Habitat Recommendations Table of Contents

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**

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.

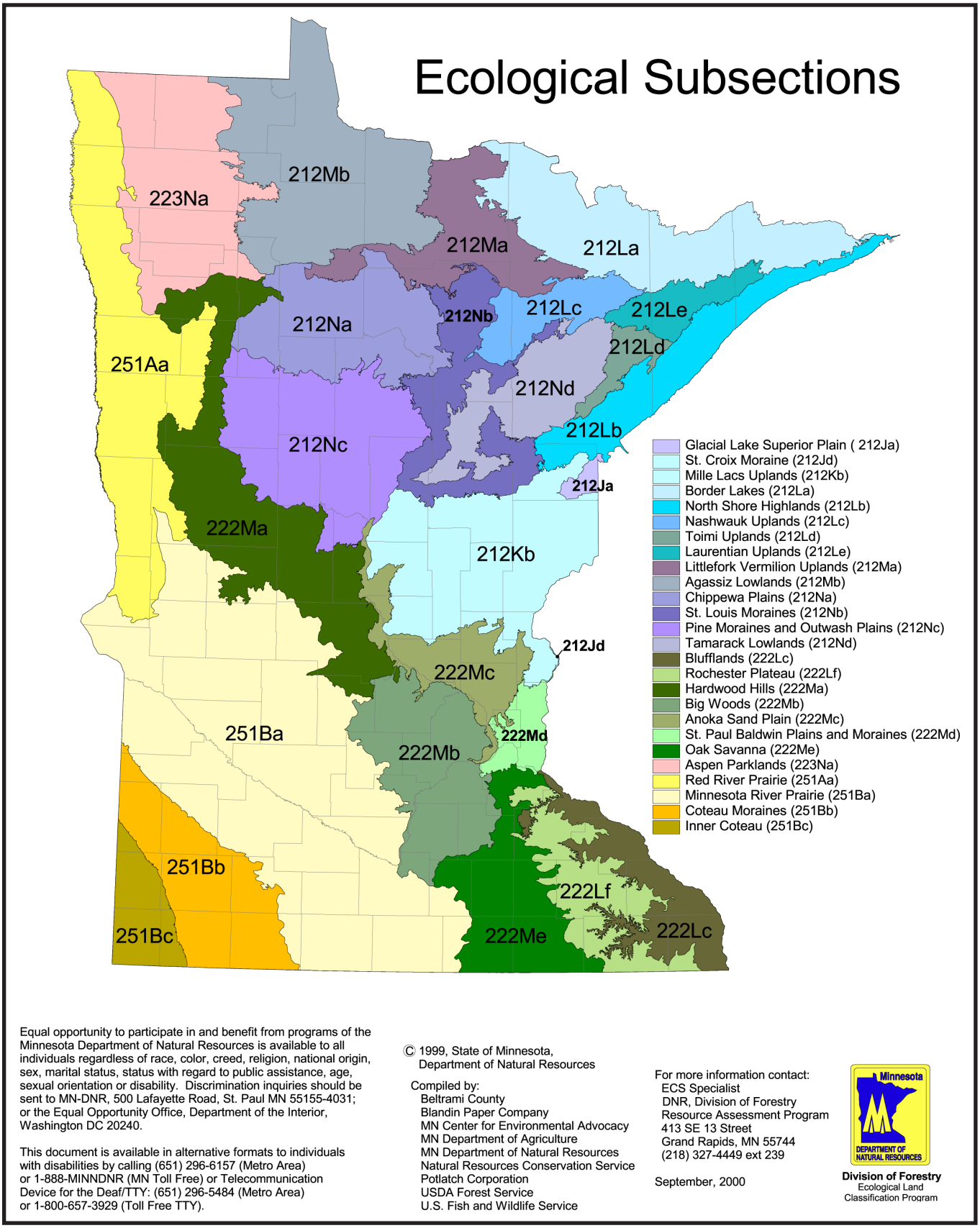


Figure H1. Minnesota Ecological Subsections. Credit: DNR.

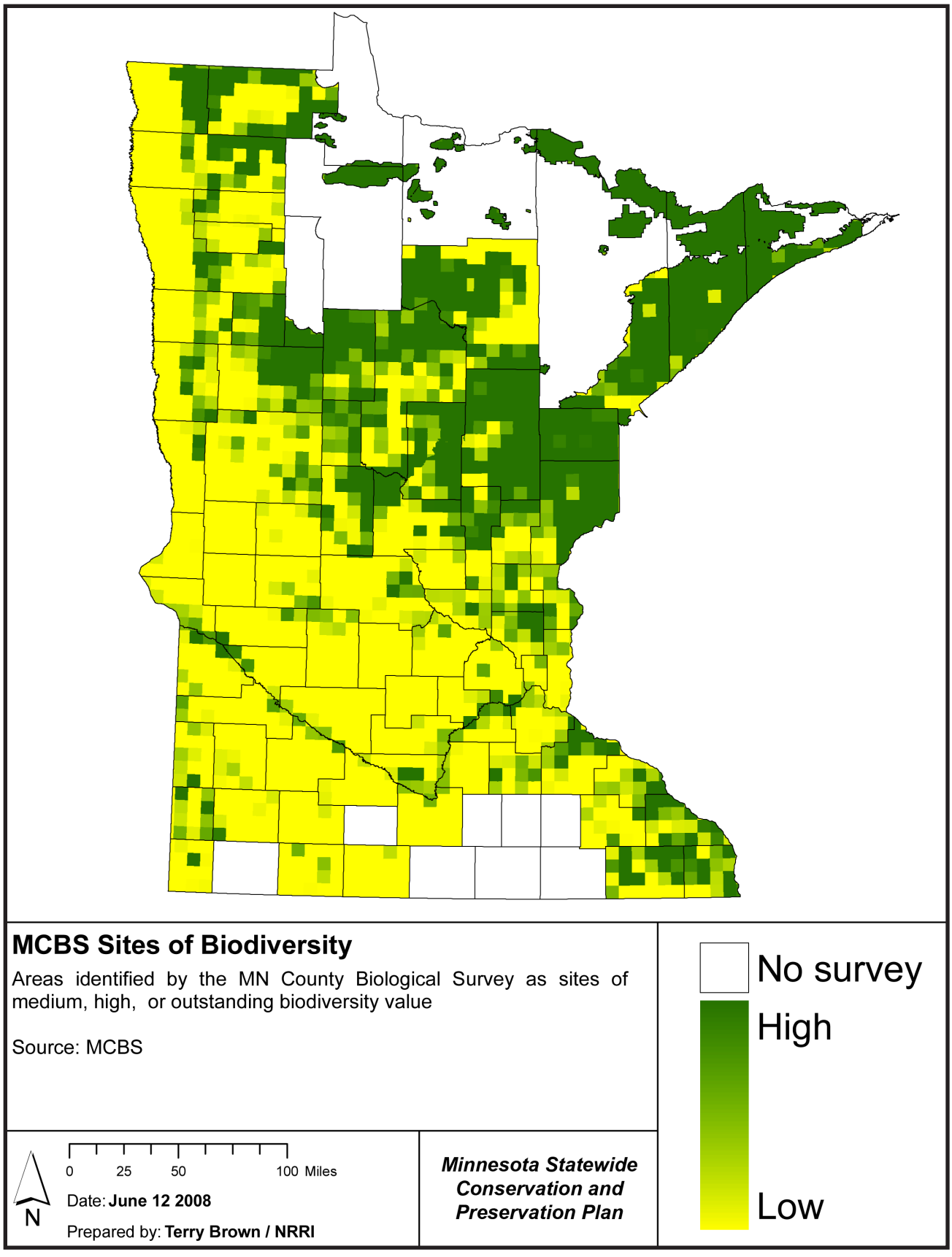


Figure H2. MCBS sites of biodiversity. Credit: Terry Brown, NRRI.

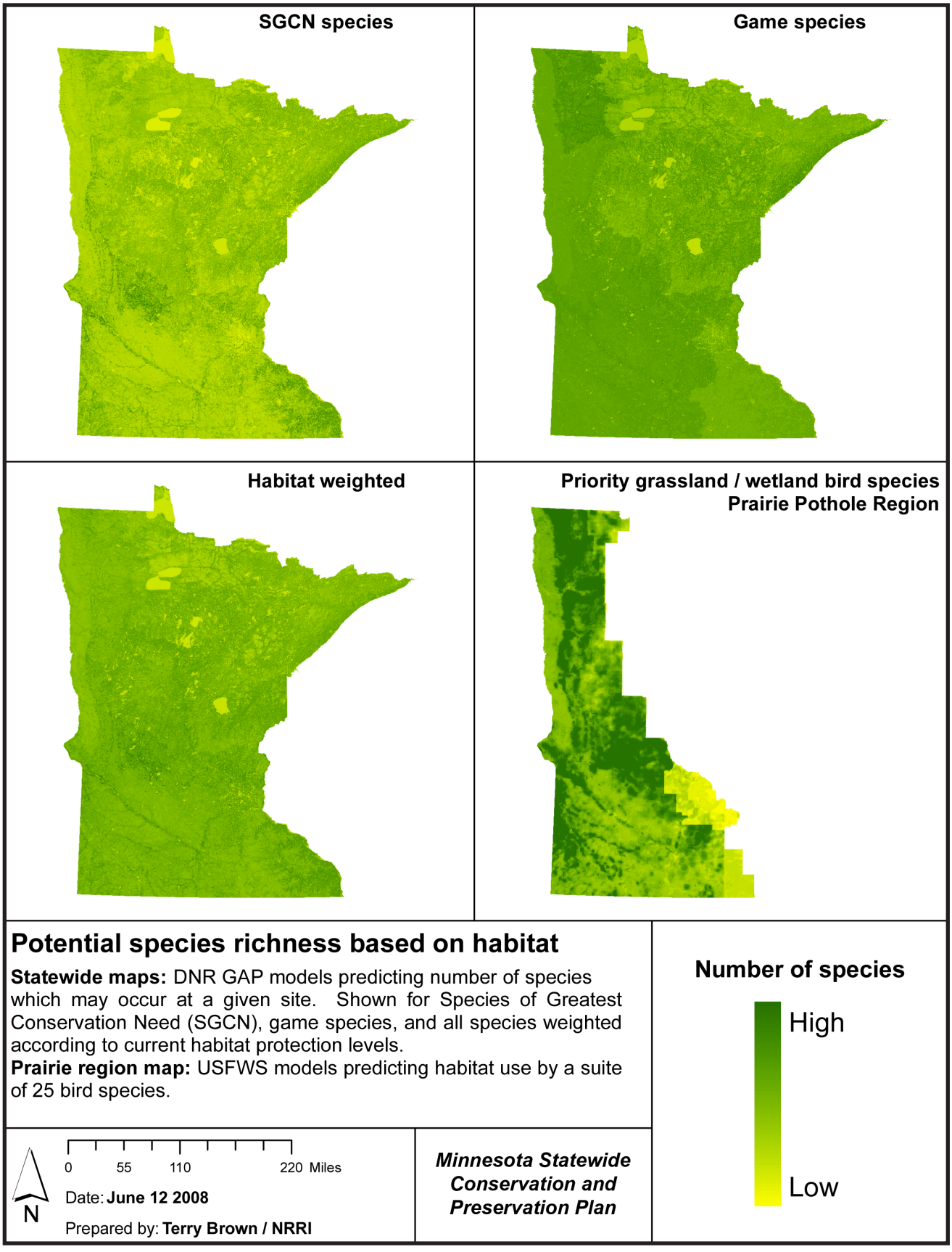


Figure H3. Potential species richness based on habitat. Credit: Terry Brown, NRRI.

