valley
NLF: Northern Lakes and Forests NGP: Northern Glaciated Plains
NCHF: North Central Hardwoods Forests DA: Driftless Area
WCBP: Western Corn Belt Plains

Land cover data from 1992 (USGS, 1999. Minnesota Land Cover Data Set)

Total phosphorus (TP) and chlorophyll *a* (Chl a) ranges are typical summer lake water quality conditions and typical annual stream water quality conditions for minimally impacted waters (MPCA. 2003. *Comparison of typical Minnesota water quality conditions.* http://www.pca.state.mn.us/publications/wq-s1-02.pdf). Lake data were collected 1985-1988 (Heiskary and Wilson 1989) and stream data were collected 1990-1992 (McCollor and Heiskary 1993).

Table 1. Regional differences in land cover and water quality. Credit: MPCA TMDL, 2007.

Mercury concentrations in fish depend on land cover and land use. Land cover and its use are very important in controlling and affecting (1) watershed transport of mercury, (2) background water chemistry and (3) nutrients (nutrients loading affect the bioavailability of mercury).

Wetlands are important sites of mercury methylation. The methylation occurs under anaerobic conditions which are usually found in wetland soils, and lake sediments (Zillioux *et al.,* 1993). Sulfate reducing bacteria reside in wetlands and are the primary methylators. Usually, wetland density is positively correlated with mercury concentration in fish and water (as seen in data presented in Table 1 and 2).

Cultivated lands are typically sources of suspended solids due to soil erosion. Mercury is associated with high suspended solids loads, but it has low bioavailability because only a small fraction is in the form of methyl-mercury. Table 1 shows regional differences in land use and water quality in Minnesota. The mercury concentrations in fish for the different regions in Minnesota are shown in Table 2.

	Northern Pike (55 cm)	Walleye (40 cm)
NE	0.320	0.268
SW	0.187	0.185
Average	**0.254**	**0.227**

Table 2. Median mercury concentrations for northern pike (NP) and walleye (WE) collected from 1970 to 2002. Credit: MPCA TMDL, 2007.

Mercury Emissions in Minnesota

The MPCA has estimated that mercury anthropogenic emissions from Minnesota sources totaled 3328 pounds (lbs) for 2005, the agency also projected emissions for 2010 (2718 lbs), and 2018 (2012 lbs) (MPCA, 2008). The emissions were divided into four categories: (1) emissions resulting from energy production, (2) emissions due to material processing largely as a result of taconite processing, (3) emission due to purposeful use of mercury, largely as a result of disposal of products and (4) mercury from difficult to categorize sources (i.e. fuel or materials). A summary of emissions sources within these categories is included in Table 3 (next page).

In 2005, 56% of Minnesota's emissions were from energy sources, 22% from taconite processing and 21% from purposeful use. The emissions for 2010 and 2018 are projected to decrease to 2718 and 2012 lb, respectively. Despite the overall reductions in mercury emissions, emissions from the taconite industry are expected to increase by about 14%.

Regulatory Overview

Mercury is released into the environment through emissions from manufacturing, use, or disposal activities. To protect the environment, the US Congress passes laws and oftentimes authorizes the Environmental Protection Agency (EPA) (and other government agencies) to create and enforce these regulations.

Mercury emissions and contamination are addressed under the Clean Air Act (CAA), Clean Water Act (CWA), Resource and Conservation Recovery Act (RCRA), and Safe Drinking Water Act. Under the CAA mercury is listed as a hazardous air pollutant. In accordance with the CAA, power plants were to reduce mercury emission by 90% by 2008, however in 2005, the EPA decided to exempt the power plants from mercury controls until 2010. In February of 2008, the D.C. Circuit court voided EPA's rule to remove the power plants from the CAA's list of resources of hazardous air pollutants.

Under the CWA, water quality standards are set for rivers, lakes, streams and wetlands. The standards identify levels for pollutants including mercury that must be met in order to protect human health, fish and wildlife.

RCRA requires that the EPA manage hazardous wastes, including mercury wastes from the time they are generated, through storage and transportation, to their ultimate treatment and disposal. Safe Water Drinking Act sets standards for drinking water that apply to public water systems. These standards protect people by limiting levels of mercury and other contaminants in drinking water.

On March 15, 2005 the EPA issued a Clean Air Mercury Rule (CAMR) to permanently cap and reduce mercury emissions from coal-fired power plants for the first time. The CAMR would take effect after 2010 and a cap and trade mechanism would be designed to reduce mercury emissions by 70% by 2018. During the same period when CAMR was proposed the EPA made a decision to exempt power plants from mercury controls until 2010. On February 8, 2008 the D.C. Circuit court vacated the EPA's CAMR.

Incidental to Energy Production	*2005 (lbs)*	*2010 (lbs)*	*2018 (lbs)*
Coal-Electric Utility	1710.3	1040.1	414.1
Coal – Commercial, Institutional and Industrial	62.9	68.9	78.6
Volatilization from coal ash	0		
Petroleum Refining	12.9	13.6	14.8
Petroleum Product Utilization	39	41.3	44.9
Wood Combustion	39.4	41.7	45.3
Natural Gas Combustion	0.3	0.3	0.3
Subtotal: Incidental with energy production	**1864.7**	**1205.9**	**598**
% of total state emissions	**56%**	**44%**	**30%**
Largely Resulting from the Purposeful use of Mercury			
Volatilization: solid waste collection and processing	169	152.8	126.8
On site household waste incineration	40	36.2	30
Volatilization from spills and land dumping	24	21.7	18
Land volatilization	2.1	1.9	1.6
Volatilization: land applications of compost	0.2	0.2	0.2
Volatilization: land applications of sludge	1.6	1.3	0.8
Smelters that recycle cars and appliances	138.7	120	90.2
Recycling mercury from products within MN	65	71.3	81.3
Non-ferrous metal recycling (Al, Pb)	7	7.7	8.8
Dental Preparations	62.4	56.4	20.1
Cremation	80	80	80
Municipal solid waste combustion	49.2	38	38
Sewage Sludge Incineration	8.5	8.9	11.9
Medical waste incineration	1.8	2.5	3.7
Hazardous waste incineration	0.3	0.3	0.3
Class IV incinerations	0	0	0
SJE Rhombus switch, Detroit Lakes	42	38	31.5
General Laboratory Use	10	8.1	5
Volatilization from dissipative use	0.8	0.6	0.4
Subtotal: Associated with purposeful use of mercury	**702.6**	**645.8**	**548.3**
% of total state emissions	**21%**	**24%**	**27%**
Emissions Incidental to Material Processing			
Taconite Processing	734.8	840.6	840.6
Thermal treatment of soil	0.8	0.8	0.8
Subtotal: Emissions incidental to material processing	**735.6**	**841.4**	**841.4**
% of total state emissions	**22%**	**31%**	**42%**
Difficult to Categorize (is Hg from fuel or materials?)			
Asphalt Manufacturing	4.3	4.3	4.3
Agriculture, Food Kinder products	1.1	1.1	1.1
Mineral Products	13.8	13.8	13.8
Miscellaneous Industrial Process	0.2	0.2	0.2
Wood, Pulp & Paper, Publishing Products	5.1	5.1	5.1
Subtotal: Emissions from difficult to categorize	**24.6**	**24.6**	**24.6**
% of total state emissions	**1%**	**1%**	**1%**
GRAND TOTAL (lbs)	**3327.5**	**2717.7**	**2012.5**

Table 3. Estimated anthropogenic mercury emissions in Minnesota for 2005, 2010, and 2018. Credit: MPCA, 2008.

On March 15, 2005, the EPA issue the Clean Air Interstate Rule (CAIR), a rule that will dramatically reduce air pollution that moves across state boundaries. CAIR will permanently cap emissions from sulfur dioxide (SO_2) and nitrogen oxide (NO_X) in the eastern US. When the rule is implemented it will reduce SO_2 emissions by over 70% and NO_X emissions by 60% from 2003 levels. This rule affects 28 eastern states and Washington D.C. Minnesota is one of the affected states.

The Minnesota state legislature has set a mercury reduction goal (Minn. Stat. 116. 915) to reduce annual mercury emissions by 60% by 2000, and 70% by 2005 from 1990 levels (MPCA, 2005). According to MPCA estimates, the 1990 Minnesota mercury emissions were 11,272 lbs and 3,328 lbs in 2005 (MPCA, 2005). The goals have been met through a combination of federal and state initiatives, voluntary actions, and programs. It is important to note that majority of these reductions were related to the emissions from products containing mercury.

Additionally in 1999, the MPCA established a voluntary mercury-reducing agreement program. The program aims to reduce emissions from electrical utilities, and it has four actions that when implemented will reduce annual mercury emissions from facilities by 275 lbs:

- In 2000, Minnesota Power switched to low mercury coal (reduction by 70 lbs)
- In 2003, Xcel Energy replaced two coal burning units at Black Dog plant with natural gas fired turbine generators (reduction 35 lb)
- By 2009, under (MERP) Xcel Energy's Allen S King, High Bridge and Riverside plants will switch to natural gas and add scrubbers and fabric filters to the King plant (reduction of 170 lbs)

In 2006, under the direction of Gov. Tim Pawlenty, the MPCA and selected stakeholders (electrical utilities, environmental groups, and government agencies) developed the Minnesota Mercury Emissions Reduction Act. When fully implemented it will result in a 90% reduction from generation units at Minnesota's three largest coal fired power plants. These include the Xcel Energy Sherco and Allen S. King plants, and the Minnesota Power Clay – Boswell plant. The plan should be fully implemented by 2014 (MPCA, 2006).

Section 303 (d) of the Federal CWA requires every state to prepare a list of impaired waters. In the state's 2004 303 (d) list of impaired waters (MPCA TMDL, 2007), about 66% of the 1,892 impaired lakes and river reaches were impaired due to mercury contamination (fish tissue, water column or both). The CWA requires that each impaired water body have a total maximum daily loads (TMDL) study. The TMDL is an evaluation of (1) pollution sources; (2) pollutant load reduction needs to meet water quality standards and (3) allocation of the acceptable load to all sources (TMDL, 2007). The Minnesota TMDL plan was approved by the EPA in 2007, and it established a new goal for mercury emissions of 789 lbs/yr.

The state of Minnesota has clearly demonstrated its commitment to reducing mercury loads into the environment through both voluntary and regulatory approaches. As discussed previously in the report the state emissions contribute a relatively small percentage to the overall mercury deposition in the state. Although welcome and important, the state actions will not be enough. The previous discussions illustrate the importance for the development and implementation of a national program that regulates emissions from existing and future mercury sources.

Mercury Fish Concentrations

Currently, the link between mercury emissions and bioaccumulation in the fish and biota cannot be modeled accurately. In the absence of such models that correctly incorporate the complexities of atmospheric chemistry, watershed transport, methylation and bioaccumulation, researchers depend on the following assumptions (Jackson *et al.*, 2000):

- A reduction in emissions from sources in a given source area (local, regional or global) results in a proportional reduction in the rate of deposition in Minnesota attributable to those sources.
- A reduction in deposition results in a proportional reduction in mercury loading to water bodies.
- Within a given water body, a proportional reduction in mercury loading in the water results in a proportional reduction in mercury concentrations in fish.

Proportionality between mercury deposition and bioaccumulation assumes that bioavailability of mercury is constant, and is unaffected by the rate of atmospheric mercury deposition. These models assume that mercury in the terrestrial watershed and sediments will equilibrate and reach a new steady state proportional to atmospheric deposition.

For the purpose of this report, we will use the EPA's Mercury Maps model to predict the effects of mercury reductions (in air) on mercury concentrations in fish. The Mercury Maps tool (EPA, 2001) has the following features:

> *"Mercury Maps is a tool that relates changes in mercury air deposition rates to changes in mercury fish tissue concentrations, on a national scale. The tool utilizes a reduced form of accepted mercury fate and transport models applied to watersheds in which air deposition is the sole significant source…The Mercury Maps model states that for long-term steady state conditions, reductions in fish tissue concentrations are expected to track linearly with reductions in air deposition watershed loads."*

The Mercury Maps report describe the relationship as:

$$\frac{C_{fish,t2}}{C_{fish,t1}} = \frac{(L_{air,t2} + L_{other,t2})}{(L_{air,t1} + L_{other,t1})} \quad (1)$$

where $C_{fish,t1}$ and $C_{fish,t2}$ are the mercury concentrations in fish at times 1 and 2, which could be the baseline and target times; $L_{air,t1}$ and $L_{air,t2}$ are the air deposition mercury loads at each time to a water body, including direct deposition and indirect deposition via the watershed; and L_{other} is loading from other sources (MPCA TMDL, 2007).

Air deposition can be describe as:

$$L_{air} = D_y * (A_L * r + A_W) \quad (2)$$

where D_y is the annual air deposition flux of mercury (g km^{-2} y^{-1}); r is the runoff coefficient (also known as the delivery ratio); A_L and A_W are the areas of land and water (km^2). Assuming areas and r for each region do not

change from t_1 to t_2, this definition of L_{air} can be substituted into equation 1, areas will not change from t_1 to t_2 and, therefore areas drop out of the equation (MPCA TMDL, 2007).

Combining Equations 1 and 2, and including the bioavailability factor, the relationship becomes:

$$\frac{C_{fish,t2}}{C_{fish,t1}} = \frac{D_{y,t2} * r_{t2} * b_{t2}}{D_{y,t1} * r_{t1} * b_{t1}} \quad (3)$$

where *b* is the bioavailability factor.

We are assuming *r* and *b* do not change over time; therefore, their ratios at times 2 and 1 equal one and drop out of the equation. Therefore, Equation 3 simplifies to:

$$\frac{C_{fish,t2}}{C_{fish,t1}} = \frac{D_{y,t2}}{D_{y,t1}} \quad (4)$$

Rearranging the equation to solve for fish concentration at time t2:

$$C_{fish,t2} = \frac{D_{yt2}}{D_{yt1}} * C_{fish,t1} \quad (5)$$

According to the data in the MPCA TMDL (2007) the most recent measurement of total mercury deposition (wet and dry) in Minnesota was based on lake sediment cores collected in 1990. The best estimate of total mercury deposition around 1990 was 12.5 g km^{-2} yr^{-1} (MPCA TMDL, 2007).

	Baseline (1988-1992) fish concentrations (ppm)	
	Northern Pike (55 cm)	Walleye (40 cm)
NE	0.293	0.262
SW	0.203	0.218
Average	**0.248**	**0.240**

Table 4. Baseline fish concentrations in Minnesota for northern pike and walleye. Credit: MPCA TMDL, 2007.

Using baseline data from the MPCA TMDL (2007) and mercury emissions from MPCA (2008) we evaluated the impacts of various mercury reduction scenarios on concentrations of mercury in fish. These findings are presented below.

Scenario 1

2010 Fish Mercury Concentrations

- Assumption
  - Only MN emissions changed (regional, national and global contributions to deposition stayed the same)
- In 2010, MN Hg emissions = 2718 lbs
  - that is 75.89% reduction from baseline established in 1990 (11272 lbs)
  - Assuming that 50% of MN emissions deposited in the state; total mercury deposition in the state was reduced by 7.59%
  - The deposition rate changed from 12.5 g km^2/yr to 11.55 g km^2/yr

$$C_{fish,\,t2} = \frac{D_{y,t2}}{D_{y,t1}} \cdot C_{fish,\,t1}$$

$$C_{NP}(2010) = \frac{11.55 \text{ g km}^2\text{/yr}}{12.5 \text{ g/km}^2\text{/yr}} \cdot 0.248 = 0.229 \text{ ppm}$$

$$C_{WE}(2010) = \frac{11.55 \text{ g km}^2\text{/yr}}{12.5 \text{ g/km}^2\text{/yr}} \cdot 0.240 = 0.222 \text{ ppm}$$

Scenario2

2018 Fish Mercury Concentrations

- Assumption
  - Only MN emissions changed (regional, national and global contributions to deposition stayed the same)
- In 2018, MN Hg emissions = 2012 lbs
  - that is 82% reduction from baseline established in 1990 (11272 lbs)
  - Assuming that 50% of MN emissions deposited in the state; total mercury deposition in the state was reduced by 8.2%
  - The deposition rate changed from 12.5 g km^2/yr to 11.47 g km^2/yr

$$C_{fish,\,t2} = \frac{D_{y,t2}}{D_{y,t1}} \cdot C_{fish,\,t1}$$

$$C_{NP}(2018) = \frac{11.47 \text{ g km}^2\text{/yr}}{12.5 \text{ g/km}^2\text{/yr}} \cdot 0.248 = 0.228 \text{ ppm}$$

$$C_{WE}(2018) = \frac{11.47 \text{ g km}^2\text{/yr}}{12.5 \text{ g/km}^2\text{/yr}} \cdot 0.240 = 0.220 \text{ ppm}$$

Scenario 3

2018 Fish Mercury Concentration

- Assumption
  - MN emissions changed
- In 2018, MN Hg emissions = 2012 lbs
  - that is 82% reduction from baseline established in 1990 (11272 lbs)
  - Assuming that 50% of MN emissions deposited in the state; total mercury deposition in the state was reduced by 8.2%
- Assumption
  - US emissions changed (decreased by 20%)
  - Assuming that US emissions contribute 30% to mercury deposition in the state (15% Midwest and 15% outside Midwest) then the projected reduced deposition in MN is by 6% (20% of 30%)
- The deposition rate changed from 12.5 g km^2/yr to 10.7 g km^2/yr

$$C_{fish,\,t2} = \frac{D_{y,t2}}{D_{y,t1}} \cdot C_{fish,\,t1}$$

$$C_{NP}(2018) = \frac{10.7 \text{ g km}^2/\text{yr}}{12.5 \text{ g/km}^2/\text{yr}} \cdot 0.248 = 0.212 \text{ ppm}$$

$$C_{WE}(2018) = \frac{10.7 \text{ g km}^2/\text{yr}}{12.5 \text{ g/km}^2/\text{yr}} \cdot 0.240 = 0.205 \text{ ppm}$$

Scenario 4

2018 Fish Mercury Concentration

- Assumption
  - MN emissions changed
- In 2018, MN Hg emissions = 2012 lbs
  - that is 82% reduction from baseline established in 1990 (11272 lbs)
  - Assuming that 50% of MN emissions deposited in the state; total mercury deposition in the state was reduced by 8.2%
- Assumption
  - US emissions changed (decreased by 30%)
  - Assuming that US emissions contribute 30% to mercury deposition in the state (15% Midwest and 15% outside Midwest) then the projected reduced deposition in MN is by 9% (30% of 30%)
- The deposition rate changed from 12.5 g km^2/yr to 10.35 g km^2/yr

$$C_{fish,\,t2} = \frac{D_{y,t2}}{D_{y,t1}} \cdot C_{fish,\,t1}$$

$$C_{NP}(2018) = \frac{10.35 \text{ g km}^2/\text{yr}}{12.5 \text{ g/km}^2/\text{yr}} \cdot 0.248 = 0.205 \text{ ppm}$$

$$C_{WE}(2018) = \frac{10.35 \text{ g km}^2/\text{yr}}{12.5 \text{ g/km}^2/\text{yr}} \cdot 0.240 = 0.199 \text{ ppm}$$

Scenario 5

2018 Fish Mercury Concentration

- Assumption
  - MN emissions changed
- In 2018, MN Hg emissions = 2012 lbs
  - that is 82% reduction from baseline established in 1990 (11272 lbs)
  - Assuming that 50% of MN emissions deposited in the state; total mercury deposition in the state was reduced by 8.2%
- Assumption
  - US emissions changed (decreased by 40%)
  - Assuming that US emissions contribute 30% to mercury deposition in the state (15% Midwest and 15% outside Midwest) then the projected reduced deposition in MN is by 12% (40% of 30%)
- The deposition rate changed from 12.5 g km^2/yr to 9.98 g km^2/yr

$$C_{fish,\,t2} = \frac{D_{y,t2}}{D_{y,t1}} \cdot C_{fish,\,t1}$$

$$C_{NP}(2018) = \frac{9.98 \text{ g km}^2/\text{yr}}{12.5 \text{ g/km}^2/\text{yr}} \cdot 0.248 = 0.198 \text{ ppm}$$

$$C_{WE}(2018) = \frac{9.98 \text{ g km}^2/\text{yr}}{12.5 \text{ g/km}^2/\text{yr}} \cdot 0.240 = 0.192 \text{ ppm}$$

Scenario 6

2018 Fish Mercury Concentration

- Assumption
  - MN emissions changed
- In 2018, MN Hg emissions = 2012 lbs
  - that is 82% reduction from baseline established in 1990 (11272 lbs)
  - Assuming that 50% of MN emissions deposited in the state; total mercury deposition in the state was reduced by 8.2%
- Assumption
  - US emissions changed (decreased by 50%)
  - Assuming that US emissions contribute 30% to mercury deposition in the state (15% Midwest and 15% outside Midwest) then the projected reduced deposition in MN is by 15% (50% of 30%)
- The deposition rate changed from 12.5 g km^2/yr to 9.6 g km^2/yr

$$C_{fish,\,t2} = \frac{D_{y,t2}}{D_{y,t1}} \cdot C_{fish,\,t1}$$

$$C_{NP}(2018) = \frac{9.6 \text{ g km}^2/\text{yr}}{12.5 \text{ g/km}^2/\text{yr}} \cdot 0.248 = 0.190 \text{ ppm}$$

$$C_{WE}(2018) = \frac{9.6 \text{ g km}^2/\text{yr}}{12.5 \text{ g/km}^2/\text{yr}} \cdot 0.240 = 0.184 \text{ ppm}$$

The previous mercury reduction scenarios show trends in fish concentrations under various circumstances. Present day concentrations of mercury in Northern Pike average 0.248 ppm. Full implementation of the Mercury Reduction Act in Minnesota would decrease these average concentrations to 0.228 ppm. If mercury emissions from outside Minnesota decreased by 50%, average mercury concentrations in Northern Pike would decrease to 0.190 ppm. This shows that the greatest reductions occur when reductions in mercury emissions occur on the national scale and not just within the state.

Reductions in mercury emissions and deposition should result in reduced fish contaminations (Harbik and Watras, 2002). Although it is difficult to monitor and report on mercury concentrations in fish because levels vary by species and size, it is possible to monitor and report trends by reporting on one species and within that species normalizing concentrations to a standard length.

Renewable Energy

The energy sector is a major source of mercury emissions into the environment. In Minnesota, electrical generators powered by fossil fuels are responsible for more then half of all mercury emissions resulting from human activity. Switching a substantial fraction of Minnesota electrical generating capacity from fossil fuels to renewable technologies such as biomass, solar or wind-powered turbines would help to reduce mercury emission from this sector. Table 5 shows the amounts of mercury emissions for each generation option. However, due to their relatively high cost, renewable energy can produce only a small percentage of total electrical power in the state and the nation.

Generation options	*Mercury emissions (kg Hg/TWh)*
Natural Gas c.c. (turbines)	0.3 to 1
Bituminous coal: modern	1 to 360
Lignite: old plant	2 to 42
Heavy oil: no scrubbers	2 to 13
Hydropower run-of-river	
Biomass combustion	0.5 to 2
Nuclear	
Wind power	0
Solar photovoltaic	0

Table 5. Electrical generation options and their impact on mercury emissions. Credit: EPA, 1997.

Increased biomass utilization would have enormous environmental and human health benefits. Compared with coal, biomass feedstock would have lower levels of sulfur and sulfur compounds, thus substituting biomass for coal in power plants has an effect of reducing sulfur dioxide (SO_2) emission. Additionally, biomass co-firing with coal has been demonstrated to reduce nitrogen oxide (NO_X) emissions (Huss and Tilman, 2000). The most significant environmental benefit of biomass is a potential reduction in carbon dioxide (CO_2) emissions.

Emerging renewable energy sources such as biofuel for ethanol, wind or solar power may require large land areas. This may be in conflict with population growth which requires more land for farms, cities and industries. Studies show that relative to coal, renewable sources of energy require a lot more land (Gagnon *et al.*, 2002). Land constraints may limit the future development of renewable energy sources. The limitations may depend on many factors including population density, compatibility of project with other land uses such as for recreation, forestry or agriculture, competition with food production.

It is important to note that many researches find that most renewable energy projects will have little negative impact on agriculture. For wind-power, the land around the windmills may be used for agriculture. Solar energy can be developed on rooftops or arid areas where agriculture is absent (Gagnon *et al.*, 2002).

For the purpose of this report we examined several different scenarios that estimated the amounts of biomass and acres of land that may be needed in order to produce a specific amount of energy in the state. Electrical demand in Minnesota was projected as a function of personal income up to 2050 (See Section IV of Energy Production and Use Report). We assumed that in-state coal would generate 62.4% of electrical demand every year (an average from 1970 - 2005). From these data we estimated amounts of biomass needed if 10, 20, 30,

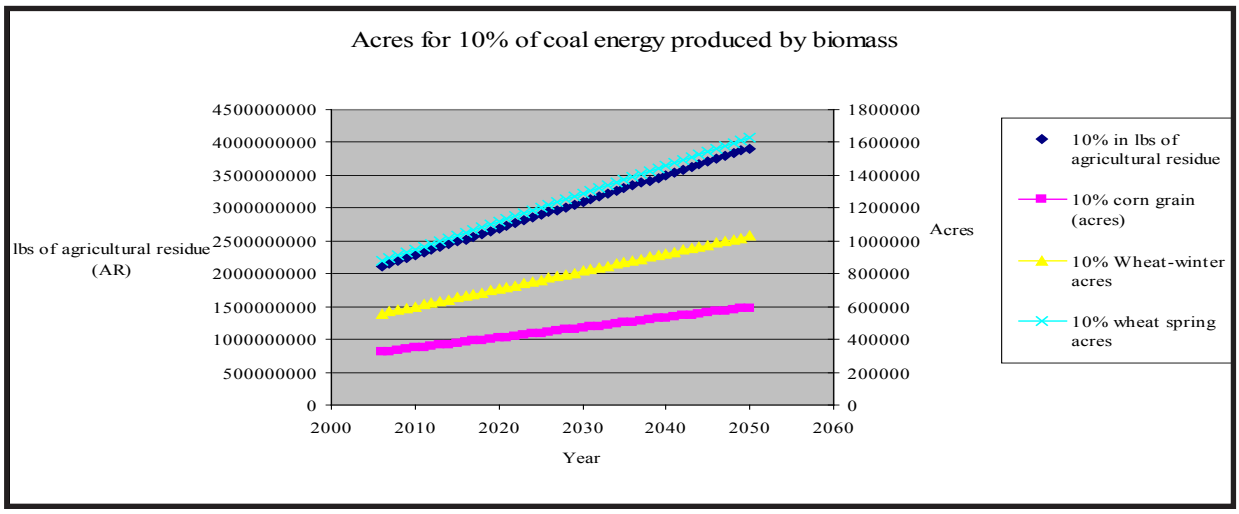
Crop	**Acres harvested or reserved**	**Product Yield**	**Fiber Yield**	**Residue Yield**	**Total crop-land plant mass**	**Total residue produced**
	million acres	dry tons/acre/year			million dry tons/year	
Corn Grain	68.8	3.3	NA	3.3	450.0	225.0
Sorghum	8.6	1.4	NA	1.4	24.8	12.4
Barley	4.3	1.2	NA	1.8	12.8	7.7
Oats	1.9	0.8	NA	1.7	4.8	3.2
Wheat-winter	31.3	1.1	NA	1.9	95.4	60.1
Wheat-spring	17.5	0.9	NA	1.2	35.5	20.1
Soybeans	73.0	1.1	NA	1.6	193.0	115.8
Rice	3.3	2.9	NA	4.3	23.7	14.2
Cotton lint	13.8	0.3	NA	1.0	17.7	13.3
Alfalfa	23.8	3.0	NA	0.0	70.6	0.0
Other hay	39.7	1.7	NA	0.0	67.4	0.0
Silage corn	6.1	6.6	NA	0.0	40.8	0.0
Silage sorghum	0.3	4.4	NA	0.0	1.5	0.0
Other Crops	20.1	1.0	NA	1.0	20.1	20.1
Crop failure	10.0	0.5	NA	0.0	5.0	0.0
Summer fallow	21.0	0.0	NA	0.0	0.0	0.0
Grasses (CRP)	25.4	2.0	NA	0.0	50.8	0.0
Trees (CRP)	2.2	2.0	NA	0.0	4.4	0.0
Environment (CRP)	6.4	2.0	NA	0.0	12.7	0.0
Unaccounted	3.0	0.0	NA	0.0	0.0	0.0
Pasture	67.5	1.5	NA	0.0	101.3	0.0
Wood fiber	0.1	0.0	6.0	2.0	0.8	0.2
Perennials	0.0	0.0	0.0	0.0	0.0	0.0
Totals	**448.1**				**1233.1**	**492.1**

Table 6. National statistics for acres of crop harvested and resulting biomass production. Credit: U.S. Department of Energy and USDA, 2005.

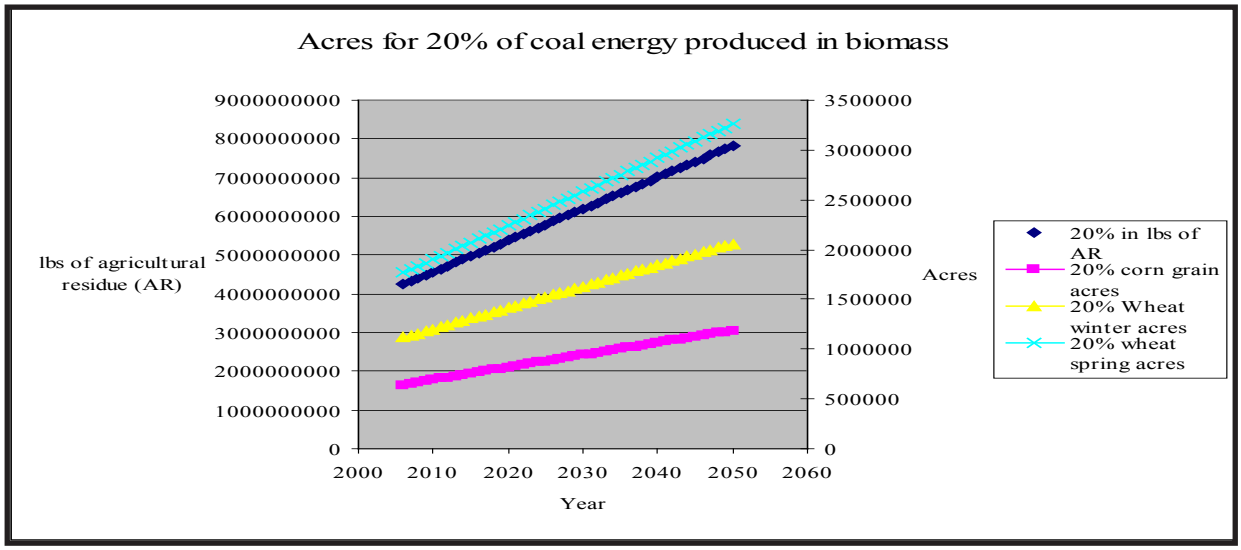
40 and 50% of Minnesota's coal generated electricity was produced from renewable sources. For each percentage we estimated the acreage needed if biomass came from corn grain residue, wheat residue (spring and summer). It was assumed that energy content of agricultural residue was 5,800 Btu/lb. This number is an average taken from data for energy content of agricultural residue provided by the US. Dept. of Energy. The average number is taken because energy content depends on the moisture content of biomass. To estimate the acreage needed to produce the biomass we used data provided in Table 6 (US Department of Energy and US Department of Agriculture, 2005).

Acreage estimates and biomass requirements for replacing coal based electricity are presented below:

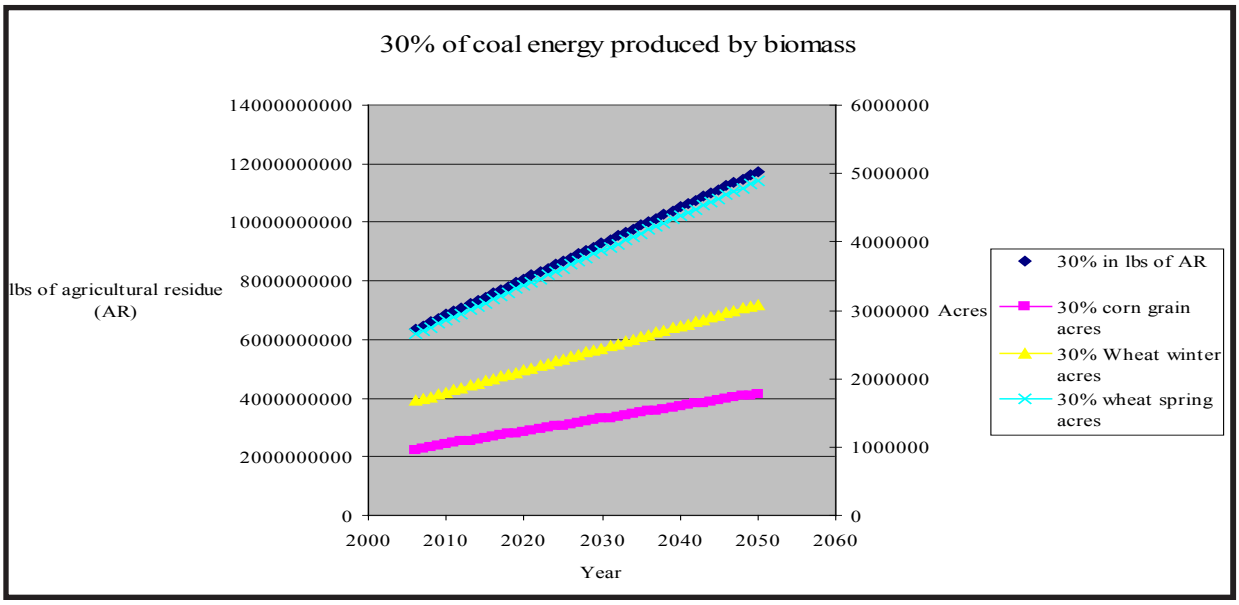
Scenario 1



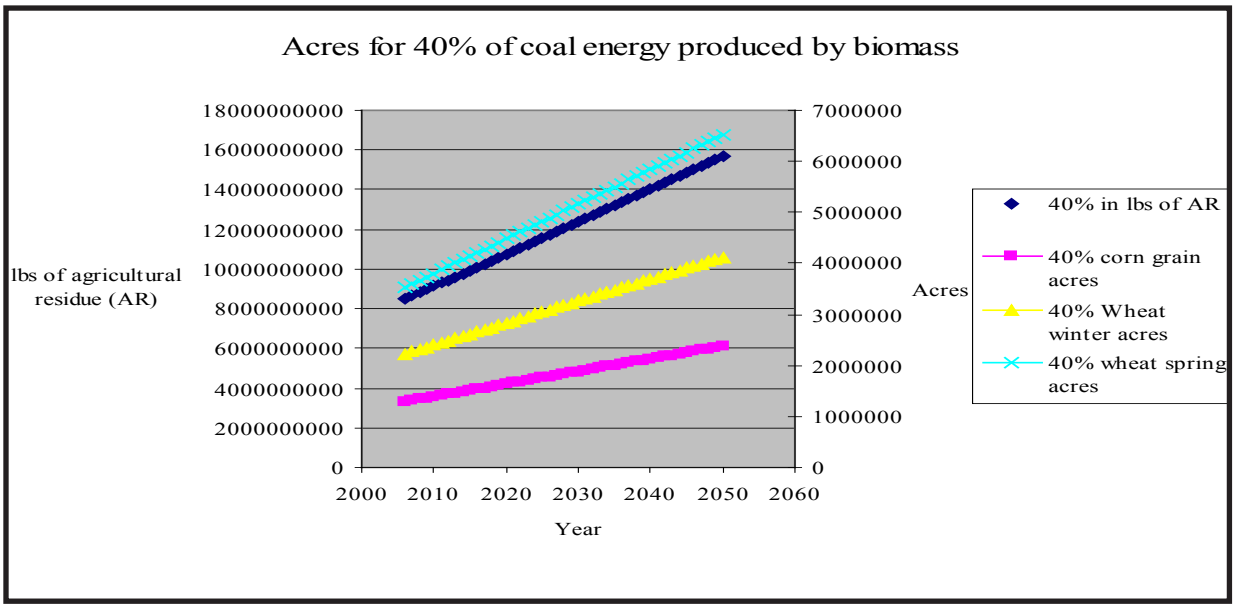
Scenario 2



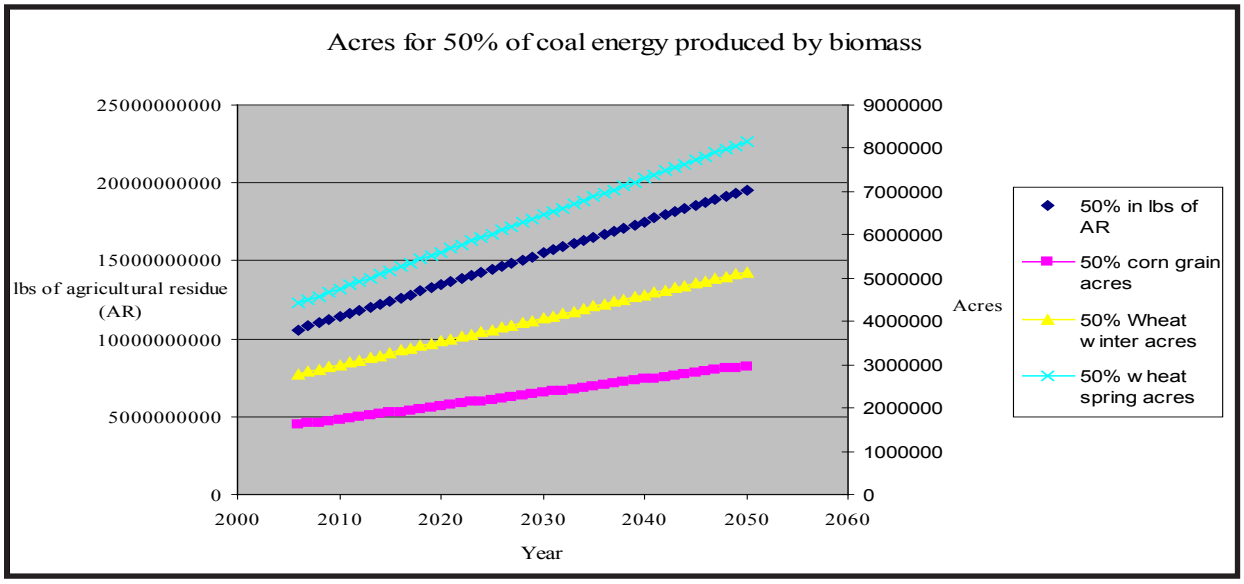
Scenario 3



Scenario 4



Scenario 5



Depending on the scenario, the amount on agricultural residue needed to replace the coal generated electricity varies between $2x10^9$ lbs to $2x10^{10}$ pounds The acreage to produce the biomass also varies depending on the scenario. Agricultural residue from corn grain requires smallest amount of acres.

Conclusions

Mercury is a naturally occurring toxic pollutant. It is also released into the environment by human activities. Mercury is an environmental problem because it bio-accumulates in fish tissue, and can adversely affect human health and wildlife.

For the most part, environmental concentrations of mercury depend on anthropogenic emissions, and reductions in the anthropogenic emissions will lead to reductions in environmental concentrations.

Minnesota has taken both voluntary initiatives and regulatory action to reduce mercury loads into the environment. Although somewhat difficult to measure, the experimental data shows that the reduction strategies have been successful in decreasing environmental mercury contamination; specifically this reduction is seen in fish mercury levels.

Scientific research has shown that the state contributes very little to the overall deposition of mercury in the state. Although these reductions are beneficial, reductions at the national/regional/global scale would have a much greater impact, because mercury is transported by the atmosphere to lakes and rivers around the world.

In Minnesota, electrical generators are the major source of mercury emissions into the environment. Switching to renewable technologies such as biomass, wind or solar power would reduce significantly reduce mercury emissions from the state and the nation if applied on a regional/national level.

Regional Climate Change Adaptation Strategies for Biodiversity Conservation in Minnesota

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University of Minnesota

May 27, 2008

Climate change adaptation planning for biodiversity involves planning for actions that may help ecosystems and species accommodate to climate change. Adaptation planning for biodiversity has received relatively little attention, despite the high likelihood of significant ecosystem change, even with mitigation to avoid further increases in greenhouse gas emissions. Using down-scaled climate projections from an ensemble of 16 models*, we conducted scenario planning for wetland, forest, and prairie ecosystems within the state of Minnesota (USA).

Situated at the intersection of three major biomes (boreal forest, temperate deciduous forest, and Great Plains grasslands), Minnesota is likely to face significant challenges for sustaining biodiversity during climate transition. We divided Minnesota into eight landscape regions and for each, developed climate change projections, assessed likely impacts, and proposed adaptation options. Climate change projections suggest that by 2069, average annual temperatures will increase approximately 5.8° F; annual precipitation will increase 6-8%, but summer precipitation will decline. Places with analogous climates currently prevail 310-440 miles to the SSW.

Although the effects of climate change may be resisted through intensive management of invasive species, herbivores, disturbance regimes, and even water supplies, eventually conservation practices must shift to facilitation and resilience strategies. Facilitation strategies help ecosystems move from current to new conditions and resilience strategies improve the capacity of ecosystems to rebound from disturbance. Key resilience strategies for Minnesota landscape regions include providing buffers for small reserves, expanding reserves that lack ad-

*We created climate change projection maps for Minnesota at a grid square resolution of 1/8° (degree latitude and longitude, approximately 8 miles on a side) for precipitation and temperature in the years 2030-2039 and 2060-2069. These were produced by downscaling the 2° grid square resolution predictions of Global Circulation Models to take into account local differences in historical temperature and precipitation as measured by weather stations throughout Minnesota. Thus, spatial patterns of precipitation and temperature (for example the effect of Lake Superior on temperature) that have occurred in Minnesota during the reference period of 1950-1999 are also assumed to persist into the future. To reduce the biases and take advantage of strengths that occur in individual Global Circulation Models, we averaged together the predictions from 16 models that were produced for the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4).

equate environmental heterogeneity, prioritizing protection of likely climate refuges, and managing forests for multi-species and multi-aged stands. Modifying practices of current restoration programs to rely on seeding (not plants), enlarge seed zones (especially in a southerly direction), and include common species from nearby southerly or drier locales is a logical low-risk facilitation strategy. Monitoring "trailing edge" populations of rare species should be a high conservation priority, to support decision-making related to assisted colonization. Despite uncertainties in climate projections and ecological responses, comprehensive climate change adaptation planning is needed for Minnesota that coordinates with adjacent states/provinces, considers the full array of organisms and their interactions, and is linked to research to fill key knowledge gaps.