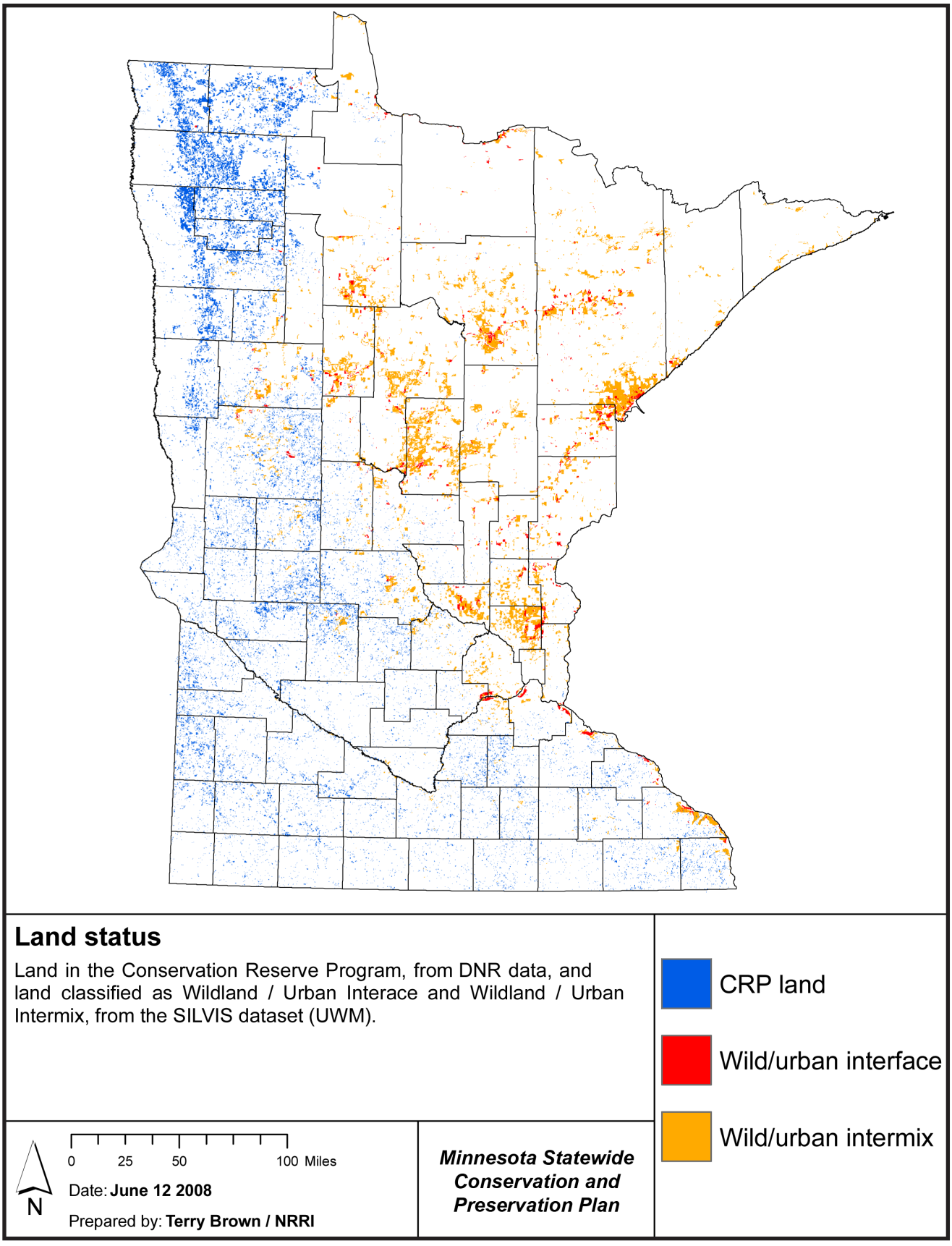


Figure H4. Land status. Credit: Terry Brown, NRRI.

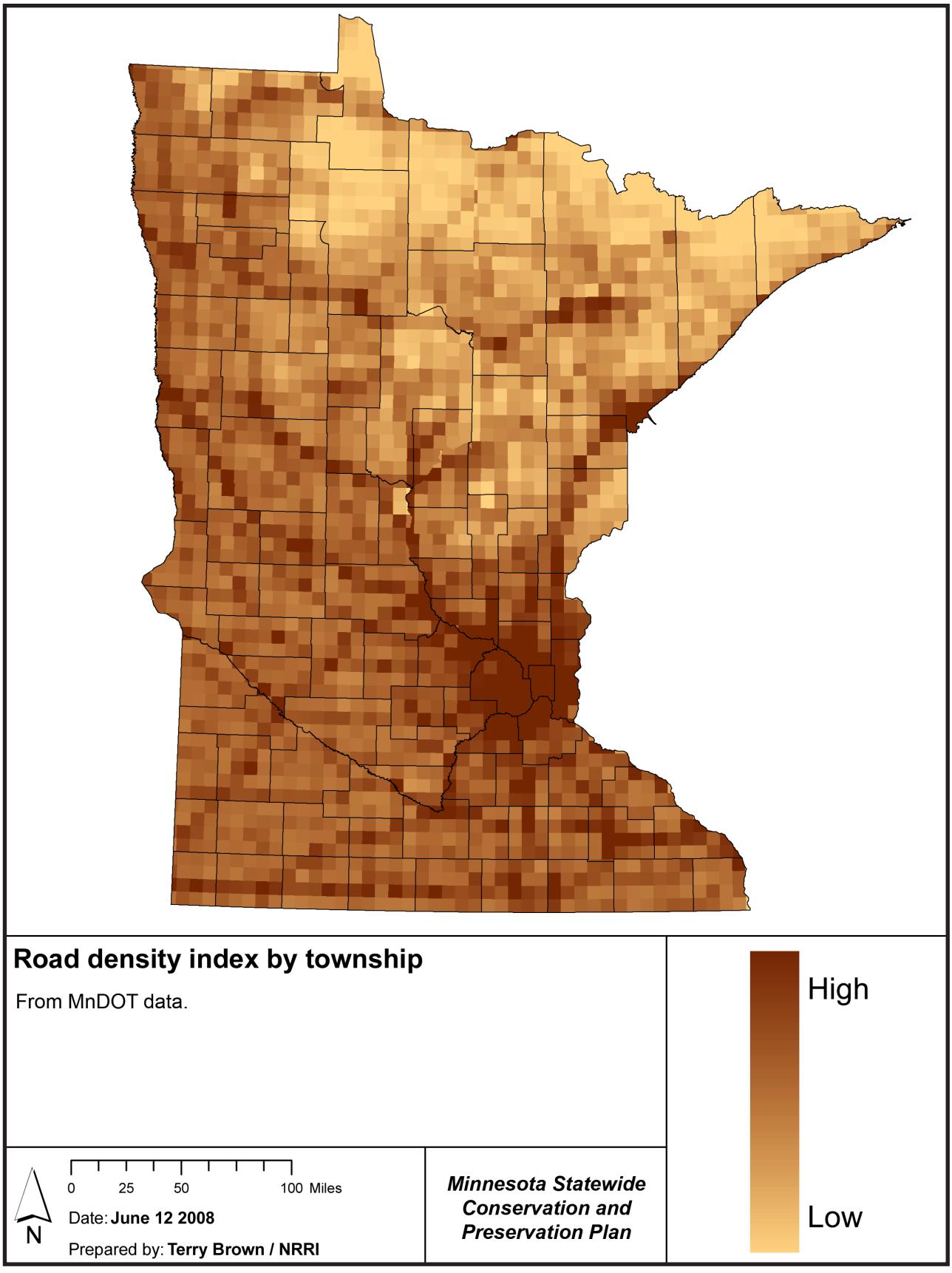


Figure H5. Road density index by township. Credit: Terry Brown, NRRI.

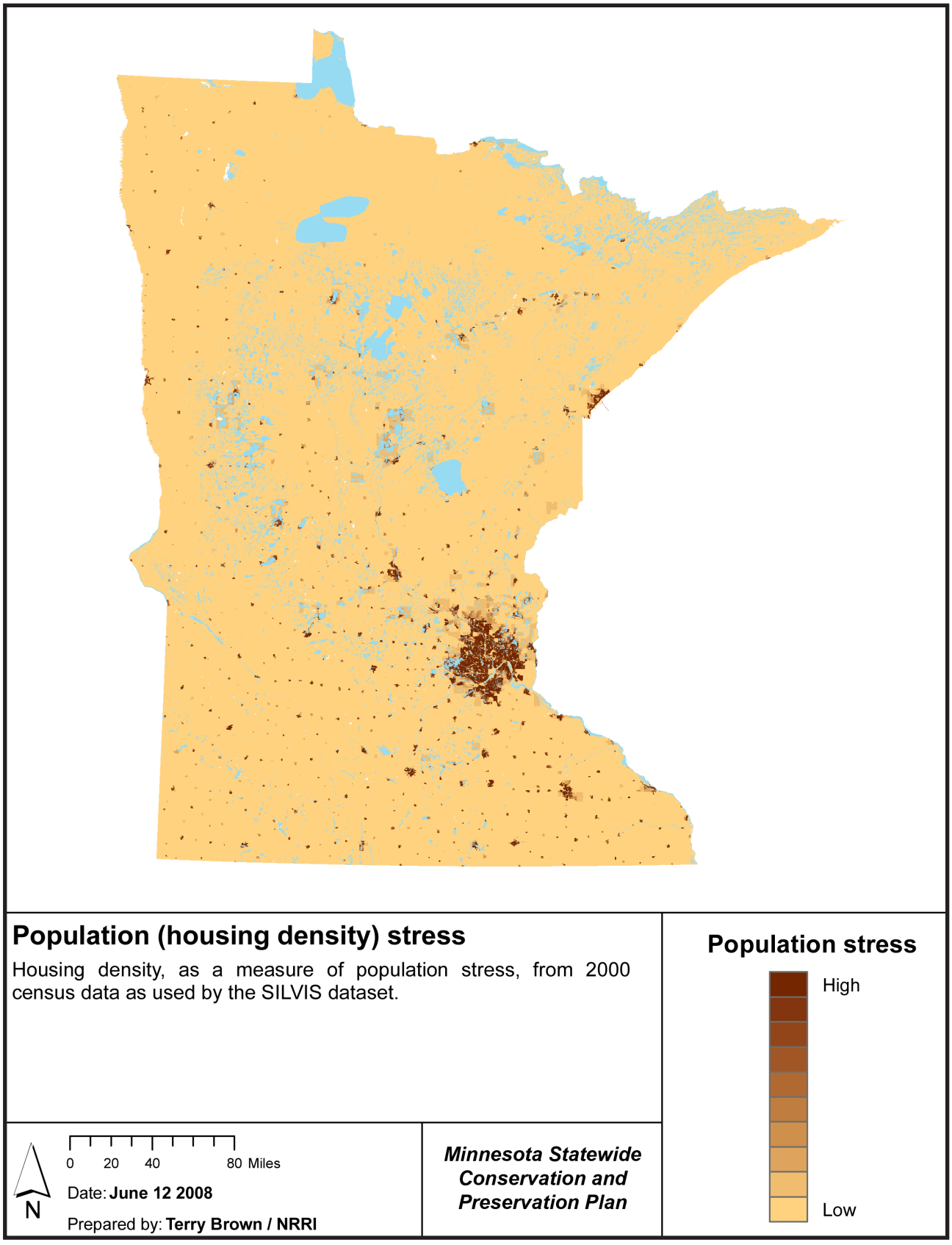


Figure H6. Population (housing density) stress. Credit: Terry Brown, NRRI.

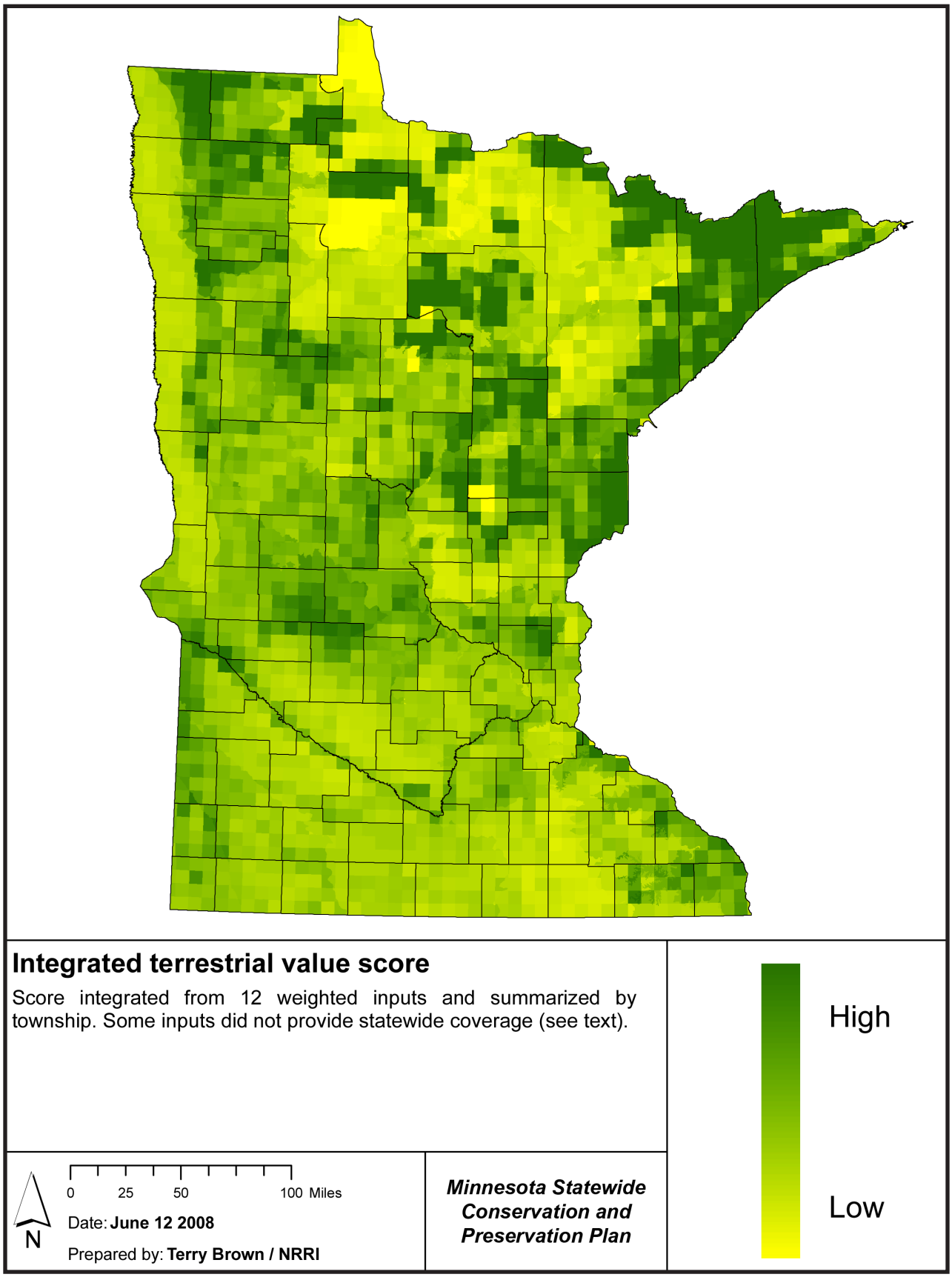
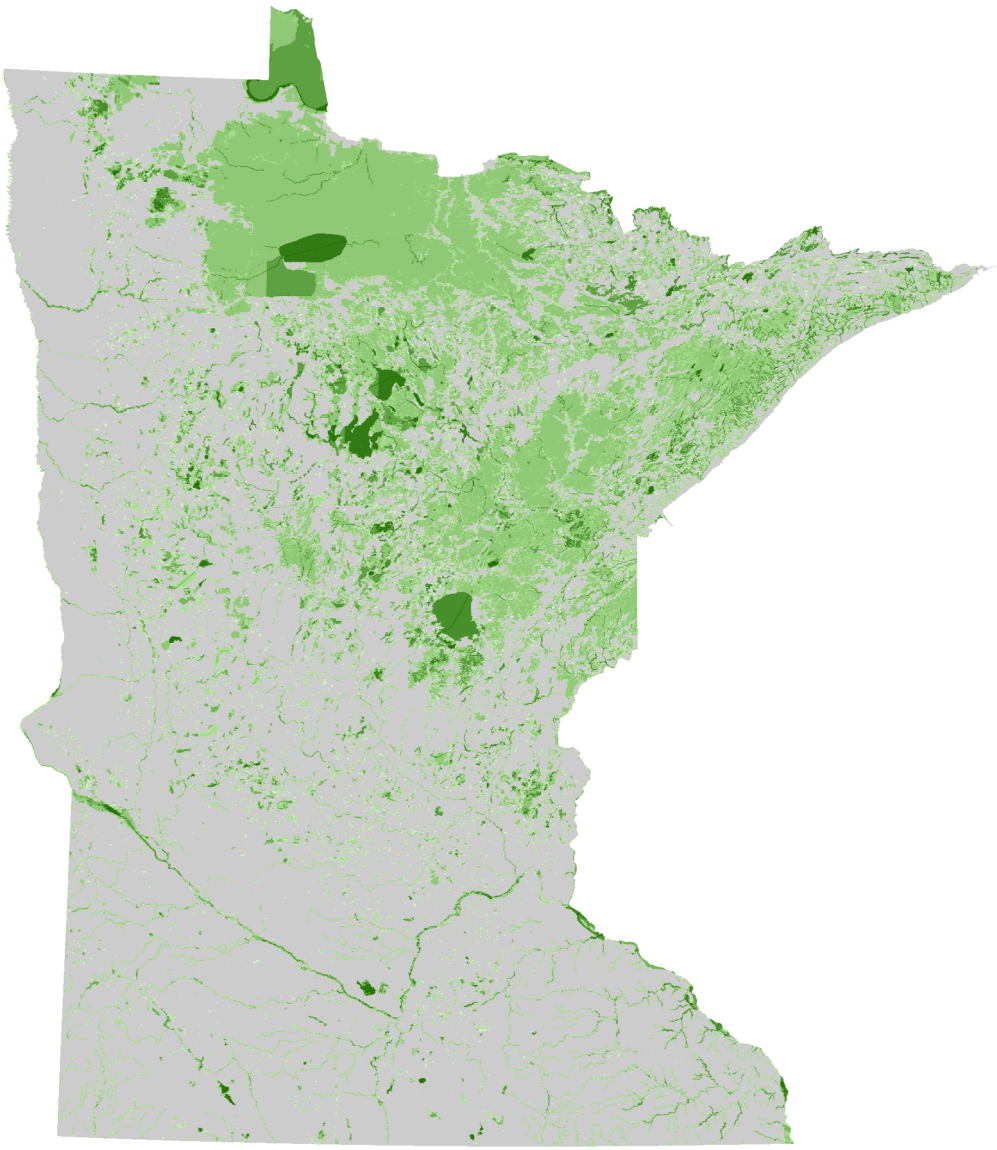


Figure H7. Integrated terrestrial value score. Credit: Terry Brown, NRRI.



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.

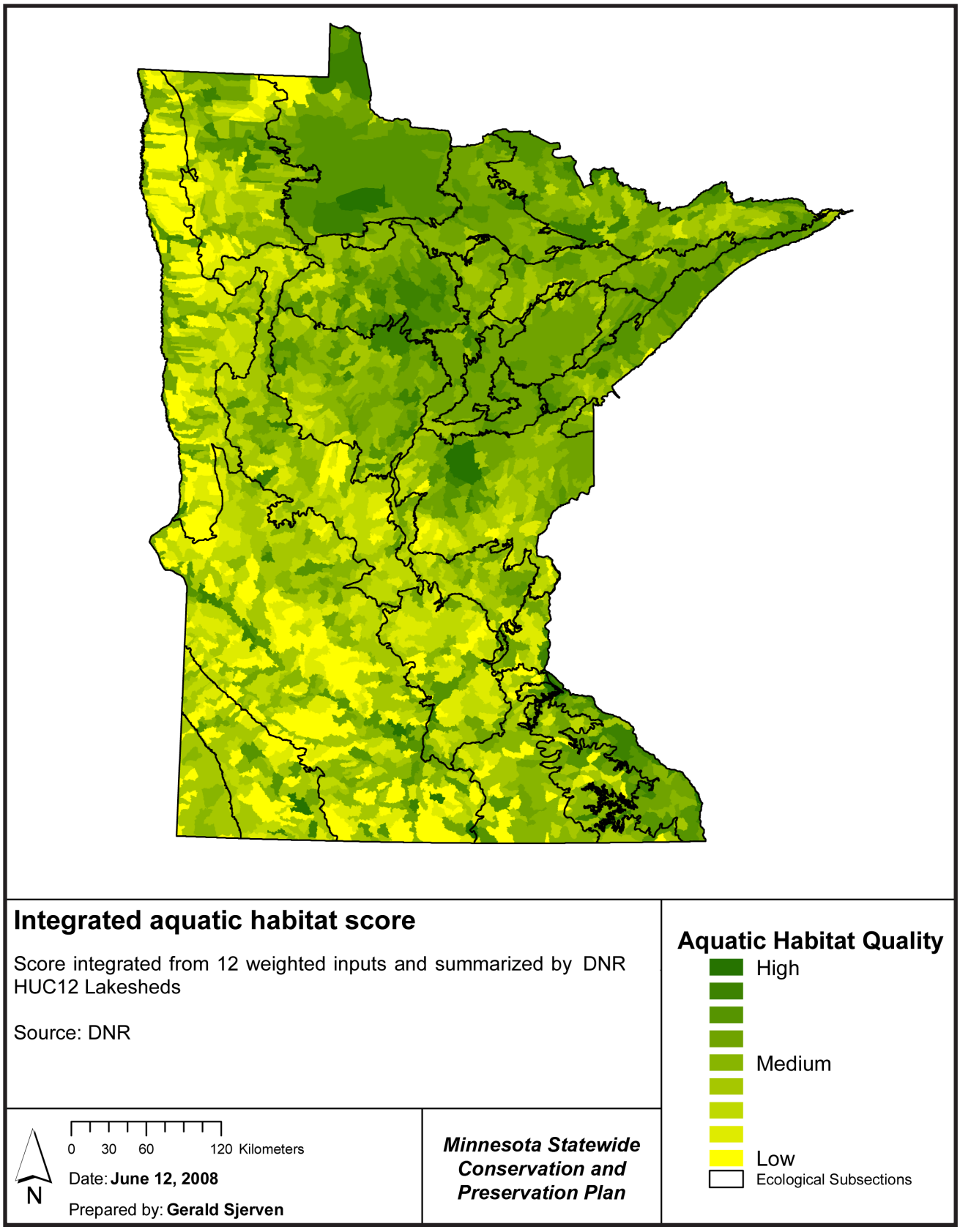


Figure H9. Integrated aquatic habitat score. Credit: Gerald Sjerven, NRRI.