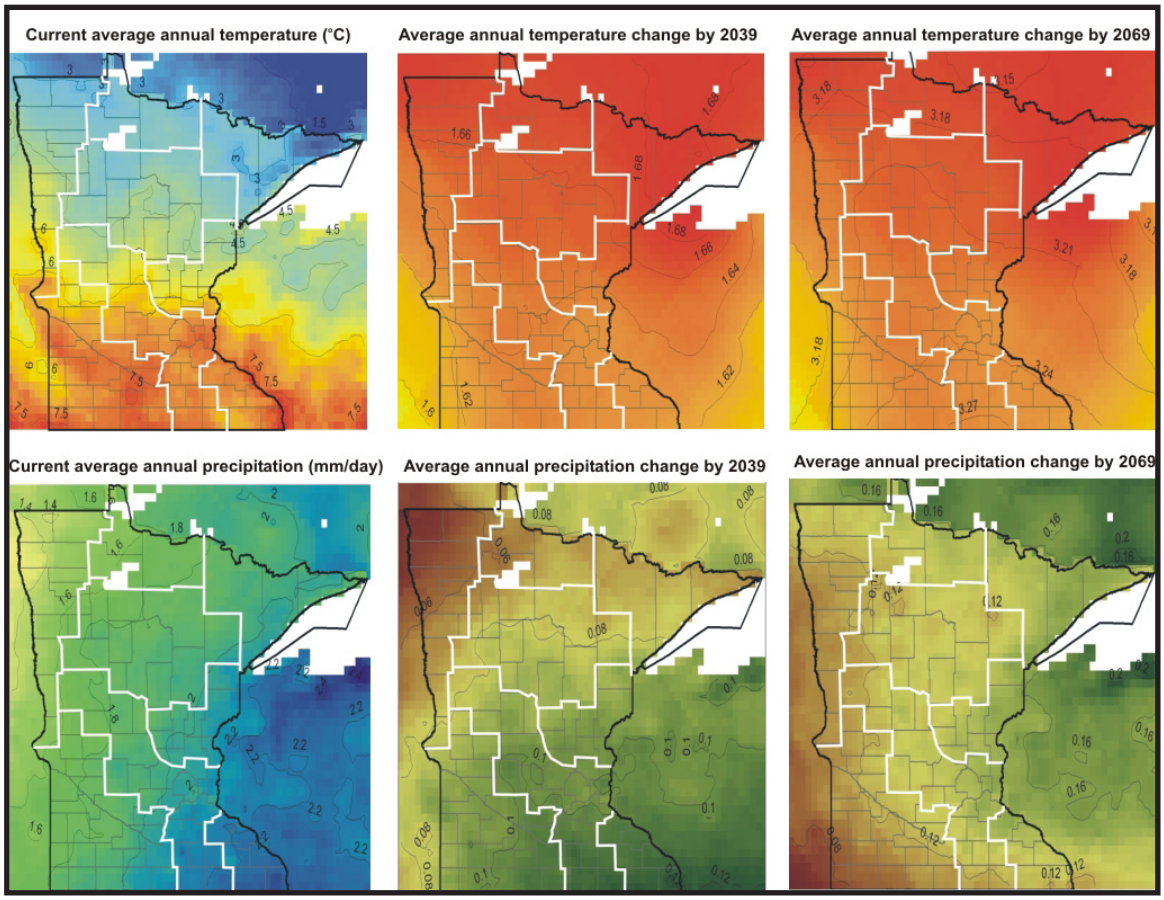

Figure 1. Predicted changes in average annual temperature and precipitation by 2039 and 2069 as compared to the 1950-1999 reference period. Mean annual temperature currently varies from 34 o F (1.5 o C) in northeastern MN to 46 o F (7.5 o C) in the southwest. These temperatures are predicted to increase by 2.9-3.0 o F (1.60-1.68 o C) and 5.7-5.9 o F (3.15-3.17 o C) by 2039 and 2069, respectively. Mean annual precipitation currently varies from 20 inches (1.4 mm/day) in the northwest to 35 inches (2.3 mm/day) in the southeast, and is predicted to increase by 0.9-1.7 inches by 2039 and 1.1-2.3 inches by 2069.For temperature change maps (first row, right two columns), the color scale indicates relative degree of predicted temperature change from yellow (less change compared to current temperatures) to red (more change). For precipitation change maps (second row, right two columns), the color scale indicates relative degree of predicted increases in precipitation from brown (little increase) to green (areas with larger increases).

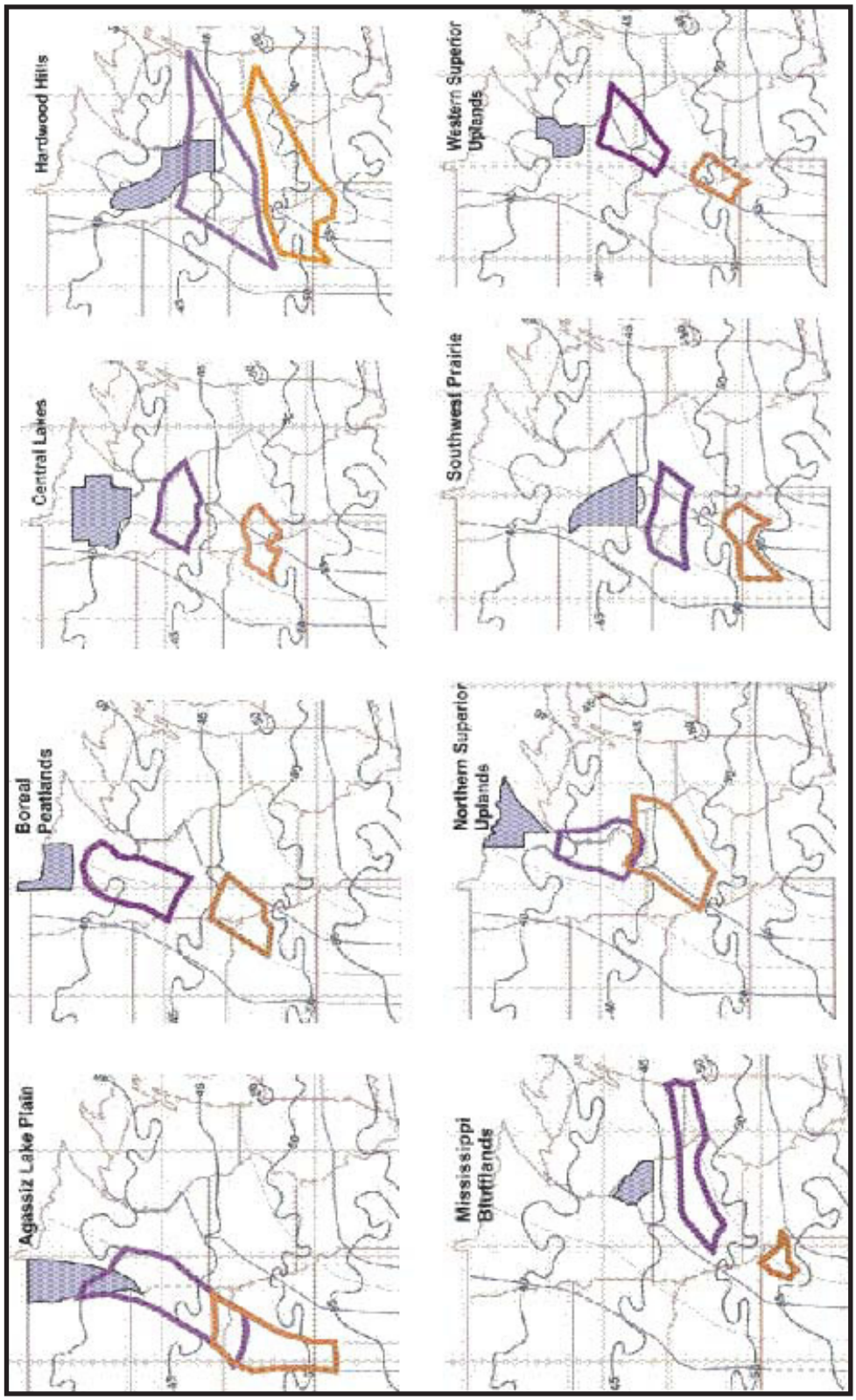

Figure 2. Migrating climate analogs for eight Minnesota landscape regions (shaded). The predicted climate analog for 2030-2039 is outlined in purple and that for 2060-2069 in brown. The migrating climate analogs are shown on a base map of mean annual precipitation (inches/year) and temperature (o F) for 1961-1990 (National Climate Data Center- Owenby et al. 1992).

Landscape Region	Conservation Context	Most Significant Ecosystem Impacts Anticipated	Key Adaptation Strategies
Agassiz Lake Plain	This region consists of extensive prairies on sandy glacial lake deposits and on heavy clays of the Red River Valley. Although there are extensive protected areas on the lake plain, the river valley is mostly converted to drained, agricultural land.	Reduced extent of wet prairies and meadows; shorter hydroperiods in wetlands; increased brackish and alkaline conditions in wetlands; reduced groundwater flow to calcareous fens.	Prohibit agricultural drainage improvements in vicinity of protected wetlands; Prohibit groundwater withdrawals in recharge areas of calcareous fens; Restore agricultural lands to expand small reserves using facilitation practices.
Boreal Peatlands	Flat, poorly drained landscape dominated by peatland vegetation, including bogs, tamarack swamps, and fens. Protected areas include several large Scientific and Natural Areas.	Lower water table in peatlands; increase in peat fires; increased shrub growth in bogs; increased tree mortality from drought, disease, insects and disturbances.	Prohibit drainage improvements in vicinity of peatlands; Control peat fires.
Central Lakes	Maple-basswood forests, oak woodlands, mixed with jack and red pine forests and woodlands on complex glacial deposits (including numerous lakes). Region includes large lake plains with extensive peatlands of bogs, tamarack swamps, and sedge meadows. Many sizeable protected areas (state parks, wildlife refuges).	Increase in large-scale tree mortality; loss of boreal forests; expansion of weedy grassland species; influx of exotic submersed aquatics in lakes; lower water table in peatlands; increase in peat fires.	Manage forests to reduce water stress; Facilitate transition from forests to grasslands (rather than invasive species) on shallow and sandy soils; Facilitate expansion of oaks on loamy soils; Remove exotic submersed aquatics from lakes.
Hardwood Hills	Hardwood forests and oak woodlands and savannas were interspersed with prairies along this 'prairie-forest border' region. This region includes the Minneapolis-St. Paul metropolitan area and extensive agricultural land. Most of the protected areas network are small wildlife management areas.	Increased tree mortality from drought, pests, disturbances; influx of exotic submersed aquatics in lakes; shorter hydroperiods in wetlands; expansion of weedy grassland species.	Manage forests for reduced water stress; Use fire to reduce dominance by weedy grassland species; Monitor changes in community composition to detect species' declines.

Table 1. Each landscape region's primary ecosystems and the extent of protected areas is summarized along with 3-6 of the most significant ecosystem impacts predicted to occur as a result of global climate change, and several key adaptation strategies that may be important for climate change adaptation during the next 50-60 years.

Mississippi Blufflands	Hardwood forests covered steep bluffs along the Mississippi River and in tributary valleys. Prairies and oak woodlands occurred on glacial river deposits in the main valley. A large state forest and National Wildlife Refuge are the most significant protected areas in this region.	Increased tree mortality from drought, pests, disturbance; reduced groundwater flow to calcareous fens.	Protect potential refugial habitats; manage forests for reduced water stress; Prohibit groundwater withdrawals in recharge areas of calcareous fens.
Northern Superior Uplands	Red and white pine forests were historically widespread, mixed with aspen, paper birch, spruce and balsam fir. Glacially scoured bedrock terrain, often rugged and with numerous lakes. Protected areas include BWCA Wilderness, Voyageur's National Park, Superior National Forest.	Increase in large-scale tree-mortality; reduced regeneration from increased deer herbivory; loss of boreal forests.	Minimize deer herbivory in white cedar and pine forests; Protect potential refugial habitats; Monitor community changes to detect species' declines; Facilitate transition from forests to grasslands (rather than invasive species) on shallow and sandy soils.
Southwestern Prairie	Bisected by the Minnesota River valley, this landscape was once a mosaic of tallgrass prairie and emergent wetlands. More than 90% is now drained agricultural land. Many small wildlife management areas comprise most of the protected areas network in this region.	Increased exotic invasions in small protected areas; loss of rare wet prairie species; reduced extent of wet prairies and meadows; shorter hydroperiods in wetlands; brackish and alkaline conditions increase in wetlands; reduced groundwater flow to calcareous fens.	Restore agricultural lands to expand small reserves using facilitation practices; Intensify invasive species removal; Prohibit agricultural drainage improvements in vicinity of protected wetlands; Prohibit groundwater withdrawals in recharge areas of calcareous fens.
Western Superior Uplands	Oak woodlands and hardwood forests on non-calcareous glacial tills, ranging from clayey to sandy. Protected areas with high quality vegetation are of minor extent, although several large state parks and wildlife areas are in this region.	Increased tree mortality from drought, pests, disturbances; shorter hydroperiods in wetlands, influx of exotic submersed aquatics in lakes.	Facilitate transition from forests to grasslands (rather than invasive species) on shallow and sandy soils; Facilitate expansion of oaks on loamy soils; Manage forests for reduced water stress: Prohibit drainage improvements in vicinity of protected wetlands; Intensify invasive species removal.

Table 1 Continued.

Appendix V

Assessment of Costs and Environmental Benefits

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Cost-benefit assessment for selected recommendations

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Introduction

An assessment of costs and benefits is an important part of policy development and implementation. Some of the costs and benefits of the recommendations presented in the Minnesota Statewide Conservation and Preservation Plan (SCPP) are fairly readily quantified—for example, the cost of a specified subsidy for electric vehicles. Many of the recommendations in this report do not lend themselves easily to a quantification of costs and benefits. What price tag do we attach to the runoff-cleansing capabilities of a wetland? How much do we gain when we save a woodpecker's nesting site, or a place to spend a day outdoors? What is the value of a bike trail or a brook trout? Nevertheless, a sincere attempt to identify, estimate, and compare costs and benefits can provide a general sense of the relative merit of alternative choices, create valuable context for decisions, and offer an indication of how we can best configure resulting policies to maximize benefits and minimize costs.

This report presents the results of cost-benefit assessment of selected SCPP recommendations. Because of time and funding constraints, the assessment was limited to seven recommendations and based on values obtained from other studies carried out previously around the United States rather than conducting original research to quantify costs and benefits. The following recommendations were chosen based on the advice of the habitat, land use, and energy team leaders and on the quantifiable nature of the parameters involved:

- ***Habitat Recommendation 2a:*** Acquire high-priority shorelands
- ***Habitat Recommendation 5:*** Restore land, wetlands, and wetland-associated watersheds
- ***Land Use Recommendation 8:*** Protect large blocks of forested land
- ***Energy Recommendation 3:*** Invest in perennial biofuel and energy crop research and demonstration projects on a landscape scale *and* ***Land Use Recommendation 4:*** As much as possible, transition renewable fuel feedstocks to perennial crops
- ***Energy Recommendation 4:*** Develop policies and incentives to encourage perennial crop production for biofuels in critical environmental areas
- ***Energy Recommendation 16:*** Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power, while simultaneously increasing renewable electricity production for transportation

The following process was used to assess costs and benefits for each of the selected recommendations:

1. ***Brainstorming:*** The team held brainstorming sessions with the resource teams that generated the recommendation to identify key costs and benefits of implementing the recommendation.
2. ***Survey:*** Cost benefit analysis team members surveyed habitat, energy, and land use team members to gather information on various aspects of each cost or benefit item, including its geographical and temporal scales. Habitat, energy, and land use team members were given the opportunity to rank costs and benefits according to their expert knowledge.
3. ***Literature Review:*** Cost benefit analysis team members reviewed relevant scientific papers and reports to estimate the potential magnitude of costs and benefits of the recommendation.

Because the analyses are based on scientific studies of similar but not identical settings and involve the application of approximation and informed judgment, the results are presented as ranges and estimates. The findings understandably should not be used as hard-and-fast indicators of the economic merits of individual recommendations. They are, however, useful for:

- Identifying costs and benefits of the recommendation
- Indicating the likely order of magnitude of the costs and benefits
- Providing ideas for how implementation might be fine-tuned to maximize benefits and minimize costs

This report is organized as follows:

- The recommendation under study is shown in bold font.
- Key benefits and costs are listed and elaborated upon in the context of relevant literature to yield a best-approximation range of values for each.
- Key benefits and costs are summarized in a table.
- Summary figures are based on a five-year period unless otherwise noted. All prices are adjusted to 2008 price unless otherwise noted.

Acquire High-Priority Shorelands

Habitat Recommendation 2a: Acquire high-priority shorelands

Natural shorelands provide multiple benefits, including recreation opportunity, public access to water, protection of wildlife species, and reduction of nutrient and solid loading into surface waters. Minnesota's water legacy features 5,508 miles of cold-water stream shoreland and more than 64,000 miles of lake and warm-water stream shorelands. Currently 46% of cold-water stream shoreland and 34% lake and warm-water stream shorelands are under public ownership. The Aquatic Management Area (AMA) acquisition planning committee recently published a report outlining the need to increase public ownership of cold-water stream shoreland to 72% and that of lake and warm-water stream shorelands to 39% by 2032 (AMA 2007). This analysis follows the plan outlined by the AMA report.

General conclusions we can draw from this analysis include:

1. Wildlife benefits are difficult to quantify but expected to be significant.
2. Recreation-related benefits and water quality–related benefits are estimated to be significant and likely larger than the numbers we use here.
3. Site selection is important to the overall cost-effectiveness of the recommendation.

Key Benefits

Acquisition of critical shorelands in Minnesota is expected to realize the following benefits:

1. Provision of recreation-related industrial production
2. Fishing- and wildlife watching–related tax revenue
3. Benefits through hunting opportunities
4. Benefits through additional public access to water bodies
5. Additional education opportunities from publicly accessible shoreland
6. Protection of species of greatest conservation need, such as common loon, black tern, and Blanding's turtle
7. Reduction of nutrient and solid loading into surface water
8. Protection of habitat for fish and wetland-dependent species, such as waterfowl and wild rice

1. Provision of recreation-related industrial production

The DNR estimates that outdoor recreation–related industries in Minnesota represent $4.25 billion per year of annual production (in fiscal year 2000) and tax revenue related to Minnesota's outdoor recreation economy amounts to $127 million per year for fishing and $32 million per year for wildlife watching (DNR 2008). According to the DNR, 29% of Minnesotans fish, and Minnesotans spend $1.46 billion for fishing-related activities (DNR 2008). Given that Minnesota's fishing and wildlife-watching activities are closely related to accessible shorelands, the recommendation is expected to increase production of related industries.

According to the AMA Report, 500 miles of cold-water stream shoreland (CSS) and 375 miles of lake and warm-water stream shoreland (LWSS) will need to be acquired for the next five years (AMA 2007). This represents about 9.1% and 0.6% of CSS and LWSS, respectively, or 1.3% of the total shoreland in Minnesota. Although the exact relationship between increased shoreland accessibility and industrial production is not found in the literature, it is considered to be reasonably conservative to assume that a 10% increase in accessible shoreland will result in a 1% increase in fishing and wildlife-watching. Assuming the 10:1 ratio, shoreland acquisition for the next five years is expected to have recreational benefits of $5.35 million per year for related industrial production.

2. Fishing- and wildlife watching–related tax revenue

Using the estimates and assumptions listed for the first benefit above, shoreland acquisition for the next five years is expected to have recreational benefits of $150,000 per year at the fifth year for fishing-related tax revenue and $40,000 for wildlife watching–related tax revenue for a total of **$190,000** per year.

3. Benefits through hunting opportunities

A study in North Dakota analyzed the recreational benefits of CRP, and annual hunter expenditures attributable to waterfowl hunting due to CRP were calculated as $6.7 million. For comparison, North Dakota's hunting-related economic activities were about one-fifth of Minnesota's in 2001 (IAFWA 2002). Thus, benefits through hunting opportunities would be **$6.7 million** per year at the fifth year.

4. Benefits through additional public access to water bodies

Benefits through additional public access to water bodies are **unquantified**.

5. Additional education opportunities from publicly accessible shoreland

Benefits through additional education opportunities via publicly accessible shoreland are **unquantified**.

6. Protection of species of greatest conservation need, such as common loon, black tern, and Blanding's turtle

Natural or well-managed shoreland provides critical habitat for multiple wildlife species. The benefits of protecting wildlife species such as common loon, black tern, and Blanding's turtle is expected to be significant. However, literature that estimates monetized benefits of protecting wildlife species was unavailable, so this benefit remains **unquantified**.

7. Reduction of nutrient and solid loading into surface water

Nutrient concentration and water clarity have an important nonlinear relationship (Radomski, 2008). According to Radomski (2008), most of the Minnesota's water bodies maintain good clarity, while water bodies with total phosphorus over 20 to 25 parts per billion quickly lose their clarity. Creating riparian buffer zones and managing shorelands can be effective ways to reduce nutrient and solid loading to surface water.

According Carson and Mitchell (1993), the average U.S. household is willing to spend $310 to $422 per year (adjusted to 2008 dollars) for boatable, fishable, and swimmable water. Assuming that increase in protected shoreland will reduce nutrient and solid loading and thus protect the water body from degrading proportionally, water quality benefits by shoreland acquisition per year for the next five years is calculated as **$7.8 million** to **$10.6 million** for 2 million households in Minnesota.

8. Protection of habitat for fish and wetland-dependent species, such as waterfowl and wild rice

Protected and well-managed shorelands are expected to provide habitats for fish and other wildlife species, and provision of such habitats is expected to have significant benefits. Literature review, however, failed to locate a published study that shows monetized benefits of protected shoreland through provision of habitats for Minnesota wetland-dependent species, including waterfowl and wild rice. As a result, this benefit remains **unquantified**.

Key Cost

We anticipate one key cost:

1. Acquisition of critical shorelands

AMA (2007) estimates that $10 million per year would be required for CSS acquisition between 2008 and 2017, and $25 million per year for LWSS acquisition between 2008 and 2017. From 2018 to 2032, estimated costs are $3.3 million and $7.7 million per year for CSS and LWSS acquisition, respectively. Overall acquisition cost per year, 2008–17, would be $35 million.

Summary of Key Benefits and Costs

Two important benefits to wildlife could not be quantified through the literature survey, although those benefits are expected to be significant when quantified. Both recreation-related benefits and water quality–related benefits are estimated to be significant. These estimates are conservative given the uncertainties associated with the data and method. For instance, for water-quality benefits, it is assumed that protected shoreland would reduce nutrient and soil erosion and thus water quality of surface water proportional to the length of protected shoreland. In reality, the water-quality benefits accruing from protecting shoreland depend on many factors, including the criticality of the shoreland in the watershed and nutrient and solid loading and hydrology of the area. Therefore, protecting 1% of the shoreland would be able to achieve much more than a 1% water-quality improvement, while the reverse can be true as well depending on the site to be acquired. This sheds light on the importance of site selection and its sensitivity on overall cost-effectiveness of the recommendation.

Benefits	**Amount (annually @ 5th year)**	**Party receiving benefit**
1. Recreation-related commercial production	$5.35 million	Local industry
2. Fishing- and wildlife watching–related tax revenue	$190,000	State and local governments
3. Benefits through hunting opportunities	$6.7 million	Citizens of region & state, hunters
4. Additional public access to water body	Unquantified	Citizens, anglers, wildlife-watchers
5. Additional education opportunities via publicly accessible shoreland	Unquantified	Citizens, anglers, wildlife-watchers
6. Protection of species of greatest conservation need	Unquantified	
7. Reduction of nutrient and solid loading	$7.8 million–$10.6 million	Citizens, anglers, wildlife/fish
8. Protect habitat for fish and wetland-dependent species	Unquantified	Wildlife, anglers
Costs	**Amount (annually @ 5th year)**	**Party incurring cost**
1. Acquisition of critical shorelands	$35 million	State and local governments

Table 1. Summary of potential costs and benefits from acquisition of high-priority shoreland. For assumptions and references, please see text.

Restore Wetlands

Habitat Recommendation 5: Restore land, wetlands, and wetland-associated watersheds

Wetland ecosystems provide multiple and essential services that benefit society. They regulate peak flows and recharge surface and ground water, store and process nutrients and sediment, and provide critical habitat to aquatic species, waterfowl, and migratory birds (Mitsch and Gosselink 2000). However, more than half of the original wetlands in the coterminous United States have been drained, filled in, and plowed under for agricultural use and expanding urban development (Mitsch and Gosselink 2000). Nearly 35 million acres of wetlands have been lost in the Upper Mississippi River basin (Dahl 1990), and more than 90% of wetlands have been converted in the former prairie of Minnesota.

A key recommendation of the SCPP is the restoration of wetlands in Minnesota and their associated uplands, particularly in the western prairie region of the state, which has lost nearly all of its original wetlands and grasslands to agriculture. This section focuses on wetland restoration in particular, and does not specifically address benefits associated with upland restoration.[1] It discusses key benefits likely to be generated through wetland restoration and evaluates the range of potential economic value that could be realized through implementation of this recommendation. These benefits are presented alongside the anticipated costs of restoring wetlands, and the overall cost effectiveness of this proposed action is discussed.

Overall, the costs and benefits of wetland restoration are highly variable and context-dependent, and it is not possible to provide simple analysis of the cost effectiveness of this action. Land acquisition and restoration costs vary widely, as will the value of benefits derived from wetland restoration. The monetary estimates included in this assessment are imperfect and include valuations for very different ecosystems not intended to apply directly to Minnesota. Wetland restoration projects should be guided by real data, and local information should be used to evaluate the ecosystem service benefits likely to accrue from any restoration effort.

Nevertheless, three broad conclusions can be derived from this assessment and used to inform potential wetland restoration in Minnesota:

1. Intact wetlands provide significant value, likely $300 to $10,000 per acre, and investment in targeted restoration would yield significant benefits.
2. Not all wetlands are created equal. Restoration of sites where multiple benefits of flood mitigation, water quality, and wildlife support can be realized likely would provide greater benefit per dollar than wetlands restored to provide a single ecosystem service.
3. The most benefits are likely to be realized from restoration of wetlands in areas with the least remaining original wetland cover. Restoration of wetlands on 3% to 7% of the land area of Upper Mississippi River basin (at most only half of the original wetland area) likely would be sufficient to significantly reduce damage from flooding and greatly enhance water quality (Hey and Phillipi 1995; Mitsch and Gosselink 2000).

[1]See the cost-benefit analysis for energy recommendation 3 for benefits associated with restored grasslands.

Key Benefits

Wetlands perform a range of critical hydrological and ecological functions that in turn provide a variety of direct and indirect benefits to society. Intact wetlands decrease the risk of damaging floods, maintain water quality for drinking and recreation, nurture healthy populations of wildlife and fish, and provide other important services such as climate regulation and ground-water recharge (Brauman et al. 2007).

Restoration of wetlands in Minnesota, particularly where low percentages of original wetlands remain intact, would generate multiple significant benefits, including the following three critical benefits:

1. Mitigation of potential flooding
2. Nutrient removal and improvement of water quality
3. Provision of wildlife habitat and unique recreational and hunting opportunities

1. Mitigation of potential flooding

Wetlands perform an important hydrological function by regulating the flow of water across landscapes and reducing peak flood levels (Mitch and Gosselink 2000; Zedler and Kercher 2005). The loss of millions of acres of wetlands in the latter half of the 20th century corresponded with a six-fold increase in the number of floods and an increase in property damage by nearly a factor of 10 (Hazards & Vulnerability Research Institute 2007). Restoration of degraded or removed wetlands could reduce significantly the incidence and impact of flood events, particularly in regions where significant portions of original wetlands have been lost. For example, analysis of the Des Plaines River in Illinois concluded that a 5.7-acre wetland could retain runoff from a 410-acre watershed (Godschalk et al. 1999), and the U.S. Army Corps of Engineers determined that decreasing runoff within a watershed by 10% might reduce the flood peaks with a two- to five-year return period by 25% to 50%, and might reduce a 100-year flood by as much as 10% (USACE 1995). Also, it has been estimated that restoration of between 5 million acres (Hey and Philippi 1995) and 13 million acres (Godschalk et al. 1999) of wetland in the Upper Mississippi River basin would have greatly diminished the catastrophic flooding in 1993.

Efforts to monetize the benefit of flood mitigation have generated a wide range of potential values. Reviewing dozens of wetland valuation studies, Woodward and Wui (2001) calculated the mean flood mitigation values (in inflation-adjusted 2007 dollars) of wetlands to be $650 per acre, within a very broad range of between $147 and $2,887. Flood control by Mud Lake, on the border between Minnesota and South Dakota, was estimated to be worth $576 per acre (Roberts and Leitch 1997). The value of wetlands for reducing flooding in the Red River basin was estimated between $341 and $507 per acre (Schultz and Leitch 2003); however, this value is likely too low because subsequent study suggested higher-than-anticipated water storage capacity by wetlands in this region (Apfelbaum et al. 2004).

The value of wetlands for flood mitigation is context dependent. Wetlands in watersheds that have lost much of their original wetland cover are more valuable than others, as are wetlands that reduce the risk of floods in highly populated areas with expensive property. For example, the flood mitigation benefit of intact wetlands within the Charles River that flows into Boston Harbor in Massachusetts was calculated to be $12,350 per acre (Mitsch & Gosselink 2000).

Using the entire range of values presented above between $147 and $12,350 per acre of wetland, flood mitigation benefits for Minnesota statewide[2] **would be between $1.8 million and $148 million per year**.

2. Nutrient removal and improvement of water quality

Agricultural runoff and urban wastewater deliver excess nutrients to associated rivers, streams, wells, and aquifers, and this nonpoint source pollution is a significant problem (Carpenter et al. 1998). Nutrient enrichment contaminates drinking water and endangers human health (Weyer et al. 2001; Townsend et al. 2003) and creates coastal hypoxic zones where these waterways flow into the ocean (Turner and Rabalais 2003). In Minnesota, although only a small portion of the state's waters have been assessed, more than 40% of rivers, lakes, and streams have been classified as impaired. Wetlands can buffer the delivery of nutrients to surface and ground water, removing significant proportions of contaminants such as nitrogen and phosphorus and improving water quality (Woltemade 2000). Wetland restoration may be a cost-effective means of improving water quality compared to conventional drinking water treatment facilities. For example, in Gotland, Sweden, nitrogen abatement using wetlands was four times more effective than abatement using sewage treatment plants (Gren 1995). In the upper Illinois River watershed, nutrient abatement through wetland restoration achieved a 50% to 70% cost savings over conventional wastewater treatment facilities (Hey et al. 2005). At a larger scale, an estimated 5 million to 13 million hectares of restored wetlands in the Mississippi River Basin (only 0.7% to 1.8% of total area) would achieve a significant reduction of nitrogen to the Gulf of Mexico and reduce the size of the hypoxic zone (Mitsch et al. 2001).

Clearly, wetlands have well-demonstrated capacity to catch runoff and process nutrients, with significant benefits for water quality. However, economic valuation of this ecosystem service is, like flood mitigation, difficult and very context dependent. One review of multiple wetland valuation studies calculated that benefits range from $208 to $2,277 per acre, with a mean value of $689 (Woodward & Wui 2001). This corresponds to **$2.5 million** to **$27.3 million** per year statewide using projections of the DNR Long Range Duck Plan, which proposed a target of 2 million acres over 50 years, with 600,000 (12,000 acres annually) being wetlands.

3. Wildlife habitat and unique recreational and hunting opportunities

Wetlands are unique ecosystems that support significant biodiversity and provide critical habitat for a wealth of species (Gibbs 2000). Despite more than a century of land use change, the northern Great Plains remain important for migratory birds, wildlife, and wetland species. In particular, the wetlands of this region support 50% to 80% of the nation's ducks (Guntenspergen et al. 2002). Not surprisingly, the loss of more than half of the nation's wetlands has seriously impacted wetland species, many of which have been listed as federally endangered in response to their precipitous declines (Wilcove et al. 1993).

Restoration of wetlands could provide significant benefits to wetland biodiversity and increase populations of species valued for bird-watching, hunting, and fishing. Restored wetlands have provided valuable habitat for amphibians in Minnesota (Lehtinen & Galatowisch 2001); increased populations of teal and other ducks in Prince Edward Island, Canada (Stevens et al. 2003), and supported a fourfold increase in the number of wa-

[2]All statewide per-year calculations used the projections of the DNR Long Range Duck Recovery Plan (2006), which proposed a target of 2 million acres restored in the next 50 years. Of this total, approximately 600,000 acres would be wetlands, with 12,000 acres of new wetland restored annually.

terfowl species in Illinois (Hickman 1994). The DNR's Long Range Duck Recovery Plan (2006) emphasizes the need to restore wetlands and their associated grasslands to support significant increases in the duck population. The plan targets a 58% increase in the breeding population to a total of 1 million ducks, and anticipates a nearly 50% rise in associated duck hunting and waterfowl watching. Assuming expenditures and tax receipts remain proportionate, future revenue associated with a larger duck population and increased recreation would total $361 million (2007 dollars) per year by 2056.

Again, the benefits of increased wildlife from wetland restoration are difficult to monetize. Evidence suggests even citizens who will not directly use or benefit from enhanced wildlife associated with wetlands are willing to pay for their existence, particularly for wetlands that support significant and rare biodiversity (Stevens, Benin, and Larson 1995). Woodward and Wui (2001) determined an average nonuse value of wetland "habitat" to be $505 per acre. Since wetlands support ducks and other species of interest for recreational use, the economic value of hunting, fishing, and bird-watching are important as well. Bergstrom et al. (1990) surveyed several thousand recreational hunters and anglers in Louisiana and calculated an average annual gross economic value of $83 per acre. Woodward and Wui (2001) found much higher values through their review of dozens of valuation studies; mean recreational fishing values were $590 but ranged as high as $2,217 per acre, and mean value of bird-watching was calculated to be $2,000 per acre, though it ranged as high as nearly $4,600 per acre. These values lead to a benefit of **$1 million** to **$55.2 million** per year statewide using the DNR Long Range Duck Plan projections as noted above.

Key Costs

Although several key benefits would be realized through restoration of wetlands in Minnesota, implementation of this action requires investment from state and local governments as well as individuals. These costs include, but may not be limited to:

1. Restoration, construction, and management of wetlands
2. Opportunity cost of alternate uses (e.g., forgone income from crop production)
3. Acquisition cost of private lands acquired for public wetlands
4. Costs of state easements, tax incentives, etc., to promote altered land use practices
5. Potential loss in local tax revenue when productive lands are restored to wetlands

1. Restoration, construction, and management of wetlands

Restoration of drained and converted wetlands is a costly, complicated, and time-consuming endeavor, and varies widely depending upon the landscape context and the size, type, and intended function of the restored wetland. For example, a 2001 U.S. Fish and Wildlife Service estimate for restoration of drained wetlands in Minnesota ranged between $235 and $360 per acre (USFW 2001) for private landowners (this and all following costs adjusted to 2007 dollars). A more recent Minnesota Board of Water and Soil Resources estimate derived a cost of approximately $3,500 per acre (Lines 2008). Large projects would likely realize some economies of scale benefits and achieve a lower per-acre restoration cost; for example, restoration of 1,800 acres of wetlands in the prairie pothole region of northwestern Minnesota in 2003 cost approximately $1,700 per acre

(Jacobson 2004), and Schultz and Leitsch (2003) suggested the cost for a "medium-sized" wetland restoration project to be approximately $1,150 per acre. The DNR Long Range Duck Recovery Plan (2006) anticipates an annual cost of approximately $67 million for restoration and management of wetlands and associated uplands. The plan suggests that 30% of the 2 million acres restored should be wetlands, totaling 600,000 acres or 12,000 acres per year. Assuming restoration costs can be divided equally between wetlands and uplands (determining the actual split would be much more complicated), the annual cost of wetland restoration needed to achieve the duck population goals would be approximately $20 million, equivalent to about $1,600 per acre. Based on this range for wetland restoration costs of $235 to $3,500 per acre and a restoration rate of 12,000 acres per year, we estimate the costs of wetland restoration statewide to be **$2.8 million** to **$42 million** per year.

2. Opportunity cost of alternate uses (e.g., forgone income from crop production)

A second significant cost associated with restoration or re-creation of lost wetlands is the forgone income that would have been realized from continued crop production or from development of land for urban or industrial uses. Since the recommendation emphasizes wetlands in the predominantly agricultural regions of the state, we will focus on profits lost from forfeited commodity production. We use corn production for the purposes of this simple calculation, and assume that all forfeited agricultural income would come from converting productive corn land to wetlands. The estimates of productivity, income, and average cost are taken from Lazarus, Taff, and Zou (2008).

Assumptions: average productivity = 158 bushels/acre
average price = $4–$8/bushel
average subsidies/other income = $53/acre
average input cost = $509/acre

Based on these assumptions, the average cost of not producing corn is $176 to $808/acre, or, applied across 12,000 acres, **$2.1 million** to **$9.7 million** per year.

3. Acquisition cost of private lands acquired for public wetlands

A recent University of Minnesota report analyzed farm real estate prices across the state. Prices vary across regions; the median price in the west-central region was determined to be $2,081, while median price in the southwest was $2,850. The price varies considerably within each region according to the location and productive capacity of the land, so individual acquisitions for wetland restoration will vary widely in cost. Using the statewide median price of $2,461 per acre (Taff 2008), we calculate the cost of acquiring 12,000 acres[3] at **$11.8 million.**

[3]The DNR Long Range Duck Plan estimates 60% of restored wetlands and grasslands will remain privately owned and 40% will become public land. For this calculation: 12,000 acres wetland restored annually x 0.4 (% acquired) x price per acre. Similarly, for annual incentive costs statewide: 12,000 acres wetland restored annually x 0.6 (% private) x incentive per acre.

4. Costs of state easements, tax incentives, etc., to promote altered land use practices
5. Potential loss in local tax revenue when productive lands are restored to wetlands

Wetland restoration on private land not acquired by the state will be possible through the use of conservation easements and tax incentives. Ideally, the level of these incentives should be commensurate with the opportunity cost of income forfeited from other uses of the land, and should provide significant reimbursement for restoration and management activities. However, current policy instruments such as CRP payments have been unable to keep up with rising commodity prices. This analysis uses the most recent cropland rental rates calculated by Hachfeld et al. (2008). Rental rates range from less than $30 per acre for Mille Lacs County to more than $130 per acre for Mower, Nicollet, and Faribault Counties. Costs are estimated at $30 to $150 per acre, with the context that cheaper land has increased in value proportionately less than more expensive land. Taxes and easements are assumed to have identical costs. Corresponding costs of incentives statewide would be **$216,000** to **$1.08 million** per year based on DNR Long Range Duck Plan projections as noted. Lost tax revenue was not calculated (that level of detail was beyond the purview of this analysis).

Summary of Key Benefits and Costs

Overall, multiple potentially very significant benefits could be realized from restoration of converted or degraded wetlands in Minnesota. Restored wetlands could reduce or prevent floods, improve local water quality, and enhance wildlife habitat to support biodiversity and increase recreational opportunities. Although valuation of ecosystem services is highly uncertain, a number of recent economic studies have estimated intact wetlands to be of considerable monetary value. Estimates (all adjusted to 2007 dollars) include $337 to $886 per acre of Louisiana wetland (Costanza, Farber, and Maxwell 1989); $1,512 to $1,630 per acre (Woodward and Wui 2001); and $1,925 per acre of wetland in the Illinois River watershed (Prato and Hey 2006). Hey and Philippi (2004) calculated an adjusted 2007 value of more than $10,000 per acre of restored wetland within the 100-year flood zone in Minnesota, and argue that conversion of all farmland within this zone is economically justified because of the overwhelming benefits that would be realized from flood mitigation.

Furthermore, existing wetlands, particularly those dependent upon direct precipitation or rain-fed streams, are vulnerable to climate change, and may provide reduced benefits as temperatures and precipitation patterns continue to change (Winter 2000; Murdoch, Baron, and Miller, 2000). Restoration of these and other wetlands and reestablishment of more natural hydrologic regimes will be critical to enhancing the resilience of Minnesota's landscape to a changing climate.

Clearly, even the lower valuations of benefits derived from wetlands are nontrivial. However, there are significant costs involved in wetland restoration, and these costs, compared to estimates of potential benefits, are well understood and more easily quantified. Substantial investment would be required on the part of the state. Costs include outright acquisition of critical wetlands, easements and other payments to individuals, ongoing management of restored wetlands, and lost income from agriculture and other land uses.

Benefits	**Annual amount**	**Party receiving benefit**
1. Flood mitigation	$1.8 million–$148 million	Communities and farms downstream
2. Water quality	$2.5 million–$27.3 million	Public water in cities and towns, landowners with wells, local streams
3. Wildlife habitat and recreational/hunting opportunities	$1 million–$55.2 million	Citizens of region and state, hunters, bird-watchers, anglers
Costs	**Annual amount**	**Party incurring cost**
1. Restoration. construction, and management	$2.8 million–$42 million	State and local governments, land owners
2. Opportunity cost	$2.1 million–$9.7 million	Farmers, developers
3. Acquisition cost	$11.8 million	State and local governments
4. Easements, incentives	$216,000–$1.08 million	State and local governments
5. Lost tax revenue	Not calculated	Counties and local municipalities

Table 2. Summary of potential costs and benefits from wetland and wetland-associated restoration. For assumptions and references, please see text.

Protect Forested Land

Land Use Recommendation 8: Protect large blocks of forested land

Large blocks of forestland provide many benefits. Ecosystem services from intact natural environments include watershed protection, carbon storage, climate regulation, and wildlife habitat. Trees add recreational value, too: A study in the Rocky Mountains, Colorado, of the effect of tree density on recreational demand and benefits suggested that increasing trees per acre 1 percent would increase willingness to pay or benefits per day in dollars by 8 percent (Walsh, Ward, and Olienyk 1989).

Of course, maintaining large blocks of forestland has costs as well, including (as elaborated upon below) the cost of acquiring and monitoring easements and the opportunity cost of forgoing development.

This cost-benefit assessment we perform here based on information gathered in studies around the country leads to the following general conclusions:

1. Because the price of forestland in Minnesota is overwhelmingly high, the benefits we were able to quantify may not be sufficient to counterbalance them. Decisions should also take into account benefits such as air purification and soil stabilization that we were unable to quantify.
2. The ecosystem services provided by large blocks of forested land influence each other and are influenced by the setting. As a result, the numbers we derive here based on information pieced together from a

number of studies carried out around the country provide only a rough approximation of the true value of services provided by large blocks of forested land in Minnesota.

An important consideration that is not easy to quantify is the impact global warming will have on the costs and benefits associated with protecting large blocks of forested land. How will the value of forests altered by climate change compare with the value we place on forests as we know them today? The answer to that will clearly make a difference in how the balance of costs and benefits plays out over time.

Key Benefits

1. Carbon sequestration
2. Air purification
3. Watershed services
4. Soil stabilization and erosion control
5. Wildlife habitat
6. Diverse recreational opportunities
7. Timber
8. Nontimber products
9. Housing prices

1. Carbon sequestration

Birdsey and Heath (1995) estimated that an average acre of public forestland sequesters about 31.45 tons of carbon per acre just in the trees. Applying this number to total acres of roadless lands in the United States that have been designated as wilderness (with some adjustments for tree density and dominant vegetation type), Loomis and Richardson (2000) came up with an estimated of $490 million to $1 billion annually for the carbon sequestration service performed by the 42 million acres of roadless areas on national forests in the United States. Applying the 31.45 tons of carbon sequestered per acre with a 2007 price base, the current estimated value is $35.7 billion. Therefore, the annual carbon sequestration benefit per acre is $14.05 to $28.67. Multiplying this by the 270,000 to 520,000 acres of large, roadless blocks of forest the forest subcommittee considered over five years, we estimate a total $18.95 million to $74.5 million carbon sequestration benefit[4].