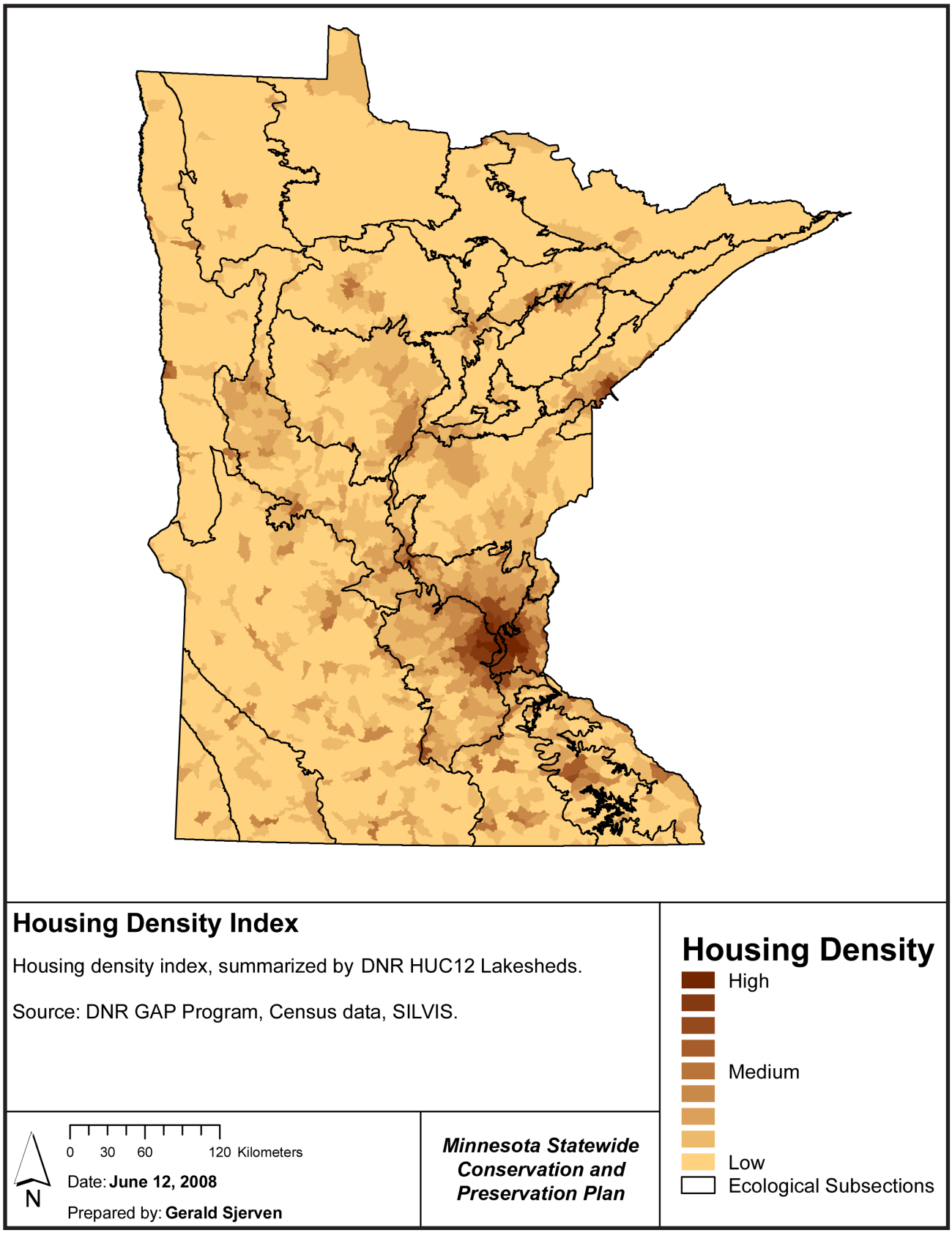


Figure H10. Housing density index. Credit: Gerald Sjerven, NRRI.

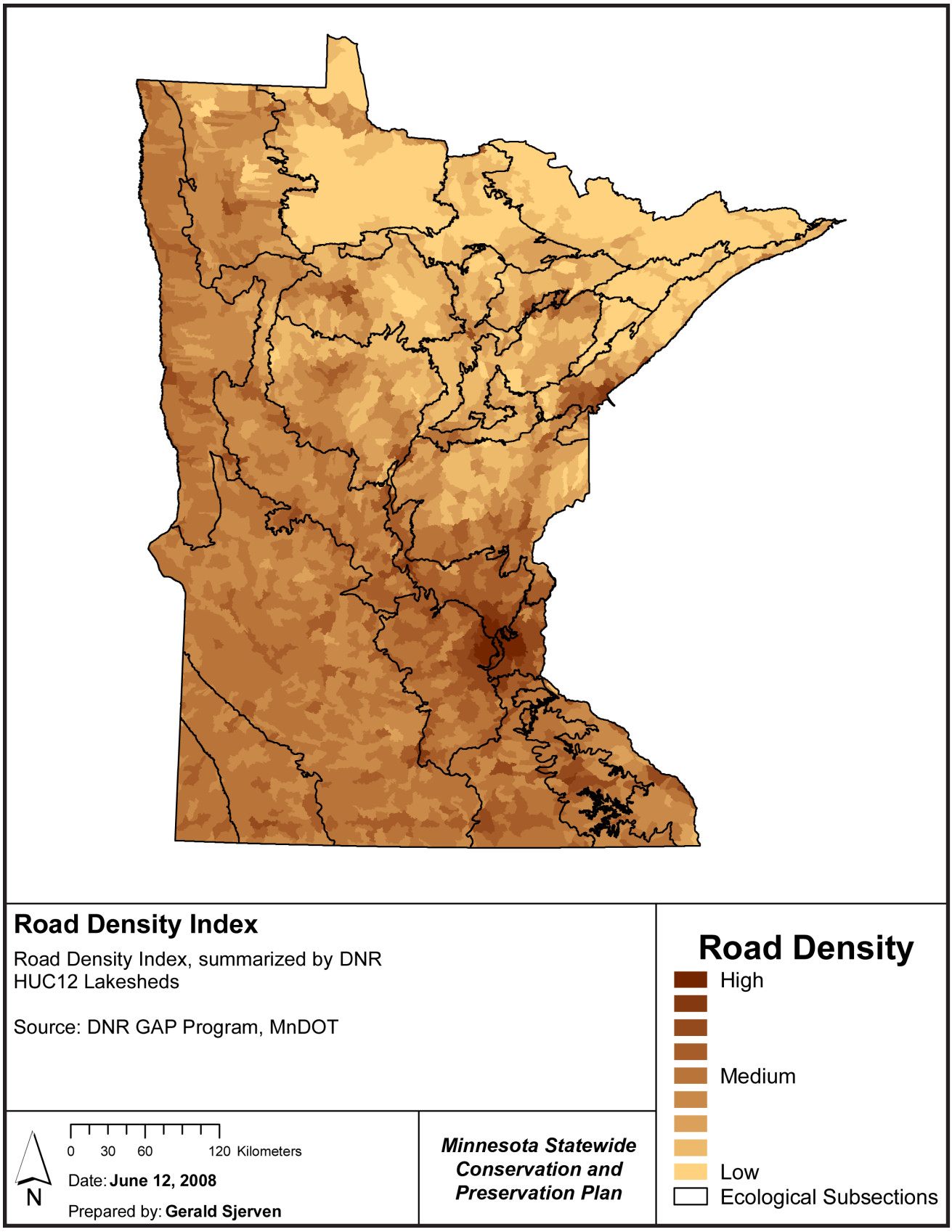


Figure H11. Road density index. Credit Gerald Sjerven, NRRI.

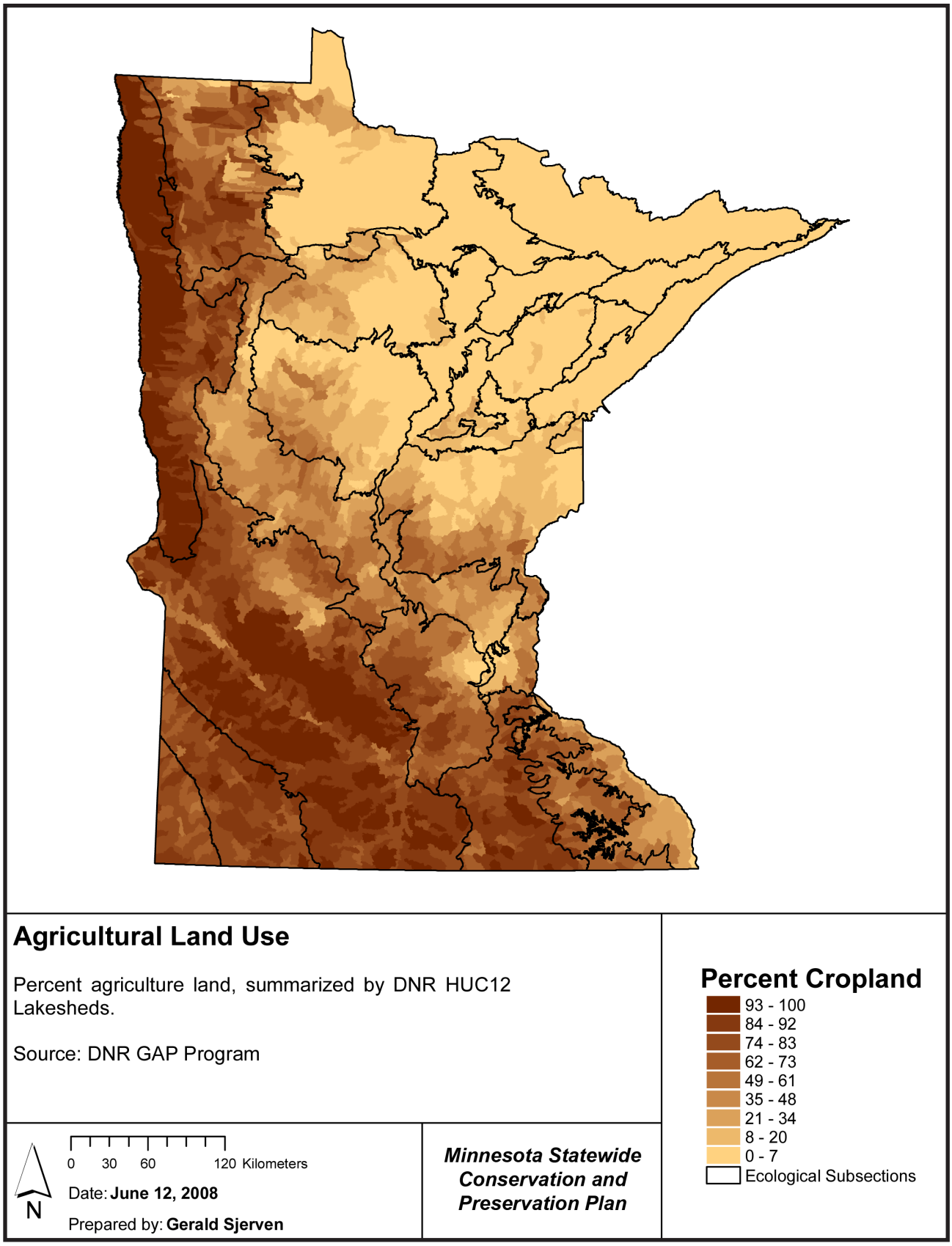


Figure H12. Agricultural land use. Credit: Gerald Sjerven, NRRI.