2. Air purification

Trees trap airborne pollutants and thus improve air quality and human health. In Chicago, Illinois, in one year, trees removed air pollutants providing $9 million in air quality (McPherson et al. 1997 via Bolund and Hunhammar 1999). McPherson (1991) determined that planting half a million trees in Tucson, Arizona, would reduce airborne particulates by 6,500 tons per year. The annual value of this pollution control mea-

[4]This is the carbon benefit stored in standing trees, compared to no trees; note this benefit does not take into account the carbon sequestration value of soil.

sure was estimated to exceed $1.5 million. Therefore, the air quality value of each tree equals $4.16. Because this monetized benefit very likely varies across tree species and regions[5], we find it is difficult to determine an exact number by applying existent results for this benefit. Thus, in this assessment this benefit remains **unquantified**.

3. Watershed services

Forested watersheds capture and store water, thus contributing to the quantity of water available and the seasonal flow of water. Forests also help purify water by stabilizing soils and filtering contaminants.

Some studies using contingent valuation estimated residents' willingness to pay for the water quality in Minnesota. Residents living near the Minnesota River were willing to annually pay $14.07 via taxes or $19.64 via water bills for a 40% decrease in phosphorus in the river (Mathews, Homans, and Easter 1999). In southwestern Minnesota, communities were willing to pay $2.4 million, $2.0 million, $6.6 million, and $2.6 million annually for water quality improvement in the levels of iron, sulfate, hardness and copper respectively (Cho 1990). In Lake Bemidji, willingness to pay for water quality improvements was $88 per household (Henry, Ley, and Welle 1988 via Wilson and Carpenter 1999). Although these numbers provide useful context, we chose not to use them to estimate the watershed service benefit in this analysis.

More than half of roadless areas intersect watersheds that provide drinking water to local communities. In particular, roadless forests safeguard clean water from watersheds nationwide. Thus, protecting roadless lands would yield cost savings to water treatment plants and highway departments from avoiding sedimentation associated with logging and roads. This benefit was estimated to range from $130,000 to $260,000 annually for one town located adjacent to a relatively small national forest of 631,000 acres (Loomis 1988). Applying the benefit transfer method by assuming that the average distance between town and adjacent forest is similar in Minnesota and the study area in the literature, preserving roadless forest on national forests in Minnesota would yield a per-acre watershed services benefit of $0.36 to $0.72 ($130,000–$260,000 divided by 631,000 acres and converted to 2007 dollars), a statewide annual benefit of $97,200 to $374,400 (2007 price base), and a five-year benefit of **$490,000** to **$1.87 million**.

4. Soil stabilization and erosion control

Forest vegetation helps stabilize soils and reduce erosion and sedimentation. Estimated values associated with soil stabilization primarily reflect the ecosystem service benefit the forest can provide. In the United States, on- and off-site costs of soil erosion are $44 billion per year (Daily et al. 1997). Values range from $1.94 per ton in Tennessee to $5.5 million annually in Oregon's Willamette Valley (Krieger 2001). In Tucson, Arizona, one mature mesquite tree is expected to reduce storm-water runoff by 9 cubic feet per year. Based on the cost of constructing detention ponds to control runoff, the value of a tree for runoff control is $0.18 annually (McPherson 1992, Dwyer et al. 1992 via Krieger 2001). The statewide estimated average annual sheet and rill erosion rate on cultivated cropland in Minnesota is 2.1 tons/acre/year in 1997. However, without information on how much of the cropland can be stabilized by the forest, it is difficult to quantify this part of the benefit, so for the purposes of this analysis it remains **unquantified**.

[5]The estimated result from other literature is based on the study of mesquite trees, which are rarely found in Minnesota.

5. Wildlife habitat

Roadless forests preserve critical habitat for fish and wildlife, including more than 1,600 threatened, endangered, or sensitive plant and animal species in the United States. Moskowitz and Talberth (1998) report that the costs to U.S. agriculture of replacing natural pest control services with chemical pesticides would be about $54 billion annually. The U.S. Forest Service also estimates that it would cost more than $7 per acre per year to replace the pest-control services of birds in forests with chemical pesticides. In addition, the pollination services of natural ecosystems provide U.S. agriculture benefits of $4 billion to $7 billion per year (Krieger 2001). By assuming the forest natural ecosystems in Minnesota can provide similar services, after adjusting for inflation to 2007 prices the average benefit per acre is estimated as at least $8.20 per year and the benefit over the acreage under consideration here would be $2.21 million to $4.26 million annually, and **$11.05 million** to **$21.3 million** over five years.

6. Diverse recreational opportunities

Wild, unroaded lands offer a unique form of outdoor recreation, and many studies have estimated the value of wilderness-related recreation. Based on an average value of $41.87 per visitor day, the economic value of recreation on the 42 million acres of roadless areas in U.S. national forests is $600 million annually (Loomis and Richardson 2000). Forest ecosystems are also important destinations for hunters and anglers. The economic impact of these activities leads to a $1.3 billion to $2.1 billion revenue for hunting and $2.9 billion for fishing nationwide. In Montana, anglers were willing to pay $2.07 million to protect high-quality recreational fishing in just one roadless area (Krieger 2001).

If we took an average of the recreational benefit measure across the United States, which is $16.73 per acre in 2007 ($600 million divided by 42 million acres, converted to 2007 dollars), and apply to the recommendation cover area of 270,000 to 520,000 acres in Minnesota, we get a potential recreation benefit from protecting large blocks of forests of $4.52 million to $8.87 million annually and **$22.6 million** to **$44.35 million** over the five-year period.

7. Timber

According to the Minnesota Department of Natural Resources (DNR)'s annual report of forest resource, the estimated value of forest products manufacturing shipments in 2006 was $6.93 billion. Value-added impact attributable to Minnesota timber equals $41.60 per dollar of timber sold, and $4.3 billion is the total that stays in Minnesota.

8. Nontimber products

Forests produce many commercially valuable products other than timber, including mushrooms, floral greens, medicinal plants, and edible plants and animals. A previous study shows the nontimber value of forest was about $50 to $20 /ha/year among different ownership types in Wisconsin. The nontimber values range from 10 times to 4 times timber revenues. The hedonic pricing model showed that stands with the same tree distribution had significantly higher nontimber values for national forests (Scarpa, 2000). Therefore, a total benefit of $25.35 million to $32.87 million/year and **$126.75 million** to **$164.35 million** for five years can be expected applying this standard in Minnesota if we assume the forest generates similar value across different ownerships.

9. Housing prices

Protecting natural environments such as roadless areas can increase the property values of adjacent private lands. One case study indicated an increase of 13% in the value of private property adjacent to the Green Mountains in Vermont using a hedonic pricing model (Phillips 1999). Other examples: In Massachusetts, trees add $2,686, or 6%, to house values (Morales 1980 via Garrod and Willis 1993); In Athens, Georgia, using hedonic pricing method, one study estimated landscaping with trees increases sale prices by 3.5% to 4.5%, with an average increase of $1,475 to $1,750 (Anderson and Cordell 1988 via Garrod and Willis 1993). However, hedonic methodology assumes a market-based homogenous preference across different individuals with regard to the same object, which rarely happens in reality. Furthermore, all these housing price changes probably reflect the private benefits and costs of a home, but not the public benefits/costs to have any alternations. Therefore, without knowing the benefit/cost from the public side, the direct market price approach would underestimate/overestimate true values, and so we leave this benefit **unquantified**.

Key Costs

We identified three key costs for this recommendation:

1. Easement acquisition
2. Easement monitoring
3. Opportunity cost of maintaining forestland

1. Easement acquisition

Easement costs would be $500[6] per acre in northern Minnesota and $2,000 per acre in southern Minnesota for a total of $165 million to $310 million for easement acquisition of 270,000 to 530,000 acres in today's dollars over the next 10 to 25 years.

2. Easement monitoring

Easement monitoring would cost $80,000 to $127,000 per year (**$400,000** to **$630,000** for the five-year period) once (and if) 270,000-acre and 520,000-acre targets are reached. However these estimates are varied across different types and locations of land.

3. Opportunity cost of maintaining forestland

The opportunity cost for maintaining forested land is defined as the additional value that could be obtained with the most highly favorable/valued alternatives. It can be calculated by multiplying the total land area that could be developed by the price of the land. However, it is difficult and almost not possible to predict how much of the land would be developed. Here, the total amount of timberland sold in Minnesota and median residential land sales prices are used to approximate the forested land opportunity cost. In 2007, the total sale

[6]The cost estimates are directly taken from forest subcommittee recommendation

of timberland was 15,759 acres, and the predicted median sales price per acre for forestland without structures was $12,000/acre (Figure 1). Thus, an estimated opportunity cost for recommended forest area converting to housing in 2007 is $189.1 million, assuming all the forestland goes to housing use.

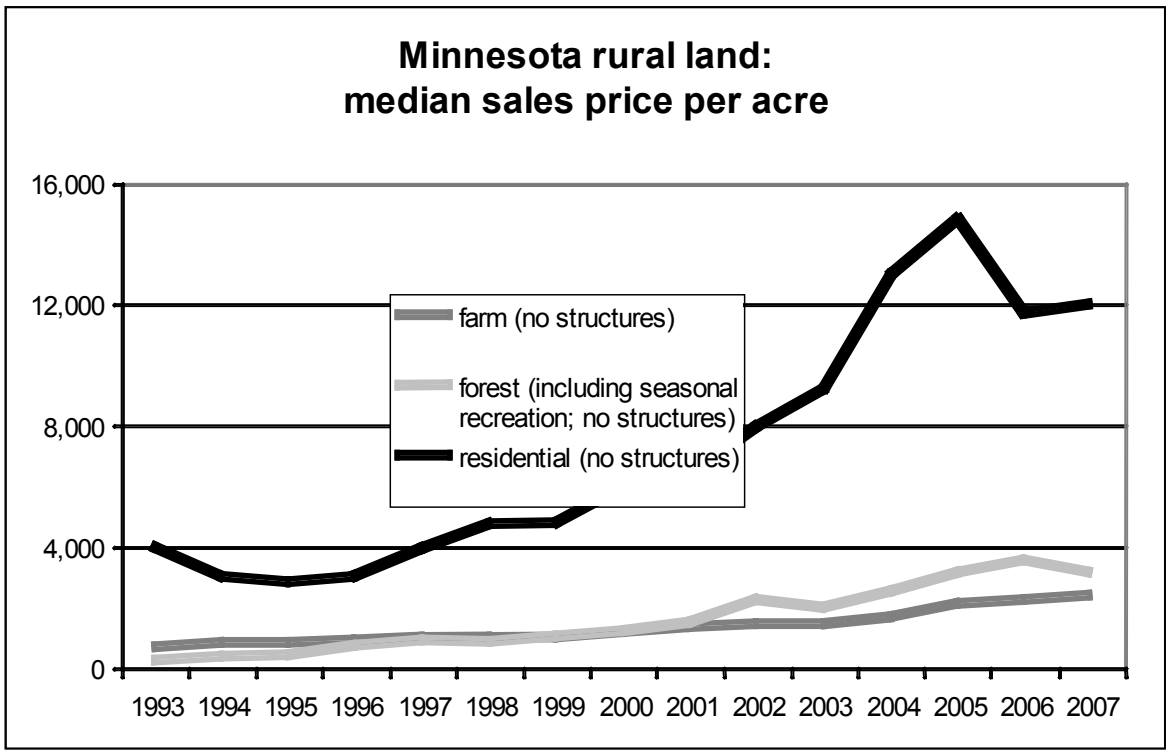

Figure 1. Data and chart are provided by Minnesota Land Economics.

Summary of Key Benefits and Costs

Estimated benefits and costs are summarized in Table 3. For the benefit side, timber and nontimber value contribute the major part of the monetary values. In addition, the forest ecosystem services provide substantial benefits on: climate regulation and carbon sequestration; watershed service; biodiversity and recreational opportunities and so on. On the other hand, as the forestland price is overwhelmingly high, there is a great chance for the cost go beyond the benefit. However, some of the benefit cannot be quantified in the table, such as: air purification and soil stabilization, the overall results could be underestimated for the benefit side.

However, there are couple issues that need to be noticed. All the services and benefits we discussed above depend on a good understanding of those services. More than often, services interact with and depend on each other. Classifications are arbitrary and useful for discussion, but in reality these services are not independent and could not operate alone (Hawkins 2003, Daily 1997b). Furthermore, the values are not necessarily comparable across regions because they often correspond to different aspects of a forest ecosystem service, were arrived at using different methods and are expressed in different units. This means that finding a total value of all services in an area is not as simple as valuing each category and adding them up.

Benefits	**Amount* (5 years over 270,000–520,000 acres)**	**Party receiving benefit**
1. Carbon sequestration	$18.95 million–$74.5 million	Citizens, society, future generations
2. Air purification	Unquantified	Citizens
3. Watershed service	$490,000–$1.87 million	Citizens, town, landowners
4. Soil stabilization	Unquantified	
5. Wildlife habitat and species	$11.05 million–$21.3 million	Citizens, business
6. Recreation	$22.6 million–$44.35 million	Citizens, communities, government
7. Timber value	$636.68 million–$1.25 billion**	Business
8. Nontimber value	$126.75 million–$164.35 million	Citizens, business
9. Housing price	Unquantified	Property owner
Costs	**Amount* (5 years over 270,000–520,000 acres)**	**Party incurring cost**
(1. Easement acquisition costs)	($165 million–$310 million)***	State, local government
(2. Easement monitoring costs)	($400,000–$630,000)	State, local government
(3. Opportunity costs)	($1.004 billion)****	Developers

Table 3. Summary of potential costs and benefits protecting large blocks of forested land in the first five years of project implementation. For assumptions and references, please see text.

*All dollar values are adjusted to 2007 price base. **Total timber sale is $6.93 billion in 2006 over 15,112,700 acres. ***Easement acquisition costs are estimated over 10–25 years ****Opportunity costs are calculated with a 3% interest rate over 5 years.

Produce Perennial Biofuel Crops

Energy Recommendation 3: Invest in perennial biofuel and energy crop research and demonstration projects on a landscape scale

Land Use Recommendation 4: As much as possible, transition renewable fuel feedstocks to perennial crops

These two recommendations share the goal of transitioning part of the Minnesota landscape to perennial energy crop production. For the purpose of this assessment, the costs and benefits of the end goal were analyzed, rather than the steps necessary to reach that goal. Therefore, this is not a cost-benefit assessment of the recommendations, which are oriented towards research. Rather, it is an assessment of the benefits and costs associated with the implementation of that research on the landscape. This assessment is also related to several other recommendations:

Habitat Recommendation 7: Keep water on the landscape

Energy Recommendation 4: Develop policies and incentives to encourage perennial crop production for biofuels in critical environmental areas

Energy Recommendation 11: Invest in research and enact policies to protect existing native prairies from genetic contamination by buffering them with neighboring plantings of perennial energy crops

Energy Recommendation 12: Invest in efforts to develop sufficient seed or seedling stocks for large-scale plantings of native prairie grasses and other perennial crops

Energy Recommendation 13: Invest in research and policies regarding "green payments"

The benefits and costs identified by each team were consolidated and are listed below. The energy team assumed an implementation scale of 2 million acres, mainly affecting counties in the Red and Lower Mississippi River basins, so that figure was used in this assessment. As with the other recommendations, the time frame for assessment was five years of implementation. However, we allowed four years for the cellulosic ethanol program to ramp up, meaning that ethanol is actually produced only in the last year of the program. The "recommendation implemented" scenario was compared with a scenario in which these 2 million acres remain in annual crops, likely a corn/soybean rotation in the Lower Mississippi basin and a wheat/soybean rotation in the Red River basin. In the "no implementation" scenario, the assumption is that no progress would be made toward the production of cellulosic ethanol in the five-year period. This recommendation is therefore designed to jump-start cellulosic ethanol production from perennial crops in Minnesota.

Several SCPP recommendations (listed above) are oriented toward the production of cellulosic ethanol using perennial crops. Cellulosic ethanol is not yet commercially viable on a large scale, but Minnesota's ethanol production industry is expected to grow in the coming decades, given state and national production mandates. The costs and benefits associated with the cellulosic ethanol industry should be periodically reevaluated as technology and industry parameters change.

Keeping in mind the inherent uncertainties, the following broad conclusions can be drawn from this assessment:

1. The benefits of carbon sequestration vary dramatically depending on crop type
2. The opportunity cost for not using land for an annual crop also shows a tremendous range, depending on commodity prices
3. Implementing the recommendations could result in a net economic loss or gain over the five-year assessment period, depending on how reality tracks our estimates and on the value associated with unquantified benefits
4. Many of the costs associated with this recommendation are startup costs and so would become less significant over time

Key Benefits

We identified nine key benefits:

1. Increased biofuel production due to better yields
2. Payments to farmers through the state perennial program
3. Secondary economic benefits of biofuel production
4. Improved water quality and reduced soil erosion
5. Reduced water runoff
6. Increased carbon sequestration and reduced greenhouse gas (GHG) emission
7. Improved wildlife and aquatic habitat
8. Improved landscape aesthetics

1. Increased biofuel production due to better yields

Assuming that the cellulosic ethanol produced from perennial crops will add to, rather than replace, the state's corn ethanol sector, eventually Minnesota would be able to use all of the land referenced in this recommendation (2 million acres) to produce feedstock for cellulosic ethanol. At an annual yield of 2 tons per acre (a conservative estimate suggested by the energy team), and 75 gallons of ethanol production per ton of material, these lands have the potential to produce 300 million gallons of ethanol annually. The gross profit to farmers is estimated at $80 to $120 per ton for sale of their cellulosic crop (Tiffany 2008). However, these profits would not be realized right away—the cellulosic ethanol industry must first develop. We therefore assume revenue from sale of cellulosic feedstock for only the fifth year of the program, allowing four years for an ethanol sector ramp-up. Gross farmer gain from biofuel production is therefore:

2,000,000 acres x 2 tons/acre x $80/ton x 1 year = **$320 million**
2,000,000 acres x 2 tons/acre x $120/ton x 1 year = **$480 million**

2. Payments to farmers through the state perennial program

Payments to farmers as recommended by the energy team are $600/acre over a four-year period, allowing time for ethanol production to ramp up. This amounts to:

$600/acre x 2,000,000 acres x 4 years = **$4.8 billion**

3. Secondary economic benefits of biofuel production

This includes the larger economic benefits of producing ethanol from the perennial crops. In 2006, the Minnesota Department of Agriculture (MDA) estimated the total economic impact of producing corn ethanol as $2.77 billion, or approximately $5 per gallon of ethanol. We assume this economic benefit for only the last year of the first five years of project implementation, allowing time for ramp-up of the ethanol industry. This results in a benefit of:

300,000,000 gallons ethanol x $5 x 1 year = **$1.5 billion**

4. Improved water quality and reduced soil erosion

Perennial landscapes provide both improved water quality and reduced soil erosion compared with annual row crop landscapes. This is because they provide year-round ground cover, which reduces the erosive impact of wind and rain, and provide root structure to hold the soil year-round. The current literature demonstrates that conversion from row to perennial crops results in improved water quality, including reduced stream sedimentation (Babcock et al. 2007). However, this benefit is highly dependent on the location of a given field in relation to a waterway, in addition to other factors such as slope and soil type. The type of perennial crop being planted is also a factor. The team assumed that for every 1% conversion of land use to perennial crops, sedimentation in rivers would also reduce by 1%.

The 2008 budget for water quality restoration projects under the Clean Water Legacy program was $4,374,000. Assuming a reduction in the amount needed for restoration activities corresponding to the amount of sedimentation reduction, over five years the benefit of perennial plantings would be:

2,000,000 acres converted/27,400,000 acres in farms in 2007 x $4,374,000 x 5 = **$1.596 million**

Sedimentation reduction would be the major benefit of the decreased soil erosion resulting from a transition from annual crops to perennials. Many soil erosion cost studies also address the cost of soil erosion incurred by farmers, who must compensate for nutrient loss with added fertilizer. However, in our example of comparing a perennial landscape with an annual crop, the fertilizer regimes would be sufficiently different that calculating a benefit to farmers of avoiding soil erosion resulting from this recommendation would not be appropriate.

5. Reduced water runoff

The specific benefit of decreased runoff from perennial landscapes identified by the land use team is reduced stream-bank erosion. This benefit remains unquantified, and would differ according to the type of perennial crops planted so this remains **unquantified**.

6. Reduced greenhouse gas (GHG) emissions and carbon sequestration

It is unquestionable that making progress toward the state goal of 80% GHG reduction by 2050 is valuable to Minnesota. Because of the global nature of climate change, Minnesota's contribution to the problem and the magnitude of the benefits incurred by reducing this contribution are nebulous. However, Minnesota's leadership could generate markets for low-carbon fuels and catalyze national progress toward a renewable energy economy. This would have large ecological and economic benefits for the state and the nation. Quantifying these indirect GHG reduction benefits is not possible given the limited scope of this assessment, so the proxy we have chosen to represent them is the price of carbon dioxide (CO2) futures sold on the European Climate Exchange (ECX). Regardless of whether the carbon credits for producing low-carbon fuels in Minnesota would actually be sold on the ECX, the price of CO2 futures is a good indication of the market value of reducing GHG emissions.

An extensive literature survey reveals that carbon sequestration increases in land that has been transitioned from annual crops to perennial grasslands, and in land transitioned from annual crops to short-rotation woody crops (Anderson et al. 2008). Increased sequestration is taken into account by life-cycle studies of GHG emis-

sions from cellulosic ethanol production and use. Displacing motor gasoline with cellulosic ethanol made from switchgrass is believed to reduce total GHG emissions by 60% (Groode and Heywood 2007). Given that Minnesota is an ethanol exporter, some of the avoided emissions from cellulosic ethanol production would take place outside the state borders. Nevertheless, Minnesota may be able to sell carbon credits from a cellulosic ethanol program or charge a premium for its low-carbon ethanol. The current price of carbon on the ECX is $40.8 per metric ton. Applying this price to be applicable to cellulosic ethanol production using switchgrass, and assuming (as above) that ethanol production ramps up in the fifth year of the program, the value of reduced GHG emissions would be:

$40.8/metric ton CO2e x 300,000,000 gallons ethanol/year x 1 gallon gasoline/1.52 gallon ethanol [due to lower energy content of ethanol] x 0.6 [reduction represented by replacing gasoline with cellulosic ethanol]) x (0.0093 tons CO2e/gallon gasoline [EPA figure]) x 1 year = **$44.8 million**

A life cycle GHG analysis of ethanol produced from short-rotation woody crops has not yet been produced.

During the first three years of the program, grasslands or lands in short-rotation woody crops would be sequestering carbon at a mean rate of 1.6 metric tons CO2/acre/year and 7.0 metric tons CO2/acre/year, respectively (Anderson et al. 2008). However, these values are uncertain given the wide variation in carbon sequestration rates gathered from the literature. For perennial grassland, sequestration rates could vary between 0 and 3.2 metric tons CO2/acre/year, and for short-rotation woody plantings they could vary between 4.4 and 9.6 metric tons CO2/acre/year.

The value of sequestered carbon for grassland during the first four years of the program is therefore between **$0** and 3.2 metric tons CO2/acre/year x 4 years x 2,000,000 acres x $40.8/metric ton CO2 = **$1 billion**

The value of sequestered carbon for short-rotation woody cropland during the first four years of the program is between 4.4 metric tons CO2/acre/year x 4 years x 2 million acres x $40.8/metric ton CO2 = **$1.4 billion** and 9.6 metric tons CO2/acre/year x 4 years x 2 million acres x $40.8/metric ton CO2 = **$3.1 billion**

7. Improved wildlife and aquatic habitats

Perennial grasslands and short-rotation woody crops both harbor more diverse bird species than do annual row crop landscapes (Dhondt and Sydenstricker 2001, Murray et al. 2003). However, the monetary benefit of this increased biodiversity is unclear. A study in North Dakota evaluated total revenue from pheasant, waterfowl, and deer hunting attributed to conservation reserve program (CRP) lands, and found this value to be $9.45/acre in 2000 (Bangsund et al. 2004). Assuming that perennial bioenergy cropland provides similar benefits, this totals $9.45 x 2,000,000 acres = **$18.9 million**.

Also, reduced sedimentation of waterways in a perennial landscape has beneficial impacts on fish communities, reducing fish kills in some watersheds (Westra et al. 2005). The monetary value of this reduction has not been evaluated.

8. Improved landscape aesthetics

This benefit remains **unquantified**, because no studies have been conducted on aesthetic preference for perennial landscapes compared with annual crop landscapes.

Key Costs

We identified four key costs associated with this recommendation:

1. Cost of farm subsidies
2. Opportunity costs of not using land for annual crops
3. Production costs of perennial crops
4. Production costs of cellulosic ethanol

1. Cost of farm subsidies

These subsidies are payments to farmers designed to encourage them to transition to perennial crops. They are equivalent to the benefit listed above: **$4.8 billion**.

2. Opportunity costs of not using land for annual crops

Without implementation of the recommendation, the 2 million acres would presumably be planted in corn in the Lower Mississippi basin and wheat in the Red River basin. Farmers would receive some revenue from these crops, but would also incur costs associated with producing them. The opportunity cost per acre is equal to the net return to the farmer for these crops. For the sake of this exercise, we assume production costs per acre are fixed, although in reality they would fluctuate depending on the cost of chemical inputs, labor, land rent, etc. Because of this assumption, the net profit for the farmer (and therefore the opportunity cost for taking land out of production) more than doubles when grain prices double. This is most likely an overestimation of opportunity costs, and makes this analysis conservative. Assuming five years of corn/wheat production at a high and low price point for each crop, using the most recent average yields for Minnesota from Lazarus et al. (2008), this cost is equivalent to:

(corn, $4/bushel): $175.50/acre x 1,000,000 acres x 5 years = **$877.5 million**
(wheat, $8/bushel) : $100.40/acre x 1,000,000 acres x 5 years = **$502 million**
(corn, $8/bushel): $807.50/acre x 1,000,000 acres x 5 years = **$4.04 billion**
(wheat, $12/bushel): $300.43/acre x 1,000,000 acres x 5 years = **$1.5 billion**
= $1.38 billion to $5.54 billion

3. Production costs of perennial crops

The per-acre costs of perennial crop production must be weighed against the gross income accruing to farmers after selling their crop to ethanol producers (calculated above in the benefits section). Lazarus et al. (2008) estimate these total costs for switchgrass to be $460/acre, including seed, fertilizer, land rent, equipment, and

labor. Assuming other perennial crops would have a similar cost profile, total costs for all land planted in perennials would be:

$460/acre x 2,000,000 acres x 5 years = **$4.6 billion**

4. Production costs of cellulosic ethanol

University of Minnesota applied economics research fellow Doug Tiffany derived the costs summarized below from several sources, including Aden et al. (2002) and Perrin et al. (2008).

Besides the cost of raw biomass (equal to the price paid to the farmer), other costs of ethanol production include transportation of material to the plant, operating costs at the plant, and the plant's start-up capital. Some electricity may be sold by the plant back to the grid, and the revenue from this activity is also considered. Total costs per gallon for a lignocellulosic ethanol process are estimated at $1.12/gallon (minus the cost of feedstock). For the one year of ethanol production we are assuming, the total costs of ethanol production are:

Price for feedstock paid to farmers (from farmer benefits above): **$320 million** to **$480 million**
Other ethanol costs: 300,000,000 gallons x $1.12/gallon = **$336 million**
Total: **$656 million** to **$816 million**

There are also critical implications for food prices and indirect land use effects of using productive land to produce energy crops. While the magnitude of these effects remains unclear, displacing commodity production in Minnesota could potentially shift corn and soybean farming to more sensitive environments in other parts of the world, with negative implications for carbon emissions, erosion, and deforestation (Fargione et al. 2008). Alternatively, removing land from soybean and corn production in Minnesota could push up food prices. One of the reasons the energy team recommended promoting electrical power for the transportation sector in Minnesota (Energy Recommendation 16) was to avoid some of these potentially negative impacts of converting land to energy crop production. However, as mentioned in the cost-benefit assessment for that recommendation, transitioning the Minnesota fleet to electric power would not necessarily replace cellulosic ethanol production for the out-of-state market. The most up-to-date scientific and economic information on ethanol production and land displacement should be used to inform discussion of this policy recommendation.

Summary of Key Benefits and Costs

The large range in potential costs and benefits for this assessment reflects the uncertainty in assigning monetary value to ecosystem benefits, particularly carbon sequestration. Several ecosystem benefits—including improved nongame wildlife habitat, landscape aesthetics, and reduced peak flows due to lower runoff rates—were too difficult to quantify to be included here.

This assessment only covers the first five years. If the changes created a landscape with dramatically lower ecosystem impacts and GHG emissions in the long term, the relative benefit would increase because many of the costs in the table represent one-time start-up costs (for example, ethanol plant construction and equipment costs), and would not be repeated annually.

This recommendation primarily involves monetary exchanges between the state government and farmers, and these are the two groups most heavily represented in the third column of the table (below). Depending on commodity prices, state programs may have to invest more or less money in subsidy payments to farmers to encourage them to transition to perennial crops.

Benefits	**Amount**	**Party receiving benefit**
1. Biofuel production	$320 million– $480 million	Farmers
2. Payments to farmers	$4.8 billion	Farmers
3. Secondary economic effects of biofuel production	$1.5 billion	Business owners, citizens, local and state governments (through taxes)
4. Improved water quality/reduce erosion	$1.6 million	State government, ecosystems/wildlife
5. Reduced water runoff	Unquantified	
6. Reduced GHG emissions	$44.8 million	State government, ecosystems/wildlife, citizens
7. Carbon sequestration	$0–$3.1 billion	State government, ecosystems/wildlife, citizens
8. Improved wildlife and aquatic habitats	$18.9 million	Citizens, businesses, ecosystems/wildlife
9. Improved landscape aesthetics	Unquantified	
Costs	**Amount**	**Party incurring cost**
1. Farm subsidies	$4.8 billion	State government
2. Opportunity cost of not using land for annual crops	$1.38 billion– $5.54 billion	Farmers
3. Production costs of perennial crops	$4.6 billion	Farmers, possibly state government
4. Production costs of cellulosic ethanol	$656 million– $816 million	Businesses

Table 4. Summary of potential costs and benefits from a perennial crop payment program in the first five years of project implementation, all adjusted to 2007 values. For assumptions and references, please see text.

Encourage Biofuel Production on Expiring CRP Lands

Energy Recommendation 4: Develop policies and incentives to encourage perennial crop production for biofuels in critical environmental areas

The outcome of this recommendation was considered by the energy team to be very similar to the outcome of the recommendation to encourage perennial biofuel production on agricultural land (Energy Recommendation 3, discussed above). The costs and benefits are therefore nearly identical, except that this recommendation was expected to apply to only 1 million acres of expiring Conservation Reserve Program (CRP) lands. The energy team considered this to be the area of land in Minnesota likely to be converted to annual row crop (corn or wheat) production when CRP contracts expire. Please refer to the cost-benefit assessment of the perennial biofuels recommendations for a full discussion of the costs and benefits and a list of references. The following table is a summary of these costs and benefits (most are half the value of the costs and benefits for the perennial biofuel recommendation, because they take place on half the land area).

Benefits	**Amount**	**Party receiving benefit**
1. Biofuel production	$160 million– $240 million	Farmers
2. Payments to farmers	$2.4 billion	Farmers
3. Secondary economic effects of biofuel production	$790 million	Business owners, citizens, local and state governments (through taxes)
4. Improved water quality/reduced erosion	$1.258 million	State government, ecosystems/wildlife
5. Reduced water runoff	Unquantified	
6. Reduced GHG emissions	$23.9 million	State government, ecosystems/wildlife, citizens
7. Carbon sequestration	$0-$1.55 billion	State government, ecosystems/wildlife, citizens
8. Improved wildlife and aquatic habitats	$11.65 million	Citizens, businesses, ecosystems/wildlife
Costs	**Amount**	**Party incurring cost**
1. Farm subsidies	$2.4 billion	State government
2. Opportunity cost of not using land for annual crops	$690 million– $2.77 billion	Farmers
3. Production costs of perennial crops	$2.3 billion	Farmers, possibly state government
4. Production costs of cellulosic ethanol	$328 million–$408 million	Businesses

Table 5. Summary of potential costs and benefits from a perennial crop payment program for expiring CRP land in the first five years of project implementation. For assumptions and references, please see text.

Encourage Electric Vehicles

Energy Recommendation 16: Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power, while simultaneously increasing renewable electricity production for transportation

Several states use incentives to promote adoption of low-emission and zero-emission vehicles. For example, California offers a tax rebate for electric vehicles (EVs) of between $1,000 and $1,500 per newly purchased vehicle. Colorado offers an income tax credit for alternative vehicles based on their emissions reduction factor compared with a traditional gas-powered car (a 2007 Toyota Prius with an estimated cost of $22,500 receives a $3,013 income tax credit under this program).

Several hybrid electric vehicles (HEVs) are expected to be offered on the market within the next several years. For this exercise, we used information for the forthcoming Chevrolet Volt offered by General Motors at an estimated cost of $40,000, which is an HEV with a battery range of 40 miles, after which the battery is re-charged using the gasoline engine. The Volt may be plugged into a standard 120-volt outlet for recharging.

We analyzed an implemented tax rebate of $3,000 for an HEV similar to the Volt over a five-year period. This rebate would be designed to encourage adoption of HEVs, as stated in the recommendation. Renewable energy would be added to the grid to supplement the additional electrical power requirements imposed by the hybrid electric fleet. We assumed in this analysis that this would be wind power.

As in all cost-benefit analyses, this analysis is based on a number of uncertainties. Nevertheless, we draw the following general conclusions that may be helpful in guiding policy:

1. Benefits would likely be on the order of millions to tens of millions of dollars over the five-year assessment period
2. Costs would likely be on the order of tens of millions of dollars over the five-year assessment period
3. This recommendation should be assessed in the context of other programs to reduce GHG emissions and gasoline/ethanol consumption and in the context of the latest scientific and economic information on the impacts of alternative fuel production

Key Benefits

We identified four key benefits:

1. Reduced CO2 emissions leading to reduced state contribution to GHG emissions
2. Reduced emissions of particulates, ground-level ozone, nitrogen dioxide, carbon monoxide, and toxics leading to human health and ecosystem health benefits
3. New labor markets and business opportunities associated with wind electricity production for the transportation sector
4. New labor markets and business opportunities associated with HEV production

In addition, the team that formulated this recommendation suggested that HEVs could reduce pressure on the land resource and stabilize commodity prices, by reducing the need to produce ethanol. Given current concern about energy crop production in the developed world leading to increased land clearing for food crops in environmentally sensitive regions of the developing world, an HEV fleet could be seen as one method of combating this trend (see the cost-benefit assessment for Energy Recommendation 3). However, these complex national and global land use dynamics are well beyond the reach of this assessment. We recommend that Minnesota legislators and citizens carefully consider the latest scientific and economic information on the impacts of alternative fuel production when drafting or revising state energy policy.

A first step in identifying benefits is to estimate the adoption rate of HEVs with and without the incentive program. Several studies suggest that consumers like the fuel flexibility, at-home recharging convenience, and environmental responsibility that HEVs offer, and may be willing to pay more for them (Golub et al. 1994, Kurani et al. 1996, Ewing & Sarigöllü 1998). A study from California that evaluated household demand for alternative vehicles found that up to 18% of households would choose an EV for their next car purchase when the price of the EV was held within $4,000 of a conventional vehicle (Kurani et al. 1996). Another study using a discrete choice model found that household choice of vehicle responded to price difference with an odds ratio of 0.8. This means that for a price difference of $1,000, 80% as many households would choose an EV over a cheaper, gasoline-burning vehicle, after the effects of other criteria on vehicle choice were removed (Ewing & Sarigöllü 1998). In the same study, for a price differential of $1,300, 24% of respondents reported that they would choose an EV as their next purchase, while 25% would choose a conventional gas-powered vehicle similar to their current vehicle (the remaining 51% would choose a more fuel efficient gasoline vehicle than the vehicle they currently own, postulated to cost $1,300 less in the study). This indicates that consumers would be *more* willing to choose an EV than purchase price alone would predict. The authors of the study explain that this is likely due to the convenience and performance features of an EV that are superior to a gasoline vehicle.

The purchase price of the Volt is expected to be $40,000 (this cost may come down over time). A comparable gasoline vehicle is expected to cost $22,500; therefore, the price differential between a gasoline vehicle and an HEV would be $17,500. If 80% as many car consumers would choose an HEV over a conventional vehicle in a given year when the price difference is between $1,300 and $4,000, as referenced in the literature above, and if the odds ratio sensitivity to price differential is 0.8, the percentage of consumers choosing an HEV in a given year would be (0.8)17.5 x 25% = 0.5%.

For the sake of simplicity, we are assuming that the only difference between the HEV and the gasoline-powered vehicle is price, although realistically this is clearly not the case. As a result, this is likely an underestimation of HEV adopters, given the performance and convenience features of HEVs that would be attractive to consumers. Other assumptions include (1) Minnesota consumers behave similarly to California consumers; and (2) HEV choice is similar to EV choice.

If the state of Minnesota were to offer tax rebates of $3,000 to offset the purchase price of an HEV, the percentage adopting this technology in a given year would be (0.8)14.5 x 25% = 0.98%.

Minnesota consumers currently purchase about 68,700 cars and light trucks per year, according to Minnesota Pollution Control Agency (MPCA) data. Presumably, all of these consumers would consider an HEV choice. Therefore, without the tax rebate, 344 HEV cars would be adopted annually, and with the rebate 673 HEV cars would be adopted annually.

1. Reduced CO2 emissions leading to reduced state contribution to GHG emissions

Without the recommendation being implemented, any HEVs added to the fleet would use electricity from Minnesota's current grid. Minnesota's GHG emissions per kilowatt hour (kWh) electricity in 2004 were 0.84 kg CO2e (Minnesota Department of Commerce 2005). In 2004, GHG emissions from gasoline vehicles were 0.000554 metric tons CO2e per vehicle mile traveled (Ciborowski 2007). An average personal vehicle in the state traveled 10,308 miles per year in 2004 (MPCA). This is approximately 28.2 miles per day; the Volt is designed to run 40 miles on the battery alone before recharging either electrically or with the gasoline motor. Therefore, the average Minnesota consumer could use the Volt as an entirely electric car, with an efficiency of 3 miles/kWh.

If the recommendation were not adopted, *avoided* emissions in the transportation sector in a given year would equal the emissions of gasoline vehicles replaced by HEVs minus emissions from adopted HEVs:

(344 cars x 10,308 miles x 0.000554 metric tons CO2e/mile) – (0.84 kg/kWh x 10,308 miles/3 miles/kWh x 1 metric ton/1,000 kg x 344 cars) = 972 metric tons CO2e.

If the recommendation were adopted, and gasoline vehicles were replaced by HEVs using entirely renewable (zero-emission) electricity, avoided emissions in a given year would equal the emissions of gasoline vehicles replaced by HEVs:

673 cars x 0.000554 metric tons CO2e emissions/mile x 10,308 miles = 3,843 metric tons CO2e

Please see the cost-benefit assessment for Energy Recommendation 3 above for a more detailed discussion of the value to Minnesota of reducing carbon emissions. For this recommendation, we used the price per ton of ECX carbon futures set for December, 2008 as a proxy for the value of Minnesota reducing its GHG emissions. This price is currently 26 euros ($40.80) per metric ton. If the carbon reduction merits of the HEV subsidy/renewable electricity program could be demonstrated, the carbon savings could presumably be sold under "Certified Emissions Reductions" trading on the ECX. This means that the value of yearly carbon savings compared with a "no adoption" scenario could be:

(3,843 metric tons – 972 metric tons) x $40.80/metric ton = $117,137

As more cars are adopted each year of the program, the value of this carbon savings compounds to **$1,757,000** over five years.

2. Reduced emissions of particulates, ground-level ozone, nitrogen dioxide, carbon monoxide, and toxics leading to human health and ecosystem health benefits

Numerous studies have dealt with the human health effects of particulate and ground-level ozone emissions from gasoline-powered vehicles (Cifuentes et al. 2001). A survey of human health impact studies from California puts the direct and indirect costs of motor vehicle emissions at between $9.4 billion and $240.3 billion annually (Plenys 2004). This value includes health-care costs, lost workdays, and the costs of restricted activity days caused by exposure to vehicle emissions. This amounts to between $266 and $6,793 per person, based on California's total population in 2003. California's CO2 emissions in 2003 from the transportation

sector were 233,875,458 metric tons (USDOE 2008). Assuming a linear relation between health-care costs and emissions for the purpose of applying these numbers to Minnesota, the health-related costs of vehicle emissions are $0.00114 and $0.02905 per person per 1,000 metric tons CO2 emitted (with CO2 serving as a proxy for emissions hazardous to human health).

If we apply these parameters to the avoided CO2 emissions attributed to the HEV program, annual savings for the baseline year 2003 would be between:

$0.00114 x (5,088,006 Minnesotans) x (3,843 – 972) metric tons/1,000 = $16,653
$0.02905 x (5,088,006 Minnesotans) x (3,843 – 972) metric tons/1,000 = $424,353

These costs would obviously be higher in the first year of the HEV program (assumed to begin in 2010), due to Minnesota's higher population at that time. However, all other costs are calibrated for year 2003–04, and there is no information on emissions beyond 2004, so we will simply consider these costs to be conservative.

For all five years of the program, cumulative savings would therefore be between **$250,000** and **$6,365,000**

Ground-level ozone emissions also negatively affect vegetation (Ollinger et al. 1997). The beneficial impact on plant and animal health incurred by reducing these emissions through replacement of gasoline-powered vehicles is unfortunately too complex to quantify here.

3. New labor markets and business opportunities associated with wind electricity production for the transportation sector

The assumption we make here is that additional wind capacity would be needed to fuel an HEV fleet. It is possible that base load power management could be introduced to fuel the fleet, but that was not considered here.

Kildegaard and Myers-Kuykindall (2006) indicate that community-based wind projects offer more benefits to local economies than large-scale corporate projects. These benefits are estimated as $18,889 per megawatt (MW) of installed wind capacity. Minnesota is currently using nearly 100% of its available wind capacity, so more wind systems would need to be built to power an HEV fleet. Assuming that community-based wind projects could be mobilized, benefits of a wind-powered HEV fleet would be:

10,308 miles x (1 kWh/3 miles) x (1 MWh/1,000 kWh) x (1 MW/8,760 MWh) x 3 (ratio of installed capacity to operational capacity for wind systems) x 673 cars = 0.79 MW annually x ($18,889/MW) = $14,959 or **$75,000** compounded over 5 years.