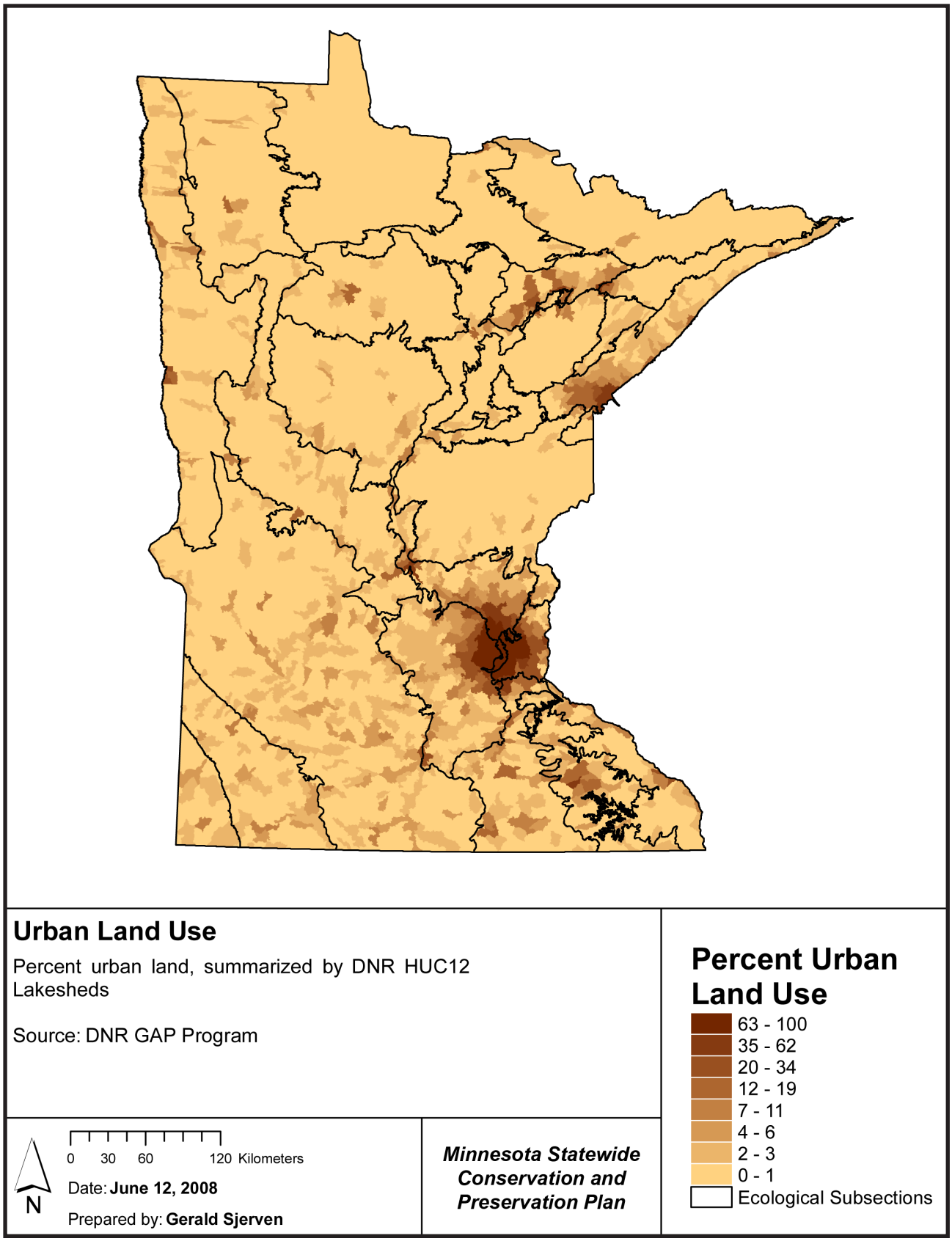


Figure H13. Urban land use. Credit: Gerald Sjerven, NRRI.

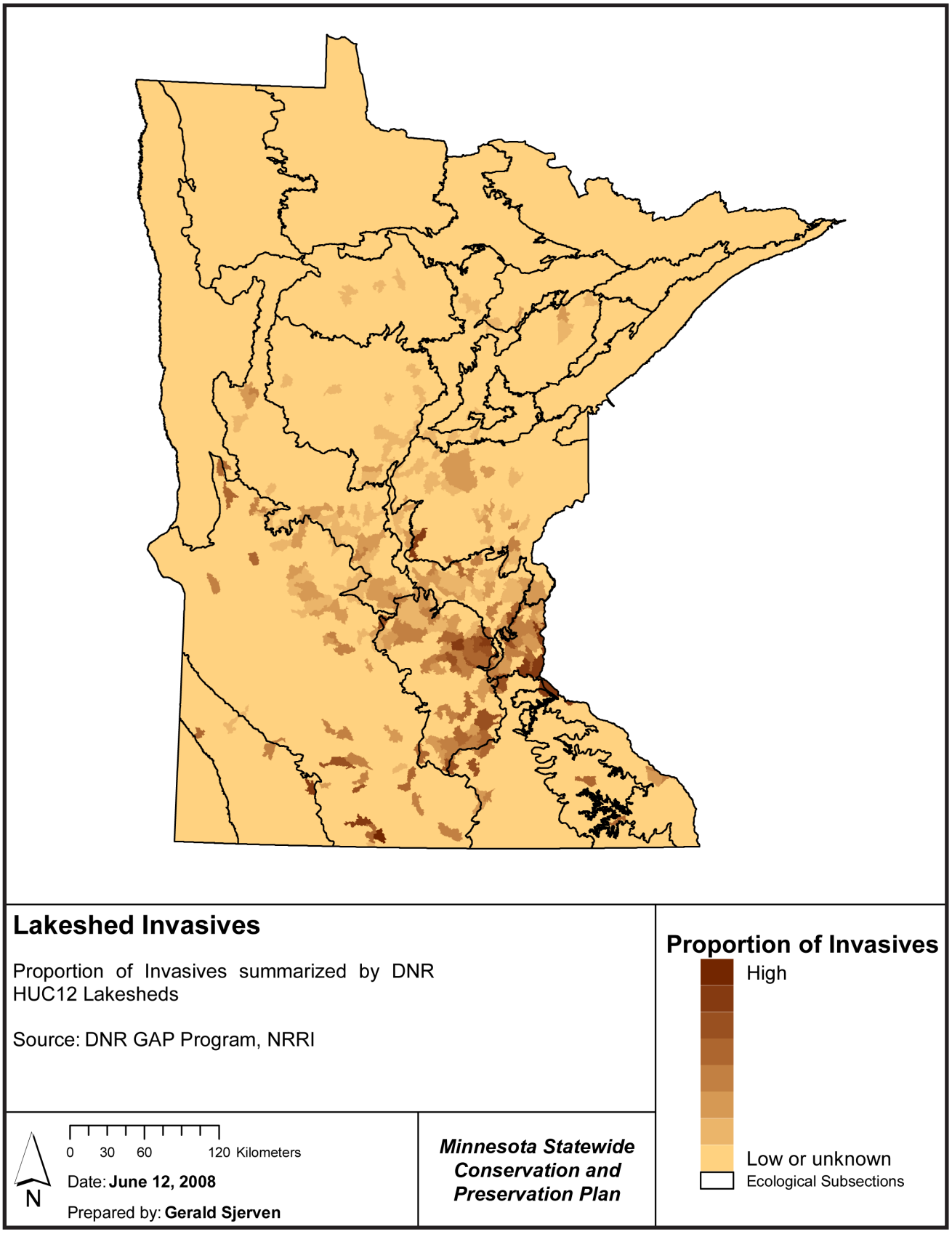


Figure H14. Lakeshed invasives. Credit: Gerald Sjerven, NRRI.

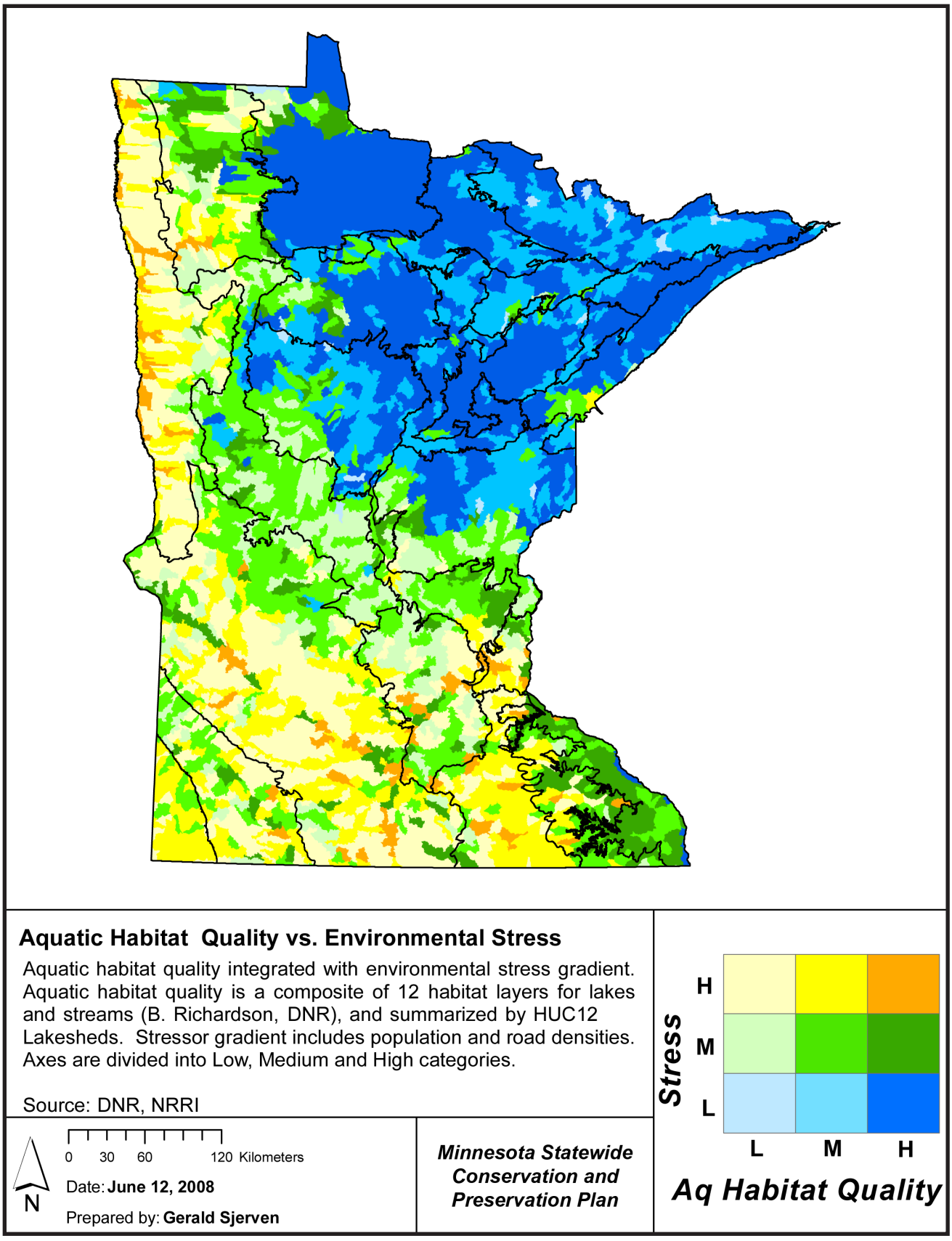


Figure H15. Aquatic habitat quality vs. environmental stress. Credit: Gerald Sjerven, NRRI.