4. New labor markets and business opportunities associated with HEV production

An analysis of the impacts of EV production on the U.S. economy generated a net positive output of $1.33 billion for a market penetration of 684,000 vehicles, compared to economic output without EV manufacture (Meade 1995). This includes the employment and economic benefits of manufacturing EVs, parts and electricity, as well as the negative effects of displacing gasoline vehicle manufacture and gasoline production. Applying these findings to the Minnesota economy is somewhat problematic because the state does not contain all of

the relevant economic sectors. However, we believe applying the national figures to Minnesota will yield a conservative estimate of benefits because more vehicle parts and fuel manufacturing for EVs than for gasoline vehicles would take place in the state. Therefore, the benefits of HEV penetration in Minnesota under the tax rebate program are estimated to be:

($1,330,000,000)/(684,000 vehicles) x (673 – 344 vehicles per year) x 5 years = **$3,199,000**

Key Costs

We identified four key costs for this recommendation:

1. Cost of subsidizing HEV purchases borne by state
2. Cost of transitioning to HEVs borne by consumers
3. Opportunity costs associated with government spending on this program and with lost revenue from gasoline/ethanol-powered vehicle production
4. Cost of adding additional wind power to the grid

1. Cost of subsidizing HEV purchases borne by state

This calculation is fairly straightforward:

$3,000/vehicle x 673 vehicles x 5 years = **$10,095,000**

2. Cost of transitioning to HEVs borne by consumers

The cost for consumers of transitioning from a gasoline vehicle to an HEV includes the price differential between HEV and gasoline vehicles minus the tax rebate payments, minus the difference in operation and maintenance costs between HEVs and gas vehicles. Essentially, it is the cost of ownership of an HEV compared with that of a conventional vehicle. This cost depends on several parameters, including the price of gasoline and the price of electricity. Because these parameters are notoriously difficult to model or predict with any accuracy, in this assessment current values are used.

The cost of wind electricity in the upper Midwest is taken to be $0.052/kWh (Jones et al. 2006). With the HEV's electric engine efficiency of 3 miles/kWh, an HEV will travel 58 miles for $1.00. A gasoline-powered vehicle will go about 5.5 miles for $1.00 with gasoline prices at $4.00/gallon and a vehicle efficiency of 22 mpg.

For a Minnesotan driving the average 10,308 miles per year in an HEV, fueling costs would total $252/year. A gas-powered car would take $1,874/year to fuel. Maintenance costs for an EV at low market penetration are estimated at 5.1¢ per mile, due to the EV engine's relatively few moving parts (Cuenca et al. 1999), while for a gasoline-powered car they are 13.2¢ per mile. This totals $529 annually for HEV maintenance and $1,358 annually for gasoline vehicle maintenance. Fueling and maintenance costs together are therefore $781/year for the HEV and $3,232/year for the gasoline vehicle.

The recommendation would put 673 – 344 = 329 more HEVs on the road compared with the "no implementation" situation, so total costs to consumers break down as follows:

Purchase price difference of HEV compared w/gasoline vehicle, with tax rebate:
5 years x $14,500 x 329 cars = $23,852,500

Operation cost difference for HEVs compared with gas vehicles:
15 years of operation (5 for cars adopted in first year; 4 for cars adopted in second year, and so on) x ($3,232 – $781) x 329 cars = –$12,095,685

Total cost to HEV consumers = **$11,757,000**

Note that, under these assumptions, an HEV would pay for its additional purchase price through reduced operating costs (compared with a gasoline vehicle) within six years.

3. Opportunity costs associated with government spending on this program and with lost revenue from gasoline/ethanol-powered vehicle production

The opportunity costs associated with no longer producing gasoline vehicles are included in the economic effects described by Meade (1995). Opportunity costs of the tax rebate program would require determining whether this program is the most effective investment of resources to achieve its stated goal. This recommendation should therefore be compared with other recommendations designed to reduce Minnesota's GHG emissions and shift the state's vehicle fleet away from gasoline and ethanol, both of which have more negative impacts on natural resources than renewable electrical power. Given that GHG emissions from the transportation sector are a large and growing portion of Minnesota's GHG budget, if the tax rebate program were to advance widespread adoption of HEVs, the effect could be extremely positive. The market penetration of HEVs would be determined by at least the following, all of which are very difficult to project into the long-term future:

- Future price of the vehicles
- Maintenance and battery replacement policies of vehicle manufacturers
- Future fuel efficiency of gasoline vehicles
- Future price of electricity and gasoline
- State transportation and development policies
- Alternative transportation availability (e.g., mass transit)

The opportunity costs associated with government spending and lost revenue are **unquantified**.

4. Cost of adding additional wind power to the grid

The cost of installing new wind projects has been estimated at $1,091,000 per MW (Jones et al. 2006). Given the electricity requirements outlined in the business opportunities section above, new installed wind capacity for the five year HEV introduction period would cost **$4,309,000**.

Summary of Key Benefits and Costs

The results of the five-year cost-benefit assessment are summarized in the table below, after being adjusted to 2007 values. However, some key costs and benefits of the program were not quantified—for example, some health benefits of gasoline vehicle reduction and opportunity costs of implementing tax rebates. With a lower purchase price for HEVs and higher gasoline prices relative to electricity prices, the benefits of a tax rebate program would rise relative to the costs. It is important to assess this recommendation in the context of other programs designed to achieve lower GHG emissions and reduced gasoline/ethanol consumption.

Benefits	**Amount**	**Party receiving benefit**
1. Reduced CO2 emissions	$1,757,000	State—credit received through ECX
2. Reduced particulate, ground-level ozone, NO2, CO, and toxics emissions	Human health benefits: $250,000–$6,365,000 Ecosystem health benefits: unquantified	Citizens, ecosystems/ wildlife, businesses
3. New labor/business opportunities associated with wind electricity production	$75,000	Business community, citizens, state and local governments through taxes
4. New labor/business opportunities associated with HEV production	$3,199,000	Business community, citizens, state and local governments through taxes
Costs	**Amount**	**Party incurring cost**
1. Subsidies for HEVs	$10,095,000	State government
2. Cost of transitioning to HEVs borne by consumers	$11,757,000	Citizens
3. Opportunity costs of government spending and lost revenues from vehicle production	Unquantified	
4. Cost of adding wind power to grid	$4,309,000	Business community

Table 6. Summary of potential costs and benefits from an HEV tax rebate program in the first five years of project implementation. For assumptions and references, please see text.

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Appendix VI

Value and Investment Prioritization

This Appendix provides a summary of the results of an Expert Consultation Workshop that was held to conduct a relative cost evaluation of the Policy and Action Recommendations of the Final Plan.

An understanding of the relative costs of recommendations is helpful to the implementation strategy of the Statewide Conservation and Preservation Plan (SCPP). While costs and benefits are not the only criteria that should be used to prioritize aspects of the plan, they can be used to inform the implementation strategy, and are also useful for budget planning by agencies responsible for implementation of adopted recommendations. A full cost-benefit analysis would require assigning dollar amounts to each of the elements that make up the overall cost of implementing each recommendation, and assigning a dollar value to the ecological, economic, and social benefits of that recommendation. Costs of implementation are very site specific—for example, the cost of purchasing land easements can vary by orders of magnitude depending on the land type and location. Valuing benefits is even more difficult because the analytical tools used to estimate value are not widely used, and basic input data for these tools are lacking. A cost benefit analysis was performed on nine of the recommendations, and can be found in Appendix V.

Given these serious constraints, our team took a different approach to providing the Legislative-Citizen Commission on Minnesota Resources (LCCMR) guidance on this issue. For a series of natural resource values, we determined the magnitude of benefit and the degree to which policy and action recommendations benefited multiple resources (see section on Strategic Framework for Recommendations and Figure 5). For each of these same recommendations, we assessed the relative cost of implementation using an expert consultation workshop. Only the policy and action recommendations were considered by this workshop, since the knowledge infrastructure recommendations were not assessed for benefits to multiple resources. This appendix presents the results of this workshop. Workshop participants included University of Minnesota economists, natural resource scientists, and policy experts[1]. They assessed the overall investment cost of a given recommendation as low (single millions of dollars or less), medium (tens of millions of dollars), or high (hundreds of millions of dollars). Generally, the group reached consensus on the investment cost.

Workshop participants felt it important to identify who would bear the cost, and divided their cost assessments between public (government, citizen) and private (business and industry) sectors. All estimates assume recommendations would be implemented statewide unless otherwise indicated. Participants also emphasized several important overarching points:

- For recommendations that are considered high cost, there is almost always a way to scale up the recommendation over time to reduce the per annum cost.
- For many recommendations, the amount of investment correlates with the effectiveness of the outcome (e.g., incentive programs with high-value incentives are more effective than those with low-value incentives).
- All of these recommendations should be considered in the context of benefit per unit cost (or dollar invested), not just total cost.

[1]Attendees included William Easter, Steven Kelley, Stephen Polasky, Laura Schmitt-Olabisi, Deborah Swackhamer, Steven Taff.

Table 1. Relative costs of implementing recommendations statewide (H = high cost, M = medium cost, L = low cost). The order of the recommendations corresponds to the order provided in Figure 5, section on Strategic Framework for Recommendations. Only Policy and Action recommendations were evaluated.

Overall Estimated Cost of Recommendations	**Relative Cost** (H = high cost, M = medium cost, L = low cost)		
Rec #	**Recommendation**	**Public**	**Private**
H2	Protect critical shorelands of streams and lakes	H	H
H1	Protect priority land habitats	H	H
H4	Restore and protect shallow lakes	H	H
H5	Restore land, wetlands, and wetland-associated watersheds	H	H
H6	Protect and restore critical in-water habitat of lakes and streams	M	M
H7	Keep water on the landscape	L	M
H8	Review and analyze drainage policy (ditch laws)	L	L
H3	Improve connectivity and access to recreation	L	L
LU1	Fund and implement a state Land Use Development and Investment Guide	M	M
LU2	Support local and regional conservation-based community planning	L	L
LU3	Ensure protection of water resources in urban areas	L	M
LU4/E4	Transition renewable fuel feedstocks to perennial crops	H	H
LU5	Reduce streambank erosion through reductions in peak flows	H	H
LU6	Reduce upland and gully erosion through soil conservation practices	M	M
LU8	Protect large blocks of forested land	M	M
LU10	Support and expand sustainable practices on working forested lands	M	M
T1	Align transportation planning across all agencies; streamline and integrate environmental transportation project review	L	L
T2	Reduce per capita vehicle miles of travel	H	L
T3	Develop and implement transportation polices that minimize impacts on natural resources	L	L
E1	Develop coordinated laws, policies and procedures across state agencies	L	L
E13	Invest in research and policies for "green payment" program	H	L
E17	Promote policies and incentives that encourage C-neutral homes, businesses, communities, and other institutions	?	L
E2	Invest in farm and forest preservation to prevent fragmentation due to development	L	M
E18	Implement policies and incentives to lower energy use of housing stock	L	L
E16	Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power and renewable electricity production	M	M
E21	Develop standards and incentives for energy capture from municipal sanitary and solid waste, and minimize landfill options	L	L
E19	Promote policies and strategies to implement smart meter and smart grid technologies	L	L
E14	Investigate opportunities to provide tax incentives for individual renewable energy investors	M	M
E20	Develop incentives to encourage widespread adoption of passive solar and shallow geothermal heat pumps in new construction	L	L
E15	Invest in efforts to develop community-based energy platforms	L	L

Table 1 provides the results of the relative cost assessments. Some important points from the discussion follow the table. These are comments, opinions, or clarifications that were offered by individual workshop experts, and captured by the facilitator to add value to the summary. They do not represent a narrative summary of the workshop itself.

Discussion points:

H2: Protect critical shorelands of streams and lakes

- Cost would depend on location. Protection might actually increase property value in some locations. Thus investment might be offset by increased property values in some cases.
- Tools might include public/private partnerships, which affects cost and who pays.
- Purchased land easement acquisition or property purchase is always expensive.
- Zoning is less expensive but less effective. (It would be more effective with more enforcement, but also more expensive.)
- Distinction should be made between commercial and residential use: In northern Minnesota, residences are causing land use impacts, while in south-central Minnesota it is agriculture. Commercial and residential uses require different tools to achieve goals.
- Property tax approaches are also inexpensive but less effective. However, more money invested in them could make them more effective.

H1: Protect priority land habitats

- See discussion points above for H2.

H4: Restore and protect shallow lakes

- To reduce sediment and nutrient loading, action is needed upstream, which is likely expensive since it deals with the watershed and land use and not just the stream or river.
- Several different goals are represented within the recommendation. Because they represent multiple strategies/actions, it would be possible to start with a less expensive action and scale up.

H5: Restore lands, wetlands, and wetland-associated watersheds

- A detailed cost-benefit discussion can be found in Appendix V.

H6: Protect and restore critical in-water habitat of lakes and streams

- This is assumed to mostly refer to restoring near-shore in-water regions affected by docks and marinas. This covers a smaller surface area than wetlands and thus would cost less.
- Costs must include enforcement.
- Costs would be incurred over a relatively small commercial or municipal sector (marinas, commercial docks), but would be high for individual property owners that have docks.

H7: Keep water on the landscape

- In urban areas, efforts to reduce or prevent future impermeable surfaces are relatively inexpensive unless there is an incentive program.
- In urban areas, retrospective work would be more expensive than prospective, unless it is done as surfaces are replaced as part of business as usual.
- Runoff laws already exist for commercial properties.
- A large educational effort would be needed for homeowners to change behavior.
- "Smart" drainage systems would be needed in agriculture.
- If activities like best management practices (BMPs) were required, the cost per acre would be low but the land area would be large.

H8: Review and analyze drainage policy

- A detailed cost-benefit discussion can be found in Appendix V.

H3: Improve connectivity and access to outdoor recreation

- Targeted land purchase to improve connectivity would involve purchasing strategic gaps (e.g., pieces of land between high-habitat-quality lands), so the amount of land would be less than for H1 or H2.

LU1: Fund and implement a state Land Use Development and Investment Guide

- Developing it would be of low cost and incurred by the public sector; implementing it would be medium cost for public and private sectors.

LU2: Support local and regional conservation-based community planning

- Incentives would be relatively low cost as described in the recommendation.

LU3: Ensure protection of water resources in urban areas

- "Credits" would be for compliance with state regulations.
- Water is already regulated, so not starting from scratch.
- If TMDLs are to be met, the cost could be very high.
- For some individuals and businesses, the cost might be high.

LU4/E4: Transition renewable fuel feedstocks to perennial crops

- A detailed cost-benefit discussion can be found in Appendix V.

LU5: Reduce streambank erosion through reductions in peak flows

- The cost would overlap with that for other recommendations, including H8.
- Initial investment would be high due to cropping and drainage changes, but the maintenance cost would be low.

LU6: Reduce upland and gully erosion through soil conservation practices

- Costs would be mostly for education and incentives.

LU8: Protect large blocks of forested land

- Some acquisition is included which is costly; the mechanism differs from that for E2.

LU10: Support and expand sustainable practices on working forested lands

- Like other recommendations, this would be low cost if the layers of strategies are implemented incrementally.
- It's unclear to what extent this would be a public cost.

T1: Align transportation planning across state agencies; streamline and integrate environmental transportation project review

- This is nearly impossible due to political barriers, but the cost would be very low.

T2: Reduce per capita vehicle miles of travel

- The strategies here are many, and the total costs could be expensive to the public sector depending on the specific strategy; but costs to private sector should be less than to public.

T3: Develop and implement sustainable transportation policies that minimize impacts on natural resources

- There would be incremental costs of building new roads with standards for runoff and habitat protection.

E1: Develop coordinated laws, policies, and procedures across state agencies

- Policies and procedures could be developed at relatively low cost to the public sector and little to no cost to the private sector.

E13: Invest in research and policies for "green payment" program

- Setting up policies for green payments is not expensive; implementing green payments can be much more expensive. Effectiveness would be proportional to investment.
- Costs are entirely public.

E17: Promote policies and incentives that encourage carbon-neutral homes, businesses, communities, and other institutions

- There are lots of variables in the equation for the costs of renewable energy and costs are very hard to predict because prices are volatile, so costs could be anywhere from low to high on the public side.
- Policy development would be low cost and have low benefit. Cost and effectiveness would depend on the degree of implementation.
- Evidence suggests energy efficiency investments are low cost and have a short payback time.
- Retrofitting is more expensive, but payback time is still relatively short.
- The renewable energy piece of recommendation could be expensive.
- The economic trade-off in cost between conservation and renewable energy should be considered. (Right now, conservation is much cheaper.)

E2: Invest in farm and forest preservation to prevent fragmentation due to development

- Zoning is a primary strategy and not expensive.
- Cost would be medium in the private sector because not a lot of large parcels are left.
- Cost depends on land demand.

E18: Implement policies and incentives to lower energy use of housing stock

- Points made were similar to those for E17, but focused on new buildings.

E16: Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power and renewable electricity production

- A detailed cost-benefit discussion can be found in Appendix V.

E21: Develop standards and incentives for energy capture from municipal sanitary and solid waste, and minimize landfill options

- Costs would be low for developing standards and policies and higher for implementation.
- A mandate would shift costs to generators (private sector).
- This would be handled through a public entity but adjusted for user volume, which shifts costs to the private sector.
- Minnesota doesn't landfill a lot; total cost would be low because it would entail retrofitting existing landfills.
- This may also include adding mechanisms for energy capture on sewage plants.

E19: Promote policies and strategies to implement smart meter and smart grid technologies

- This recommendation is mostly about research and changing rate structure, which is not expensive.
- The challenging part would be integrating it into homes.

E14: Investigate opportunities to provide tax incentives for individual renewable energy investors

- This includes the incremental costs of distributed rather than centralized energy, and renewable fuels rather than coal.
- On a big scale, it's expensive.
- Estimated cost is at least $20 million per year if voluntary. (The cost in Massachusetts is $68 million per year.)

E20: Develop incentives to encourage widespread adoption of passive solar and shallow geothermal heat pumps in new construction

- Environmental impacts of shallow geothermal are unclear.
- Previous comments about incentive programs apply.

E15: Invest in efforts to develop community-based energy platforms

- The incremental cost would be low because we already pay for current energy.

Appendix VII

Public Outreach Efforts and Summary of Public Outreach Comments

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Public Outreach Efforts

Through the course of this project there were many efforts made to reach multiple public audiences. These efforts included public outreach forums, presentations, brochures, media coverage and the use of websites. Outreach efforts were spread across the state and presentations alone reached an audience of over 2,000.

Date	Audience/Group/Location	Number of People
	Governor's Clean Water Council (bi-monthly updates)	35+
1/07	Project MN 2050/Crookston	27
1/07	Environmental Quality Board	25
2/07	Project MN 2050/Tower	25
2/07	UM Foundation Board of Directors	
2/07	MPCA Sr. Management	25
3/07	Project MN2050/Wadena	25
3/07	Rotary Club Twin Cities	50+
3/07	MN Native Plant Society	150
4/07	Project MN 2050/Spicer	35
4/07	Project MN 2050/Rochester	35

Figure 1.
St. Paul Public Outreach Forum

5/07	Project MN 2050/St Paul	28
9/07	Minnesota Land Trust Conservation Summit	150
10/07	MN Community Foundation Annual Meeting	75+
10/07	MPCA Sr. Management	25
11/07	DNR Sr. Management	30
12/07	UM Regents	35+
12/07	Minnesota Department of Health Sr. Staff	3
12/07	Environmental Quality Board	25
12/07	Minnesota Department of Agriculture Sr. Management team	5
1/08	Project MN 2050/Baxter	25
1/08	Project MN 2050/Stewartville	25
1/08	UM Alumni "Minne-College"/Naples, Florida	200+
1/08	Pheasants Forever Pheasant Fest (display with brochures and mentioned in two workshops)	2000+

2/08	Project MN 2050/Alexandria	30
2/08	MN Senate Committee on Enviro & NR	35
2/08	Embrace Open Space Quarterly Meeting	60
2/08	DNR Ecological Roundtable/St Cloud	300+
2/08	MPCA Stormwater Steering Committee	35
2/08	Metro Watershed Partners	10
3/08	MN Senate Committee on Enviro & NR Finance Division	30
3/08	Environmental Quality Board	30
4/08	MPCA Sr. Management	25
4/08	DNR Sr. Management	30
4/08	Regional Council of Mayors	25
5/08	Hennepin County Environmental Services	35+
5/08	Board of Water and Soil Resources Sr. Staff	2
5/08	Sustainable Land Use Coalition	140
6/08	MDH Sr. Staff	3
6/08	Minnesota Environmental Initiative Policy Forum	150+
6/08	Environmental Quality Board	25
6/08	Metro Chapter MN Association of Watershed Districts	15
6/08	MPCA Stormwater Steering Committee LID Workgroup	15

Public Outreach Forums

Date	Location	Number of People
5/08	Morris	21
5/27	Grand Rapids	28
5/29	St. Paul	50

Media Coverage

Date	Publication
6/07	Press release on Preliminary Plan to Bonestroo media list - coverage by Pioneer Press
Fall 08	Institute on the Environment Magazine
2/08	UM Office of the Vice President for Research Annual Report

Figure 2. Morris energy tour. Photograph by Les Everett

Brochures

Date	Location
3/07	5,000 brochures printed and distributed through out project

Website

Date	Website
2/07	Initial MNConservationPlan.net website established
9/07	Preliminary Plan added to website
5/08	Webcast recorded at St. Paul Outreach Forum and put on website
5/08	Outreach materials and comment forms added to website

Report of the Public Input Forums

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Public Forum Overview

Plan Background

In 2006, the Legislative-Citizen Commission on Minnesota Resources (LCCMR) awarded the Institute on the Environment a contract to produce a Minnesota Statewide Conservation and Preservation Plan (SCPP) with funds from the Minnesota Environment and Natural Resources Trust Fund. The intent was to create a comprehensive inventory and assessment of Minnesota's environment and natural resources that could assist decision-makers with relevant short and long-term planning, policy and investment The SCPP plan will be completed July 2008 and consist of recommendations for addressing critical issues and trends identified as having significant impacts or implications for Minnesota's environment and natural resources.

Public Forum Purpose and Process

The planning effort included a series of statewide forums to engage the public in further developing the SCPP recommendations. Outreach forums were held in several locations to seek public feedback for improving the plan and advising effective implementation:

- Morris, Minnesota May 22, 2008
- Grand Rapids, Minnesota May 27, 2008
- St. Paul, Minnesota May 29, 2008
- Mankato, Minnesota June 5, 2008 *(Note: The Forum was postponed to July 14, 2008 due to a storm)*

Each forum was a facilitated, three-hour workshop with the following objectives:

- *Explain* the purpose of the MN Statewide Conservation and Preservation Plan and its development
- *Overview* the draft recommendations
- *Seek* participants' active evaluation/advice for improving and implementing the recommendations

Public comments were invited and received before and after the outreach forums and are recorded as part of this report.

Public Forum Agenda

Part 1: Overview of the LCCMR and the MN Statewide Conservation and Preservation Plan: 5:00-5:30 PM

- Introduction of forum participants, conveners, presenters and facilitators
- ***Plan description.*** Overview of the LCCMR, its purpose for commissioning the SCPP, guidelines and process for plan development and what the plan is meant to do and not meant to do.
- ***Public forum and input description.*** Explanation of the goals and role of the outreach and processes for providing input at the forum and through written and/or electronic input.

Part 2: Presentation and Discussion of Draft Recommendations: 5:30-7:00 PM

- Presentations by each of three teams representing the main sections of the plan.
- Discussion and observations following each team presentation:
  - What caught your attention or stood out for you?
  - In assessing how the plan benefits the natural resources of Minnesota…
    - … what are key strengths of the plan and/or recommendations?
    - … what are main weaknesses or gaps of the plan and recommendations?
  - Which recommendations are most critical for your region?
- Viewing of maps, displays and identifying critical regional issues on a wall chart.

Part 3: Public Feedback Work Session: 7:00-8:00 PM

- Input and advice from participants:
  - What might be potential challenges to effective implementation?
  - What advice do you have for making the recommendations better?
  - What other feedback or suggestions do you have for the teams or the planning effort?
- Review of next steps and ongoing opportunities for input.

Public Forum Report

Following is a report of the questions, comments and advice that participants shared in the forum discussions and through input forms as well as feedback received by the LCCMR before and after the forums.

Issue-Specific Questions and Comments

This section records the public questions and comments that were made in response to each of the three primary issue sections of the plan. The comments from each forum are listed under the key questions.

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Land and Aquatic Habitat: Issue-Specific Questions and Comments

A. Questions and reactions: What are questions or aspects that caught your attention?

Morris Forum:

- ***Comment:*** Happy to see that shallow lakes are being addressed in the recommendations
- ***Comment:*** Happy to see the recommendations to acquire choice habitat, but what about including a recommendation focused on maintaining good habitat?

- ***Question:*** By acquiring habitat, do you mean under agency programs?
  - ***Team response:*** Would include a variety of mechanisms. Once all the maps have been developed and evaluated, we may be able to identify which mechanisms might be most appropriate in which cases.
- ***Question:*** In referring to drainage laws – do you mean in general or do you mean 103E?
  - ***Team response:*** We think it means in general. What do you think of that?
- ***Comment:*** The drainage law statute works when it is implemented the way it is written. Drainage is essential to the economy out here, so it makes me nervous when we start talking about drainage laws.
  - ***Team response:*** You said "implemented," are there cases when it is not being implemented properly?
  - ***Participant answer:*** Yes. But most farmers are under NRCS and have to follow rules. Some farmers are getting out of the Farm Program and don't have to follow the rules. Farmers join up to pay to maintain drainage in that area. It is true that a huge part of drainage isn't regulated at all. A lot of ditch systems were installed in the early 1900s. Most townships are doing well with enforcement but some counties are not doing a good job of oversight.
- ***Comment:*** We shouldn't lose what is working
- ***Question:*** Was there discussion about revamping the drainage law or was it more multi-faceted?
  - ***Team response:*** This recommendation is about habitat. An analogous recommendation is under land use. We can revisit it there.

Grand Rapids Forum:

- ***Question:*** Some recommendations deal specifically with shallow lakes. What about other lakes, including fragile deep lakes in more northern parts of the state that are a unique and important Minnesota resource?
  - ***Team response:*** There is concern about other water bodies. This particular set of recommendations is habitat-oriented so it is oriented more toward shallow lakes.
- ***Question:*** So are there strategies for deep lakes already developed?
  - ***Team response:*** Deep trout lakes need lots of oxygen and cold water. The nutrient loading and other policies are oriented to deep lakes.
- ***Question:*** How deep is a lake before it is a deep lake?
  - ***Team response:*** Under 15 feet is a shallow lake.

St. Paul Forum:

- ***Question:*** Shorelines are mentioned quite a bit, does this include lakes AND streams?
  - ***Team response:*** Yes, final recommendations will reflect this.
- ***Question:*** In recommendation #7 do you include upland areas and agricultural areas in terms of keeping water on the land?
  - ***Team response:*** Yes. We plan to have good convergence of recommendations from different teams.
- ***Question:*** Recommendation #1 talks about climate warming and how that might affect habitat. Is adaptive management being looked at in addition?
  - ***Team response:*** Because of the constraints of time and resources, they did not feel they had time to do detailed downscaling and analysis to address this specifically. The recommendations are fairly general at this time. We will be going through all recommendations and address places where recommenda-

tions would help with adaptation to climate as well. We will keep bringing up connection to climate change in final recommendations. There may be an addendum on the final report that describes recommendations that have a positive impact on climate change, etc. It is important to draw connections between our recommendations and climate change.

- ***Question:*** I am interested in dams and dam management, where would I find it in recommendations?
  - ***Team response:*** We haven't done a lot with dams specifically, but there probably are elements in recommendations that address this - probably in the "in-water" recommendations, also those recommendations that deal with drainage. The "keeping water on the landscape" recommendation is somewhat related. I encourage you to list it as one of your comments on the recommendations.

B. Strengths: In assessing how the plan/recommendations benefit the MN natural resources, what are key strengths?

Morris Forum:

- ***Comment:*** The drainage recommendations - working with nature rather than against it. Need to identify what you are going to solve regarding wetlands when you speak of drainage
- ***Comment:*** Any of the recommendations based on water resources are going to be very beneficial. We think it is tough to have oil problems, wait until we're out of **water**! It will be the "new gold."
- ***Comment:*** Anything we do to improve MN and MS rivers are critical. The Red and Mississippi Rivers are indicators of problems. I think of the Mississippi - below the junction with the Minnesota - as the "lower digestive tract." What are we doing to it? We are sending channeled water and nutrients to the rivers.
  - ***Team response:*** In our recommendations, how do we say, "keep water on landscape" without making it sound like we will flood all agricultural land? We need to let the soil do its job and replenish groundwater without getting rid of agricultural land and harming economic vitality. For the MN River Basin, a team member is looking for tools/funding to find the places for infiltration and use LIDAR to do fine resolution topography. Also, trying to get funding for that - precision agriculture. Doing precision drainage would also help.

Grand Rapids Forum:

- ***Comment:*** One strength of the plan is that there is a lot of focus on education. Maybe we need more on implementation details even in the summary.
- ***Comment:*** I feel that the focus made on acquisition and protection is not accidental or coincidental. We need to focus funds on acquisition. Acquisition is a big need that can have a huge positive impact.
  - ***Staff response:*** LCCMR invests a lot of funds in that and wanted specific direction on acquisition.

St. Paul Forum:

- No specific comments at this point of the discussion

C. Weaknesses: In assessing how the plan/recommendations benefit MN natural resources, what weaknesses or gaps?

Morris Forum:

- No specific comments at this point of the discussion

Grand Rapids Forum:

- ***Comment:*** Need to include more on assessing and attending to impaired lands. If we can start to do things proactively to prevent impaired waters, we can save lots of money.
- ***Comment:*** In the education recommendations, nothing was called out in the summary about K-12 education.
- ***Input form comment:*** Water surface use is not addressed (motor boating in shallow water, re-suspension of sediment and phosphorus).
- ***Input form comment:*** Money. Acquisition is expensive.

St. Paul Forum:

- ***Work session comment:*** Rivers and stream aren't mentioned.
- ***Work session comment:*** Groundwater is lacking.
- ***Work session comment:*** Invasive species appears to be left out of the plan.

D. Implementation Challenges: What are potential challenges to effective implementation of the recommendations or plan?

Morris Forum:

- ***Comment:*** Modifying drainage laws is a huge, long struggle. There are phenomenal hoops that need to be jumped through to block a drainage ditch. Current law does not support restoration.
- ***Comment:*** The biggest issue is lack of consistency in how the same rules are implemented from one area to the next. Things need to be on a more level playing field.
  - ***Team response:*** Perhaps we need to add to the recommendation that the review of laws should also include a review of drainage law *implementation practices*.
- ***Comment:*** Drainage is impacted greatly by agricultural policy (e.g. barrier related to "protected water").
- ***Comment:*** Ten counties have proposed "no net gain" of public land. Some counties have no net gain laws. A possible solution to this impasse is to put responsibility back in local unit of government's hands. Having the program in DNR's hands is putting a barrier up to acquiring land. Let local unit be the assessing and taxing authority and have the DNR review the process. Let local governments tax the state for land that is set aside.
- ***Comment:*** Conservation Reserve Program is not a good solution. Now, as lands go out of CRP, even though we have spent tons of money on it, we have nothing to show for it. CREP program is better as a long-term solution.
- ***Comment:*** SWCDs don't have taxing authority.

- ***Comment:*** We are not as well prepared as the Western states in terms of water law. We are used to having water in abundance. We haven't evaluated our water resources enough.
- ***Comment:*** On the flip side, we have a law that we can't mine our water.
- *Comment:* Climate change will change precipitation rates, etc. We need to incorporate climate change scenarios into this.
- ***Comment:*** What do we do about water impairments? Once we determine that waters are impaired, what are we doing about it? The program is voluntary.
- ***Comment:*** You are speaking to the choir here tonight. When this goes out and have to deal with landowners and the public – the biggest challenge will be getting people to deal with change.

Grand Rapids Forum:

- No specific comments at this point of the discussion

St. Paul Forum:

- No specific comments at this point of the discussion

E. Improvement Advice: What suggestions and advice or do you have for making the plan/ recommendations better?

Morris Forum:

- No specific comments at this point of the discussion

Grand Rapids Forum:

- ***Comment:*** Recommendation C12 regarding a program to restore natural features of shorelines should acknowledge the programs that already exist and avoid duplication of effort.
  - ***Team response:*** We tried to avoid sanctioning specific programs.
- ***Comment:*** More emphasis on K-12 education would be good.
- ***Input form comment:*** Recommendation A.2.a; Land and aquatic habitat conservation –acquisition. Please define your strategy for implementing long-term habitat acquisition and protection in the final report.
- ***Input form comment:*** Recommendation D regarding outdoor recreation: I believe that the LCCMR's 207 project titled " Regional Park for Minnesota's New Urban Areas" by George Orning already catalogs and positions this recommendation. If possible, have a look at it.

St. Paul Forum:

- No specific comments at this point of the discussion

Energy Production and Use: Issue-Specific Questions and Comments

A. Questions and reactions: What are questions or aspects that caught your attention?

Morris Forum:

- ***Comment:*** You imply in Recommendation 24 that the forest data in the data table is all forest and it is not.
  - ***Team response:*** You are right. It is the "elephant in the room." The key issue is that we need to know more about consequences, what is happening, implications of genetic modification on native species, etc. We need multi-dimensional solutions for what are very complex problems.

Grand Rapids Forum:

- ***Question/comment:*** Is methane being considered as strongly as it should? Landfills produce methane gas. What about a system to recover?
  - ***Team response:*** There is a company that is geared up to capture that gas. But we shouldn't be throwing so much energy away into landfills in the first place. We should change that practice. Europe and Japan are way ahead on this.
- ***Question:*** Did you look at anything to do with transportation system?
  - ***Team response:*** We looked at hybrid cars and battery systems.
- ***Input form comment:*** The fuel biomass crop idea is really interesting. Is it possible to use public lands for biomass production and is that type of crop production beneficial to wildlife.
- ***Input form comment:*** Addressing energy and ethanol stood out for me.

St. Paul Forum:

- ***Question:*** I am curious about the construct of healthy "rural economy" and you have a number of things listed that way. Why are these recommendations set in the frame of "rural" in these recommendations? How will this frame of rural be big enough?
  - ***Team response:*** It should probably be changed to say "state economy." It doesn't just apply to rural. (*Team note:* Change 'rural' in text; some of these recommendations pertain to urban residents).
- ***Question:*** This is a lot of really excellent material. Have any current energy production entities been involved in developing these recommendations, such as Xcel and other big energy producers?
  - ***Team response:*** We have not had any official involvement of large energy producers, but there has been some input regarding bio-fuel production.
- ***Question:*** Did you talk about the challenges provided by the energy grid infrastructure for electricity recommendations? For example, how to get smaller entities onto the grid? (expansion, renewable, etc)
  - ***Team response:*** It was part of team discussion and appears in the detailed recommendations.
- ***Comment:*** Two years ago, local energy production was proposed in Philips neighborhood in Minneapolis. Was unsuccessful. Could it be revived?

B. Strengths: In assessing how the plan/recommendations benefit the MN natural resources, what are key strengths?

Morris Forum:

- ***Comment:*** Thank you to your staff for remarkable work you've done. Geothermal is a good option. There are several new examples of geothermal applications that should be mentioned. There a many local pilots in new energy sources and uses that should be mentioned.
- ***Comment:*** Pleased with consideration of the impact of GMOs vs. locally established species and sustainable, local food systems.

Grand Rapids Forum:

- ***Comment:*** I think energy is great unifier in three theme areas. Fisheries people can't easily manage fishing pressure, even if they can manage other aspects of fisheries.
- ***Input form comment:*** More use of methane gas from landfill areas would produce billions of gallons of fuel.
- ***Input form comment:*** Use of peat for fuel.

St. Paul Forum:

- ***Comment:*** Impressed w/integration of issues in recommendations.
- ***Comment:*** Energy is a new direction for LCCMR.

C. Weaknesses: In assessing how the plan/recommendations benefit MN natural resources, what are weaknesses/gaps?

Morris Forum:

- ***Comment:*** The impact of food production and its relationships and strengthening local sustainable food systems needs stronger emphasis. Are we ready for victory gardens again? Food production and distribution is a major cross-cutting issues across all issue areas.

Grand Rapids Forum:

- ***Question:*** Why don't you have CRP on your list of potential crops? Why couldn't you harvest CRP lands for a fuel crop? I recommend that you include it on list of options for biofuels on that map.
- ***Comment:*** We're going to lose at least last 6 inches of topsoil and aquifers to support SUVs! We take food on long journeys to get it to market. This is not sustainable and a weakness in recommendations. Transportation must be considered more deeply. It is fast becoming a major drain on energy and a huge impact on the resource. Current transport practices, policies, behaviors are based on a "no cost" mentality about natural/energy resources. We can't keep transporting people in huge vehicles alone. We need policy changes!
    - ***Team response:*** Land use recommendations include some of this. Things that have to be done in regions and in nation as a whole. We've looked at the pre-ignition catalytic converter, using fuel burned by catalytic converter in cars, etc. We need to look at unique, new ideas (e.g. Re-tooling corn-based alcohol plants to work sustainably).

- ***Comment:*** Was part of the strategy in the plan to use public land to grow biomass?
  - ***Team response:*** We have to make sure that we are using all land appropriately to meet energy goals and conservation goals while letting rural families make a living.
  - ***Team response:*** It is beneficial to rural communities to use biomass locally vs. transporting it long distances. Communities should be paying close attention/finding ways to use energy locally. The technologies are there.
- ***Input form comment:*** In the energy recommendations, need greater emphasis on local energy production down to the individual level – incentives, research, programs to implement; need to foster a different paradigm to be successful in changing this through more individual accountability.

St. Paul Forum:

- No specific comments at this point of the discussion

D. Implementation Challenges: What are potential challenges to effective implementation of the recommendations or plan?

Morris Forum:

- No specific comments at this point of the discussion

Grand Rapids Forum:

- No specific comments at this point of the discussion

St. Paul Forum:

- No specific comments at this point of the discussion

E. Improvement Advice: What suggestions and advice or do you have for making the plan/ recommendations better?

Morris Forum:

- ***Comment:*** Take advantage of the increased energy prices to increase awareness and action on resources issues – peak oil, peak food.
  - ***Team response:*** Peak-food and peak-oil are closely tied together. Producing ethanol is essentially mining water and shipping it out of state.

Grand Rapids Forum:

- ***Comment:*** With respect to the energy gap, it seems like studies are showing that corn ethanol isn't working. We need to deal with it directly.
  - *Team response:* The existing study looking at old technology vs. new. There are things that can be done to make plants more energy and environmentally efficient in terms of water and energy. On the flip side, there are opportunities around putting incentives into cellulose and other opportunities.

- ***Comment:*** Ten years ago we were talking about corn ethanol as great savior, how do we know that in ten years we won't say cellulose was a big mistake? Need to get away from corn-based ethanol and alcohol as the current "savior" of the energy problem OR replacing it with another simple solution. We need to take a more holistic, longer-rage approach vs. relying on silver bullets
- ***Comment:*** The balancing act among food, feed, fiber, fuel is critical. Keen awareness is needed about resources that will be needed to produce this stuff. Bureau of Reclamation did a resource study and determined there wasn't enough water for new ethanol plants OR new population in the Red River Valley. In keeping the Four F's in balance we need to stay focused on the production of raw materials required to supply all the demands. Have to keep an eye on technology. Some things may happen faster than we think. Look at transportation as a more holistic picture rather than just looking for a substitute for gasoline.
  - ***Team response:*** Food, feed, fuel, fiber – there are truly many conflicting resource issues in that set of four. It's a balancing act to say the least. There needs to be lots of discussion about these balancing acts.
- ***Comment:*** A potential weakness with the recommendations is that they focus on improvements on mass production and energy, but don't say much about how we can scale down (reduce use). We need a reality check on consumption vs. just production.
- ***Comment:*** But I'm even looking at an individual house. LCCMR could provide models of how to be a sustainable household. Recommendations should be strengthened with regard to this. I would like the individual scale to be called out a little bit higher in the recommendations. There are lots of system level but not much individual ones.
  - ***Staff response:*** Commission could shape general RFP and would invite a variety of proposals.

St. Paul Forum:

- ***Comment:*** Role of local governments and non-profits is important.
- ***Question:*** Having heard about rationing of WWII and gas prices of the 70s, I would like to see something more specific about conserving. Is there anything more tangible/immediate recommendations in the energy plan (e.g. reducing speed limits)? Is there anything "newsworthy" that people will be able to see quick results from?
  - ***Team response:*** Good point, we will note this suggestion.
- ***Work session comment:*** Recommendations #27 and #40 need to focus on perennial-based livestock production.

Land Use Practices: Issue-Specific Questions and Comments

A. Questions and reactions: What are questions or aspects that caught your attention?

Morris Forum:

- ***Comment:*** A lot of the land in our area is all rented. Does that have an impact on buffer strips? Landowners don't live in area and don't care.
  - ***Team response:*** Data on farmland rental was hard to get.
- ***Comment:*** One idea is to contact the landowners and try to get them to participate in the buffer strip program.

Grand Rapids Forum:

- ***Question:*** Will you be looking at other reports and efforts like this before recommendations come out – like the *Forests for the Future*?
  - ***Staff response:*** *Forests for the Future* has influenced our forestry recommendations. We have tried to bring a lot of that in already.
- ***Question:*** More effective and coordinated land planning is a good recommendation, but who is going to coordinate that? Shouldn't the recommendations identify specific agencies and organizations for coordination responsibilities?
  - ***Team response:*** We purposely didn't say any organization. But there are several potential groups.
- ***Comment:*** What about re-building inner city instead of people moving out? What is done about people moving out of cities by incorporating urban re-development to attract people to stay in cities including more compact development, building "complete," multi-use roads etc. This has major impact on the environment related to reducing driving miles, impervious surfaces, etc.
  - ***Team response:*** There is one re-development oriented recommendation, but maybe we need to add recommendations about adopting some of these conservation and land use practices to urban redevelopment. The opportunity in the market right now is to institutionalize conservation into redevelopment.
- ***Comment:*** I need a point of clarification on Recommendation 56. This is not talking just about large projects is it?
  - ***Team response:*** No, it could be small blocks in large blocks or how blocks relate to one another.
- ***Comments:*** Regarding recommendation #54: The DNR manages over 5 million acres of land. The plan calls for incentives for private forest-land management, what are incentives for agencies that manage public lands? How do you apply incentives to the state-managed land?
  - ***Team response:*** Incentives that we've described are oriented toward producers. The mechanisms for influencing practices could be incentives or a policy. Policy might be more oriented toward agencies and continue to be the guiding tool for managing public forest land management. Forest certification applies to both.
- ***Input form comment:*** I liked recommendation 46B bring natural resources to the table.
- ***Input form comment:*** Forest land practices stood out for me

- ***Input form comment:*** Recommendation 25-26: I'm very concerned about social and environmental justice issues here. When we start talking about seed stocks and profit models for biofuels production – you are going to seriously grapple with patent issues and indigenous rights, etc.
- ***Comment:*** I'd like to see comprehensive risk assessment protocol development here with genetic contamination and biofuels – buffer width is very myopic in terms of genetic pollution issues.

St. Paul Forum:

- ***Question:*** In recommendations #16 and 40 related to biomass on private lands: We are losing CRP acres and have a gap between ethanol and cellulosic sources. How do we take the risk out of farmers having those acres lying fallow on land when there isn't a market yet?
- ***Question:*** What about animal livestock being raised on perennials? Did the team consider that?
  - ***Team response:*** The team has to identify a need and come up with an instrument to address that need.

B. Strengths: In assessing how the plan/recommendations benefit the MN natural resources, what are key strengths?

Morris Forum:

- ***Comment:*** Great effort to put this all together, but the implementation will happen at the tractor and the plow level. Need the money to get it done. Encourage everyone to support the Outdoors Amendment!

Grand Rapids Forum:

- ***Input form comment:*** Use of all wood products. (GR Input Form 3).

St. Paul Forum:

- No specific comments at this point of the discussion

C. Weaknesses: In assessing how the plan/recommendations benefit MN natural resources, what are weaknesses/gaps?

Morris Forum:

- No specific comments at this point of the discussion

Grand Rapids Forum:

- ***Comment:*** Recommendation 46 and items beneath that regarding urban land use recommendations: This is a weakness of plan – going into that level of detail about conservation planning, but not going into level of detail in the agricultural part of plan. Recommendation 44 could take a look at watershed planning efforts in Red River Valley as a model from agricultural land use perspective. Local planning efforts are critical to accomplishing these goals. State agencies can't do it on their own.
- ***Comment:*** Aquatic invasives didn't really show up in the plan. Lots of communities are fighting this issue. Set up a taxing body at local lake association level to finance cleaning up public waters. Lakes with aquatic invasives ought to be classified as impaired.

  - ***Team response:*** Limited resources caused the project team to not deal with invasives. However, we do agree that this is important.
- ***Comment:*** In the area of TMDLs and impaired waters, there is this big category of waters that are not impaired. I would like to see some assessment of unimpaired areas with respect to their sensitivity to impairment and have some protection measures for those types of waters.
- ***Input form comment:*** Recommendation 45: Remove landfill from sand and gravel areas (more education on all).

St. Paul Forum:

- ***Work session comment:*** The connection to food (livestock) isn't there, or difficult to see; there isn't an emphasis on local food, which will be necessary to conservation in the future.
- ***Work session comment:*** Soil is lacking.

D. Implementation Challenges: What are potential challenges to effective implementation of the recommendations or plan?

Morris Forum:

- ***Comment:*** Counties are dealing with a double-edge sword. Taxation and county budget are huge issue. Counties tend to follow the money. They believe they need development to increase assessment rates rather than conservation and setting land aside. They don't know about all these studies and plans that might help them decide for conservation.
  - ***Team response:*** Jean Coleman does a lot of work with rural counties and tries to get local governments to look at both sides of the balance sheet. What about infrastructure costs of new developments? Let natural resources be the driving force for development.
- ***Comment:*** Zoning has huge effects in influencing land and forest protection. As with TMDLs in urban areas, cities and smaller communities have a lot of regulatory controls available to them that they don't use. They need to be more use of them. Local governments have zoning rights and therefore control over fragmentation but cities are not using the regulatory authority they have.
  - Its is a political "hot potato" to take land out of production
  - Local leadership makes the laws but they also need to live by them
  - Local politicians need to know about negative financial aspects of development, such as infrastructure, public services, etc., which cause development to not necessarily make money for local governments.
- ***Comment:*** Forest fragmentation – State can't afford to buy the lands, but local government has the ability to zone the land properly so they wouldn't lose the timber rights and only allow parcels up to 320 acres or so, they could control the fragmentation.
- ***Comment:*** More land is going out of production.
- ***Comment:*** Need to take responsibility for our "past sins:" Many of the current practices, patterns and issues we have in MN are things that government agencies and the University have promoted in the past. How do we deal with the fact that land owners do what we told them to do in the past when we were wrong? How do you change that?
- ***Comment:*** Study in the metro area showed that costs to local government of developing an area is more than the tax money coming in.

- ***Comment:*** Remember that engineered solutions don't deal with waterfowl or other habitat issues. We might just have to accept that we have to give up some farmland.
- ***Comment:*** Enforcement of buffer strips is a problem. The federal farm bill policy encourages people to farm right up to the edge. Farmers will tend not to implement BMPs voluntarily. It only works when you pay people to comply with the laws. If we lose CRP as a program, if farm bill goes away, we need more incentives, but how do we get those in place without CRP and farm bill? How does this impact rented farmland? How do we do conservations without CRP?
- ***Comment:*** People think doing a TMDL study means water is cleaned and no longer a problem, when in reality it can take years and years for water to become clean as the result of BMPs from a TMDL.
- ***Comment:*** Money directs a lot of things. The almighty dollar tends to drive practices - this is both a tool and a challenge. When we operate under "no new taxes" policies, society isn't willing to support these things. How do we address this factor of the economic side?

Grand Rapids Forum:

- ***Input form comment:*** Recommendation A:42: Round up ready seeds – reduces use of grasses in conservation practices.

St. Paul Forum:

- No specific comments at this point of the discussion

E. Improvement Advice: What suggestions and advice or do you have for making the plan/ recommendations better?

Morris Forum:

- ***Comment:*** Solutions might include working to provide other economic benefits for farmland owners.
- ***Comment:*** Also need to be considering new potential markets such as seed perennial crops in places where you can flood - crop it when it is not needed for wildlife support and then re-flood it the next year. Need to look for new ways to do business. Make a note that not everything being farmed is farmland (we farm unsuitable land).
- ***Comment:*** Recommendations should include helping local governments be more aware of both sides of the balance sheet.

Grand Rapids Forum:

- ***Comment:*** One suggestion for recommendations is the idea that local governments have incentives to plan for conservation rather than development. It might be useful for local government to have some protection when they make decisions that may be controversial or are not popular with everyone, especially the development community.
- ***Comment:*** On recommendation 52 regarding reduced per capita vehicle miles. Revitalizing downtowns is a way to reduce vehicle miles.
  - ***Team response:*** We need to more explicitly express "compact development." Commute times have increased.
- ***Comment:*** Promote complete roads. Bike trails and walking paths should be associated with all roads.

  - ***Team response:*** This does show up in complete recommendation. There are permeable highways that could be put in, but cost more. Federal dollars are available to do better road design for wildlife, etc. We don't use those dollars very well.
- ***Comment:*** Increase emphasis on promoting local food. This encourages smaller farms most focused on conservation and emphasizes decreasing the miles that food travels
- ***Comment:*** Focus some of land use planning on watersheds or ecological subsections rather than political boundaries. Base planning more on ecological boundaries.
- ***Comment:*** The deep lakes are probably most amazing natural resources in Minnesota that need to be emphasized more. This plan doesn't include enough about northeastern and north-central Minnesota and doesn't focus on protection enough. The current plan could almost be for any state.
- ***Comment:*** I would like to see more about conservation/recreation easements (Forest Legacy Program). It pays to keep recreation areas open while protecting working forests and timber production.
- ***Input form comment:*** Recommendation B.45: MS 1030 (and I think 1038 also) allows for the development of a water management district that could get at implementing this.
- ***Input form comment:*** Recommendation 46.E; Land use practices: Establish a statewide grant program etc. – the Local Initiative Grant Program, including the Regional Park Grant Program is already a statewide program. It is chronically under-funded. You could really help by calling this program out.
- ***Input form comment:*** Within our forestry land practices, recommendations are great. I would just like to remind the group the significance and importance are some very traditional forestry uses that should not be overlooked. Examples would include balsam boughs, maple syrup, etc., that are called non-timber forest products. There are many people from the bottom rung of the economic ladder. (Fact: Balsam bough wreaths contribute $21 million each year to the state's economy). We need to remember our forests can be managed for many products. And, that our forests are our 'community forests!" – especially when we need to diversity and help people find a niche in a global market.

St. Paul Forum:

- ***Comment:*** The stream bank erosion under agricultural recommendations – reduction in peak flows – should be an agriculture and urban recommendation. You could copy it directly to the urban and add reduction in bankfull flows.
- ***Comment:*** Under the transportation section, first time nonpoint source pollution (NPS) has been mentioned. Specific reduction in NPS should be mentioned in several sections.
- ***Work session comment:*** Recommendations #27 and #40 need to focus on perennial-based livestock production.

General Feedback for the Plan

This section records the public questions and comments about the plan as a whole. The comments from each forum are listed under the key questions.

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B. Strengths in benefitting the natural resource.....318
C. Weaknesses in benefitting the natural resource.....319
D. Challenges to implementation..... 320
E. Improvement advice.....322

A. Questions and reactions: What are questions or aspects that caught your attention?

Morris Forum:

- No specific comments at this point of the discussion

Grand Rapids Forum:

- ***Comment:*** I need a point of clarity. Is this plan destined for use by LCCMR to guide how it invests in funding?
  - ***Staff response:*** This is an LCCMR-funded project. The intention is that it will be plan for the state, but it is up to agencies and local governments in terms of what they want to do. There is not a real sharp line. Others will hopefully embrace at least some of the recommendations, as will LCCMR in their funding directions.
- ***Question:*** Will you be looking at other reports and efforts like this before recommendations come out – like the *Forests for the Future*?
  - ***Staff response:*** *Forests for the Future* has influenced our forestry recommendations. We have tried to bring a lot of that in already.
- ***Question:*** The consideration of multiple landscapes and areas across the state is a strength. I am curious about how the plan developers rank different parts of the state with very different levels of impact. How do you rank different parts of state in terms of funding priorities when comparing severely impacted to less impacted but threatened landscapes?
  - ***Staff response:*** We segmented state into eco-regions and looked at analyses by ecological subsection.
  - ***Staff response:*** The LCCMR is required to have a strategic plan to be revisited every 6 years. LCCMR tries to get geographic representation in each funding round.
- ***Comment:*** There are lots of competing land use priorities including the need to produce crops for fuel, wetland restoration, agricultural BMP practices, habitat, production, etc., but has there been any discussion on identifying priority areas? Will there be conflicts among these priorities? The Red River Valley has identified priority areas for agricultural conservation, etc. in advance. Have used a lot of tools to do

that such as thunderstorm maps, fisheries data, etc.. I suggest adding a recommendation to establish priority areas for certain activities in advance such as providing tools for local implementation.

- ***Team response:*** We have done pieces of that but haven't integrated or focused it to the level you are suggesting.

St. Paul Forum:

- ***Question:*** It is an ambitious plan – who's plan is it? I hope that it will filter up to policy level and influence the legislative agenda and action. Will it really be implemented?
  - ***Staff response:*** It is designed to serve as a guide at many different levels.

B. Strengths: In assessing how the plan/recommendations benefit the MN natural resources, what are key strengths?

Morris Forum:

- No specific comments at this point of the discussion

Grand Rapids Forum:

- ***Comment:*** Good presentations! Assessment work that has been done would be good to get out to locals for water conservation planning and other local planning efforts. Provide local governments with more support and tools to implement conservation and preservation priorities.
- ***Input form comment:*** Focus on behavioral change and the barriers to making/realizing those changes. Education and outreach is only as good as the intention behind it – keep the focus on removing barriers to sustainable behavior change. Great start here!
- ***Input form comment:*** Incentive-driven should be an easy (ier) way to get buy-in vs. the stick" approach.

St. Paul Forum:

Work session comments:

- ***Theme:*** Systemic approach
  - A systems perspective
  - Addressing the large systemic issues within a longer time frame
  - I like its comprehensive nature in addressing all the issues vs. the "issue of the moment" and the possibility that it will provide a continuity of focus as LCCMR members change overtime.
- ***Theme:*** Broad and bold goals and recommendations
  - Establishes broad recommendations
  - People can "find themselves" in the recommendations
  - Contains aggressive, bold ideas
  - Clearly stated endpoints
- ***Theme:*** Diversity of natural resource issues

- It is good to have the diversity of natural resource aspects and threats identified and presented in one place and in one reference.
- The "web" framing of the plan to demonstrate interconnectivity of issues and the interdisciplinary reality of issues. The challenge is re-integrating the recommendations.

- ***Theme:*** Nothing blatantly wrong
  - It passes the "sniff test" (it doesn't have anything blatantly wrong with it).

C. Weaknesses: In assessing how the plan/recommendations benefit MN natural resources, what are weaknesses/gaps?

Morris Forum:

- No specific comments at this point of the discussion

Grand Rapids Forum:

- ***Input form comment:*** There are a lot of recommendations that target assessment and mapping, but I feel like there wasn't a lot of detail on the next phase: action toward what end are we collecting data? Is there a way to put some target recommendations?
- ***Input form comment:*** K-12 education. We need to make the investment no in teaching the next generation how to live more lightly in Minnesota.
- ***Input form comment:*** Highlight need to collaborate efforts on all fronts – 87 counties, SWCBs, BOWSR, MPCA, DNR, EPA, USDA…
- ***Input form comment:*** Getting all landowners on board and working together

St. Paul Forum:

Work session comments:

- ***Theme:*** Inter-relationships between elements is missing
  - The inter-relationships among elements are lacking
  - Reintegrating the team's recommendations in the final phase of the planning
  - The are similar strategies across several recommendations (e.g. supporting local planning). What is the strategy for linking the cross-cutting recommendations?
- ***Theme:*** Unclear implementation steps and strategies
  - What is missing is the "how to" accomplish these recommendations.
  - What theory of change are we acting under? The plan doesn't show how these different things will actually be implemented.
  - The plan focuses on the way things are now. The plan needs bolder, more aggressive ways to do these recommendations, instead of simply what needs to be done.
  - The plan needs concrete suggestions.
  - The plan has clearly stated endpoints but needs to identify...
    - ...the key interim steps to get from here to the endpoints and...targeting the pressure point areas that are time-sensitive issues that would be addressed substantively.

    - NOW vs. later. This might form basis for priorities.
- ***Theme:*** Minimal role and understanding by the public
    - Public participation is very limited in this process, i.e. they have no idea this process is going on.
    - The plan needs better public education recommendations
- ***Theme:*** Prioritization needed
    - How is LCCMR going to prioritize? How will the priorities be narrowed down?
        - There is a danger of spreading LCCMRs attention and interests too thin.
        - Distributing limited funds over too many targets
- ***Theme:*** Need a way to measure the progress of the plan
    - There is no obvious "reality check"
    - How will the progress or success of plan implementation be measured and monitored?
        - What changes would we be monitoring and for what purpose?
        - What indicators and measures are we committing to?
        - How will we utilize and practice adaptive management?
- ***Theme:*** Groundwater is not well represented
    - Groundwater is not well represented in recommendations, in particular, groundwater contamination from feedlots, sewage systems, etc. as delayed feedback from land use practices. Was the MPCA plan addressing groundwater degradation used in developing this plan?
- ***Theme:*** Missing a focus on historic/cultural resources
    - There is no mention of historic and cultural resources and the influence of land use, energy use and economic impacts on those resources. Include standards for aesthetic values and other new and existing values for conservation and preservation.

D. Implementation Challenges: What are potential challenges to effective implementation of the recommendations or plan?

Morris Forum:

- ***Comment:*** Challenge will be money. The almighty challenge is the almighty dollar
- ***Comment:*** Coordinating the efforts of all public/government agencies will be a challenge. How do we coordinate and get willingness? We need to figure out a much better way of coordinating the efforts of all public agencies.
- ***Comment:*** Lack of local technical support is a problem: The Extension Service lacks funds to provide the needed level of technical support. State agencies are too St. Paul-centric.
    - ***Team response:*** Can private sector crop professionals etc. be brought in to help with technical assistance if the Extension Service put together workshops and training for them?
- ***Comment:*** With energy becoming more expensive, I don't really know how other things will change - nitrogen for fertilizer, distance we transport materials, etc. How will changing economy change things?

Grand Rapids Forum:

- ***Input form comment:*** I think agency momentum will be a real barrier to implementation. The cross agency coordination is a real challenge as is the funding mechanisms that support them in their current trajectories. I think agency momentum will be a real barrier to implementation. The cross agency coordination is a real challenge as is the funding mechanism that support them in their current trajectories.

St. Paul Forum:

Work session comments:

- ***Theme:*** Minimal public role and understanding
  - Nobody reads the whole plan
- ***Theme:*** Actions exceed funding capacity to fund them. Prioritization to guide implementation/ investment.
  - How do you identify the most important aspects that much be preserved, such as water or land?
  - The scope is ambitious scope. You could argue that all recommendations are immediate. Narrowing down the scope would enhance chances for implementation.
  - Need to prioritize investments and align with other plans and efforts! I counted the number of times the word "invest" and "research: were mentioned – 30 times for invest and 15 for research! Move forward on dimensions that are being addressed by other plans and efforts.
- ***Theme:*** Need for more overall investment of resources
  - Where you can, quantify the investment that is required to implement needed conservation and preservation priorities. Adding up the costs of these recommendations would show the need for this fall's ballot initiative to generate more money. Use this opportunity to communicate the major gap in funds needed to have substantive impact on the resources. Make a compelling case for the need to increase the total amount of money available to make a difference.
- ***Theme:*** Assuring leadership, coordination and mindset for implementation
  - The plan requires active management.
  - "Actors" for recommendations are not identified. It may be difficult to get things changed if the way to get things changed isn't also recommended.
  - Political leadership and capacity-building is needed (e.g. from the Legislature and other state agencies); need capacity building. Implementation could be a challenge if agencies stay within their "oh we don't do that" comfort zones and are not able to work across their traditional boxes and silos.
  - Making necessary mid-course corrections if these conditions start to change.
  - These recommendations only work if there is no risk to land owners.
  - A large paradigm shift will be necessary for the plan to work.
- ***Theme:*** State boundaries constrain eco-space strategies
  - Organizing recommendations within state boundaries is a limiting factor to truly addressing eco-spaces and the issue within them.

E. Improvement Advice: What suggestions and advice or do you have for making the plan/ recommendations better?

Morris Forum:

- ***Comment:*** Education is critical; Education and increased recreation will help people value the changes being made.
- ***Comment:*** When carbon gets monetized, all the rules will change.
- ***Comment:*** Provide generous county-based local technical assistance and demonstration projects! There is a good example of demonstration project showing how you can make money from grass and water. Advertise existing ones and fund new ones for landowners seeking change. Keep the quality aspect in mind in all production (e.g. local examples); need to think of new ways to do it (i.e. cattails for wetlands benefits and biofuels).
- ***Comment:*** Incorporate real scenarios about how we will become if we implement various strategies.
- ***Comment:*** Track change over time as these recommendations are put into place. Incorporate "evaluation" into implementation.
    - ***Team reflection (post-session):*** Fear that recommendation for coordination looks like it is top down and will be resisted for that reason.

Grand Rapids Forum:

- ***Comment:*** Need more application details in the recommendations.
- ***Comment:*** Provide local governments with more support and tools to implement conservation and preservation priorities and efforts such as status information on natural resources assessment, analysis and projections.
- ***Input form comment:*** Start with small pieces and build on successes. Are priorities built into recommendations in each area? If you could only do one listed thing, which would it be? Start there.
- ***Input form comment:*** The devil is in the details, yet they are not presented here. Many plans lack the real "how to's" to implement the plan. Please make this easy to use with details.
- ***Input form comment:*** In the last legislative session, capital bonding projects were selected one by one in the legislation – no funds were provided for post-session open project selection. This is really problematic for communities who do not participate in session politics for whatever reason.
- ***Input form comment:*** Include key assumptions in the plan.

St. Paul Forum:

Work session comments:

- ***Theme:*** Include mechanisms to coordinate, steer and incent implementation
    - A really strong recommendation regarding planning would be helpful.
    - Needs a strong follow-up and support piece to make sure the plan does what it's supposed to.
    - Need to have a champion for the plan - someone people can see as a very strong supporter.
    - Hard regulations or enforceable standards are needed to drive the plan
    - Need "carrots not sticks" to inspire implementation

  - Make "doing the right thing" the most cost effective
  - Need a "go to " resource to get assistance to local governments and communities who want to implement directions and tackle problems at various levels.
- ***Theme:*** Incorporate a process for monitoring progress
  - Include a recommendation to monitor how things are going
- ***Theme:*** Add tools and models to communicate threats and opportunities
  - Include models of ecosystems to envision the future
  - Conduct economic modeling to show what will happen if we do nothing - start with the groundwater scenario.
- ***Theme:*** Use the plan and project educate the public about real needs for action and investment
  - The plan is a good opportunity to make the state's gaps visible.
  - Make a more readable version of the plan for non-professionals.
  - Take the plan to Minnesotans. Get feedback about how far they are willing to go to fix MN's natural environment.
  - Present the environment as commodity and emphasize tangible benefits using citizen stories, quotes and voices.
- ***Theme:*** Lead the state's long-term resource conservation imperatives
  - LCCMR can do what agencies and the legislatures can't do - put money towards long-term projects, efforts and initiatives. Take advantage of this. LCCMR has the opportunity to use its unique, overarching role to jump in, innovate and take the lead in advancing statewide resources conservation and preservation.
- ***Theme:*** Other additions and considerations
  - Consider what negatives might result from this plan (think E85)
  - Needs to include eco-industrial complexes
  - Needs an "ethic of stewardship"
- ***Comment:*** Make it clear which audience this plan is written for

Recommendations Most Critical in each Region

Participants at each forum were asked to identify the recommendations most critical to their region by placing seven dots on a wall chart showing all the recommendations.

Land and Aquatic Habitat Recommendations

MN SCPP Recommendation	Morris Forum	Grand Rapids Forum	St. Paul Forum
A Maintain or restore critical habitat	0	1	0
A1 Research on fish, wildlife, bio- diversity, stressors etc.	0	5	1
A2 Acquisition – protection of land habitats	3	1	6
B Maintain/restore critical habitat vulnerability	0	4	1
B3 Research near-shore habitat vulnerability	1	4	0
B4 Acquisition of critical shore land habitat	0	2	4
B5 Acquisition to protect shallow lake shorelines	2	0	6
B6 Consolidate, adapt, and develop educational materials on watershed principles	0	6	1
B7 Keep water on the landscape	0	0	13
B8 Restore and rehabilitate shallow lakes	4	0	3
B9 Restore and rehabilitate wetlands	6	0	7
C Maintain or restore critical in-water habitat	0	1	1
C10 Research and assess groundwater/surface water information and connections	1	0	6
C11 Policy to remove barriers/facilitate wetland restoration	5	0	4
C12 Restore and rehabilitate shallow lake habitats in priority watershed and restore natural features of lake shores	3	1	2
C13 Build capacity of resource managers to understand and manage water resources factors	0	1	0
D Outdoor recreation recommendations	0	1	3
D14 Improve connectivity of/access to outdoor recreation areas	2	18	11

Energy Production and Use Recommendations

MN SCPP	Morris Forum	Grand Rapids Forum	St. Paul Forum
A Promote alternative energy production strategies	0	0	0
A15 Invest in research/demonstration projects on a landscape scale	2	1	5
A16 Develop policies/incentives to grow perennial crops for bio-fuels	1	1	4
A17 Develop coordinated laws, policies, procedures for government entities	0	0	0
A18 Invest in data collection to support assessment process	0	0	0
A19 Invest in research for sustainable corn stover removal rates/establish incentives for BMP's	2	0	0
A20 Invest in research to review MN thermal flow	1	1	0
A21 Invest in applied research to reduce energy and water consumption and emissions in ethanol plants	0	0	1
A22 Invest in research to determine the life cycle impacts of renewable energy production systems	0	0	1
A23 Invest in research and demonstration projects to develop, and incentives to promote, combined wind power/biomass, wind power/natural gas, and biomass/coal co-firing electricity projects	3	3	0
A24 Invest in farm and forest preservation efforts to prevent fragmentation due to development guided by productivity and environmental vulnerability research	0	5	2
A25 Invest in research and enact policies to protect existing native prairies from genetic contamination by buffering them with neighboring plantings of perennial energy crops	0	0	1
A26 Invest in efforts to develop sufficient seed or seedling stocks for large-scale plantings of native prairie grasses/other perennial crops	0	0	0
A. Promote a healthy rural economy	0	0	1
B27 Invest in research and policies regarding "green payments"	2	0	2
B28 Investigate opportunities to provide tax incentives for renewable energy investors	2	0	2
B29 Provide incentives and invest in research to determine the costs and opportunities of electricity production for transportation	0	0	2

B30 Invest in efforts to develop/research to support, community-based, locally owned energy platforms for producing electricity, transportation fuels, fertilizer, etc	2	1	2
C Promote energy conservation efforts	0	0	7
C31 Promote policies and incentives that encourage carbon-neutral businesses, homes, communities and other institutions	0	4	3
C32 Invest in public education focusing on benefits and strategies for energy conservation	2	1	4
C33 Develop standards and incentives for energy capture from municipal sanitary and solid waste, and minimize landfill options	0	2	1
C34 Implement policies and incentives to lower energy use of housing stock while monitoring the performance of improvements	0	0	2
C35 Promote policies and strategies to implement smart meter and smart grid technologies emissions	0	1	1
C36 Develop incentives to encourage the widespread adoption of passive solar and shallow geothermal heat pump systems in new residential and commercial building construction	0	6	1
D Promote reductions in mercury deposition	0	0	6
D37 Develop mercury reduction strategies and assessment tools for the state to meet federal Clean Air and Clean Water Act standards	0	1	1
D38 Develop a strong public education and outreach focusing on mercury health risks and techniques for reducing mercury loads	0	0	1
D39 Provide adequate resources to continue to enforce/support existing mercury regulations and programs for reduced mercury	0	0	0

Land Use Practices Recommendations

MN SCPP Recommendations	Morris Forum	Grand Rapids Forum	St. Paul Forum
A. Agricultural land use practice recommendations	0	0	2
A40 As much as possible, transition renewable fuel feed stocks to perennial crops.	0	0	6
A40 a) Research to assist producers select site-specific perennial species for cellulosic feedstocks.	4	0	2
A40 b)Policy to incentivize a shift to perennial plant feedstock sources	4	0	2
A41 Reduce streambank erosion through reductions in peak flows	0	5	0
A41 a) Research quantitative relationship among precipitation, artificial drainage systems, stream hydrology trends.	5	0	1
A41 b) Policy for peak flow reductions and mitigation of peak flows from artificial drainage systems.	3	0	2
A41 c) Protection investment to strategically target programs for reduction of peak flows	1	0	1
A42. Reduce upland and gully erosion through soil conservation practices	2	0	0
A42 a) Policy to phase in outcome-driven, practice-flexible soil and water conservation plans for all farms	0	0	6
A42 b) Protection investment in education/incentive programs for land owners in critical sediment source areas	0	0	0
A43 Improve design/targeting of conservation through improved/timely data collection & distribution	0	2	0
A44 Increase protection of important agricultural lands in local land use planning	0	5	3
A44 a) Policy to encourage land use suitability modeling and mapping and programs	0	0	0
A44 b) Investment in technical assistance and outreach materials and tools for ongoing support to local governments	4	0	0
B Urban land use practice recommendations	0	0	6
B45 Ensure protection of water resources in urban areas by valuating/improving current programs	0	1	3
B45 a) Establish a credit system for storm water and Low-Impact Development (LID) BMPs	0	1	1
B45 b) Simplify modeling for Total Maximum Daily Load (TMDL) compliance	0	0	0

B45 c) Monitor TMDL BMP implementation	0	0	1
B46 Establish a more effective and coordinated land planning process	0	9	4
B46 a) Conservation-based planning	0	0	5
B46 b) Land use, development and investment guide	0	2	5
B46 c) Invest in a pilot planning project along a MN corridor that focuses on integrating "gray infrastructure" with existing "green infrastructure"	0	1	2
B47 Establish funding sources and tools for community conservation-based comprehensive plans	0	2	0
B47 a) Fund the creation of a user-friendly carbon calculator for communities	0	0	5
B47 b) Invest in a Conservation Catalyst Fund	0	0	0
B47 c) Provide communities with the tools necessary for developing and implementing conservation-based comprehensive plans	0	1	1
B47 d) Provide communities with support and technical assistance through a Minnesota Community Enterprise Partnership	0	0	3
B47 e) Establish a statewide grant program to build capacity to conserve water quality, natural lands and parks	0	2	6
B47 f) Support state agencies to provide conservation and development assistance to growth communities	0	0	1
B48 Invest in generating base data and information necessary to support decisions or tools	0	0	2
B48 a) Update land cover databases and remote sensing capabilities	0	1	0
B48 b) Develop data in areas vulnerable to development or conversion of land cover	0	0	1
B48c) Develop statewide Light Detection and Ranging (LiDAR) database	0	0	2
C. Transportation practice recommendations	0	0	0
C49 Integrate streamlined environmental transportation project review	0	0	2
C50 Reduce per capita vehicle miles of travel	0	0	0
C51 Align transportation planning across agencies and across projects	1	2	5
C52. Develop research programs on habitat fragmentation	0	0	2
C53 Reduce nonpoint source pollution to surface and ground waters	0	1	0
D. Forestry land practice recommendations	0	2	1

D54 Provide incentives for sustainable forestry	0	1	1
D55 Assess tools for forest land protection	0	1	1
D56 Protect large blocks of forest land	0	2	1
D57 Establish state leadership on natural resources and land use	0	6	0
D58 Connect best management practices to biomass harvesting	0	0	1
D59 Assess and improve sustainable forestry best management practices	0	1	0
D60 Fulfill the Scientific and Natural Areas (SNAs) mandate	0	1	4
D61 Expand the supply of, and demand for, sustainably harvested wood	0	2	1
D62 Promote collective/cooperative management of forestlands at a landscape level	0	2	0
D63 Increase our understanding of invasive species	0	2	1
D64 Create deer exclusion pilot projects in every ecological subsection	0	1	0
D65 Support the use of fire to increase forest health and biodiversity	0	6	0

Public Comments

The following compiled comments were submitted to the project team before and after the outreach forums from 28 sources, including two of which were state agency comments that were a compilation of multiple personnel in each agency. All comments are listed under the question or category designated by their authors.

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A. Reactions: What aspects of the plan or specific recommendations caught your attention?

Energy issues

Energy related issues appear to be much more prominent than in previous LCMR or LCCMR issue documents. While many of the energy related issues are related to natural resource conservation and preservation, some are more distantly related. To some extent the prominence of energy recommendations dilutes the importance of the "traditional" natural resource issues. Perhaps energy issues deserve a separate report.

Many financial recommendations

Nearly every recommendation includes a financial recommendation. The recommendations may be best received if there is a clear demarcation between the technical, science based recommendation first.

High number of Energy recommendations

There is a very high number of recommendations that are focused on Energy Production and Use – surprising.

Good holistic approach

The plan seems to take a holistic, comprehensive, systems approach from a landscape point of view to the issues and opportunities. Thank you to all for the hard work. We are pleased because an approach based on Best Management Practices (best management practices) is too limited because many BMPs are intended as a simple substitution or reduction of usage within a dominant system that is unchanged. Research, as least

in agriculture, is clear that while best management practices are needed, the landscape must be diversified in some areas to achieve water quality and water storage improvements needed to achieve major landscape goals.

Areas where land use changes may limit future opportunities

Many references are made in the "Brief summaries of DRAFT Recommendations" document about the preservation and protection of forest lands including: Implementing a long-term habitat acquisition and protection plan as soon as possible. The State should focus on shore land large contiguous land areas; threatened habitat areas; rapidly growing areas; and areas where land use changes may limit future opportunities.

The project team recommends that the State develop firm policies that would incentivize the growth of energy crops on conservation lands and marginal farmlands...Strategies and policies are needed to protect farms and forests, and prevent fragmentation....achieving carbon neutrality.....a statewide land use, development and investment guide is vital given the intense competition for land and resources and the scarcity of funds.... Develop research programs on habitat fragmentation....payments for conservation easements,...Protect large blocks of forest land. Expand the supply of, and demand for, sustainably harvested wood.

The strategic report entitled "Minnesota Forests for the Future" for the DNR Commissioner is targeted at "Conserving Minnesota's working forestlands to meet the state's future recreation, economic, and ecological needs", I would ask that the recommendations found in that document be included in the Minnesota Conservation Plan. I think that you will find valuable, concrete recommendations that will make your task much simpler especially in regard to Forest Legacy and Fee Acquisition initiatives for keeping working forests working. Nothing reduces carbon like a forest full of vibrant, young, growing trees and nothing prevents land fragmentation better or less expensively than a well designed Conservation Easement.

Cold water streams

Minnesota is a state with awesome lakes, but it also has one of the highest concentrations of coldwater streams in the nation. These coldwater streams have great recreation potential as well as potential for restoration. I felt after reviewing the plan that not enough information was presented on coldwater streams.

B. Strengths: In assessing how the plan/recommendations benefit the MN natural resources, what are key strengths?

Acquisition of critical land and habitat

Recommendations for acquisition of critical land and habitat would result in the most benefit, assuming this acquisition is completed in a relatively short time frame.

Strong connections between land use and conservation

There is a strong connection between land use and conservation that is made. In general, this is the first 'wholistic' approach to land and water management that has been done to date.

Energy Use and Production

Energy Use and Production section C is foundational. If we do not take conservation seriously all the other efforts will essentially fail.

Restoring coldwater streams

Spring creeks are extremely vulnerable to degradation. Early European settlement and agricultural practices from 1850's to 1930's led to wide scale erosion, flooding, and the altering of the region's streams and valleys. As a result, hundreds of miles of clean coldwater spring creeks were inundated with tons of fine sediment. As much as 12 to 15 feet was deposited in the valley floors. Although land use practices, erosion control, and stream health have improved tremendously since the 1930s, the legacy of the past continues to haunt Southeast Minnesota coldwater streams. Many of the streams today still have steep eroding banks, incised channels, and poor in-stream habitat. Annual sedimentation coming off streambank ranges from 250 to 1000 tons per mile and is responsible for as much as 85% of the total sediment load that enters the stream. Minnesota's coldwater streams have a potentially bright future, though. The rivers and fishery have responded strongly and quickly to straightforward techniques to control erosion by stabilizing the banks with limestone rock covered with soil and seeded to native vegetation; reconnect stream to the floodplain; and improve in-stream habitat for both game and nongame species.

C. Weaknesses: In assessing how the plan/recommendations benefit MN natural resources, what are weaknesses or gaps?

Weak Urban Land Use recommendations

Recommendations in land use urban development are weak. It is no longer a matter or lack of tools/knowledge in metro areas, but lack of political will! E.g. high density development, mass transit, eco-industrial complexes.

Underdeveloped surface water recommendations

The recommendations on surface waters seem underdeveloped. I would expect that the 'land of 10,000 lakes' would have more emphasis on water management. WE ARE AT THE HEAD OF 3 MAJOR WATERSHEDS HERE IN MINNESOTA. We of all states should recognize that a huge percentage of water quality problems in the state are due to us, and no one else (aside from Aeolian transported pollutants).

Lack of farmer input

I noticed in the draft report that there has been very little involvement from agriculture on the team who wrote this draft or provided "expert" testimony. Tonight's forum was going to be the first one were several farmers were planning to participate. Since there are many recommendations related to agriculture and biofuels, we would like to have a more active role in this process, beyond simply submitting written comments. Is it possible for the Ag groups to sit down with the leadership of the team who put this draft plan together? How can we be more involved as the process moves forward?

Lack of forests/forest resources in the plan

The recommendation that we would offer is to enhance the inclusion of forests and forest resources in the plan. Specifically, we were surprised that the recommendations on alternative energy (#'s 15-26 had scant mention of forests, woody biomass, tree plantations, etc. but other energy sources were specifically mentioned (#19 corn stover, #'s 25 & 26 native prairies, as examples). This seemed like a major omission.

Although the last set of recommendations in the plan specifically address forests including forest biomass harvesting (#58), it doesn't seem necessary to keep most forest-related recommendations in only this section. It would be appropriate to include the term "woody biomass" somewhere in the alternative energy section.

Minnesota has approximately 16 million acres of forestland, and it is important that this land base, the products and resources it offers, and the benefits it provides to our citizens is robustly included in the Statewide Conservation and Preservation Plan.

Too many research recommendations

While some of the research related recommendations might result in future benefits, much of the research may be useless if the resource base is allowed to be developed, converted to other uses, degraded, etc. Research is important, but seems to represent a much greater proportion of the recommendations than warranted. I assume this is due to the fact that the University is the major research institution of the state.

Uneven levels of detail and emphasis

The document is uneven between sections in the level of detail and emphasis. Specifically, the "Land and Aquatic Habitat Conservation" section is incomplete, and the "Land Use Practices" section is at a different level of depth in the strategies, providing comparatively (overly) detailed strategy statements. Non-forest native terrestrial habitats (e.g., native prairie and savanna) are under-represented in the strategies, as are other unique and rare native plant communities (e.g. fens and rock-outcrop plant communities), whose protection and restoration is important. I am surprised over the relative absence of restoration as a strategy (versus just having the word in the title) despite your own findings that habitat fragmentation, degradation, loss, and conversion is a concern for land and water.

Narrow scope of people involved

I received the preliminary state conservation plan and thought I would provide initial comments before I dig further into the details. With a document as potentially valuable as this could be for our state and region, it is unfortunate that the scope of those involved was quite narrow. It will be difficult for this document to gain social, political or industry support under this circumstance. The drivers listed seem to be one removed from the actual driver, or the definition of a driver should be evaluated. As a farmer, my primary driver is the demand for products which is driven by consumers. My secondary driver is federal farm policy (this has just recently flip-flopped). The impact I have on the natural resource is driven by these two forces. Soil erosion is not driving anything, although it is impacting both production and natural resources. It may seem redundant to continually refer to consumers as the driver of our resource consumption and impact, but it seems more relevant than not addressing this. The boat wake impacts the resource, but the driver is the consumer demand for recreation opportunities on clean water. I would change the entire document perspective and call it:

> ***Preserving and Expanding Minnesota's Bio-Economy and its vital Production and Natural Resources.*** I guess a defining question becomes if we are wiling to include our billion dollar fishing industry as a component of a bio-economy. I can debate the merits of that. I know my farm is part of the bio-economy whether my production is used for food, fuel, or fiber. Forests are also part of the bio-economy whether it is hiking, logging, or carbon sequestration. We have many natural 'recreation opportunities' in Minnesota. Basically, consumers spending their money to access and enjoy. It may sound more Thoreau than a bio-economy, but it isn't. I think this document holds up our state's resources to a level that is not viewed by

society, or one that is even able to be integrated into society. Consumers need to understand that they and the related policies are the drivers of the condition of resources of the bio-economy whether that is soil, lakes, rivers forest or open space. And while policies can greatly influence how the resources are managed, they can not trump consumers' wants and needs. With all that aside, we do need to accomplish many and most of the outcomes as identified in the document. My opinion is that the road to get there needs to be based upon how the production and natural resources in our state are consumed, used and valued by consumers, society (policy) and industry.

No consideration of beavers

The Statewide Conservation and Preservation Plan would be much more useful for local water resource managers if it were to consider in at least some small way the keystone role of beaver in Minnesota streams and on the historical landscape. John Nieber may have some suggestions for how that might be done.

We don't have any specific beaver restoration projects in this region but we likely will have a beaver removal project on the Cedar River in the Austin area. The Mower County SWCD staff is proposing to remove the dams to alleviate localized flooding and increase stream conveyance. If that occurs, Joe Magner from the UM/MPCA will likely have a graduate student study the hydrologic impacts and Neal Mundahl from WSU will have his undergraduate students study the biological changes – particularly the changes in macroinvertebrates. The Cedar River survey is attached.

Lack of ground water emphasis

Ground water is not given much emphasis in the proposed plan. It is mentioned only with respect to groundwater's connection to surface water and ecosystem management. We believe that ground water's role should be fundamental in each of the major recommendation groupings. We also believe that the it needs to address the interaction between surface and ground water and the need to protect ground-water resources with stronger statements than are currently in the Plan. There is one solid recommendation under the "land and aquatic habitat" section of the draft statewide conservation strategy but we feel that ground water needs to appear more systematically throughout the document. We understand that the series of recommendations reviewed at the meeting on May 29 were summaries only. The summary with respect to ground water may have understated the depth of the full recommendation.

We believe that ground-water quantity and quality have not received the attention they deserve. The challenge is to identify solutions in the form of research, policy changes, education, or other action that can be taken. The recent 2008 Clean Water Act Section 305(b) Report by MPCA states that a panel of nine experts representing five state agencies identified these five activities as the major sources of ground-water contamination in Minnesota:

- animal feedlots
- fertilizer applications
- pesticide applications
- storage tanks (underground)
- septic systems

These land use practices that would logically be addressed under LAND USE PRACTICES A. Agricultural and B. Urban. Many people continue to use their faucet as an indicator that "everything is OK" with ground water and ignore the fact that wells are constructed specifically to avoid contamination. Monitoring programs that sample water that is hundreds or thousands of years old and have little to do with land use practices are another source of false feedback. Maybe a good recommendation is that monitoring be conducted in the unsaturated zone, or at the water table, to determine how much of the fertilizer and pesticides are passing through crops or turf. Gyles Randall's work in this area was very revealing. We might also suggest that ground water monitoring results always include some indication of the age of the water being tested. You wouldn't need a date for every test, but a date or other indication of age for each monitoring well would give context to the results related to samples from that well. The paragraphs below contain some ideas about work that could be done to address these problems.

The quality of ground water (and related surface water in Minnesota) continues to degrade due to the inadvertent loss of waste products and the loss of fertilizer and pesticide compounds we intentionally apply. Monitoring of the long term effects of these losses is ill-served by monitoring that focuses on water-supply aquifers. These aquifers generally are deep in ground water flow systems and when the contaminants are detected in them the damage is not easily corrected. Monitoring nearer the point of application (the land surface) is needed to determine the contaminant load being introduced. Additional monitoring along the flow path would address the ability of the system to reduce or delay the contaminant load to aquifers as well as understanding the fate of contaminants. Subsoil drainage systems are an example of convenient and direct access to ground water that has passed through crop systems or turf and into soils. Sampling techniques for areas without drainage are available. The quality of this subsoil water that will either recharge aquifers or discharge to surface water bodies is the key to understanding and managing the long term quality of our water.

Two goals are important to managing the impact of septic systems on ground water. One is to ensure that all systems in use are constructed and maintained in a manner that allows them to function properly. This goal could be achieved by regular and ongoing assessment of existing systems. The second goal should be a re-examination of the technology of individual sewage treatment systems with respect to the waste stream they receive. If the current technology is not able to reduce nutrient loads, or is not able to break down the pharmaceutical compounds or household cleaning and personal hygiene products commonly in use, then the technology must be improved, or the waste stream must be controlled. This goal will be achieved by research and demonstration projects.

The quantity of water available is already a factor in lifestyles and economic development in some parts of Minnesota. It will become a factor in other areas as population grows. Managing the availability of ground water will require more data than is currently available and it will take a steady and long term commitment to gather those data. Withdrawal of ground water from an aquifer can result in one of three reactions. One is that the rate of recharge will increase. This means water will enter the ground and this aquifer faster than it did before. This may affect the availability of water somewhere else-- such as a stream or lake. Secondly, the rate of discharge may decrease. An example is that the base flow of a river would decrease because less ground water is discharged to the river from the affected aquifer. This has implications for habitat, and for human populations that rely on surface water. The third reaction is a reduction in the amount of water remaining in the aquifer. Over time water levels fall. This is not yet a common problem in Minnesota, but it is in adjacent

states. It is unsustainable. The acquisition of geologic mapping, hydrologic properties, and aquifers and stream level data will facilitate better monitoring and recognition of aquifer reactions, and better simulations of proposed water uses or predicted future demands.

We also have attached the detailed recommendations on ground water that was prepared for this plan. We believe they should be considered again in preparation of the abbreviated recommendations in the Plan.