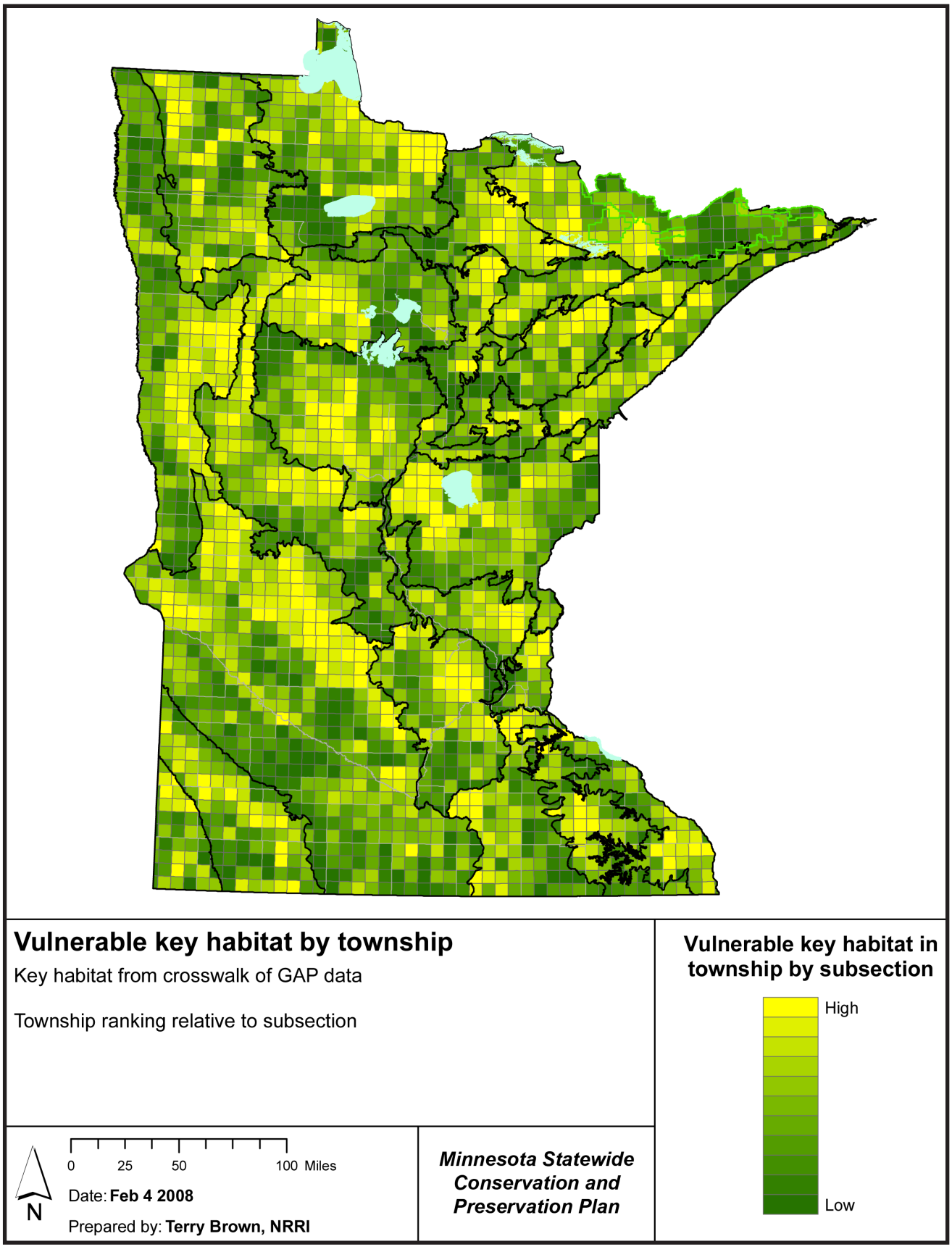


Figure H16. Vulnerable key habitat by township. Credit: Terry Brown, NRRI.

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.

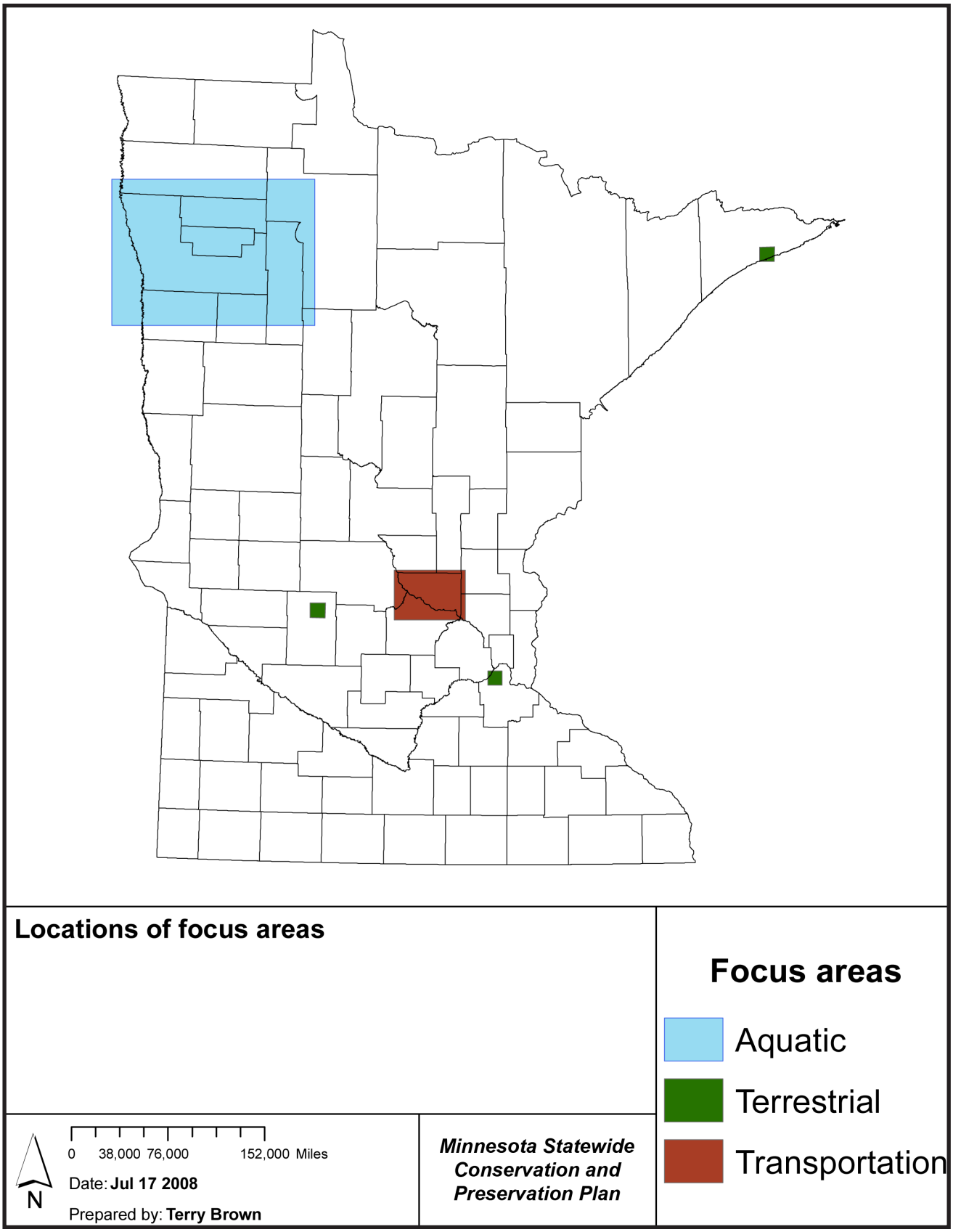


Figure H17. Locations of terrestrial and aquatic focus areas. Transportation example is covered in the transportation recommendations section. Credit: Terry Brown, NRRI.

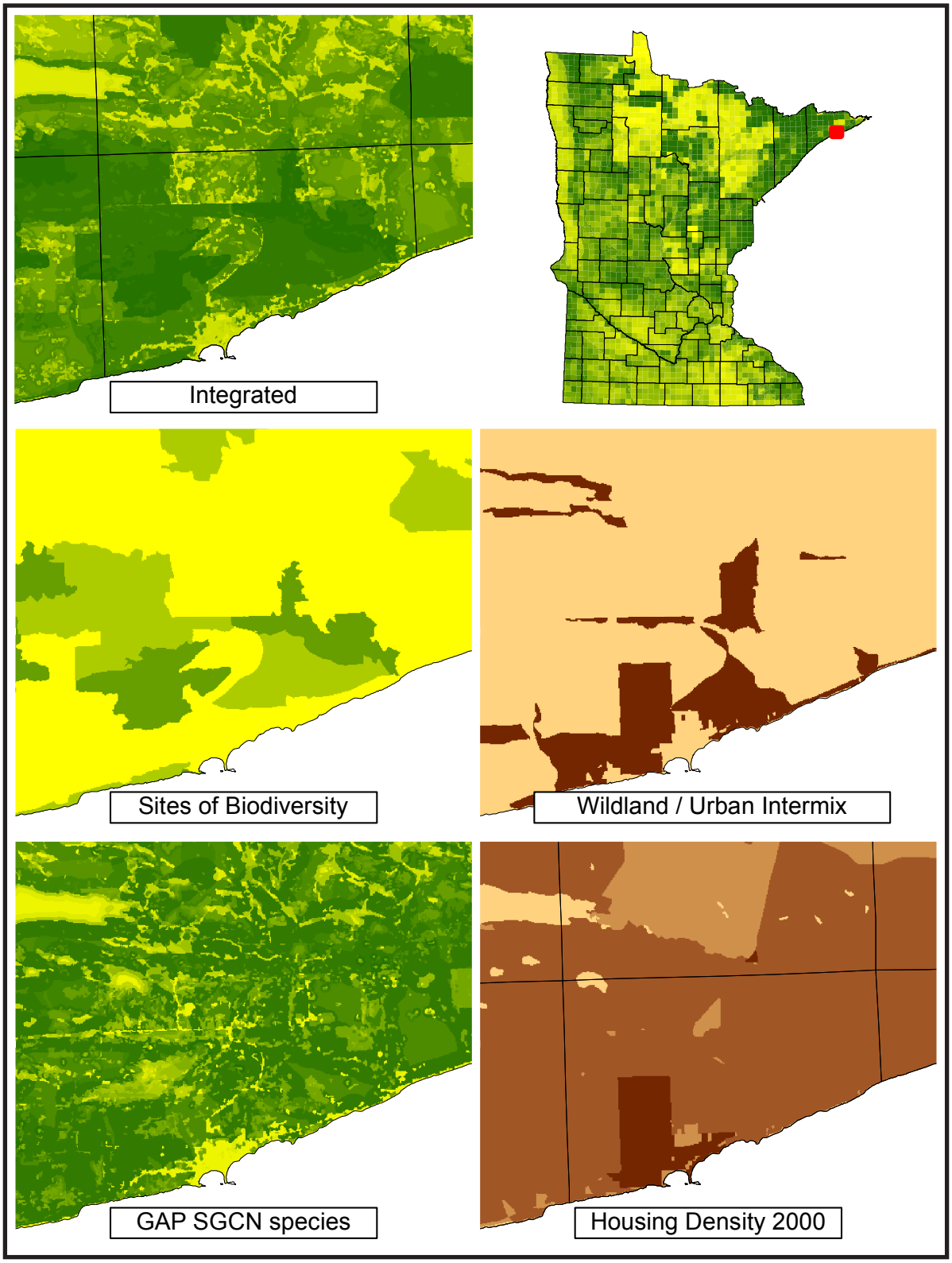


Figure H18. Summary of ecological values and stresses around Grand Marais along the North Shore of Lake Superior, Lake County. Dark areas have higher ecological value and low stress; lighter areas have lower ecological value and high stress. The panel labeled "Integrated" is the final conservation priority 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.