D. Implementation Challenges: What might be potential challenges to effective implementation of the recommendations or plan?

Getting people to act

How do we get the public and our political systems to act?

Dispersed land use authority

Dispersed land use authority. Small LGUs (who may have good intentions) may not have the technical capacity to evaluate the short or long term effects of land use on natural resources.

High commodity prices

In agriculture, high commodity prices always prove a challenge. This is because the paradigm in farming, research, marketing and policy is typically based on maximizing yield and gross profits. When prices are high, too many are encouraged to and decide to rip out conservation to achieve maximum production.

A stewardship ethic is not widely embedded in agriculture

Therefore decisions about conservation come second to production, even thought those decisions may harm future production potential or the long-term sustainability of the resource or profit for small and mid-sized family farms.

Climate warming with more high intensity storms requires conservation systems and landscape diversity at least in key areas. Research has shown that single best management practices will not be adequate in the face of significantly increased amounts and intensity of precipitation (SWCS 2003, Digiacomo et al 2001).

Narrowing down number of recommendations

I think it will be difficult to narrow down the numerous recommendations to a smaller number that the LCCMR can actually use as a focus for funding decisions. The funding needed to adequately address even a small portion of these recommendations far exceeds the resources available through the LCCMR process. This is an issue that should be highlighted in the report.

Funding and lack of expertise

Funding and lack of technical expertise are two of the primary challenges to effective restoring SE Minn streams. Currently participation by landowners using Farm Bill dollars for streambank stabilization is limited because of low cost-share rates placed on rock rip-rap/bank stabilization. By piggy backing the Environmental and Natural Resources trust fund dollars with federal dollars, streambank stabilization projects will once again be affordable.

Outcomes:

- Increase the effectiveness of stream restoration efforts by coordinating them with upland soil conservation and land protection efforts.
- Improve water quality by reducing sediment inputs from eroding stream banks and other contributing sources.
- Benefit fish populations by expanding aquatic habitat through channel and riparian vegetation restoration.
- Increase community support and awareness by engaging volunteers in restoration and monitoring activities.
- Build capacity of Soil and Water Conservation Districts, NRCS, local TU chapters and their agency partners to implement stream restoration projects.
- Raise public awareness of the unique resources Southeast Minnesota's Driftless region and support their restoration and protection.
- Create an economic benefit to local communities.

E. Implementation Advice: What suggestions and advice or do you have for implementing the recommendations effectively?

Focus on a smaller number of recommendations

I think the LCCMR should try to focus on a fairly small number of recommendations and try to have a real impact in those few areas. There should be an effort to provide these recommendations to other committees of the legislature that deal with natural resource issues. The University should pursue many of the research recommendations regardless of whether they may be funded through the LCCMR process.

Multiple benefit recommendation evaluation

Each recommendation could be evaluated based upon the multiple benefits that are realized when the recommendation is implemented. E.g. If habitat corridors are established, infiltration may be improved, reducing the impact of increased stormwater volumes to waterways and improving the water quality (not a great example, but you get the idea). Recommendations that have the greatest effect on other recommendations should be implemented first.

Identify public values

It would be very beneficial to identify the PUBLIC VALUES of natural resources. Example: encroachment of homes on WMAs and other natural landscapes. Due to the very nature of homes ringing a WMA, the wildlife is negatively effected, the use of the public land for wildlife is reduced. What was gained by individuals around the WMA (open space out their back door, great viewsheds) comes at a cost to the public.

Natural resource information

Additionally, the plan would be well served by characterizing the role of the State in providing a foundation for natural resource information. Investments in durable, baseline, cost effective natural resources information that is common to all parts of the state (not just the Metro, as in TMDL identification) will yield dividends in the form of better decisions by those who have been given the power to guide the use of the state's resources.

Education programs

Education programs need to help create a stewardship ethic by providing more background on ecosystem dynamics, tours on farms that have adopted high levels of stewardship and are profitable over time with high prices and low prices and droughts and high rains.

Three useful concepts to help the plan address conservation and preservation in a more holistic manner

1. There is an opportunity in the Minnesota Statewide Conservation and Preservation Plan to incorporate broader system-wide approaches to Minnesota's environmental challenges. Three useful concepts that could be incorporated into the plan to help it to address conservation and preservation in a more holistic manner are:

- LEED-ND
- Eco-Industrial Development
- Community Sustainability

Community Sustainability integrates the natural, built and social environment and is a useful lens for viewing environmental issues and preparing for the future. It encourages efforts that will simultaneously work to preserve biodiversity, local economies, and clean energy - and it's ultimate goal is to conserve human and natural capital. The Minnesota Statewide Conservation and Preservation Plan should reference the concept of sustainability and seek to promote assistance to communities to become more sustainable. Many assistance providers, in and outside of Minnesota state government, have been providing sustainable communities assistance for a number of years. Communities throughout the state, as diverse as Minneapolis, Steele County, Duluth, Winona County, and Dakota County have demonstrated the usefulness of a sustainability-related approach.

Where possible, the plan should not prescribe specific tools that are needed to accomplish goals (i.e., carbon calculator, land use development guide, scenario planning tools) but should instead focus on the ultimate broader goals. As the needs that are addressed in this plan will evolve over the next years, it will remain a more useful document if it does not lock in the need for certain specific tools which may or may not be necessary over this time period. Also, it is often more effective to survey communities to help assess their assistance needs first and then to follow up with the specific tools and approaches needed, rather than to develop preselected tools first.

Specifically for recommendation #47, the language could be broadened to something like "Establish an assistance program that will provide funding and tools for Minnesota communities seeking to implement conservation and sustainability-related activities." The recommendation would focus less on specific tools and planning in the bullets below, and more in providing resources, funding and assistance to communities.

- Instead of focusing on a specific tool, the language for #47. A. could be broadened to "Provide assistance to communities to measure their carbon impact. This could include training of communities to use carbon calculators, development of Minnesota-specific tools as needed, and development of a statewide database on community carbon impacts. This recommendation also links to #18.
- #47 C. could be broadened to "Provide communities with assistance necessary for developing and implementing conservation activities, including planning."

Recommendation # 32 could be expanded from a focus just on energy conservation education to other activities related to conservation and preservation. It would be helpful to increase the degree of public education in

the plan. This would help to assure public involvement in activities implemented under this plan as well as encourage actions by individuals to meet plan goals.

Change some language

A change in some language:

> Urban/Community land use practice recommendations include: 47. Establish funding sources and tools for Minnesota communities seeking to prepare and implement conservation-based comprehensive plans. Support state agencies to provide conservation and development assistance to growth communities. Projected increases in population pose imminent threats to Minnesota's unprotected natural habitats and serious land availability issues for developing communities. The project team recommends providing incentives AND TOOLS for communities to develop in ways that conserve natural resources. Incentives AND TOOLS could include natural resources information, data and analysis; technical assistance IN USING TOOLS SUCH AS THE NATIONAL LEED-ND RATING SYSTEM AND A MINNESOTA-SPECIFIC CONSERVATION DESIGN SCORECARD; training workshops; site and community design; and mentoring opportunities.

F. Other Feedback: What are other comments or suggestions ?

Need more emphasis on aesthetics

There should be more recognition and discussion of the aesthetic and scenic benefits of natural resource conservation and preservation. While perhaps more difficult to describe or quantify than benefits such as conserving water quality, preventing soil erosion, habitat and species protection, carbon sequestration, etc, these aesthetic benefits are real and important from both a social and economic perspective. Much of the attraction of the North Shore area, for example, is due to the scenic nature of the land and lake shore. People simply enjoy beautiful scenery and may well be more easily persuaded to protect natural areas based on their scenic values than on the basis of species protection or sound principles of ecosystem management. These aesthetic benefits are clearly reflected in the writings of Aldo Leopold and Sigurd Olsen but too often seem to be neglected by natural resource specialists and professionals today. We need to recognize the importance of scenic vistas, inspiring panoramas, lack of man-made noises, natural displays of color, etc. These are important natural resource experiences worthy of protection and conservation.

Feedback on specific recommendations

Land and Aquatic Habitat

- B. Please add language about upland impacts in steeply sloped areas that drain into tributaries, rivers and lakes.
- B.7 Add keeping water in the landscape in agricultural areas. The way to do that with the most multiple benefits is by increasing organic matter in the soil. That means not only reducing tillage but also high levels of nitrogen fertilizer. It means adding cover crops in row crops, more areas with diverse (including organic) rotations, more grass for animals and cellulose in environmentally sensitive areas and beyond, as well as wetland restoration covered in B.9.

Energy Production and Use

- The idea of growing row crops for energy in steep areas or near water bodies should be directly challenged. It does not make ecological or energy sense. In general in this section more should be said about protecting diverse lands, whether or not it is in the farm bill (observing sodbuster, swampbuster, converting CRP to Conservation Stewardship Program working lands using grass for animals or energy), etc. I appreciated the discussion about community scale described more in section B. Please be sure section A references or is clearly linked to B, if that is your intention.
- A. 25 is key
- B. 27 Use RIM-CE and Conservation Security Program as models for how to do this. Both are based on a tiered system with highest payments for the most multiple benefits such as wildlife habitat, watershed protection, soil erosion reduction, biodiversity, water storage, etc.
- Section C. Add energy conservation in agriculture, including more regionalized and sustainable food production systems.

Land Use Practices

- 40. Add a transition to animal production as well as renewable fuel stocks to perennial crops. Talk about the value of mixed stands of forbs and grasses that have built in N fixing potential.
- 42. The intent is good, need to mention the value of restoring perennial grasses for animals and energy on steeply sloped lands —look at choosing slopes greater than 6% or another justifiable slope for example) as well as proximity to water bodies.
- A. 44 Add soil quality - This needs protection as well as agricultural lands per se.

Specific comments on recommendations

Land and Aquatic Habitat

- (B) Maintain/restore critical habitat at the land/water interface - Recommendations include:
  - Keeping water on the landscape - Assist LGUs by identifying land areas where stormwater infiltration can be best achieved (soils with high rates of transmissivity and available capacity to absorb). Make recommendations to preserve these areas for future use as local / regional infiltration. **Also, although peak flows are important, the duration of high water events is equally as important – this will grow in importance as global climate change has been changing the distribution of precipitation – more intense bursts.
  - Livestock producers are highly regulated on their use of manure as fertilizer by the MPCA under the banner of water quality protection from Phosphorus (and to a lesser extent nitrogen and pathogens). Trainloads of commercial fertilizer is imported into the state and applied to the landscape UNREGULATED. The loading of Phosphorus in the soil and the subsequent loss of topsoil to surface waters in these intense rain events causes phosphorus loading in our rivers and lakes.
- (C) Maintain or restore critical in-water habitat - Recommendations include:
  - Policy - The Legislature should consider enacting statewide, mandatory shoreland ordinances that are responsive to cumulative impacts, viewsheds, and shoreland impact areas.
  - Evaluation and understanding *** - The State should **complete a rapid water quality / habitat assessment of all streams in the state**, based upon the abundance and diversity of invertebrates (Hilsenhoff Biotic Index, or HBI).

Energy Production and Use

- (A) Promote alternative energy production strategies - Recommendations include:
  - 24. Invest in farm and forest preservation efforts to prevent fragmentation due to development guided by productivity and environmental vulnerability research - Valuation of property based upon a future highest and best use fosters the actualization of those future uses. Property valuation should be 'stepped up' only after the land use has changed to that future, higher value use (development), and not before. The Green Acres model is good.
- (B) Promote a healthy rural economy - Recommendations include:
  - 27. Invest in research and policies regarding "green payments." - Learn from the USDA's Conservation Security Program, which mirrors the intent of this item. The CSP is data hungry, burdensome to administer and monitor. It pays ag. Producers for doing the right thing, which is good. ** By the way, the RIM program has been only effective in the focus areas of the Minnesota River Valley and in areas where it was combined with USDA in the Conservation Reserve Enhancement Program. The RIM is largely invisible in the rest of the state due to low funding levels and 'siphoning' of resources to select landscapes.

Land Use Practices

- (A) Agricultural land use practice recommendations include:
  - 41. Reduce streambank erosion through reductions in peak flows. Not only peak flows, but sustained high flows. This is a very important area of consideration in general.
- Urban/Community land use practice recommendations include:
  - 45. Monitor TMDL BMP implementation - There are many data sets out there – paired watershed studies, USDA's RUSLE. Gather existing data first.
  - 46. Establish a more effective and coordinated land planning process - Yes, indeed. The present organization of land use authority is unwieldy at best with multiple, independent jurisdictions permitting individual projects with little recognition of cumulative impacts. Solution? I don't know.
    - B. Land use, development and investment guide - Interesting and a GREAT use of state resources.
    - C. Invest in a pilot planning project along a Minnesota corridor that focuses on integrating "gray infrastructure" with existing "green infrastructure." WHAT A GREAT IDEA!!! I will add another wrinkle to that and suggest that a new WAY of making land use decisions – the collaborative model.
  - 47. Establish funding sources and tools for Minnesota communities seeking to prepare and implement conservation-based comprehensive plans.
    - Conservation-based planning - Recommendation: 1. Develop statewide green infrastructure, 2. Entice cities / twps. to adopt, 3. Provide significant resources to buy interest OR PROTECT THROUGH LAND USE TOOLS. Especially for smaller jurisdictions, the State should require and enforce a conflict of interest requirement of all LGUs so that
  - (E)Establish a statewide grant program to build capacity to conserve water quality, natural lands and parks. Coordinate public acquisition thorough comprehensive open space planning and Statewide GI planning.
  - 48. Invest in generating base data and information necessary to support decisions or tools.
    - B. Develop data in areas vulnerable to development or conversion of land cover. May I suggest the Statewide Green Infrastructure as one geographical area to concentrate?

Big 10 list of conservation challenges *(From a presentations by Mike Dombeck, June 29, 2003 at the Society for Conservation Biology Annual Meeting in Duluth, Minnesota)*

- Fresh Water
- Land fragmentation and sprawl
- Wildland Fire
- Loss of biodiversity
- Exotic species
- Old growth forests
- Off-road vehicles
- 1872 Mining Law
- Private land conservation
- Ecological Literacy

Are we taking the right course of action?

Close look at ethanol-water- what are the impacts? Are we locating plants in the right place?

- Are we putting all of our eggs in the biomass basket?
- Will the grid be receptive? i.e. will Co. buy excess energy from private parties.
- What about eco-industrial complexes? This is an interesting approach and reassess energy needs in production and life cycles.
- What about selling energy as a service – Would it drive conservation at the company level?
- We have the tools in the Metro area (through Met. Council) to consolidate planning and address transportation. We lack the political will to do what is necessary i.e. high density development, reduce development on urban fringe, mass transit. You need some bolder recommendations here!

Detailed recommendation suggestions

Land and Aquatic Habitat Conservation

- Part A. - Add a third strategy in this section on "Restoration and rehabilitation—land habitat" to address critical terrestrial habitat and its management, restoration, reconstruction, and rehabilitation. Among the priorities that need to be explicitly addressed are restoration and management of public and private lands for rare species and species of greatest conservation need; restoration and management of buffer areas and other sites achieving landscape level connectivity of high quality habitat; invasives species, and in prairie and savanna habitats, also woody encroachment control, etc.
- Part A. Strategy 2. - Given that less than 1% of the state's native prairie remains and even less of its savanna communities, these types of habitats should be explicitly listed for protection and restoration.

Energy Production and Use

- Part A. - References throughout this section (and the agricultural land use section) on "perennial biomass crops" should be modified to be those with "native species diversity."
- Part A. Strategy 16. - Add: Develop policies and incentives to encourage "Low Input, High Native Diversity" crops.

- Part A. Strategy 26. - Add: Retention of native genetic diversity is needed to provide species resiliency in the face of climate change.

Land Use Practices

- Part A. - Same as above on native species diversity substituting for perennial crops.
- Part A. Strategy 40A. - Add: The Ecological Classification System should be used to guide selection of species (with emphasis on native species diversity) and the locations for biomass crop plantings in order to maximize ecosystem services.
- Part D. Strategy 57. - The natural resource-based land use plan referenced in this strategy should explicitly say that the goal also is to improve native biological diversity.

Rationale for comments. The loss of biodiversity and healthy ecosystems in our state has progressed to the point that protection of natural areas is no longer an adequate response. To halt or reverse the decline in biodiversity we need to actively restore areas so they regain their former ecological trajectories, and to provide effective habitats for valued species. As your own research states, our habitats face serious threats to their sustainability from a variety of stresses and pressures, including climate change, larger and more frequent catastrophic wildfires, widespread insect and invasive species infestation, pollution and human use, and also disease. Also, restoration is a strategy in meeting water quality goals, in particular within in the framework of a TMDL process. In short, in coming decades, restoration as a tool, community builder, and philosophy will only grow rather than lessen in importance.

Ways to include historic and cultural resources in the plan

Looking to the draft Statewide Conservation and Preservation Plan, the following are areas into which historic and cultural resources should be woven. It is important to note that while historic and cultural resources are often categorized within "other resources" or "outdoor recreation," the existence and treatment of these resources have wider applicability across the natural resource spectrum, and, specifically, in each of the groupings of the draft conservation and preservation plan, as described below. Some suggestions relating to historic and cultural resources would fit neatly into the existing recommendations, others not so precisely.

Land And Aquatic Habitat Conservation

- Note: The Land and Aquatic Habitat Conservation section contains a number of Research and Acquisition recommendations that would also apply to historic and cultural resources, as noted below:
- A. 1 Research - Just as other types of natural resources would benefit from a greater level of research, so would cultural and historic resources, to better understand how these resources are impacted by and interact with larger changes in settlement patterns, human behaviors, etc.
- A. 2. Acquisition - When various types of habitats are acquired for preservation, care should be given that cultural resources are considered and preserved as well. For example, when water-related properties are acquired, careful consideration of potential impacts on archaeological resources should be considered.
- B. 3 Research - See A. 1. As Above
- B. 4. Acquisition - See A. 2. As Above
- B. 5. Acquisition - See A. 2. As Above

Energy Production and Use

- Overall, use of existing resources, including cultural resources should be given specific consideration within this section. For example, in C. 34. the recommendation states that the "state [should] develop specific policies and incentives to improve construction practices for **new** residential homes." [Emphasis added]. In the historic preservation field, we have a saying: "The greenest building is the one that is already built." The thinking should move towards preserving existing resources. Similarly, in recommendation C. 32, the Society could play a role in assisting with public education.
- Also, arrayed throughout this section are recommendations for financial incentives for alternative energy sources and approaches. Similarly, financial incentives are needed, particularly at the state level, to assist with preservation of historic resources. Thirty other states provide a state level financial incentive for private owners of historic resources to improve their properties, and Minnesota should join this group.
- Recommendation cluster B suggests, "Promote a healthy rural economy." Preservation and promotion of cultural and historic resources can help to achieve this goal through:
  - stimulation of the construction economy through a sustainable renewal of historic structures on Main Streets of small and large towns across the state.
  - Promotion of sustainable tourism, close to home, through preservation and promotion of existing cultural features.

Land Use Practices

- This area contains a number of current practices in which cultural resources are currently part of the land use planning process. However, greater awareness is needed in the areas of the importance and value of cultural resources.
- Specifically some of the recommendations that relate or could relate to cultural resources include:
  - Agricultural land use practices - efforts should be made to identify and protect historic resources including, but not limited to historic agricultural structures, such as barns and other structures; historic agricultural districts, or concentrations of historic resources retaining historic and scenic characteristics; and scenic areas.
  - Cultural and historic resources should be specifically woven into the following recommendations:
    - 46. - Establish a more effective and coordinated land planning process
    - 47. - Establish funding sources and tools for Minnesota communities seeking to prepare and implement conservation-based comprehensive plans.
    - 48. - Invest in generating base data and information necessary to support decisions or tools.
    - 49. - Integrate streamlined environmental transportation project review and
    - 51. - Align transportation planning across agencies and projects. (Cultural resources are part of state and federally-mandate transportation reviews, and should be included in any reforms of these processes.)
- Suggested Language in Specific DRAFT Recommendations:
  - 32. - The MN Historical Society could play a role in public education. Add a sentence to the end--"Form partnerships with public education organizations like the Minnesota Historical Society to take the message to the public in innovative ways."
  - 34. - The MN Historical Society can promote historic preservation thereby lowering . "Implement policies and incentives for reuse of existing structures, thus sustaining the existing materials."

- 46. - considers urban planning and could integrate historic preservation into the larger planning framework. In part A, add, "Reuse of existing structures helps to limit urban expansion and should be encouraged."
- 47. D. - Add: "One such activity is historic preservation which reuses existing structures and contributes significantly to the quality of life."
- 47. E. - Revise title sentence to read "Establish a statewide grant program to build capacity to conserve water quality, natural lands, parks and historic resources." In sentence three insert "...to protect natural **and historic** resources." And in the last sentence repeat the phrasing of the first with "...natural lands, parks **and historic resources**."

• Other Specific Recommendations to incorporate into the Statewide Conservation Plan:
- Support and fund research efforts to identify important historic and cultural resources, as well as emerging issues in the cultural resource management field.
- Support efforts to preserve important historic sites and cultural resources by providing funding for preventative maintenance and preservation.
- Protect important archival documents that yield or may yield important natural resource information.

Historical and cultural observations relating to the plan

In its original form, the Legislative Commission on Minnesota Resources was a significant source of funding for projects related to the identification and protection of Minnesota's historic and cultural resources. Among the projects funded by LCMR was the Minnesota Statewide Archaeological Survey, which lasted from 1978 to 1981. Other projects aided in the protection of important archaeological properties and the interpretation of significant historic sites that contribute to educational and recreational opportunities throughout the state.

- Historic or cultural resources are the cultural counterpart to the ecological resources that have shaped the experiences of Minnesotans for thousands of years. Their protection and interpretation contribute to the state's quality of life and are consistent with a conservation ethic.
- During review of the draft "Minnesota Statewide Conservation and Preservation Plan", several areas were identified where there are intersections between the Commission's proposed priorities and the protection of historic and cultural resources.
- A number of identified priorities involve acquisition of critical habitat lands. In Minnesota, there is a strong correlation between the presence of ecologically important features and the presence of archaeological sites reflecting human occupations reaching back almost 10,000 years. Protection of cultural resources could be included as a consideration when setting priorities for acquisition of sensitive habitats.
- This is a particularly important point when considering acquisition of land for improving outdoor recreation opportunities. Historic and cultural sites are significant components in outdoor recreation networks, and heritage tourism is a growing segment of the overall tourism market. Investing in acquisition of lands that contain features of both natural and cultural significance would increase the overall value of the investment to the citizens of the state.
- Another proposed priority is support for local communities developing conservation-based comprehensive plans. Those plans should take into account the presence of cultural resources in areas that may be subject to future development. This is particularly important in the case of resources such as burial mounds, for which protection is mandated by State law. Similarly, grants and other forms of support for locally-based conservation efforts can encourage communities to incorporate consideration of cultural resources into their planning efforts.

- Recommendations for sustainable forestry land practices can also provide opportunities for protection of cultural resources in forested landscapes through the use of landowner incentives and conservation easements. Targeting areas that are of both natural and cultural sensitivity will contribute to long-term protection for a range of important resources.

Cold water streams

I would suggest additional information about Minnesota's cold water streams be added to the plan, with language encouraging LCCMR to partner with other organizations. Just last month Trout Unlimited did a survey - The Economic Impact of Recreational Trout Angling in the Driftless Area (attached to this e-mail). **Recreational Angling** in the Driftless Area of southeast Minnesota, southwest Wisconsin, northeast Iowa, and northwest Illinois generates an impressive $1.1 billion annual economic benefit to the local economy.

Feedback on specific recommendations

B. Urban/Community land use practice recommendations include:

- ***45. Ensure protection of water resources in urban areas by evaluating and improving current programs.***
  - A. ***Establish a credit system for stormwater and Low-Impact Development (LID) BMPs.*** Various stormwater regulatory programs have the potential to significantly improve water quality in a large number of water bodies throughout Minnesota. However, their implementation is inhibited by the absence of a meaningful credit system for stormwater and LID BMPs. The project team recommends the development of a credit system that would address and provide incentive toward a wide range of BMPs.
    - Comment: The issue of credits has been a common theme that has merit but requires better definition. This recommendation could be strengthened by referencing Conservation Design as well as LID practices.
    - Comment: There are a wide range of factors influencing performance BMPs, of which the details of proper design, installation and operation/maintenance are critical. For example, substantial areas of the state have heavy soils that will need additional design and construction considerations.
    - Comment: From a TMDL and basin management standpoint, primary emphasis is upon mass balance assessments of stormwater flow networks and hence, credits will need to be related to reasonable estimation of water and pollutant loads.
    - Comment: This recommendation seeks a credit system to provide incentives for construction of BMPs. The credit system could also specifically include incentives to ensure success of long term operation and maintenance of the BMPs. This might include requirements for design of BMPs in the first stage of development, education/certification of those constructing BMPs, post-construction inspections for plan conformance, and operation and maintenance plans for new owners or management companies as examples.
  - B. ***Simplify modeling for Total Maximum Daily Load (TMDL) compliance.*** Cities need a relatively simple stormwater modeling system to provide reasonably accurate estimations of runoff and a range of pollutant loading and the changes to their loading if various BMPs are implemented on portions of the land in their jurisdiction. The project team recommends the development of a model that could be used by all cities and other landowners with low technical knowledge and manageable input requirements.

    - Comment: There is an increasing need for planning tools. Stormwater surface water monitoring and assessment is complex and BMPs cover a range of structural and nonstructural practices. However, simplified tools are needed with clearly defined expectations as to appropriate usage and limitations. Modify language as underlined

- 47. ***Establish funding sources and tools for Minnesota communities seeking to prepare and implement conservation-based comprehensive plans.***
    - F. ***Support state agencies to provide conservation and development assistance to growth communities.*** Projected increases in population pose imminent threats to Minnesota's unprotected natural habitats and quality of lakes, rivers and streams and serious land availability issues for developing communities. The project team recommends providing incentives for communities to develop in ways that conserve natural resources and protect water quality. Incentives could include natural resources information, data and analysis; technical assistance; training workshops; site and community design; and mentoring opportunities.
        - Comment: Modify language as underlined

A. Promote Alternative Energy Production Strategies. Recommendations include:

- 15. ***Invest in research and demonstration projects on a landscape scale.*** Energy crops are expected to play a major role in development of biomass resources for next-generation biofuels or carbon-neutral electricity. The project team recommends coordinated research and policy experimentation to develop and refine renewable energy production systems. The efforts should focus on biomass farming that emphasizes perennial biomass crops. A workable quantitatively-based definition of 'carbon-neutrality' should be developed that will be useful for purposes of long-term state energy and environmental policymaking. This initiative has potential to improve environmental quality and support economic revitalization in rural Minnesota.
    - Comment: Modify language as underlined
    - Comment: Consider research and demonstration projects on a landscape scale. Perennial biomass crops, unless native, may not be able to efficiently provide the desirable qualities of less water and management (e.g. less energy input for cultivation). This recommendation could also incorporate learning from low impact development regarding natural water flows of a region.
- 16. ***Develop policies and incentives to encourage perennial crop production for biofuels.*** Currently, there is little economic incentive for farmers to grow energy crops in Minnesota. This contrasts with subsidies for other crops that are provided from federal sources today. The project team recommends that the state develop firm policies that would incentivize the growth of energy crops on conservation lands and marginal farmlands, while also reflecting environmental and ecological needs for animal habitat and water resource conservation.
    - Comment: Consider policies and incentives to encourage perennial crop production for biofuels. Reference preservation of habitat as a balance within this recommendation.
- 21. ***Invest in applied research to reduce energy and water consumption and emissions in ethanol plants.*** A criticism of Minnesota corn-based ethanol plants is the small net gain of energy output from the energy expended to produce ethanol. Criticism has also focused on the high water resource needs that accompany current production techniques. Current production methods also lead to significant co-product generation of carbon dioxide. The project team recommends funding for applied research and demonstration of ways to reduce water consumption and energy use and reduce carbon dioxide emissions at corn-based ethanol plants.

- Comment: Consider applied research to reduce energy and water consumption and emissions in ethanol plants. This recommendation could include biodiesel production as well and could reflect that use of a "lifecycle" approach that mimics natural systems may be the desired approach for production of biofuels.

- 22. ***Invest in research to determine the life cycle impacts of renewable energy production systems.*** This recommendation aims to inform Minnesota's renewable energy development through data collection and analysis. The project team recommends that energy policy and incentives at the state level take a "systems view," accounting for the resource benefits and impacts associated with each stage of energy production, transport, consumption and associated waste processing to facilitate this work a workable quantitatively-based definition of 'carbon-neutrality' should be developed that is consistent with analytical frameworks within which GHG emissions are generally treated and that would enable emission credit trading.
  - Comment: Modify language as underlined

C. Promote energy conservation efforts. Recommendations include:

- 31. ***Promote policies and incentives that encourage carbon-neutral businesses, homes, communities and other institutions.*** Much more could be done to encourage Minnesotans to reduce their carbon footprints, through energy conservation and low-carbon fuel use. Most likely, achieving carbon neutrality will require a portfolio of energy technologies and lowered energy consumption, as seen at the University of Minnesota, Morris (wind, biomass, etc.). Policies and incentives should be targeted to assist individuals, businesses, communities and institutions in developing renewable energy portfolios to facilitate this work, a workable quantitatively-based definition of 'carbon-neutrality' should be developed that is consistent with analytical frameworks within which GHG emissions are generally treated and that would enable emission credit trading.
  - Comment: Modify language as underlined
- 33. ***Develop standards and incentives for energy capture from municipal sanitary and solid waste, and minimize landfill options.*** An underutilized energy source exists in most communities that could reduce the need for new energy production—namely, municipal solid waste (MSW) products that remain after recycling and reuse options are exhausted. A state mandate should be established that requires the capture of energy units from MSW. Statutory actions should be taken to establish targets for MSW use and minimization of landfill options.
  - Comment: Assumption needs further analysis and does not necessarily represent a win in terms of carbon emissions. The combustion of presently landfilled MMSW would add about 1.8 million tons of fossil CO_2 to the atmosphere (from plastics), annually.
- 34. ***Implement policies and incentives to lower energy use of housing stock while monitoring the performance of improvements.*** Housing improvements should consist of locally-manufactured building material resources, especially those that use industry byproducts as their primary production feedstock. The project team recommends that the state develop specific policies and incentives to improve construction practices for new residential homes. The University of Minnesota has developed new technologies that present alternative means and methods for achieving vastly improved energy code compliance; these technologies should be further investigated to overcome implementation barriers.
  - Comment: Consider polices and incentive to lower energy use of housing stock while monitoring the performance improvements. This recommendation could note that locally-manufactured building materials are preferable or desired, the need is to ensure the capacity is developed to support this recommendation. At this time, it is not practical for locally-manufactured products to be the only products used for home improvements.

- **36.** ***Develop incentives to encourage the widespread adoption of passive solar and shallow geothermal heat pump systems in new residential and commercial building construction.*** The use of alternative heating technologies will allow significant reduction in natural gas, heating oil and electrical energy requirements for the state. In addition, the greenhouse gas impact associated with water and structure heating will be reduced. The project team recommends that policies be established to promote the widespread adoption of passive solar and shallow geothermal heat pump systems in new residential and commercial building construction.
  - Comment: Review a recent report commissioned by the Department of Commerce Office of Energy Security that addresses geothermal systems (Janet Streff, Office of Energy Security).

B. Maintain/restore critical habitat at the land/water interface. Recommendations include:

- 6. ***Education.*** In order to provide a better understanding of the factors surrounding land and water resources, the state must invest in the consolidation, adaptation and development of educational materials on watershed science principles. In addition, significant efforts are needed to communicate this information to the public. Potential approaches include the development of a "master watershed practitioner," recognition certificates and awards, and college credits for people interested in watershed management work.
  - Comment: The recommendation could reference that state investment in educational materials meet the environmental education goals of the state contained in 115A.073, and in particular development of educational materials that meet the objective of reaching environmental literacy for all Minnesotans (see GreenPrint—Minnesota's state plan for environmental education at http://www.seek.state.mn.us/eemn.cfm) People who are environmentally literate:
    - Understand the complexity of natural and social systems and their inter-relationships
    - Demonstrate the knowledge skills, attitudes, motivation and commitment to working individually and collectively toward sustaining a healthy natural and social environment
    - Have the capacity to perceive and interpret the health of environmental and social systems.

B. Urban/Community land use practice recommendations include:

- 45. ***Ensure protection of water resources in urban areas by evaluating and improving current programs.*** Establish a credit system for stormwater and Low-Impact Development (LID) BMPs. Various stormwater regulatory programs have the potential to significantly improve water quality in a large number of water bodies throughout Minnesota. However, their implementation is inhibited by the absence of a meaningful credit system for stormwater and LID BMPs. The project team recommends the development of a credit system that would address and provide incentive toward a wide range of BMPs.
  - Comment: Credit system could include incentives to ensure success of long term operation and maintenance of the BMPs and might include requirements for design of BMPs in the first stage of development, education/certification of those constructing BMPs, post-construction inspections for plan conformance, and operation and maintenance plans for new owners or management companies as examples.

G. Feedback received before draft recommendations were released:

Solar Collectors

Our proposition to reduce the CO_2 emissions and reduce the fuel consumptions is the installation of solar collectors. The solar collectors are installed on the side of a barn, industry or building. Its pre heat the air before entering the ventilation system. We have a wide experience on Canada. We should present the advantages, the statistics values of this technology, how we evaluate its performance, etc. The industry and agricultural sector need to improve their efficiency by reducing their fixed costs, and being more competitive. They also need the support of grant programs to implement these technologies. On Canada, the federal government funds 25% of project total cost.

The companies of fuel fund between 0.30$ to 1$ by m3 of natural gas saved. They also fund the feasibility study. The Ontario's government also fund 25% of project total cost. This is only to mention few politics applied for the federal and state government. We are planning to install the solar collectors on a Minnesota's poultry farm as a demonstration, but we are waiting to be granted by anyway.

Need a roadmap to evolve from un-sustainable to sustainable

The problem with this framework is that it does not provide a road map or even the language on how to evolve from un-sustainable to sustainable society. The realistic conservation plan to forge sustainable society should include system approach of three sectors: natural, social and economic capitals. One cannot find reliable statistics in Minnesota on economic analysis health to the health of the environment that support the economy.

I realize that the plan is to address only the natural capital, but even within the natural capital many components for sustainable society are missing. For example, ecosystem services, biodiversity, watershed services, sustainable forestry, ecological infrastructure, etc. The key role of this plan should be the values in policy making and public opinion. The purpose of this plan should be to bring a concept of sustainable society to the attention of the general, usually uninformed and forgetful public. But how this could be done when the evolving language of sustainability is rarely mentioned in the plan?

It appears that this conservation plan is trying to develop new framework from existing outdated conservation framework which is based on "non-sustainable society" principals. This old framework should be completely discarded. We should start from the scratch because none of the policy philosophies dominant today embraces the values essential to sustainable society.

Statewide look at protecting water quality regarding ethanol/cellulosic plants

I'd like to see a watershed by watershed plan to improve and protect water quality and river ecological integrity with a statewide perspective. I want to make sure resources are protected as ethanol and cellulosic plants are developed. If there isn't enough water in a particular area to allow ethanol production and the river ecosystem then the plant won't get built. If there isn't enough energy to go around then we need to promote smaller human population size.

H. Comments from stakeholders not involved in developing the Plan:

No mention of tribes in plan

The 1854 Treaty Authority is an inter-tribal natural resource management agency governed by the Bois Forte Band and Grand Portage Band of Lake Superior Chippewa. The organization is charged to preserve, protect, and enhance treaty rights and related resources within the 1854 Ceded Territory of northeastern Minnesota. We would like to offer comments on the Statewide Conservation and Preservation Plan.

It doesn't appear that tribes have been consulted with in the development of the plan. Tribes are sovereign nations, and key stakeholders within the state. We see no mention of tribes or treaty rights within the document. This oversight should be corrected. Furthermore, along with general concerns over environmental and natural resource health, some specific issues may arise with tribes. The 1854 Treaty Authority is concerned over specific resources such as fish, moose and other game species, and wild rice. Wild rice is of extreme importance to the bands, and should be referenced in the document. Other issues include public land ownership and available access for the exercise of treaty rights, and protection of cultural resources (which include natural resources).

It is our understanding that the plan was developed primarily by those from the academic profession, with some natural resource managers providing consultation. While both views are important, we question if resource managers had enough input in the process. Communication must flow effectively in both directions between researchers and managers. If the plan is utilized to guide planning, policy, and funding investment, it is important that resource managers (including tribes) be actively involved. The plan contains a considerable amount of good information. However, specific recommendations and implementation of those recommendations is the most important part of the process.

Spirit Lake storm water pipes

Spirit Lake is a beautiful 115 acre lake that has been condemned to die. It is surrounded on three sides by state highways 71 and 87. Over the years area DNR hydrologists have permitted two storm water pipes to enter the lake, one two feet in diameter. We, the (Spirit Lake Association, SLA) have fought hard to reverse these decisions, but to no avail. I'm going to keep this letter short. We are a modest community with a beautiful asset and fearful of losing it. We no longer know where to turn in order to reverse the damage. To be include as part of the Minnesota Conservation Plan at least puts our problem on the map and hopefully includes us in future funding.

Legislative-Citizen Commission on Minnesota Resources:

MN Statewide Conservation and Preservation Plan

Public Input Forum

Forum Report

July 14, 2008,

Mankato, Minnesota

A public outreach forum was scheduled in Mankato to receive comments on the draft recommendations. This outreach forum was cancelled due to weather. It was rescheduled and held after the recommendations became final. Comments at this forum were on the final recommendations so the structure of the forum was adjusted and the recommendation reference numbers are different than those referenced previously in this Appendix.

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Minnesota Statewide Conservation and Preservation Plan

Public Forum

Mankato, Minnesota, July 14, 2008

Purpose

The forum is an opportunity to overview the MN Statewide Conservation and Preservation Plan (MSCPP) and provide input regarding its use and implementation. Specific objectives include:

1) Explain the purpose of the plan how it was developed
2) Overview the plan and recommendations
3) Seek stakeholders' questions and advice for implementing the recommendations

Agenda

5:00 pm - Forum Introduction

- Welcome and opening remarks
- Introductions and expectations
- Agenda overview

5:10 pm - Overview of the LCCMR and the MN Statewide Conservation and Preservation Plan

- Plan description
  - What is the LCCMR and its purpose for commissioning the MSCPP?
  - What were the guidelines for the plan and role of project teams in developing the plan?
  - What the plan is meant to do, not meant to do?
  - What process, timeline and roles were involved in developing the plan?

- Public forum
  - What is the goal of the forum?
  - How will the public feedback be used by the LCCMR?

5:30 pm - Briefing of the Plan and Recommendations

- Presentations by each team
- Q&A and critical issue selection following team presentations:
  - What are questions of clarity?
  - Which recommendations are most critical for your region?

6:40 pm - Break - Opportunity to view maps/displays and identify critical recommendations for the region

7:10 pm - Public Feedback Session

- Plan feedback
  - In assessing how the plan benefits the natural resources of Minnesota…
    - … what are key strengths of the plan and/or recommendations?
    - … what are main weaknesses or gaps of the plan and recommendations?
  - Implementation advice:
    - What might be potential challenges to effective plan implementation?
    - What advice do you have for using and implementing the plan?
  - Additional comments:
    - What other feedback or suggestions do you have for the LCCMR and the plan?
- Forum Wrap-Up
  - Acknowledgements
  - Review of next steps for the MSCCP

8:00 pm - Adjourn

General Suggestions for the Plan and Recommendations

A. Questions and reactions

What are questions or aspects the caught your attention?

- *Vulnerable Key Habitat by Township* map is very confusing! Should reconsider how it is portrayed or at least provide a better legend that explains it better. Actually representing "risk".
- ***Question:*** Who made the decision of what was high stress versus low stress? Was it a small group of people making subjective decisions?
  - ***Project Team Response:*** Decision was based on data sets. There may be some subjectivity in it, but it is the best data available and there was a lot of cross-checking among teams.
  - The practice listed on page 320, bottom left section could help us reduce the effects of a future "500 Year" floods (*Input Form*)

B. Strengths

In assessing how the plan/recommendations benefit the MN natural resources, what are <u>key strengths</u>?

- Practically everything is listed in a form that shows you (we) listened to well-informed people (*Input Form*)
- It's focus and attention on energy and conservation.
- Pleased to see all the references to using perennial plants as solution.
- Emphasis on preservation of agricultural land (LU5).
- Recognition that the ethanol industry is going to have negative impacts on water quality and quantity. Emphasis on cellulosic ethanol is a very important part of this plan.
- Happy to see recommendations for acquisition of land, especially of critical habitat. This is particularly important with the loss of CRP.
- Good to see some acknowledgement of the TMDL process and bringing forward an understanding of the cause-effect linkages of water quality. Stakeholder involvement in the Lake Pepin TMDL process has forced to the surface the true cause-effect of sources of impairment to streams – in-stream channel sources.
  - ***Response from audience:*** I believe that much of what is in stream channel came originally from land.
- A lot of land that went into CRP shouldn't have gone into it in the first place. Good to see that deciding what should go into it is a recommended priority.
- Good to see the focus on local ownership and tax incentives.
- Pleased to see the plan take a long-term view.
- Glad to see that land use rather than water quality is listed as a core problem. Water quality is a symptom of the problem.
- Glad to see that water ties everything together (either quality or retention), including the regions of the country. The related question is how we pass water resources between regions - e.g., how long will it be before we are sued for what is happening in the lower Mississippi?

- The plan does a good job of identifying what additional understanding regarding water to better understand landscapes. Wisconsin has a "discovery farms" program that helps people discover what needs to happen on the land. It helps them understand what happens on a farm scale.
- The plan integrates a lot of information. Trying to do it all is ambitious but how feasible is the plan?
- Importance of soil quality is acknowledged

C. Weaknesses

In assessing how the plan/recommendations benefit the MN natural resources, what are weaknesses or gaps?

- Soil quality is reflected in the plan, but it needs a better definition of what soil quality actually means. It is ambiguous as currently stated. Need to acknowledge the importance of soil productivity and that factors that affect that as well. The plan doesn't address it at all. Conserving and preserving soil productivity is a critical issue.
- The CRP recommendation emphasizes how we might do it right. However, economics has to drive this effort to conserve lands and I don't see those economic mechanisms/incentives in the plan. Also, the plan should show CRP land that never should have gone into CRP.
- Minimal stakeholder involvement is a big gap in this plan. The effort was primarily driven by an academic and agency perspective. It will be hard to carry forward without strong stakeholder involvement. For example, the sediment-loading analysis missed a lot due to the lack of broader stakeholder involvement and practitioner knowledge.
- The word acquisition is overused. Acquisition should be de-emphasized. Instead, meeting multiple state goals (economic, ecological etc.) and achieving multiple benefits on landscapes should be emphasized more strongly.
    - ***Audience follow-up response:*** Maybe we need to broaden the definition of acquisition to include acquisition of ecological services, acquisition of title, acquisition of easement. etc – a package of options.
- Most of what is talked about in this plan is dictated by Federal policy. In order to get real results on landscapes, the state needs to work with the Federal government to see any measurable changes on the land.
- In order to assure sustainable implementation by multiple generations, we need to incorporate economics, market incentives and other mechanisms that incent people to follow the recommendations. We cannot rely on voluntary stewardship alone. into these recommendations. People won't do it if the economics don't make sense.
- I am not hearing much about the reality of our assumed projections in light of the complex interaction of variables that contribute to trends. For example, projections about mileage traveled assumes that gas prices won't impact mileage. Most likely mileage traveled will go down just because gas prices are so high with subsequent spinoff effects to whole system. The plan needs to build in ways to cycle back to refine and re-assess projections.
- The social aspect of conservation is missing in some sections and did not carry through the whole plan. Things should be standard across sections. If one of the teams includes recommendations to fix something and other teams do not, the problem won't get solved in the end.
- Integration in energy and transportation section is strong. But in some other sections it wasn't as strong.