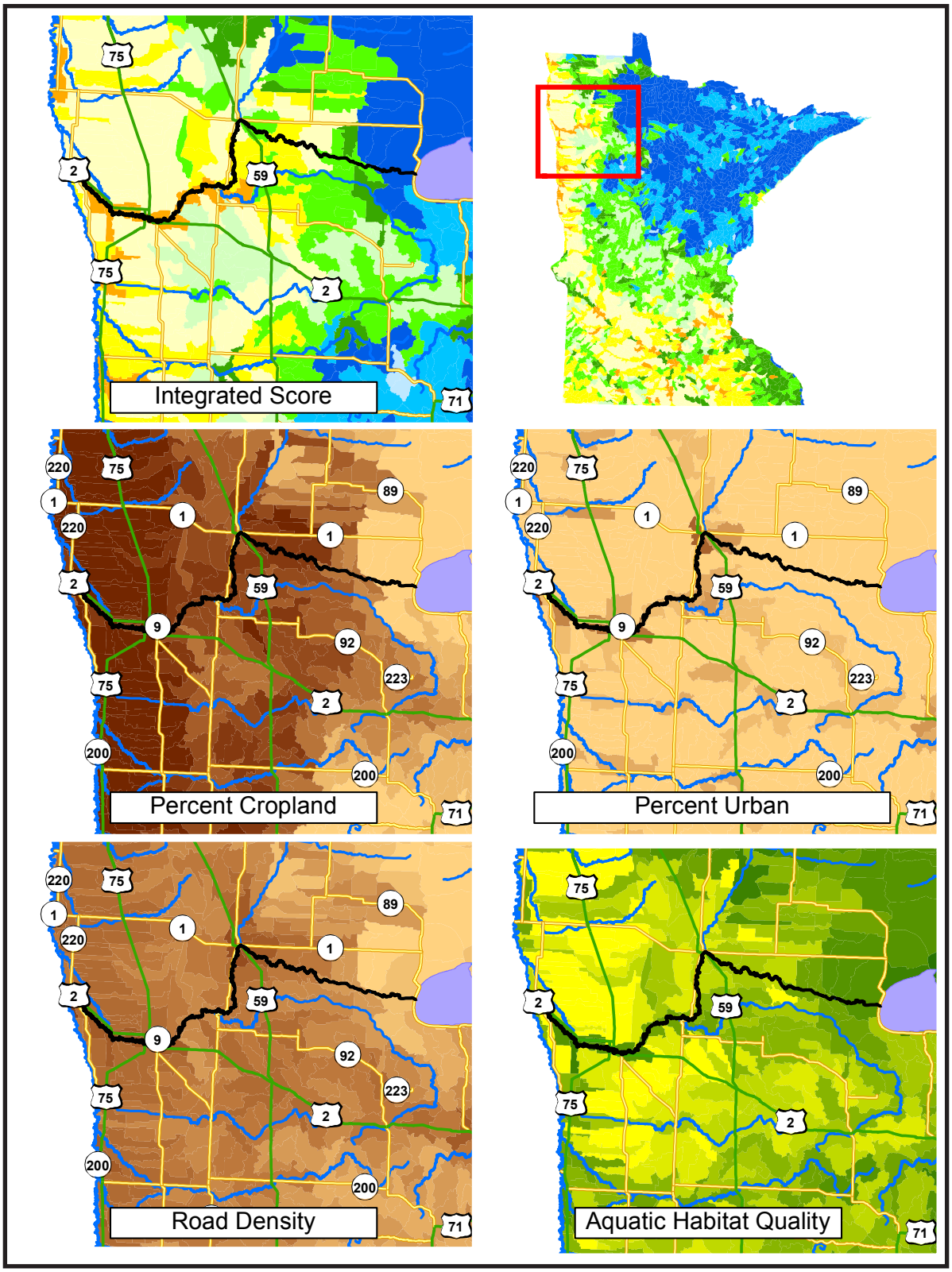


Figure H19. Summary of ecological values and stresses in the Red Lake River watershed in northwestern Minnesota. Orange areas show a combination of high aquatic ecological value and high stress. The panel labeled "'Integrated" is the final ecological values/stress map, while the other panels show selected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

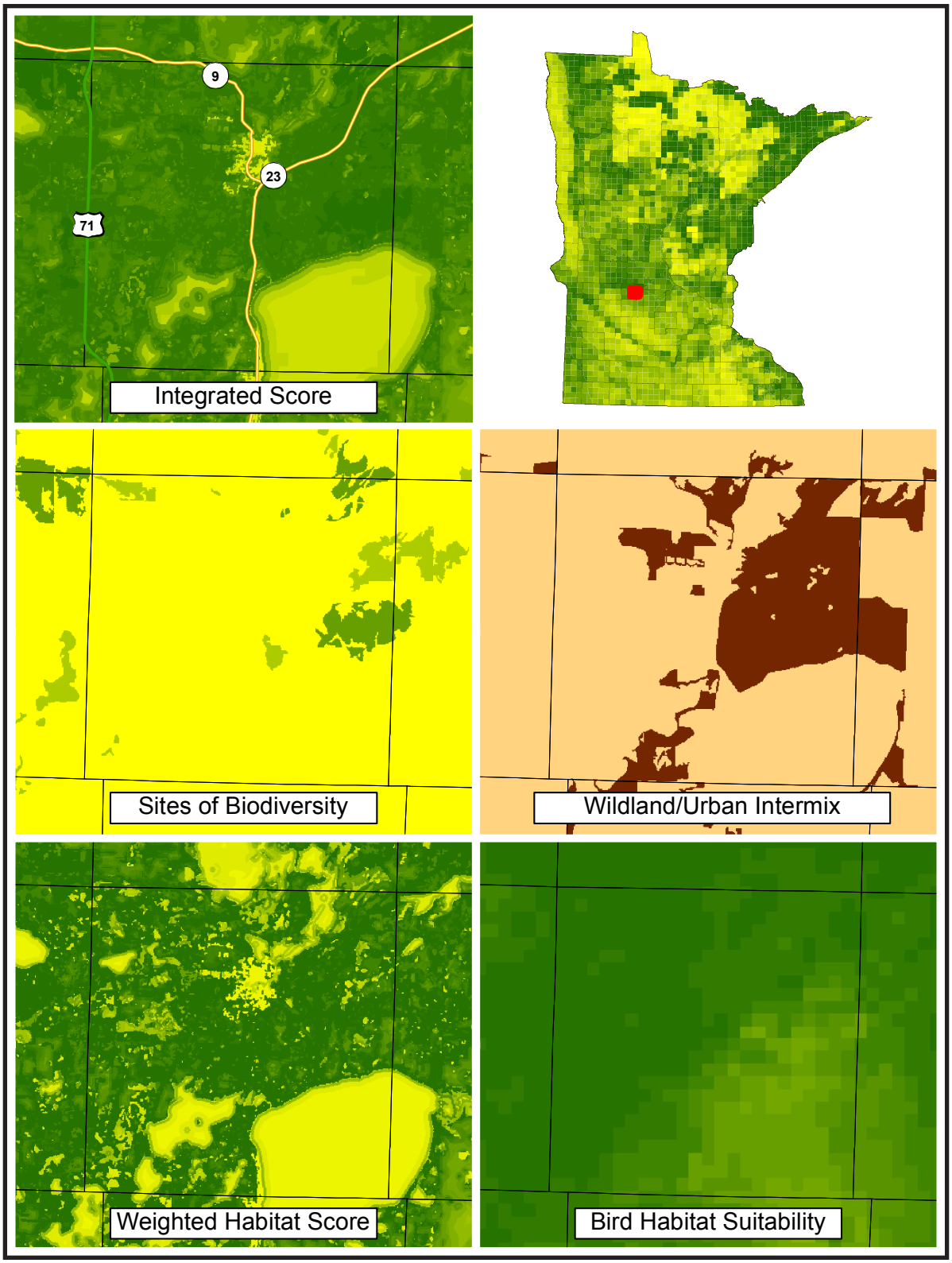


Figure H20. Summary of ecological values and stresses in western Minnesota, near New London (Kandiyohi County) and the Minnesota River prairie ecological subsection. Dark areas have higher ecological values and low stress; lighter areas have lower ecological values and high stress. The panel labeled "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.

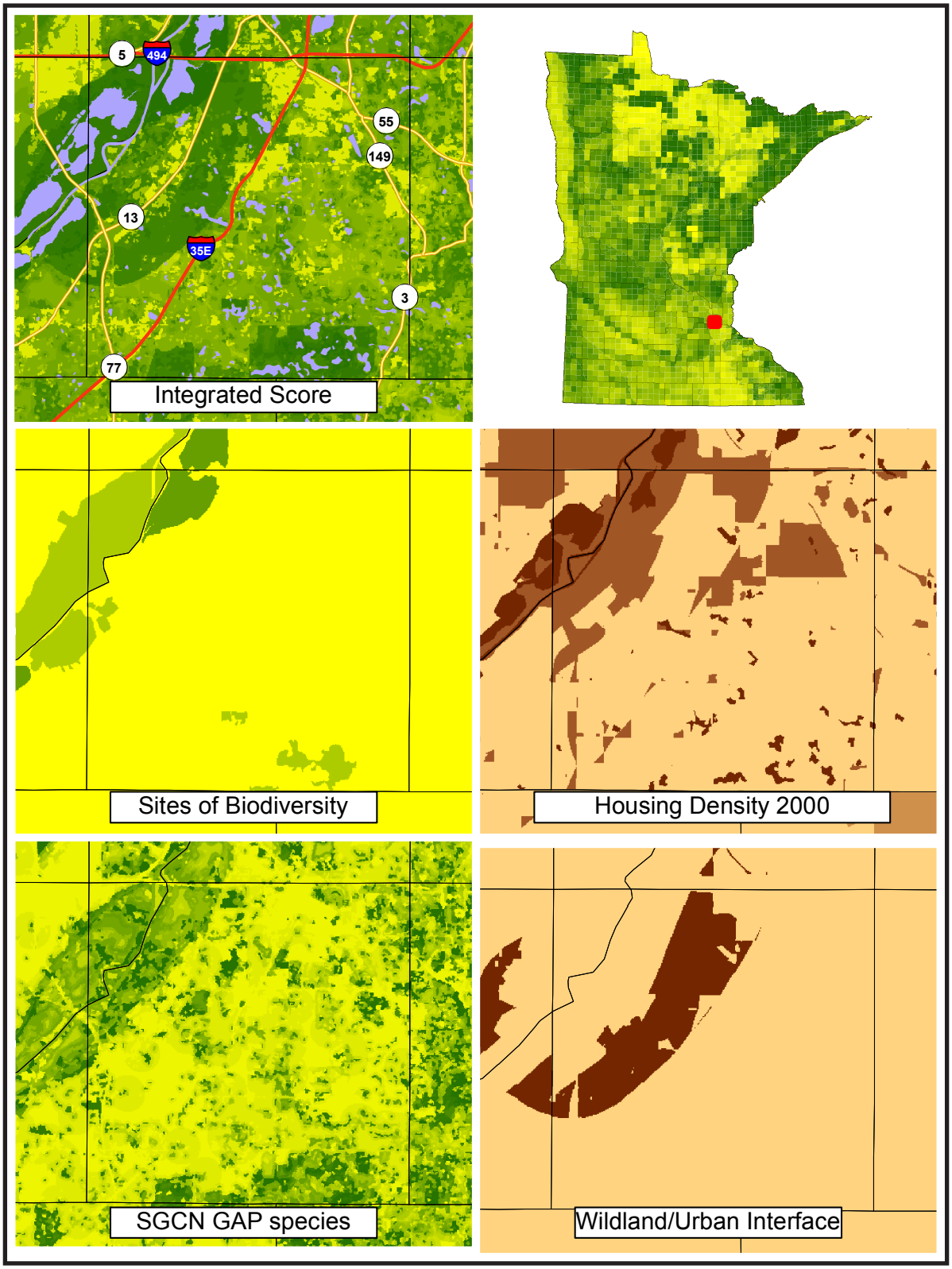


Figure H21. Summary of ecological values and stresses in the Twin Cities metropolitan area near Eagan, Dakota County. Dark areas have higher ecological value and low stress; lighter areas have lower ecological values and high stress. The panel labeled "Integrated" is the final ecological values/stress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