- Recreation and other social needs are not emphasized universally. E.g., In the map showing public lands by subsection, should additional land be set aside in areas where we see very little public lands? Need more integration among disciplines.
- When it comes to prioritizing in the plan, which comes out ahead, restoration of degraded areas or protection of high quality places?
- Need to empower local governments to do better planning.
- Energy section is too crop-focused and there is too much emphasis on fuel. The plan is missing consideration of solar, wind, etc. in looking at the best energy returns for resources invested.

D. Weaknesses: Continued

In assessing how the plan/recommendations benefit the MN natural resources, what are <u>weaknesses or gaps</u>?

- Plan will help LCCMR determine how to channel their funds. The plan attempts to encompass so much information. A comprehensive plan such as this is both a strength and a weakness. It is very hard to prioritize from this massive plan.
- The plan needs a better definition of soil quality. It is very ambiguous and subjective. We need to look at soil productivity more. Soil is key to necessities like food and energy. Productivity of soil needs to be protected and preserved.
- We have known these recommendations (BMP's) for a while and yet have not had the will and/or critical mass of implementation to result in enough change to be sustainable in the long-term. (*Input Form*)

E. Implementation Challenges

What are potential challenges to effective implementation of the recommendations/plan?

- Implementing the CRP lands recommendation will be difficult. How do we fairly and wisely look at what is coming out and going back into cropland? Who will make the decision as to what should come out and what shouldn't? Some should go back into cropland and some should not. How will the value be placed on crop production versus CRP?
- Data collection could be a barrier to implementation. Farmers are pretty private group. There will be discussion of what is private data and what is public data. For example, we thought we had already mapped wetlands and public drainage ditches. Getting farmers to agree to mapping private tile lines will be a challenge.
- Traditionally all these efforts are voluntary rather than regulated. Can they remain voluntary? Will voluntary efforts be enough to get the job done?
- The biggest elephant in the room is the reality that we do not have enough money to do these recommendations. We need to make it a true priority to "clean up our house" and make more money available to really change things.
- Challenge is having enough technical assistance to implement. This should be strengthened in the plan. Need more long-term technical assistance to any players who seeks to do the right thing locally, regionally and statewide. For example, who can deliver assistance for water planning efforts?

- Surprised that water planning wasn't mentioned. Real gap in plan in terms of who is going to deliver.
- A challenge is trying to get the state to work in concert. Agencies in state are often working against each other.
- Money, political support, connecting with even more people in the Minnesota legislature or Federal government. (*Input Form*)
- Societies' increasing emphasis on health care issues and other non-environmental issues in the budget. (*Input Form*)
- Aversion by elected officials to increase costs (taxes) to citizens to reflect the costs of benefits received from the environment. (*Input Form*)
- Not enough people doing the kind of work needed (education and land management) to get where we want to go. (*Input Form*)

F. Implementation Advice

What suggestions and advice or do you have for implementing and using the plan and recommendations effectively?

- Make maps as easy to read and understand as possible. They present multi-layered information that is good but not obvious to all.
- Utilize existing education program as initiatives that are ongoing in schools and communities.
- In implementing the habitat recommendation #13 regarding education, the best way to educate is through your kids. *Project Wet, Project Wild, Project GLOBE* are few of the many excellent ways to reach kids.
    - ***LCCMR member comment:*** This plan is not just for LCCMR action. The LCCMR will help channel emphases and funding statewide but all communities, entities and people are welcome to use it as a guide.
- Hopefully the committee will continue to emphasize on-the-ground activities and practices, not just research.
- On-the-ground activities are needed but I would like to emphasize the importance of continued research. I have relied greatly on research over the years to direct my agricultural practices. Research is essential and needs continued investment.
- Evaluating water usage from ethanol plants should only be done if done in correlation to what amount of water other industries use. Ethanol got a lot of attention because it was a new water use, but how bad is it relative to other industries? A cost-benefit analysis should be done comparing to other industries.
- Need to avoid equating ethanol to all renewable energy. Should not confuse the two. Renewable energy is much more than corn ethanol and, in fact, more than just ethanol. And many renewable energy sources could benefit local communities.
- Share the workload among agencies. Particularly in the area of research. The people are out there to do the work.
- In the past, LCCMR has been innovative in terms of what they have funded. It offers the opportunity for doing things that the state normally wouldn't fund. It is very important that the funding process continues to support innovation.

- This document could really help with targeting where dollars might be directed. Local resource manager could use this document to target where to direct efforts. This plan can become a tool, in and of itself.
- Coordinate requests for funding among agencies.
- Make a broad-based group of people, communities and organizations aware of resources and RFP opportunities to submit requests for grants.
- I think we need an offer to connect with stakeholders to urge them to support parts of he plan that may be a part of a political effort in the future (*Input Form*)
- Use local leadership teams to roll out the plan in all areas of the state, provide them with lots more support and funds than what currently exists today (increasing funding to water resources centers, experiment stations, environmental learning centers, citizen monitoring programs, etc.) This needs to be a long-term emphasis – 15-25 years. (*Input Form*)

Recommendations Most Critical to the Region

Participants at the forum were asked to identify the recommendations most critical to their region by placing seven dots (votes) on a wall chart showing all the recommendations. Each participant vote indicates that the topic of the recommendation is critical to their region but may not necessarily reflect complete agreement with the recommendation.

Land and Aquatic Habitat Recommendations

Recommendations	Votes
Land and Aquatic Habitat Recommendations	0
I. Land Protection	0
Habitat Recommendation 1: Protect priority land habitats	9
Habitat Recommendation 2: Protect critical shorelands of streams and lakes	3
Habitat Recommendation 2A: Acquire high-priority shorelands	0
Habitat Recommendation 2B: Protect private shorelands via economic incentives and other tools	0
Habitat Recommendation 3: Improve connectivity and access to outdoor recreation	2
II. Land and Water Restoration	0
Habitat Recommendation 4: Restore and protect shallow lakes	9
Habitat Recommendation 5: Restore land, wetland and wet-land- associated watersheds	18
Habitat Recommendation 6: Protect and restore critical in-water habitat of lakes and streams	3
Habitat Recommendation 6A: Restore habitat structure within lakes	0
Habitat Recommendation 6B: Protect and restore in-stream habitats	0
Habitat Recommendation 6C: Protect deep-water lakes with exceptional water quality	0
III. Sustainable Practice	0
Habitat Recommendation 7: Keep water on the landscape	6
Habitat Recommendation 8: Review and analyze drainage policy	4
IV. Knowledge Infrastructure	0
Habitat Recommendation 9: Overall research on land and aquatic habitats	0
Habitat Recommendation 10: Research on near-shore habitat vulnerability	0
Habitat Recommendation 11: Improve understanding of groundwater resources	7
Habitat Recommendation 12: Improve understanding of watersheds to multiple drivers of change	1
Habitat Recommendation 13: Habitat and landscape conservation education/ training programs for all citizens	3

Energy Production and Use Recommendations

Recommendations	Votes
Energy Production and Use Recommendations	4
Goal A: Promote alternative energy strategies	0
Energy Recommendation 1: Develop coordinated laws, policies, procedures for government entities to assess renewable energy production impacts on the environment	1
Energy Recommendation 2: Invest on farm and forest preservation efforts to prevent fragmentation due to development guided by productivity and environmental vulnerability research	0
Energy Recommendation 3: Invest in perennial biofuel and energy crop research and demonstration projects on a landscape scale	6
Energy Recommendation 4: Develop policies and incentives to encourage perennial crop production for biofuels in critical environmental areas	1
Energy Recommendation 5: Invest in data collection to support the assessment process	1
Energy Recommendation 6: Invest in research to determine sustainable removal rates of corn stover and to establish incentives and Best Management Practices	0
Energy Recommendation 7: Invest in research to review thermal flow maps for Minnesota	0
Energy Recommendation 8: Invest in applied research to reduce energy and water consumption and green house gas emissions in present/future ethanol plants. Enact policies to encourage conservation technology implementation	0
Energy Recommendation 9: Invest in research to determine the life cycle impacts of renewable energy production systems	0
Energy Recommendation 10: Invest in research and demonstration projects to develop, and incentives to promote, combined wind power/biomass, wind power/natural gas, and biomass/. coal firing electricity projects	5
Energy Recommendation 11: Invest in research and enact policies to protect existing native prairies from genetic contamination by buffering them with neighboring plantings of perennial energy crops	4
Energy Recommendation 12: Invest in efforts to develop sufficient seed or seedling stocks for large-scale plantings of native prairie grasses and other perennial crops	1
Goal B: Promote a healthy economy including strategies that promote local ownership of alternative energy	0
Energy Recommendation 13: Invest in research and policies regarding green payments	3
Energy Recommendation 14: Investigate opportunities to provide tax incentives for individual investors in renewable energy (e.g. individuals who wish to install solar panels)	8
Energy Recommendation 15: Invest in efforts to develop/research to support community-based energy platforms for producing electricity, transportation fuels, fertilizer, and other products that are locally/cooperatively owned	0

Goal C: Promote efforts to improve energy conservation and energy efficiency among individuals, businesses, communities and institutions	4
Energy Recommendation 16: Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power, while simultaneously increasing renewable electricity production for transportation	4
Energy Recommendation 17: Promote policies sand incentives that encourages carbon-neutral businesses, homes, communities and other institutions with an emphasis on learning from institutions already working toward this goal	0
Energy Recommendation 18: Implement policies and incentives to lower energy use of housing stock while monitoring the performance of improvements and calling on the utility industry to join the effort	0
Energy Recommendation 19: Promote policies and strategies to implement smart meter and smart grid technologies	0
Energy Recommendation 20: Develop incentives to encourage the widespread adoption of passive solar and shallow geothermal heat pump systems in new residential and commercial building constructions. Invest in research to develop improved technology for storing renewable energy	0
Energy Recommendation 21: Develop standards and incentives for energy capture from municipal sanitary and solid waste and minimize landfill options from MSW	0
Energy Recommendation 22: Invest in public education focusing on benefits and strategies for energy conservation targeted toward individual Minnesota residents and businesses	1
Goal D: Promote regulations, policies, incentives and strategies to achieve significant mercury emission reductions	0
Energy Recommendation 23: Develop mercury reduction strategies for out-of-state sources	0
Energy Recommendation 24: Continue state enforcement programs to reduce mercury loads	
Energy Recommendation 25: Develop public education on actions that individuals and communities can take to reduce mercury loads	0

Land Use Practices Recommendations

Recommendations	Vote
Land Use Practices Recommendations	0
Community Land use	0
Land use Recommendation 1: Fund and implement a State Land Use Development and Investment Guide	0
Land use Recommendation 2: Support local and regional conservation-based community planning including planning for agricultureal land	19
Land use Recommendation 3: Ensure protection of water resources in urban areas by evaluating and improving current programs	1
Agriculture Land Use	0
Land Use Recommendation 4: As much as possible, transition renewable fuel feedstocks to perennial crop	2
Land Use Recommendation 4A: Research investment	1
Land Use Recommendation 4B: Policy	0
Land Use Recommendation 5: Reduce streambank erosion through reductions in peak flows	5
Land Use Recommendation 5A: Research investment	7
Land Use Recommendation 5B: Policy	0
Land Use Recommendation 5C: Protection investment	1
Land Use Recommendation 5D: Policy	14
Land Use Recommendation 6: Reduce upland and gully erosion through soil conversation practices	0
Land Use Recommendation 6A: Protection investment	1
Land Use Recommendation 6B: Policy	1
Land Use Recommendation 7: Enable improved design and targeting of conservation through improved and timely data collection and distribution	1
Forestry Land Use	0
Land Use Recommendation 8: Protect large blocks of forested land	1
Land Use Recommendation 9: Assess tools for forest land protection	0
Land Use Recommendation 10: Support and expand sustainable practices on working forest land	1
Transportation	
Transportation Recommendation 1: Align transportation planning across state agencies and integrate transportation project development and review across the state, regional, metropolitan and county/local transportation, land use and conservation programs.	3
Transportation Recommendation 2: Reduce pre capita vehicle miles of travel (VMT), through compact, mixed use development and multi-and intermodal transportation systems	1
Transportation Recommendation 3: Develop and implement sustainable transportation, research, design, planning, construction practices, regulations, and competitive incentive funding that minimizes impacts of natural resources, especially habitat fragmentation and non-point sources water pollution	0

Appendix VIII

Sources

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Strategic Framework

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Appendix IX

Short Descriptions of Recommendations

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Habitat Recommendations

Land Protection

Habitat Recommendation 1: Protect priority land habitats

LP

Description of recommended action. The SCPP has identified many critical land habitats throughout the state based on an integrated approach that considers such issues as SGCN, outdoor recreation such as hunting and fishing, protection of water quality, and threats to these resources (Figure H7). Critical land habitats were identified through a combination of existing government, UM, and selected private data sets. These data sets were spatially explicit and, with rare exception, statewide (Table H1). The criteria for critical habitat identification were developed by a group of public and private stakeholders and optimized to provide the most benefit to the most constituents.

These areas have been prioritized for conservation and preservation. A variety of public and private mechanisms are available to protect these areas, including acquisition, conservation easements, and restoration/remediation of impacted habitats. Public education will play an important role in protecting priority land habitats, and coordination among public, nonprofit, and private entities to protect critical habitats will be increasingly paramount.

The SCPP outlines important land habitats that benefit wildlife, fish, water quality, and outdoor recreation in the context of threats to these important natural resources. The SCPP allows considerable flexibility for conservation of lands and appropriate protection of economic activity such as logging or other compatible uses. Conservation and protection of these land areas will require multiple mechanisms and a coordinated effort among local, county, regional, state, and national public agencies; nonprofits; and private entities. Of particular importance are rare land features and areas such as native prairie and savanna that have been converted to other land uses. This is among the reasons that SOBS received a relatively high weight in the integrated analysis (Table H1).

The state must further strengthen its leadership to coordinate and stimulate efforts for the protection of these critical land areas among current and potential partners. This activity would include identification of relevant landowners; identification of the most cost-effective measures for protection, restoration, and education on the importance of the area; and development of a comprehensive plan to ensure the economic, environmental, and social benefits of protection.

The integrated mapping analyses provide a basis for and opportunity to develop regionally specific strategies for conservation and preservation of Minnesota's critical habitats, using the suite of policy and incentive options from voluntary implementation of BMPs to permanent land acquisition. Implicit within this recommendation is continued support for ongoing programs such as acquisition of the 54,000 acres of private land within state parks. Acquisition of these lands should remain a high priority because they reduce fragmentation and help to maintain large, intact ecosystems.

Habitat Recommendation 2: Protect critical shorelands of streams and lakes **L P**

Description of recommended action. A holistic approach is needed for shoreline protection that integrates acquisition with diverse private-land protection strategies such as conservation tax credits, trading of conservation tax credits, BMPs, shoreland regulations and incentives, zoning ordinances, conservation development, and technical guidance for shoreland owners. Fully funded acquisition programs are essential, but not sufficient to protect large enough areas of shoreland to ensure water quality and habitat protection, and thus sustain healthy lake, river, and stream ecosystems. It is doubly important to protect these aquatic habitats at a large scale to make them more resilient to the significant warming and altered precipitation projected for Minnesota over the next century (Appendix IV). Therefore, the state needs a diversity of economic incentives and other tools for private landowners.

2A. Acquire high-priority shorelands

The highest priority shorelands within each of Minnesota's 22 ecological subsections should be permanently protected through acquisition. This is one essential component of a multistrategy approach to preserving the clean water legacy that Minnesota's citizens and visitors are used to experiencing. Acquisition may protect critical shoreland habitats from degradation; assure public access for fishing, hunting, wildlife viewing, and natural resource management, which is especially important given the continuing loss of access to natural shores; and provide areas for education and research. Suggestions for prioritizing shoreland acquisition appear in several recent reports, including DNR's 2008 aquatic management area (AMA) acquisition plan, the DNR long-range duck recovery plan, and a 2008 report identifying lake conservation priorities for The Nature Conservancy (TNC).

2B. Protect private shorelands via economic incentives and other tools

Minnesota should greatly increase the use of economic incentives and other tools for private landowners to protect shorelines and other sensitive land along lakes, especially along shallow lakes and shallow bays of deep lakes, and streams and rivers throughout Minnesota. This is also needed for riparian buffers around sinkholes in agricultural lands in southeastern Minnesota (see further discussion under habitat recommendation 7).

Protection of private shorelands should combine various tools, such as tax credits, conservation easements for shoreland protection and restoration, BMPs, technical guidance to shoreland owners, shoreland regulations, and zoning ordinances. It is especially important to scale up and combine these tools, for example, by providing technical guidance to landowners on how to implement BMPs on shorelands put under a tradeable conservation tax credit.

Tax credits could dramatically catalyze private shoreland protection. The idea is to provide state income tax credit for conservation easements. In their simplest form, conservation tax credits are applied to perpetual conservation easements or donations of fee-title land. Perpetual conservation easements could be donated to the state or legal land trusts. A further innovation is to allow trade of conservation tax credits among taxpayers: Landowners with

low state tax liability could sell their credits to landowners with higher tax liability, thereby giving landowners with low tax liability an incentive to become interested in making land conservation donations. Although conservation tax credits were initially conceived as a protection strategy for shallow lake habitats in agricultural areas, this approach could expand to protecting a broader array of shorelands (streams, rivers, lakes, wetlands) throughout the state.

Habitat Recommendation 3: Improve connectivity and access to outdoor recreation **L P**

Outdoor recreation was not one of the three focal issues chosen for the final SCPP; however, the State Comprehensive Outdoor Recreation Plan (SCORP) has already provided a comprehensive plan and the SCPP preliminary plan provided recommendations for research to support quality outdoor recreation in the future (see Appendix I). To complement these recommendations, the habitat team offers an additional recommendation regarding the important connection between habitat conservation and recreation and considering the distribution of historical and cultural resources in the state.

Description of recommended action. Land use patterns are changing in Minnesota. Lakeshore development is increasing, urban areas are expanding, and forests are being divided into small, privately owned parcels. These changes and others are affecting outdoor recreation. Land needs to be acquired, protected, and restored to provide Minnesotans and visitors an outdoor system where they can recreate.

Action should be taken to improve connectivity of and access to outdoor recreation areas (parks, natural areas, wildlife management areas, etc., Figure H30) and document the connectivity and experience opportunities through a statewide recreation system. Such connectivity would require enhancing connections among state, federal, and local government lands and facilities. Prioritization for acquisition, protection, and restoration of the natural resource base that supports outdoor recreation should focus on large, contiguous land areas suitable for: natural resource–based outdoor recreation; shorelands; threatened habitat areas with opportunities to improve connectivity of underserved areas; and rapidly growing areas or areas where land use changes may limit future outdoor recreation opportunities.

The trends in recreational use and changes in land use patterns all support this recommendation. These primary drivers include land use conversion patterns and changes in population demographics in areas such as the Twin Cities metropolitan area and locations with lakes, rivers, and forests. Participation in hunting and fishing continues to decline, while nonconsumptive activities such as wildlife watching and hiking remain stable or are growing. Increasing human population is projected to lead to an estimated rise in state park visitors, from 8.6 million in 1998 to 9.2 million by 2025. If energy costs continue to increase, there will be a growing demand for outdoor opportunities that limit the need to travel great distances for recreation.

Habitat Recommendation 4: Restore and protect shallow lakes **R P**

Description of recommended action. Minnesota should accelerate efforts to restore and improve shallow-lake habitat (including shallow bays of deep lakes) in priority watersheds in order to reduce the number of lakes in a turbid-water state, and to restore some of the 1,000-plus drained shallow lakes in the state. Active management of Swan, Christina, and Thief Lakes shows that many shallow lakes with poor water quality and little habitat can be restored through active management.

Sensitive shallow lakes frequently winterkill (fish); are subject to mixing from wind, surface use, and large fish (carp); and typically exist in either a turbid- or clear-water state. Unfortunately, most shallow lakes in the prairie and forest-prairie transi-

tion zones of Minnesota are in the turbid-water state. This is due to the combination of increased flows of water and nutrients into them from intensively drained and cultivated landscapes that surround them, and abundant populations of invasive fish (e.g., carp and black bullhead) that result from increased connectivity (i.e., ditches) and persist due to lack of natural winterkill. Some shallow lakes are so turbid that they are listed as impaired by the MPCA. Dense human housing development and inappropriate surface uses are also increasing threats to shallow lakes.

Funding is needed to purchase conservation easements around shallow lakes to restore their lakesheds (small wetlands and grass buffers) and prevent development. Funding is also needed to install fish barriers to keep out invasive species such as carp. Finally, funding is needed for water control structures that state agency managers can use to conduct temporary drawdowns to consolidate and aerate sediments, induce natural winterkill of fish, and rejuvenate aquatic plants. The level of development and management of the landscapes around shallow lakes necessitates active in-lake management in order to maintain water quality and good habitat.

Habitat Recommendation 5: Restore land, wetlands, and wetland-associated watersheds **R P**

Description of recommended action. Minnesota must invest in prioritized areas to restore degraded and rare land features, wetlands (especially many that have been drained and converted), and watersheds associated with wetlands. This will provide benefits for wildlife, SGCN, water quality, and important ecological processes. This is especially imperative in the prairie and prairie-forest transition zones of the state. Restoration should consider the need to encourage landowners to restore these lands and compensate them above and beyond the fair market value of the land, since most sites are not for sale and high crop prices inhibit conversion of land from agriculture to other uses. Consideration must also be given to using easements on private lands to achieve habitat restoration goals. It is imperative to recognize the huge loss of native prairie and small wetlands in the prairie region of Minnesota (99% and 90%, respectively). Wildlife does not require restored lands to be in public ownership to benefit from them as critical habitat. Restoration, however, is not only needed in the prairie regions, though it is of high priority there. Other land uses such as savanna and forests are also in need of attention. For instance, riparian forests need restoring, and regeneration of oak, white cedar, and white pine requires attention. Similarly, restoration of wetlands alone cannot restore their appropriate structure and function; restoration efforts must also consider the watersheds that drain into wetlands.

Habitat Recommendation 6: Protect and restore critical in-water habitat of lakes and streams **R P**

Description of recommended action. Accelerate and expand the relatively small current efforts to restore critical habitat for aquatic communities in near-shore areas of lakes, in-stream areas of rivers and streams, and deep-water lakes with exceptional water quality.

6A. Restore habitat structure within lakes

We recommend developing a program to restore the natural features of lakeshore habitats (shoreland, shoreline, and near-shore areas). The program would add woody habitat where it has been removed, and restore emergent and floating vegetation where it has been lost. The program would also work with lake-home owners and lake associations to achieve restoration goals.

Increasing development pressure along lakeshores has negative impacts on these species and water quality—and Minnesota's lakeshores are being developed at a rapid rate. The shallow areas in large lakes are crucial to fish, wildlife, and water quality.

An estimated 20% to 28% of the near-shore emergent and floating-leaf coverage has been lost due to development in bass and walleye lakes. On average, there is a 66% reduction in aquatic vegetation coverage with shoreland development. These declines in aquatic vegetation coincide with lower fish production and reduced water quality in lakes. Woody habitat losses are also occurring in Minnesota lakes but have not been quantified. Many fish depend on aquatic vegetation, woody habitat, and shorelines to provide spawning habitat, cover, and refuge from predators. Downed trees provide important in-lake structure, habitat, food, and shelter for fishes, frogs, turtles, water birds, and mammals. This woody habitat is also important for aquatic invertebrates such as snails and bryozoans. Turtles need to bask on deadfalls or floating logs. Near-shore downed trees also blunt waves and ice action that scour the lake bed. Because trees often grow slowly and their density has been reduced due to past shoreline alterations, this important habitat element in Minnesota lakes may not be replenished without substantial efforts.

6B. Protect and restore in-stream habitats

A priority for rivers, particularly the Mississippi River, is to reduce the negative effects of recreational boat traffic, especially from medium to large cruisers, on sensitive shoreline habitats. Stream-bank erosion from recreational boat wakes adds large sediment loads, which increases water turbidity and disrupts the growth of beneficial aquatic plants and reproduction of native mussels and some fish. Other habitat impacts include breakage of aquatic plants; impingement and various disturbances of fish and wildlife; and dislodging of woody debris that normally provides important cover and food production for fish, as well as habitat structure for turtles and birds. Systemic solutions include enforcing no-wake zones or no-wake periods in sensitive habitats, which requires revision of local, state, or federal surface water use regulations; and design of more river-friendly boats, which requires engineering research and development. Past education efforts and voluntary no-wake zones have not worked.

A priority for former prairie zones of Minnesota is to reverse the negative effects of stream channelization on in-stream habitats for fish and other aquatic organisms. Channelization has changed the hydrology of streams, which has then made them wider and more deeply incised. In many locations, negative effects of stream channelization have been exacerbated by removal of riparian vegetation and wetlands, and altered upland land use. Several approaches can be implemented to protect and restore in-stream habitats. Riparian vegetation can be restored to stabilize stream banks (several state and federal programs, such as RIM, CRP, CREP and CSP, can provide financial assistance). Two-stage channels (Figures H33 and H34) can be constructed where streams have been channelized to provide a flood plain to dissipate stream energy and allow the channel to remeander, which will provide more diverse habitat for aquatic organisms. Restoring wetlands and altering upland vegetation (state and federal programs provide financial assistance) will hold water on the landscape or allow for increased infiltration, both of which can help mitigate the altered hydrology of streams.

Minnesota has hundreds of low-head dams and culverts that restrict movement of aquatic organisms. Inappropriately sized culverts also may contribute to localized flooding. Removal of dams and installing culverts with increased capacity would improve connectivity of aquatic systems. An alternative approach to removal of low-head dams is to provide for fish passage through the dam (e.g., recent construction providing passage for lake sturgeon in the Wild Rice River). Opportunities to remove higher dams or alter them to provide fish passage should also be explored.

6C. Protect deep-water lakes with exceptional water quality

Clear lakes with large, oxygen-rich deep-water zones provide critical habitat for native cold-water fish such as cisco, lake whitefish, and lake trout in

Minnesota. In the summer, lakes stratify into three layers; an uppermost epilimnion, which is warmest and oxygen poor; a middle thermocline; and the lowest hypolimnion, which is coldest and oxygen rich. During warm summers, cold-water fish find refuge in the cold hypolimnion if it has sufficient oxygen. Only lakes with the most exceptional water quality maintain enough oxygen in the hypolimnion for cold-water fish to thrive. Climate warming and poor land use in Minnesota pose imminent threats to oxygen levels in these deep-water zones. First, increased duration of stratification from climate warming decreases their oxygen content late in the summer. Second, oxygen concentrations are reduced by poor land use when decaying organic matter from algae and plants, stimulated by high nutrient loading, consumes oxygen in deep water. Both of these threats have the potential to severely limit habitat for cold-water fish in Minnesota.

Deep lakes with exceptional water quality will represent important sanctuaries for cold-water fish as the climate warms in Minnesota. However, future deterioration of water quality would greatly jeopardize the ability of these lakes to provide that refuge. These potential refuge lakes are being identified by the DNR and the UM. Many of these lakes are the "crown jewels" of Minnesota and deserve special status in addition to their value as refuges from climate change. Examples include Ten Mile Lake in Cass County, Big Trout Lake in Crow Wing County, Big Sand Lake in Hubbard County, and Trout and Wabana Lakes in Itasca County. Also, these types of lakes are not completely limited to forested ecoregions. Big Watab Lake, located in agricultural Stearns County, and Square Lake, located in the Twin Cities metropolitan area, also represent lakes with excellent oxygen resources in the hypolimnion.

Once identified, lake watershed protection efforts should be initiated with a special commitment. These protection efforts could include land purchase, easement protection, and BMP implementation. Many are already "high-profile" lakes with active and dedicated lake associations and local users. Implementation of high-intensity watershed and shoreland protection efforts would largely be welcomed. Protection of these lakes may actually be cost effective (high value for modest investment). Many are characterized by small, forested watersheds and protection efforts can be targeted at relatively few parcels with great cost efficiency.

Sustainable Practice

Habitat Recommendation 7: Keep water on the landscape **SP**

Description of recommended action. Retaining water on the landscape over broader areas and for longer periods is critical for improving water quality, reducing flooding, maintaining habitat for wildlife and game species, and enhancing biological diversity. The intent of this recommendation is to have water move more slowly across and through the landscape to return to more natural conditions. This need is acute in agricultural and urban landscapes of Minnesota. We suggest three strategies that complement other landscape-focused recommendations in this plan:

- Perennial vegetation
- Storm water controls
- Riparian buffers

Habitat Recommendation 8: Review and analyze drainage policy **SP**

Description of recommended action. The state should invest in a comprehensive review and analysis of laws relating to drainage, including Minnesota Statutes Chapter 103E, and recommend changes to the legislature that would remove barriers and facilitate the restoration of critical wetlands in order to improve water quality and aquatic habitats.

Knowledge Infrastructure

Habitat Recommendation 9: Overall research on land and aquatic habitats

LP

Description of recommended action. The SCPP has developed and implemented a mechanism to integrate a portfolio of spatial data layers summarizing important natural resources and environmental threats in Minnesota. These data layers quantify the loss of native biodiversity, distribution of important outdoor resources (e.g., fish and wildlife populations), impairments to aquatic resources, degradation of critical ecological processes (e.g., nutrient cycling, predator-prey interactions), and locations of biologically significant and large, intact natural ecosystems. The spatial data layers were also examined in relation to where housing development was most likely to occur in the future, locations of road networks, current and future agricultural-bioenergy activity, and land ownership (Figures H2–H16).

Research is essential to improve understanding of the risk of extinction of Minnesota's native biological diversity; continuing availability of quality outdoor recreation; and confidence in the ability to protect aquatic resources in the face of risks such as climate change, invasive species, and expanding human population. Information on important historical and cultural resources should also be researched and incorporated into decision making on conservation, protection, or restoration efforts.

The state of Minnesota should continue to appropriate funds for improving understanding of fish and wildlife populations, native biological diversity, and water quality, and mitigating the stressors that affect them.

Habitat Recommendation 10: Research on near-shore habitat vulnerability

RP

Description of recommended action. There is a need to increase understanding of near-shore habitat vulnerability. This would be best accomplished through research on the human behaviors that degrade and destroy near-shore habitat, as well as pilot policies or programs that preserve or restore near-shore fish and wildlife habitat. Research can also address historic and cultural resources associated with near-shore habitat.

Habitat Recommendation 11: Improve understanding of ground water resources

RP

Description of recommended action. Ground water is an indispensable natural resource for human activities and human health. Partly because ground water is a hidden resource, Minnesota has not yet adequately answered critical questions about it. We need to understand how much ground water we have, where we can find it, its quality, how it moves, where it is recharged, where it discharges, and how much we can safely tap, both seasonally and long term.

The state needs to make a major, sustained investment in the collection and assessment of information about ground water and its connection to surface waters. We need to fill information gaps at the site-specific scale and the scale of entire hydrologic systems, including aquifers and watersheds. Given the relatively complex hydrology in our state, Minnesota may be decades away from acquiring sufficient information to inform site-specific decisions about ground-water usage throughout the state. Filling critical information gaps at both scales is essential for achieving sustainable management of ground water that meets the needs of humans and habitats.

The overall goal of this recommendation is to develop a large-scale, hydrologic-system framework for understanding how today's decisions may affect

tomorrow's needs. This systems approach will offer insights into the more strategic questions that are beyond the reach of the current site-by-site focus of decision-making for ground-water use. A systems approach will make it possible to answer questions about (1) how much water can be committed to human activities without adversely affecting ecosystems, (2) how much growth a specific region can sustain based upon its water budget, and (3) how land use changes and climate change may shift the whole equation.

Habitat Recommendation 12: Improve understanding of watersheds' response to multiple drivers of change **R P**

Description of recommended action. Effective water quality protection and restoration will require additional monitoring, research, and evaluation of aquatic and land responses to land use, climate, and other changes. While much is known within various spatial and temporal scales, interactions and responses across scales are not well understood. Research is needed to build the capacity of resource managers to understand and evaluate the multitude of factors that affect these resources across the state.

To accomplish this recommendation, investment is needed for research across many watershed scales to improve understanding of pollutants, pollution sources, movement across the watershed (e.g., hydrology), and physical, chemical, and biological responses. There have been significant advances in monitoring methods and technologies, plus increased funding (e.g., through the Clean Water Legacy Act). The use of biological monitoring has become better integrated with water quality. The next step to achieve a better understanding of watershed systems and an assessment of their health is to gain a more holistic and comprehensive understanding of how a water body and its watershed function. This would result in more effective protection, restoration, and conservation for both land and aquatic habitats.

A formal physical watershed evaluation monitoring effort is also needed to assess habitat and underlying geomorphic conditions as a component of Clean Water Legacy monitoring and assessment activities. Greater use of geographic information system (GIS) data layers and analysis tools is essential as data layers become more detailed and analytical techniques improve. The DNR Watershed Assessment Tool should be improved to enable the identification of priority habitat investment areas. Use of tools such as the U.S. Environmental Protection Agency (USEPA) Watershed Assessment of River Stability and Sediment Supply (WARSSS) procedures should be supported for developing and completing physical channel, bank, and watershed condition monitoring and evaluation.

The state lacks the basic information needed to understand how multiple drivers of change affect Minnesota's watersheds. The state should conduct a rapid assessment to gather baseline information on the physical, biological, and chemical conditions of streams important to understanding these effects.

Attention is also needed in the evaluation of the potential impacts of climate change on land and aquatic habitats. State-level studies are needed to improve projections of how climate change will alter habitats, the distributions of species, and the stressors that affect both. Studies are also needed to inform strategies that will support adaptation of biodiversity to a changed climate (see Appendix IV).

Habitat Recommendation 13: Habitat and landscape conservation and training programs for all citizens **R P**

Description of recommended action. The state should invest in education to improve public understanding of the need for better conservation, protection, and restoration of Minnesota's habitats and landscapes. Expanded education, information, and training efforts are needed to bring focus to the complexity of land, water, and land-water interactions in

a landscape context. These efforts must be directed to all citizens from K–12 educational levels to higher education, and the general public. A broad range of teaching and information sharing materials has been developed. Means of delivering the materials, goals for communicating them, and ways to measure success need yet to be developed.

As people have migrated to cities over the past 50 years, awareness of natural resources has declined. To attain a more informed constituency, whether as interested citizens or as professionals doing natural resources work, investment is needed. Technical information and transfer of that information is needed for people to grow an awareness of natural resources, and appreciation for monitoring, assessment, and data evaluation.

Land Use Recommendations

Community Land Use

Land Use Recommendation 1: Fund and implement a state land use, development, and investment guide IP

Description of recommended action. The state spends billions of dollars each year on infrastructure, local government and business assistance, and regulation in order to safeguard the environment, help business and communities thrive, and improve the quality of life in Minnesota. However, there is no system or guide in place to provide an overview of how these funds are spent across agencies, to track how these dollars come together on the land and in communities, and to determine whether investments in one sector put those in another at risk.

In addition, while most land use decisions are made at the local level, state-level vision and leadership are needed on many natural resource issues. The state needs to clearly define its interests and use its resources to engage others in securing those interests for the long term. Therefore the preparation and implementation of a state land use, development, and investment guide should be funded. The guide would provide a way to define, quantify, and unify state goals and investment objectives across social, economic and environmental sectors. It would offer the opportunity to reconcile conflicting goals and preserve Minnesota's natural resources. This is more important than ever, given the intense competition for land and resources and the chronic scarcity of state funds coupled with the uncertainties introduced by climate change.

Land Use Recommendation 2: Support local and regional conservation-based community planning IP

Description of recommended action. The objective of this recommendation is to promote land use planning that advances the permanent protection and restoration of Minnesota's natural resources, important agricultural areas, and open space by supporting conservation-based planning in local and regional communities. The recommendation contains four elements:

- Demonstration (pilot projects)
- Incentives
- Tools and technical assistance
- Investment in base data

This strategy builds on the broader vision, goals, and criteria established under land use recommendation 1—the state land use, development, and investment guide—and refines it for local and regional use. Local governments and conservation organizations can be key agents in implementing the SCPP and local stewardship significantly expands the state's capacity to protect and restore natural areas. Supporting local and regional communities in conservation-based planning will help communities establish long-term goals that are consistent with the state's goals, and allow communities to implement those goals as development occurs.

In order to support conservation-based planning in local and regional communities, four elements are needed: Demonstration, incentives, tools and technical assistance, and base data. The following subrecommendations describe each of these elements.

2A. Demonstrate conservation-based planning through pilot projects

Pilot projects that embody all the elements of good conservation-based planning, as outlined above, would help create an understanding among local and regional communities of the processes involved, identify barriers, and demonstrate benefits. The projects would also generate feedback on adapting strategies for optimal function and effect. Different approaches may be appropriate in different parts of the state, depending on the issues of concern to a particular community or region. Therefore, funding for three types of pilot projects is recommended.

- Conservation-based planning in a variety of local communities
- Conservation-based planning along a rapidly developing transportation corridor (involving multiple communities)
- Conservation-based planning resulting in an AUAR-certified comprehensive plan

2B. Provide incentives to local governments and conservation organizations for conservation-based planning

Recent trends in decreasing federal and state natural area grant programs and decreases in general state aid to local governments have undermined local planning and stewardship capacity, even as growth pressures on natural resources have increased. Financial incentives are needed to engage local partners in planning and implementation that meets local and statewide conservation goals.

- Provide financial assistance to communities to undertake conservation-based planning
- Provide financial assistance to communities to support implementation of conservation-based plans

2C. Provide tools and technical assistance for conservation-based planning

To develop conservation-based plans, communities must have access to appropriate tools and technical assistance. These include:

- Carbon calculator for communities
- Improve agricultural land preservation tools
- Develop and deliver outreach materials
- Establish a Minnesota natural resources and development partnership
- Invest in building state assistance capabilities

2D. Invest in generating base data and information necessary to support conservation-based planning

Accurate information about the type and quality of natural resources is essential for making sound planning decisions. Improved planning that uses land cover and other types of natural resources information can identify areas in need of restoration, areas for protection, areas for landscape connectivity, and areas more suitable to development that minimize or avoid environmental degradation and loss. Nearly all of these proposed land use recommendations require accurate, reliable, and standardized information about the type, location, and quality of existing resources as well as an understanding of general land cover type. However, this information is currently severely lacking in the majority of the state, particularly in critical areas.

- Develop appropriate MLCCS data in areas vulnerable to near-term development or conversion of land cover
- Update statewide land-cover databases and remote sensing capabilities

Land Use Recommendation 3: Ensure protection of water resources in urban areas by evaluating and improving current programs IP

Description of recommended action. Changes to surface water runoff due to new development and redevelopment have significant impacts on most of the major drivers of change of Minnesota's natural resources. The state of Minnesota has a set of powerful surface water regulatory programs that are largely directed at controlling land use change and development practices to improve and protect water quality. These programs are supported and driven by federal and state statutes and rules, and include:

- Impaired waters and Total Maximum Daily Loads (TMDLs)
- National Pollutant Discharge Elimination System (NPDES) storm-water permitting
  - Municipal separate storm sewer systems (MS4)
  - Construction sites
  - Industrial sites
- Nondegradation for all waters
- Shoreland management

3A. Credit system for storm-water and LID BMPs

For a limited number of storm-water BMPs, such as storm-water National Urban Runoff Program (NURP) ponds, a strong system of credits is integrated into the storm-water regulatory framework at multiple levels. This system of credits needs to be extended to a much wider range of BMPs, including low-impact development (LID) practices, conservation design, and nonstructural BMPs.

NURP developed a system that was very effective in supporting the design and installation of storm-water ponds.

The result of this effort was the universal adoption and acceptance of storm-water ponds across all sectors. Designers working on projects could use the design guidelines to include storm-water ponds in their projects in order to meet permit and design standards from multiple reviewing and approving government entities.

This system needs to be extended to a wide range of relatively new BMPs. Many of the design standards are currently incorporated into the Minnesota Stormwater Manual. What is missing is a credit system for implementing the BMPs. A well-defined and strongly-supported credit system is needed to motivate developers, builders, and local government units (LGUs) to include these practices in their projects.

This credit system must apply to multiple levels of the landscape. In a manner similar to NURP ponds, the credit system should apply to individual sites and construction projects. The credit system should also function at the regional and statewide levels. The Lake Pepin TMDL, for example, will probably call for a significant phosphorus reduction across the 60% of the lake's watershed in Minnesota. An effective credit system should function at this level to enable cities to determine whether their storm-water BMP programs are sufficient to meet the waste load allocation from the TMDL.

3B. Simple modeling protocols for TMDL compliance

TMDL studies produce waste-load allocations and load allocations for pollutants. These allocations result in a responsibility for implementation of restoration measures by cities, other LGUs, and other landowners. In the case of municipal wastewater treatment plants and cities covered under the NPDES MS4 storm-water program, these responsibilities take the form of permit requirements.

This simple modeling system would consist of a load estimating model based on land use and loading rates combined with a total load reduction model based on load removal rates and volume reduction rates appropriate for a wide range of BMP systems. This simple model could be used by all cities

and other landowners with relatively low technical knowledge and manageable input requirements.

3C. TMDL BMP implementation monitoring

Draft and implement a program of detailed BMP monitoring in selected representative watersheds with TMDL studies and implementation plans. In addition to monitoring the water body itself, this program would involve monitoring throughout the watershed to determine the effectiveness of BMP systems implemented by various entities and types of entities (agriculture, silviculture, cities, storm-water, wastewater, etc). It would also involve detailed in-stream or in-lake monitoring to better understand processes in the water bodies themselves, as well as contributions from the landscape and municipal infrastructure.

This monitoring program may include some BMP implementation monitoring – simply counting and documenting the extent of the implementation of BMP systems across the landscape. The main focus, though, will be water-quality monitoring to directly measure the impact and effectiveness of BMPs by measuring water-quality parameters at discharge points and in water bodies near or adjacent to the BMP systems.

This scale of monitoring would provide an important accountability framework for all parties involved in implementing BMPs and meeting water-quality standards (cities, watershed organizations, agriculture, etc.). This type of monitoring program has also been referred to as "sentinel watershed" or "representative watershed" monitoring.

The equipment to perform this monitoring, if purchased using state funds, should be owned by the state. This will significantly expand the state's monitoring capacity.

3D. Water quality media campaign

Further develop and expand the reach of Minnesota Water—Let's Keep It Clean!, a storm-water pollution prevention campaign produced by a coalition of cities, nonprofits, agencies, watersheds, and others working to develop pollution prevention resources for the Twin Cities metropolitan area.

This campaign is designed to enhance public education and awareness of storm-water pollution prevention strategies by disseminating messages in mass media and providing educational materials for educators and municipal staff through the www.cleanwatermn.org Web site.

Agricultural Land Use

Land Use Recommendation 4: As much as possible, transition renewable fuel feedstocks to perennial crops **S P**

Perennial species protect the soil from erosion throughout the year and reduce the volume of early-season water runoff (related to stream-bank erosion) because of a longer annual duration of evapotranspiration and increased infiltration. Additionally, the use of perennial cellulosic crops as feedstock for biofuels can significantly reduce life-cycle GHG emissions relative to grain-based ethanol production systems. Because an appropriate selection of perennials is less sensitive to risks such as temporary flooding and drought, and presents less risk of erosion and nutrient runoff, it can complement annual food and feed crops by occupying the more vulnerable land areas, stabilizing incomes and protecting the environment.

Conservation and protection of water quality and soils are strongly influenced by land cover. Perennial species protect the soil from erosion throughout the year and reduce the volume of water runoff (related to stream-bank erosion) because of a longer annual duration of evapotranspiration and increased infiltration. Additionally, the use of perennial crops as

feedstock for biofuels can significantly reduce life-cycle GHG emissions relative to grain-based ethanol production systems.

4A. Invest in research on parameters that control successful perennial feedstocks

Description of recommended action. Invest in research to determine ecoregion and site-specific suitability and management of perennial species for use as feedstock for biofuels and other products. Minnesota agro-ecoregions (Figure L9) differ significantly in suitability for perennial species that can serve as feedstocks for biofuels and other products. Growing season length and temperature, precipitation, and soil characteristics are important determinants of species suitability. Research is necessary to help producers select site-specific perennial species for use as cellulosic feedstocks.

4B. Investigate policy changes on fuel feedstock transition

Description of recommended action. Investigate, analyze, and adopt policy that will gradually transition biofuel feedstocks produced for the Minnesota ethanol mandate to perennial crops. The transition should be matched to availability of processing technology and requirements for infrastructure development.

Land Use Recommendation 5: Reduce stream-bank erosion through reductions in peak flows **R P**

Reductions in peak and total flows by modification of drainage systems, and constructing and restoring wetlands and riparian areas in strategic locations, will reduce attendant stream-bank and near-channel erosion, a major source of sediment in the Minnesota River basin. While agricultural drainage is necessary, research-based modifications such as shallower tile placement can reduce downstream impacts. With placement guided by more accurate digital elevation data, strategically located water storage would lessen the impact of both surface and subsurface drainage systems on stream channels and reduce nutrients in water. Some water storage areas could be occupied by biomass crops not sensitive to temporary flooding.

5A. Invest in research that quantifies the relationship between artificial drainage and stream flows

Description of recommended action. Invest in research to determine the quantitative relationship among trends in precipitation, artificial drainage systems, and stream hydrology.

Determination of the quantitative relationship among trends in precipitation, artificial drainage systems, land cover, and stream hydrology would allow more precise targeting of mitigation strategies, since the relationships are complex and strategies will be site specific.

5B. Investigate policy changes for goals for peak flow reductions

Description of recommended action. Set research-based goals for peak-flow reductions through hydrologic detention, wetland and riparian zone restoration, and other measures.

5C. Invest in targeted water detention

Description of recommended action. Invest in strategically targeted programs for reduction of peak flows through increased water detention in agricultural drainage systems, including wetland construction and restoration, in-ditch storage, and conservation drainage.

Targeted drainage water detention will reduce peak flows and attendant stream-bank erosion. It will also reduce sediment and nutrient contributions from uplands through sediment deposition and denitrification. Hydrologic detention measures should

complement programs and policies to reduce flows through more perennial crops and buffers.

5D. Investigate policy changes for peak flow reduction

Description of recommended action. Investigate, analyze, and adopt science-based policy that strengthens mitigation of peak flows from artificial drainage systems.

Land Use Recommendation 6: Reduce upland and gully erosion through soil conservation practices **R P**

Education, targeted incentives, and practice-flexible, outcome-based soil and water conservation plans where needed would reduce soil erosion from fields and areas of concentrated flows. The result would be reduced sediment and phosphorus delivery to water and protection of soil productivity. Certified crop consultants already deliver conservation-related services (nutrient and pest management) and can provide other field-based services in support of soil conservation to augment services provided by the USDA, NRCS and Soil and Water Conservation Districts (SWCDs).

Soil erosion from sloping fields, especially those near unbuffered streams, is a significant source of sediment and associated phosphorus. Current federal Farm Bill and energy policies and incentives are increasing row-crop production (Figure L8), especially on the sloping soils of southeastern Minnesota, where a high proportion of land has been in pasture and perennial crops. The increased width of tillage, planting, and spraying implements makes maintenance of erosion-control structures such as terraces and grassed waterways more difficult and less likely. The increased prevalence of corn following corn for ethanol production increases the prevalence of intense tillage to reduce crop-residue effects on corn early growth and yields. The percentage of cropland operated by renters, many of them with short-term leases and cash rents, exceeds 40% (2002 Census of Agriculture), lessening the incentive for long-term soil stewardship. Reductions in upland and gully erosion will require stronger incentives and standards for soil conservation if the trends above continue.

6A. Invest in soil conservation practices

Description of recommended action. Invest in education and incentive programs, leveraging federal, state, and local resources when possible, that target landowners in critical sediment source areas.

Landscape areas differ in potential to deliver sediment and nutrients to water, based on proximity, slope, and other factors. Education and incentive programs that target high-contributing areas will achieve more mitigation per dollar invested than nontargeted programs (Figure L5).

6B. Investigate policy changes to reduce upland and gulley erosion

Description of recommended action. Investigate the feasibility of developing or amending policy, such as water quality rules, to phase in outcome-driven, practice-flexible soil and water conservation plans for all farms with potential to deliver sediment and nutrients to water bodies. The phase-in priority could begin with farms in watersheds with sediment and phosphorus-related impairments.

Land Use Recommendation 7: Enable improved design and targeting of conservation through improved and timely data collection and distribution **S P**

Determination of sediment source areas, targeting of conservation practices, determination of effectiveness of practices, and installation of conservation structures all require adequate resource data. These include high-resolution digital elevation data, land cover, crop residue coverage, and conservation practice effectiveness monitoring.

7A. Invest in data collection

Description of recommended action. Invest in the following basic information to support soil and water protection:

- Statewide high-resolution digital elevation data (LIDAR) and associated high-resolution watershed delineation
- Statewide updated land-cover data
- Maps of the artificial drainage network
- A long-term program monitoring the effectiveness of BMPs on critical source areas
- An annual crop residue survey (following planting) of sloping lands near streams
- A periodic detailed survey of benchmark sampling sites to determine trends in soil erosion, as was carried out previously by the NRCS for the National Resources Inventory
- Periodic remote sensing by aircraft and/or satellite for land cover and other attributes

Forestry Land Use

Land Use Recommendation 8: Protect large blocks of forested land **L P**

Description of recommended action. The objective of this recommendation is to identify, prioritize, and promote protection of large blocks of forested land, focused on areas that are adjacent to large publicly held blocks and that are at risk of parcelization, conversion, and fragmentation.

8A. Identify forestlands for protection

Research is needed to indicate the location and characteristics of land that should be targeted for protection. Specifically, research is needed to:

- Provide a detailed map of land parcelization trends in Minnesota
- Identify targeted blocks of threatened land near large blocks of publicly held land

8B. Prioritize forest lands for protection

Prioritization should be based on proximity to large blocks of already protected land (both public and private) to maximize the resiliency of the forests, and should include a specific focus on protecting working forests so that forest products can continue to support regional economies of Minnesota. Protection should focus on at-risk and high-priority lands (generally 100 acres or more) in both the Laurentian mixed forests and eastern broadleaf forests.

8C. Support and promote permanent protection of forest lands

Permanent protection of forestlands through fee title acquisition or conservation easements will need to be supported and promoted to landowners through financial incentives, education, and technical assistance.

Land Use Recommendation 9: Assess tools for forest land protection **L P**

Description of recommended action. This recommendation is focused on identifying, examining, and monitoring the impacts of diverse tools in order to assess their effectiveness for forest land protection.

The state can make a spectrum of investments to protect forestland. Some directly support permanent protection of forestland, such as fee title acquisitions, conservation easements, and tax policies. Others, such as cost share, forest certification, and forest stewardship planning, support forestland protection indirectly by supporting sustainable management practices.

Each tool has a role in protecting Minnesota's forests, and the choice of tools depends on many factors, including site-specific conditions and cost effectiveness. Protection tools have been successful in protecting critical forest lands in Minnesota, but a comprehensive assessment of their appropriateness in various settings is lacking.

Land Use Recommendation10: Support and expand sustainable practices on working forested lands

SP

Description of recommended action. The objective of this recommendation is to promote and implement sustainable forest practices in working forests in Minnesota. This strategy builds on the accomplishments of the MFRC voluntary guidelines. Strategies include education, financial incentives to landowners, research and demonstration, and direct investment in specific management strategies.

10A. Educate consumers on benefits of certified wood to increase the demand for sustainably raised timber in Minnesota

10B. Educate landowners and forest managers on best management practices to protect working forests

10C. Promote collective/cooperative management of forestlands at a landscape level in order to increase the multiple benefits of forests (timber, air quality, carbon sinks, water quality, etc.)

10D. Provide incentives for sustainable forestry practices

10E. Develop and test new management practices to improve ecosystem resilience

Invest in research and demonstration areas that identify, examine, and monitor the impact of management scenarios on ecosystem resilience and increase understanding of the impact of climate change and other key drivers on forested ecosystems.

10F. Support the use of fire to increase forest health and biodiversity

Use of fire is supported by management strategies currently being developed by DNR for newly updated Ecological Classification System (ECS) plant community classifications.

Transportation Recommendations

Transportation Recommendation 1: Align transportation planning across state agencies and integrate development and review across state, regional, metropolitan and county/local transportation, land use and conservation programs

IP

1A. Institute interagency alignment of planning to coordinate transportation with other state planning cycles

The state should coordinate cyclical statewide plans across state agencies (e.g., MnDOT, Minnesota Pollution Control Agency [MPCA], DNR) and provide environmental data coordination and analysis, including determination of vulnerable ecological areas by resource, cumulative impact analysis and projection, performance standards and best practices research, and recommendations for land acquisition. MnDOT would continue to have the role of responsible governing unit (RGU) for surface transportation projects.

If implemented, integration would provide incentive for feedback systems through monitoring and strategic research programs, organize and align early review of projects, and promote nonstructural and structural practices and performance measures.

1B. Integrate streamlined statewide environmental transportation project review with other statewide and cross-jurisdictional planning, design, budgeting, and review programs

Adopt environmental interagency stakeholder involvement (streamlining) project planning protocols through coordination across state, metropolitan, and county/local transportation, land use, and conservation decision-making responsibilities.

Modify the highway project development process (HPDP) to create a cross-consultative regional

and local forum and an environmental team to lead federal- and state-mandated impact assessment. MnDOT and the EQB would create the forum and teams with participation of other review agencies, including MPCA, DNR, the Minnesota State Historic Preservation Office (SHPO), and metropolitan and county units.

Description of recommended action. A coordinated statewide interagency planning process around transportation and other statewide initiatives will enhance efficiencies and coherence of funding and other efforts with resource conservation objectives.

Once a project is approved in the annual review process associated with the STIP, the purpose and need statements that formed their environmental assessment parameters will have been set. Since these projects have already been prioritized at the MnDOT district level through the regional ATP using the STIP projection of costs of minimization/mitigation, they would be potential candidates for streamlined environmental review. When streamlined environmental assessment occurs, EQB and MnDOT (and in the cases of transit corridors, the Metropolitan Council and/or the counties that are the joint RGUs for the project) are responsible to align all interagency environmental processes and to set and coordinate project performance standards and best practices and develop monitoring. This process will have local coordination based on analysis and cross-consultation via a new ETAT process.

Transportation Recommendation 2: Reduce per capita vehicle miles of travel (VMT), through compact mixed-use development and multi- and intermodal transportation systems

Description of recommended action. The principal means by which VMT can currently be reduced are through reducing growth in lane miles and increasing intermodal and multimodal (including nonmotorized) transportation access and use. In the context of an automobile and truck fleet that cannot turn over (i.e. be replaced by more efficient vehicles and new fuels) in less than a decade regardless of other conditions, current efforts should concentrate on supporting planning and design of compact, mixed-use urban and suburban development and corresponding intermodal and multimodal transportation networks. Existing and proposed MnDOT plans and processes (e.g., interregional corridor plan, ATP, ETAT) should be used as foundations for support of compact urban and suburban development.

2A. Use alternative transportation planning and design processes and tools to support compact mixed-use development

Incorporate expanded transportation demand modeling (TDM) and Access Management modeling and other related strategies in statewide and local planning and project design to enhance local multimodal and passenger intermodal access that supports compact mixed-use development and resource conservation. For example, expanded Transportation Demand Management (TDM) analysis of MnDOT interregional corridor commutesheds, (i.e., areas of service at peak across modes) could suggest alternatives to usual applications of the functional classification standards. It is also important to have uniformity among expanded TDM requirements across neighboring communities so cities that implement expanded transit and nonmotorized TDM are not penalized budgetarily for their efforts by placing themselves at a disadvantage compared to civil divisions that do not implement TDM.

2B. Provide incentives for compact mixed-use development

Encourage and prioritize qualified transit and nonmotorized system fiscal investments in the STIP for regions that integrate local resource planning and performance-standard based design for compact development (Figure T6). Incorporate economic and employment development into resource protection.

For example, focus these approaches on the Twin Cities metropolitan area and other employment and service centers.

2C. Augment and communicate information on practices and performance of compact mixed-use development and transportation

Conduct interdisciplinary research (e.g., case studies) to correlate VMT changes with types, locations and scales of development in relation to transportation demand and planning for systems and modes. Establish databases on VMT-related statistics for resource-sensitive roadway network design and for patterns, intensities and combinations of land uses in multimodal and passenger intermodal development. EQB could provide research coordination of state agencies (e.g., MnDOT, MPCA); counties and localities (including minor civil divisions), educational institutions, and nonprofit stakeholders and foundations. Use this information to develop planning and design toolkits for the state, counties, metropolitan and local communities, developers, and citizens that include performance standards scorecards of structural and nonstructural approaches to VMT minimization/mitigation (e.g., based on models of per capita/per household VMT by land use configuration).

Transportation Recommendation 3: Develop and implement sustainable transportation research, design, planning, construction practices, regulations, and competitive incentive funding that minimize impacts on natural resources, especially habitat fragmentation and nonpoint source water pollution

Description of recommended action. This recommendation seeks to minimize, adapt, and mitigate habitat fragmentation and nonpoint source pollution from surface transportation (and related land uses) through research and design linkages via EQB, MPCA, and other stakeholders with MnDOT, and through expanded regulation and funding incentives for innovative project approaches and increased environmental innovation on roadway design standards.

3A. Develop research programs on habitat fragmentation and planning, design, and construction techniques for adaptation, minimization, mitigation, and restoration

Roads fragment habitat. Some species are more or less impacted by road network configuration, width, pavement and shoulder treatments, bridging, and sizes and types of culverts. Species are generally also benefited by vegetated edge design and management and grade-separated crossings such as bridges or culverts. While there is a body of existing research around the academic efforts of Richard Forman, Daniel Sperling, and others, the main foci of environmental mitigation of habitat loss are still largely practice-based. See, for example, the FHWA CSS Web site (http://www.fhwa.dot.gov/context/index.cfm). For cases, see http://www.contextsensitivesolutions.org/.

Research is needed to explain land-cover and species relationships to local and regional impacts of road functional classification changes (widening and/or curbing), new routes, bridges, culverts, and other projects. Further research is needed to document effectiveness of innovative techniques including hybridizations of the functional classification, CSD/CSS, and innovative crossings of water.

3B. Develop research and design linkages of nonpoint source pollution to surface and ground waters from right-of-way and adjacent land uses that would improve performance of roadway-based infrastructure in relation to hydrological resource resilience and overall stability

In this state, water is always close, whether on the surface or in the ground. The cumulative and spatial impacts of transportation and associated land use development on water quality and aquatic habitat

are only beginning to be understood (Figure T7). Research is needed to develop a finer understanding of the spatial and biophysical dynamics and metrics of transportation-induced contamination of water, especially surface water, but in areas of high permeability, also ground water. Research on fate to ground and surface waters by land cover, land use, and soil types is needed to improve statewide storm-water performance standards for sediments and contaminants TMDLs. These standards could inform review of all transportation projects for NPDES permits as recommended here. The research would identify issues and model and test hypothetical conservation planning, design, implementation, and management practices across scales.

3C. Implement a standard baseline of habitat fragmentation and nonpoint discharge review for all projects that increase impervious highway roadway or drainage infrastructure surface in Minnesota

Require all new roadway projects or functional classification upgrade projects on existing roads to secure NPDES permits.

This recommendation could link project development more closely to comprehensive habitat data and impact analysis via the connection between the MnDOT statement of project purpose and need and environmental review. The statement of purpose and need provides the basis for developing a range of reasonable alternatives and, ultimately, identification of the preferred alternative. It also sets budgetary frameworks. If properly described, it also limits the range of alternatives that may be considered reasonable, prudent, and practicable in compliance with Council on Environmental Quality (CEQ) regulations, Section 4(f) of the Executive Order on Wetlands and Floodplains, and the Section 404(b)(1) guidelines. Further, it demonstrates the problems that will result if the no-build alternative is selected (http://www.dot.state.mn.us/tecsup/xyz/plu/hpdp/book1/2b/class1/purpose-need.html).

3D. Pilot incentive program grants for habitat and water-quality conservation design and construction innovations in transportation projects

The state should consider creating a grant program which would offer grants to MnDOT, counties, and local governments for transportation projects that demonstrate new or catalytic conservation approaches to road and related drainage design, development or (re)construction (Figure T8).

Energy Recommendations

Goal A

Promote alternative energy production strategies that balance or optimize production of food, feed, fiber, energy and other products with protection or improvement of environmental quality, including:

- water quality and water resource supply
- wildlife habitat
- greenhouse gas emissions
- soil quality and critical landscapes

Energy Recommendation 1: Develop coordinated laws, policies, and procedures for governmental entities to assess renewable energy production impacts on the environment

IP

Develop laws, policies, and procedures for governmental entities to assess and manage the cumulative impacts on the environment of proposed and established energy production facilities, focusing on both individual and combined impacts. Information from this effort should be used to develop a biennial report to the legislature that informs the direction of the statewide conservation planning strategy.

Description of recommended action. Minnesota Statutes 116D.10-.11, require state agencies and the governor to prepare a biennial report to the legislature on efforts to address Minnesota's energy and environmental policies, programs, and needs. This requirement provides an ongoing vehicle within state government for internalizing, integrating, and tracking implementation of recommendations developed by the SCPP. Further, while the SCPP lays much of the foundation for future strategy reports, these reports will need to address other issues and describe how SCPP recommendations fit with them. For example, biofuel production initiatives are one component of a proposed package for meeting state greenhouse gas emission reduction goals. In addition, they are potentially a significant vehicle for addressing impaired waters. The biennial strategy report must ensure that these efforts complement one another (along with other state goals, such as enhancement of wildlife habitat) and that they are kept on track. This report would integrate information coming out of the permitting process for individual biofuel plants to paint a statewide picture of how energy production in Minnesota impacts state resources.

Two actions are needed. First, the law should be amended to explicitly reference the SCPP and to streamline requirements. Second, strategic investments are required to build state capability to develop biennial assessments and track progress across issues. A third package of actions, those investments needed to follow up on other conservation strategy recommendations, will contribute to the foundation upon which biennial assessments will be based.

Energy Recommendation 2: Invest in farm and forest preservation efforts to prevent fragmentation due to development guided by productivity and environmental vulnerability research **LP**

Description of recommended action. Farm and forest fragmentation is a serious threat to wildlife habitat and ecosystem biodiversity. Expansion of urban and agricultural areas often produces fragmentation of forests, and urban expansion reduces the land resource available for producing food, feed, fiber, and fuel. Strategies and policies are needed to protect farms and forests, and prevent fragmentation. The 2008 legislature provided a $53,000 grant to the Minnesota Forest Resources Council (MFRC) to match $150,000 in funding from the Blandin Foundation and Iron Range Resources for a study of forest parcelization and development, an assessment of available policy responses, and policy recommendations to the 2010 legislature. The 2007 legislature provided a $40,000 grant to the UM Institute on the Environment that built on earlier MFRC research to assess potential impacts of parcelization and development on wildlife habitat and biodiversity in northern Minnesota. The state should consider recommendations from these studies relative to potential changes in policy or law, and relative to potentially funding specific proposals to prevent forest and farmland fragmentation due to development.

Energy Recommendation 3: Invest in perennial biofuel and energy crop research and demonstration projects on a landscape scale **SP**

Invest in research and demonstration projects on a landscape scale to evaluate management and harvest techniques and yield potentials for various perennial biofuel crops (including monocultures of perennial grasses or woody biomass and polycultures) on different soils and agroecoregions throughout the state.

Description of recommended action. Based on nationwide analyses of potential biomass resources done by the U.S. Department of Energy (DOE) and USDA, energy crops are expected to play a major role in development of biomass resources for next-generation biofuels or carbon-neutral electrical generation. Coordinated research and policy experimentation should be carried out to develop and refine renewable energy production systems based on diversified biomass farming that emphasizes perennial

biomass crops. This initiative has great potential to improve environmental quality and support economic revitalization in rural Minnesota, while providing large amounts of biomass for renewable energy and bio-products. Developed properly, diversified biomass farming can help support current production agriculture while enhancing rural economic opportunities, producing locally grown renewable energy, and addressing important statewide water quality and environmental issues. In order to make energy crops a practical reality in the state, work is needed to improve yields through genetics and through identification of the optimal sites and BMPs for these crops. The state should support demonstration projects that bracket the various parts of the state so both yield and environmental questions associated with perennial crop production for given state locations can be ascertained in a timely manner. Existing data generated by the MFRC on forestry issues and county-based agricultural production data developed by the Center for Energy and Environment may be used to determine biomass availability. Opportunities and limitations associated with use of these resources should be identified. The effects of various assumptions about environmental impacts and biomass availability should be analyzed.

To move forward on commercial-scale pilot renewable-energy projects based on diversified biomass farming, it will be necessary to take a comprehensive approach to establish a bio-refining system that integrates production, processing, feedstock conversion/refining, and end-use market applications including but not restricted to energy production.

Energy Recommendation 4: Develop policies and incentives to encourage perennial crop production for biofuels in critical environmental areas S P

Invest in research and develop policies and financial incentives to encourage perennial crop production for biofuels on expiring CRP lands and other environmentally sensitive or low-productivity lands. These research efforts, policies, and incentives should result in a balance between profitability and productivity on one hand, and benefits to the environment and wildlife habitat on the other hand.

Description of recommended action. The state should develop firm policies that would encourage the growth of energy crops on conservation lands and marginal farmlands and also reflect environmental and ecological needs for animal habitat and water resource conservation. There is currently an economic incentive for producers to plant productive expiring CRP land with row crops and small grains. Currently, there do not appear to be economic incentives for farmers or growers to grow perennial energy crops on these expiring environmentally sensitive lands. Policies and incentives are needed to encourage perennial biofuel crops on the most productive expiring CRP lands. Managers of low-productivity CRP lands should be encouraged to re-enroll them in conservation programs.

Energy Recommendation 5: Invest in data collection to support the assessment process S P

Invest in data collection to support the assessment process described in energy and mercury recommendation 1.

Data collection is needed in the following areas:

- Water quality
- Water resource sustainability (surface and ground water)
- Wildlife habitat and biodiversity
- Invasive species
- Land use changes
- Soil compaction, cover, and residue levels
- Infrastructure and storage needs for alternative fuel strategies
- GHG emissions

Description of recommended action. Minnesota needs a comprehensive approach to monitoring the cumulative impact of its energy production on the state environment. Data collection to support the monitoring and assessment of energy production should cover every step of the production process, and has the potential to inform the biennial report described in energy recommendation 1. Currently, many of the data needs listed above are incomplete or lacking entirely. Minnesota should fund data collection in these categories in locations around the state.

Energy Recommendation 6: Invest in research to determine sustainable removal rates of corn stover and to establish incentives and Best Management Practices (BMPs)

S P

Invest in research to determine sustainable removal rates of corn stover for animal feed and biofuel production, and to establish incentives and BMPs for mitigating the adverse impacts of corn stover removal on soil carbon and erosion.

Description of recommended action. There is currently a debate among researchers and practitioners regarding how much corn stover may be removed from a field for biofuel or animal feed processing without significant negative impacts on soil carbon and erosion rates. Since the corn stover biofuel industry is close to being operational, the answer to this question in the Minnesota context is needed as soon as possible. If negative impacts of corn stover removal may be mitigated through farmer-installed BMPs (riparian buffer strips or cover crops), the state should encourage adoption of these BMPs.

Energy Recommendation 7: Invest in research to review thermal flow maps for Minnesota

S P

Invest in research to review current thermal flow maps for Minnesota to assess their validity/accuracy, and if necessary develop improved thermal flow maps, with the goal of informing geothermal power development in Minnesota

Description of recommended action. As a first step, the existing heat flow map for the state that was produced some years ago should be critiqued by experts from the Minnesota Geological Survey and their counterparts at the NRRI. Recent investigations of the current map seem to indicate that the existing projections for heat flow may be significantly underestimated due to the sampling technique used in the original data collection effort. Other countries at similar or higher latitudes, most notably Germany and Denmark, are adopting deep geothermal energy systems in order to produce necessary electrical power while reducing GHG emissions. A critical tool for assessing the viability of deploying this environmentally friendly energy technology is a thermal flow map for the state that relates the depth of the resource to the expected energy capture that may be possible.

Energy Recommendation 8: Invest in applied research to reduce energy and water consumption and green house gas emissions in present and future ethanol plants, and enact policies to encourage implementation of these conservation technologies

S P

Description of recommended action. Minnesota should invest in applied research and demonstration projects that reduce water consumption, energy use, and CO_2 emissions at corn-based ethanol plants.

Energy Recommendation 9: Invest in research to determine the life cycle impacts of renewable energy production systems

S P

Invest in research to determine the life-cycle impacts of renewable energy production systems on the rural economy, greenhouse gas emissions, water sustainability, water quality, carbon sequestration, gene flow

risks, and wildlife populations at landscape and regional scales while building on previous studies. This research should be used to direct the development of the renewable energy industry in Minnesota, including the storage and infrastructure needs associated with alternative fuels.

Description of recommended action. This recommendation is compatible with energy recommendations 1 and 5 in that it aims to estimate the cumulative impact of Minnesota's renewable energy development through data collection and analysis. Basically, the recommendation is that energy policy and incentives at the state level take a systems view, accounting for the resource benefits and impacts associated with each stage of energy production, transport, consumption, and associated waste processing. Research will be needed for legislators, citizens, and industry to make informed decisions about these benefits and impacts. Language to this effect should be added to legislation relevant to alternative energy development.

Energy Recommendation 10: Invest in research and demonstration projects to develop, and incentives to promote, combined wind power/biomass, wind power/ natural gas, and biomass/coal co-firing electricity projects

Description of recommended action. Integration of various energy production techniques that can help optimize the energy production system is an important opportunity for local communities, medium-size commercial and industrial users, and institutions in the state. As shown with the energy modeling work at the UM Morris, campus, a combined wind and biomass energy system allows overall optimization of energy production and the potential of almost complete energy self-sufficiency for the institution. The adoption of combined systems allows energy storage, peak loading, and stable energy generation issues to be addressed in a holistic fashion. For rural applications where biomass availability is high and wind conditions are favorable, systems can be envisioned where a wind turbine system is coupled with a biomass gasification system to enhance the storage of off-peak power through generation of hydrogen and oxygen using water electrolysis. The produced gases then can be utilized to help facilitate improved gasifier operations. The stored oxygen can be used to displace air in the gasifier combustion process, and the hydrogen can be added to the producer gas to enhance its chemical potential to produce a syngas for natural gas replacement or additional power generation. The enhanced syngas can also be utilized to produce liquid fuels for use locally. Additionally, wind power/natural gas and biomass/coal electrical generation projects should be demonstrated that will allow GHG reductions while stabilizing electrical generation capacity in the state.

Energy Recommendation 11: Invest in research and enact policies to protect existing native prairies from genetic contamination by buffering them with neighboring plantings of perennial energy crops

Description of recommended action. In developing Minnesota's perennial biofuel industry (see energy recommendation 3), varieties may be selected for widespread planting that are not native to Minnesota, or that have been genetically modified from native plants. These biofuel plantings have the potential to genetically contaminate the state's native prairie remnants if they are close to these ecosystems. Research should be undertaken on the potential for this contamination, and policies should be developed to prevent it through mandated buffer plantings.

Energy Recommendation 12: Invest in efforts to develop sufficient seed or seedling stocks for large-scale plantings of native prairie grasses and other perennial crops

Description of recommended action. If perennial crops are to become a significant component of biofuel production in Minnesota, sufficient genetic stock for large-scale plantings will be necessary.

Goal B

Promote a healthy economy, including strategies that promote local ownership of alternative energy production and processing infrastructure, where appropriate.

Energy Recommendation 13: Invest in research and policies regarding "green payments" SP

Invest in research and policies on implementation strategies and optimal pricing schemes for green payments. These payments may be applied to perennial energy crop production on expiring CRP land, in impaired watersheds, on environmentally sensitive or low-productivity land, on DNR working lands, and on annual cropland. Multiple tiered payments for water quality, carbon, wildlife, fuel production, and other benefits may be considered, and special attention should be paid to helping producers through the transition period for perennial energy crop production. Knowledge and insights gained from previous multifunctional fuelshed experiments (at Waseca, Madelia, and UM Morris, for example) should be applied.

Description of recommended action. This recommendation fits well with energy recommendation 2. If adopted together, these two recommendations would strengthen the state's efforts to protect environmentally sensitive land from intensive production, while providing benefits to farmers, local communities, natural resources, and wildlife. A green payment program should be informed by the most up-to-date scientific information on how biofuel production strategies impact natural resources. Farmers should be encouraged to plant perennial energy crops appropriate to their region (see energy recommendation 1).

Energy Recommendation 14: Investigate opportunities to provide tax incentives for individual investors in renewable energy (e.g., individuals who wish to install solar panels) ES

Description of recommended action. The state should make it easy and cost effective for individual homeowners or businesses to get their electricity from solar, geothermal, or wind power sources they install themselves. The specific financial mechanism needed to accomplish this goal should be developed in consultations between economists, policy makers, and citizen stakeholders. Other states (such as Massachusetts) have programs that might serve as an example.

Energy Recommendation 15: Invest in efforts to develop, and research to support, community-based energy platforms for producing electricity, transportation fuels, fertilizer, and other products that are locally/cooperatively owned SP

Description of recommended action. Many renewable energy sources (e.g., wind, biomass, and solar power) are located in the rural parts of the state. The localized development of alternative energy systems that can be placed at the source or nearby the source of the biomass materials will reduce the problems associated with logistical movement of unconsolidated biomass and reduce the transportation costs for biomass energy conversion. At the same time, the production and use of energy and energy products on a local basis will reduce infrastructure costs associated with power and fuels distribution. Both factors should allow localized development of smaller scale alternative energy systems that will benefit the local rural communities and add valued products to their economies. The state should encourage the development of these localized alternative energy systems by adoption of policies and incentives to facilitate their adoption. In addition, research and demonstration for systems that can facilitate the implementation of

this localized energy solution should be supported. Part of this support will involve transferring the lessons learned from successful community-based energy platforms (e.g., at UM, Morris; and Madelia, Coleraine Minerals Laboratory) to other communities interested in developing their own renewable energy platforms. The integration of local waste streams into energy production mechanisms is a key part of this recommendation.

Goal C

Promote efforts to improve energy conservation and energy efficiency among individuals, businesses, communities, and institutions.

Energy Recommendation 16: Provide incentives to transition a portion of Minnesota's vehicle fleet to electrical power, while simultaneously increasing renewable electricity production for transportation

ES

Description of recommended action. Powering Minnesota's current transportation fleet solely with biofuels or fossil fuels is not feasible in the long term. Fueling our vehicles predominantly with ethanol would place enormous pressure on the state's land resources, and would take land out of food production and conservation. Gasoline -powered vehicles contribute substantially to global climate change, and the rising price of gasoline creates an economic burden for Minnesota residents and businesses. Therefore, a state goal should be to transition the vehicle fleet away from dependence on both fossil fuels and biofuels. Powering vehicles with electricity derived from renewable sources makes sense from an ecological and sustainability standpoint, but is not yet economically viable. Several automakers have announced plans to sell electric vehicles within the next two years. However, the up-front cost for these vehicles will likely be more than for a conventional gas-powered vehicle. Minnesota should therefore provide appropriate incentives to encourage state residents and businesses to purchase electric vehicles, with the goal of creating a robust electric vehicle sector in the state. The use of electric vehicles for commuting to work and while shopping locally in metropolitan environments where the commuting distances are relatively short should especially be encouraged.

These vehicles will require more capacity in the electricity sector, which should be provided with renewable sources (wind, solar, and geothermal). Some of this excess capacity may be mitigated by encouraging electric vehicle owners to charge their vehicles during off-peak hours (i.e., at night).

Energy Recommendation 17: Promote policies and incentives that encourage carbon-neutral businesses, homes, communities, and other institutions with an emphasis on learning from institutions already working toward this goal (e.g., UM, Morris)

SP

Description of recommended action. Energy conservation and renewable fuel goals should be advanced simultaneously in Minnesota. Much more could be done to encourage businesses, homes, communities, and other institutions in Minnesota to dramatically reduce their carbon footprint through energy conservation and low-carbon fuel use. This recommendation fits well with energy recommendation 14—providing incentives for individuals to take advantage of solar, wind, and geothermal technologies would help them to become carbon neutral. Most likely, achieving carbon neutrality will require a portfolio of energy technologies and lowered energy consumption like that seen at UM, Morris (wind, biomass, etc.). Policies and incentives should be targeted to help individuals, businesses, communities, and institutions develop renewable energy portfolios appropriate for their situation.

Energy Recommendation 18: Implement policies and incentives to lower energy use of housing stock while monitoring the performance of improvements and calling on the utility industry to join in the effort SP

Description of recommended action. The envisioned housing improvements should consist of locally manufactured building material resources, especially those that use industry byproducts as their primary production feedstock. It is further recommended that the state develop specific policies and incentives to greatly improve construction practices for new residential homes. This can be accomplished by employing regional, sustainable building materials, and promoting the application of breakthrough systems approaches to new housing construction in an effort to drive down residential energy consumption. The UM has developed new technologies that present alternative means and methods for achieving vastly improved energy code compliance; these technologies should be further investigated to overcome implementation barriers.

Energy Recommendation 19: Promote policies and strategies to implement smart meter and smart grid technologies SP

Description of recommended action. Smart meter and smart grid technology is the next generation of electrical distribution technology. It provides for more local management and control of the energy used in the region and on site.

- The use of both smart meter and grid technology requires a series of advancements and changes in the current distribution practices. On a national level, there should be a uniform interconnection standard that would allow for a more robust mix of distributed and central-based power generation.
- At a state level, guidelines should be established for purchase of backup and supplemental power so that distributed combined heat and power (CHP) plants are not put at an economic disadvantage when negotiating with investor-owned utilities.
- At a state level, investor-owned and electric cooperatives should be encouraged to move to smart grid technology and economic studies should be carried out to determine the benefit of incorporating distributed generation into the state's transmission grid.

Energy Recommendation 20: Develop incentives to encourage the widespread adoption of passive solar and shallow geothermal heat pump systems in new residential and commercial building construction; invest in research to develop improved technology for storing renewable energy SP

Description of recommended action. It is recommended that policies be adopted to encourage the widespread adoption of passive solar and shallow geothermal heat pump systems in new residential and commercial construction. Furthermore, it is recommended that incentives be developed to allow more widespread adoption of these technologies in existing structures where it is deemed to be a practical method for reducing water and habitat heating and cooling requirements. Utilities should be asked to incorporate specific programs to encourage structure owners to adopt these technologies in order to help meet the state's conservation goal as noted in existing Minnesota statutes.

Energy Recommendation 21: Develop standards and incentives for energy capture from municipal sanitary and solid waste, and minimize landfill options for MSW ES

Description of recommended action. A state mandate should be established that requires the capture of energy units from municipal solid waste (MSW) or municipal sanitary waste generated in the state. Appropriate statutory actions should be taken to establish targets for MSW use and minimization of landfill options for this waste material.

Energy Recommendation 22: Invest in public education focusing on benefits and strategies for energy conservation targeted toward individual Minnesota residents and businesses

SP

Description of recommended action. Individual action is critical in reducing state energy demand, which will lower GHG emissions and reduce pressure on the land resource to provide alternative fuels. Specific examples of actions that should be encouraged may be found in the MCCAG recommendations. These include bicycle/pedestrian/public transit commuting, slower highway driving speeds, and purchasing energy-efficient appliances. There is a need to educate the public about lifestyle choices to reduce their energy consumption, particularly related to homes and transportation. Advertising and communications experts should be brought into this effort to disseminate the carbon reduction message in a creative way that reaches the broadest segment of the population possible.

Goal D (see related Appendix III)

Promote regulations, policies, incentives, and strategies to achieve significant reductions in mercury deposition in Minnesota.

Energy Recommendation 23: Develop mercury reduction strategies for out-of-state sources

IP

Minnesota state agencies should work closely with the U.S. Environmental Protection Agency (USEPA) to develop mercury reduction strategies and assessment tools for the state, with the goal of meeting federal Clean Air Act and Clean Water Act standards. A mercury-reduction strategy should be developed that includes reduction of in-state demand for coal-powered electricity, and addresses mercury deposited in Minnesota from out-of-state sources.

Description of recommended action. Development of the national program that regulates mercury emissions from existing and future sources is very important in addressing the overwhelming contribution by sources from outside of Minnesota to the Minnesota environment (e.g., Minnesota water bodies). A federal mercury emissions program would minimize competitive disadvantage that regulations on the state levels potentially could create. Coordinated and joint efforts between the state agencies and the EPA would strengthen existing laws and reduce environmental loads of mercury.

Energy Recommendation 24: Continue state enforcement programs to reduce mercury loads

IP

The MPCA should be provided with adequate resources to continue to enforce/support existing mercury regulations and programs that lead to reduced emissions of mercury in Minnesota through market restrictions, pollution control techniques, and disposal requirements.

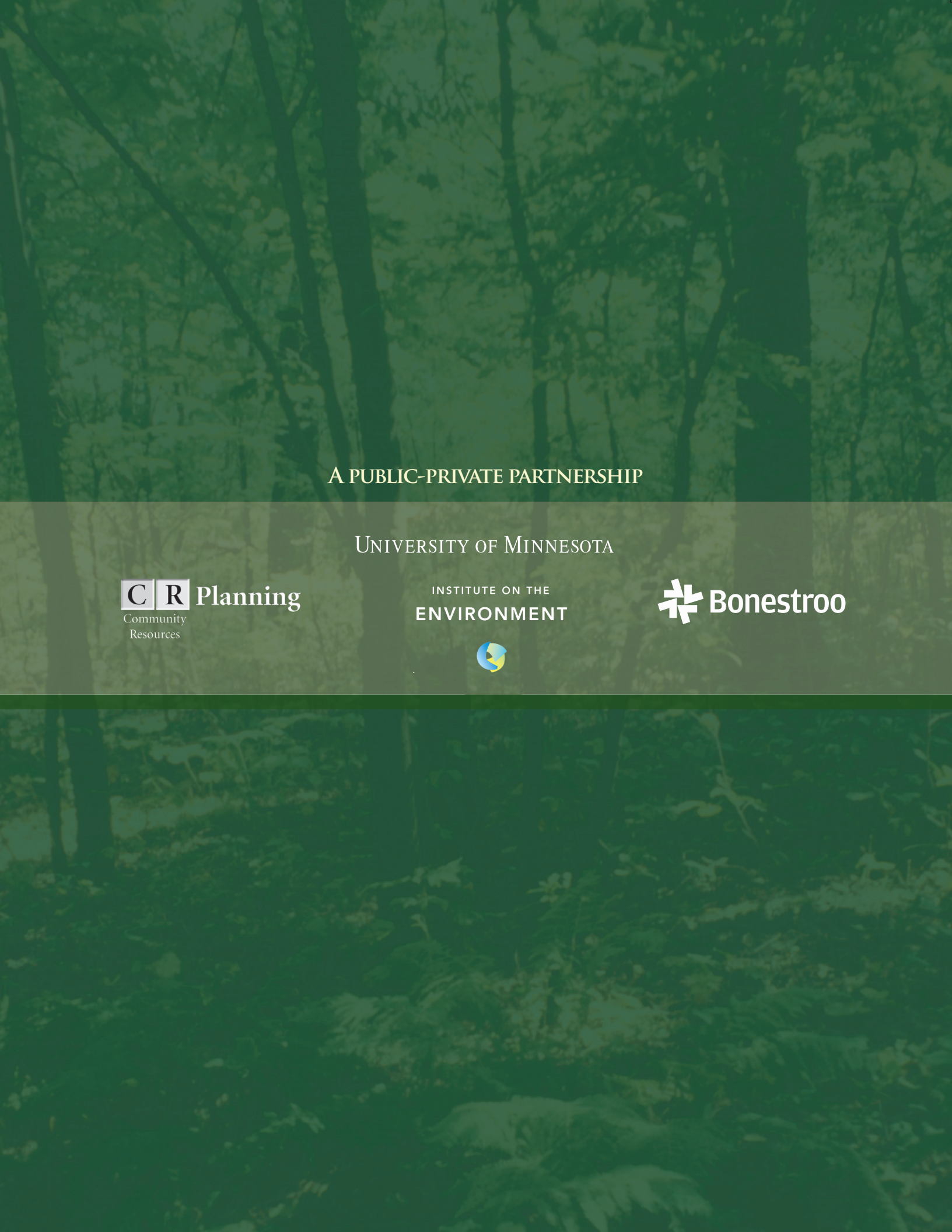
Description of recommended action. Existing regulations reduce product-sector emissions. The MPCA works closely with and provides education to the industry sectors on mercury reduction strategies and new control technologies. The voluntary/enforcement programs have been successful in reducing mercury air and water emissions.

Energy Recommendation 25: Develop public education on actions that individuals and communities can take to reduce mercury loads

SP

Minnesota should develop a strong public education and outreach effort focusing on the health risks associated with mercury pollution and on techniques for reducing mercury loads (including energy conservation and proper disposal of light bulbs) in the environment.

Description of recommended action. Currently there are a number of state-sponsored and community-based public education and outreach programs addressing mercury emissions. They are specific to certain industries (e.g., energy producing facilities), activities (e.g., disposal of light bulbs) or public health advisories (e.g., mercury fish concentrations). Although beneficial, the programs are often inaccessible by many Minnesota citizens because they are not greatly publicized. Creation of a single, large, well-coordinated interagency public-outreach and education program could potentially address many issues more effectively and efficiently. Promotion and recognition of a single program may be easier to achieve.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