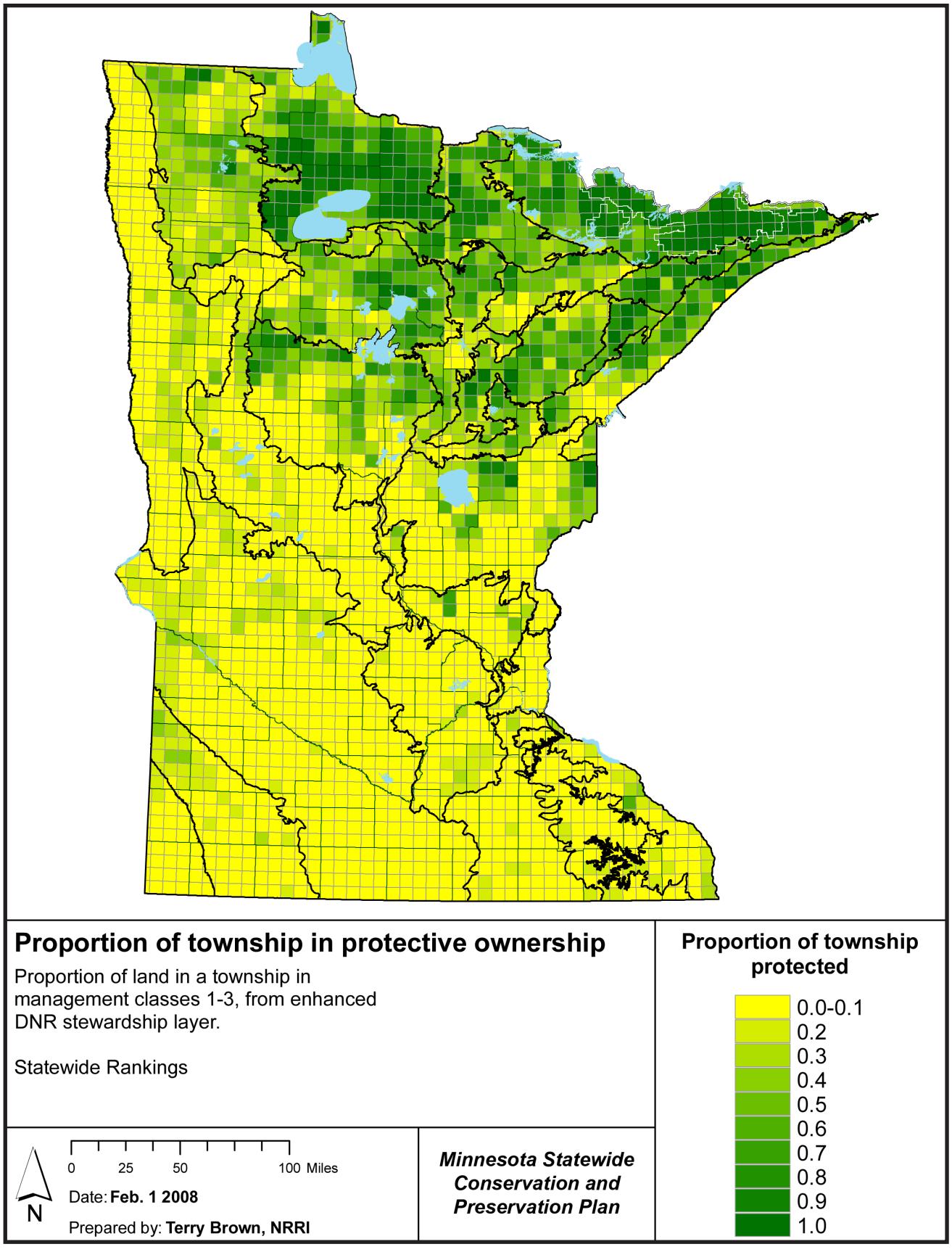


Figure H22. Ownership of land by entity. Credit: Terry Brown, NRRI; DNR.

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-

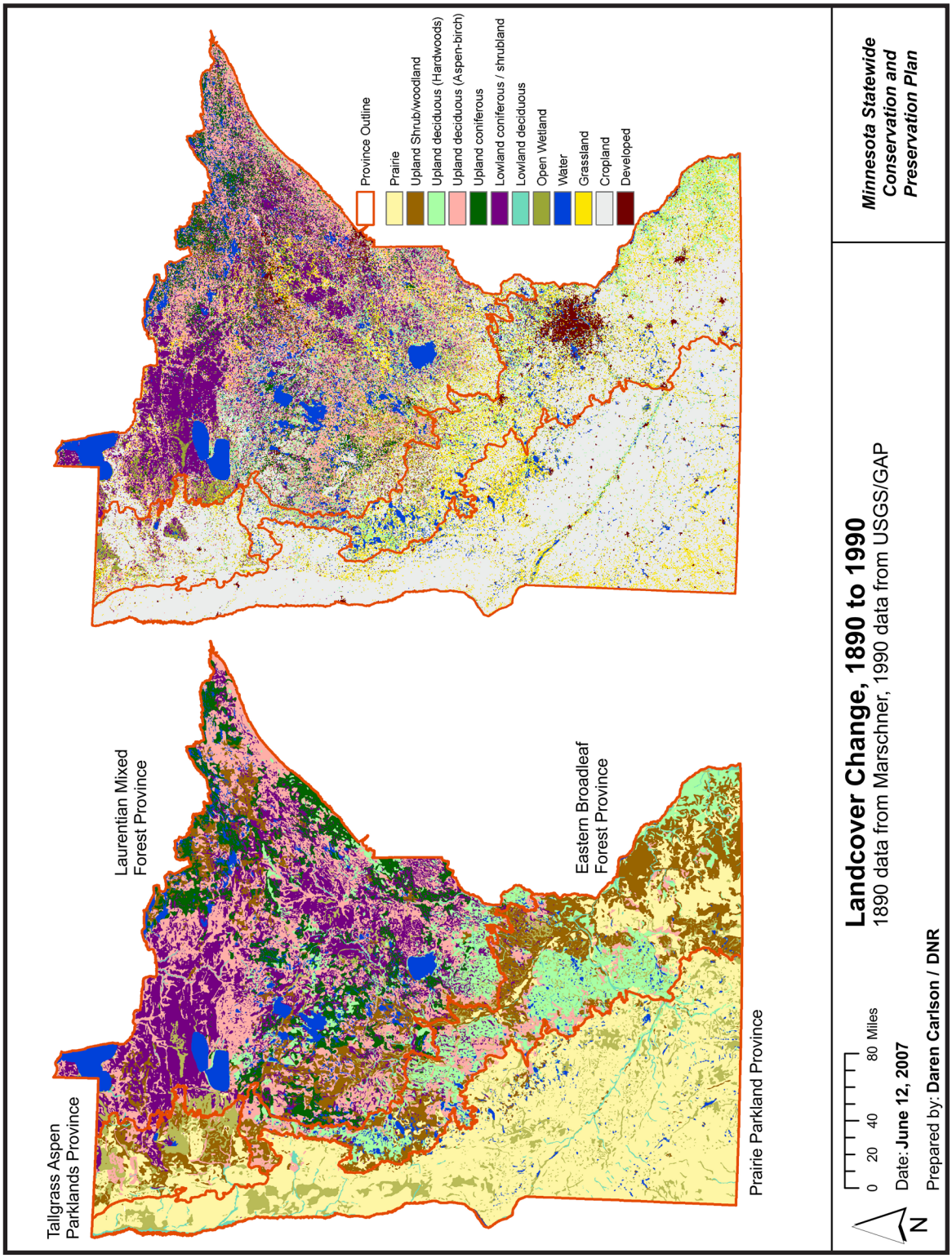


Figure H23. Marschner's map of vegetation around the time of European settlement and contemporary land cover, based on 1990 GAP data. Credit: Daren Carlson, DNR.

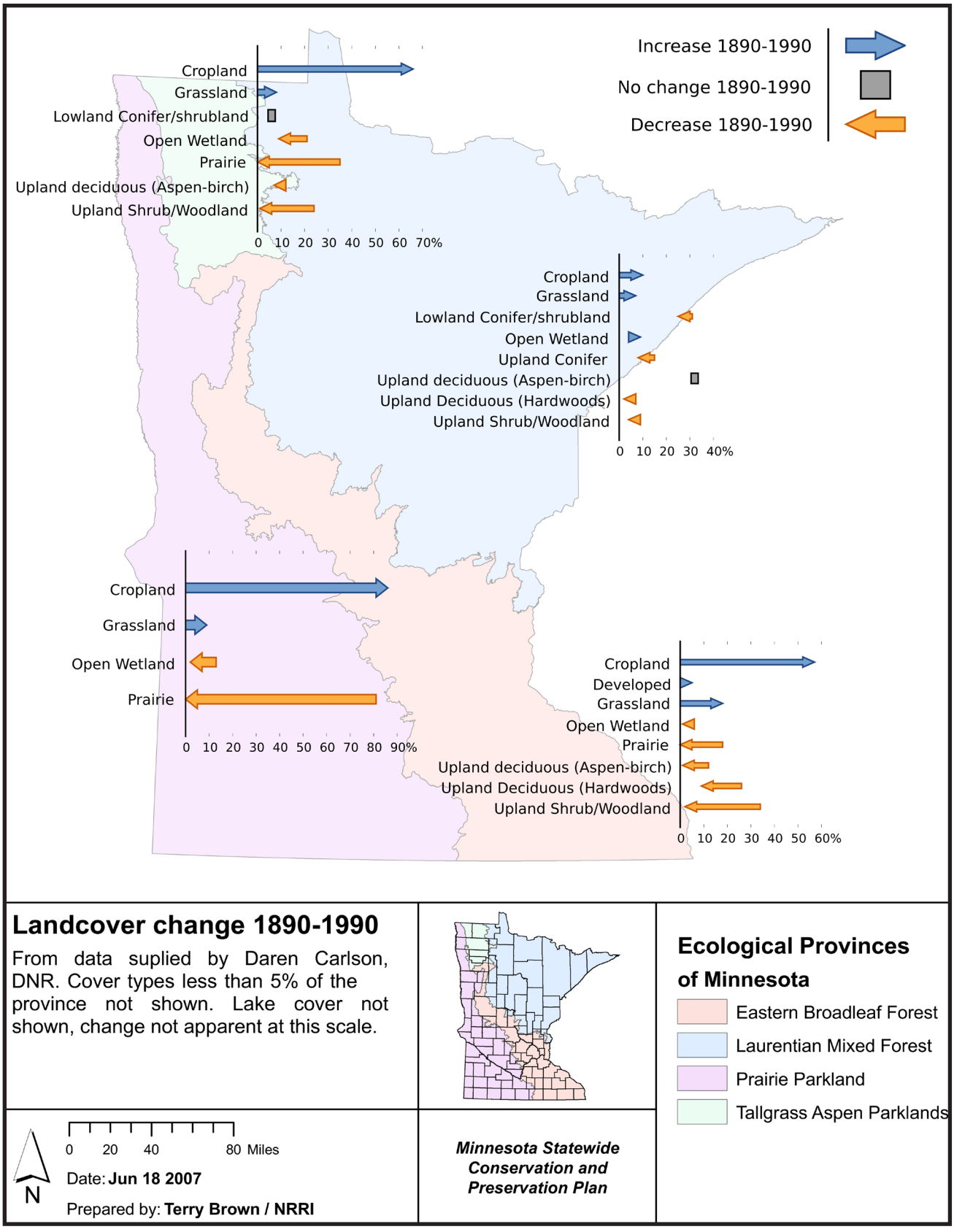


Figure H24. Land cover change, 1890–1990. Credit: Terry Brown, NRRI.

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.

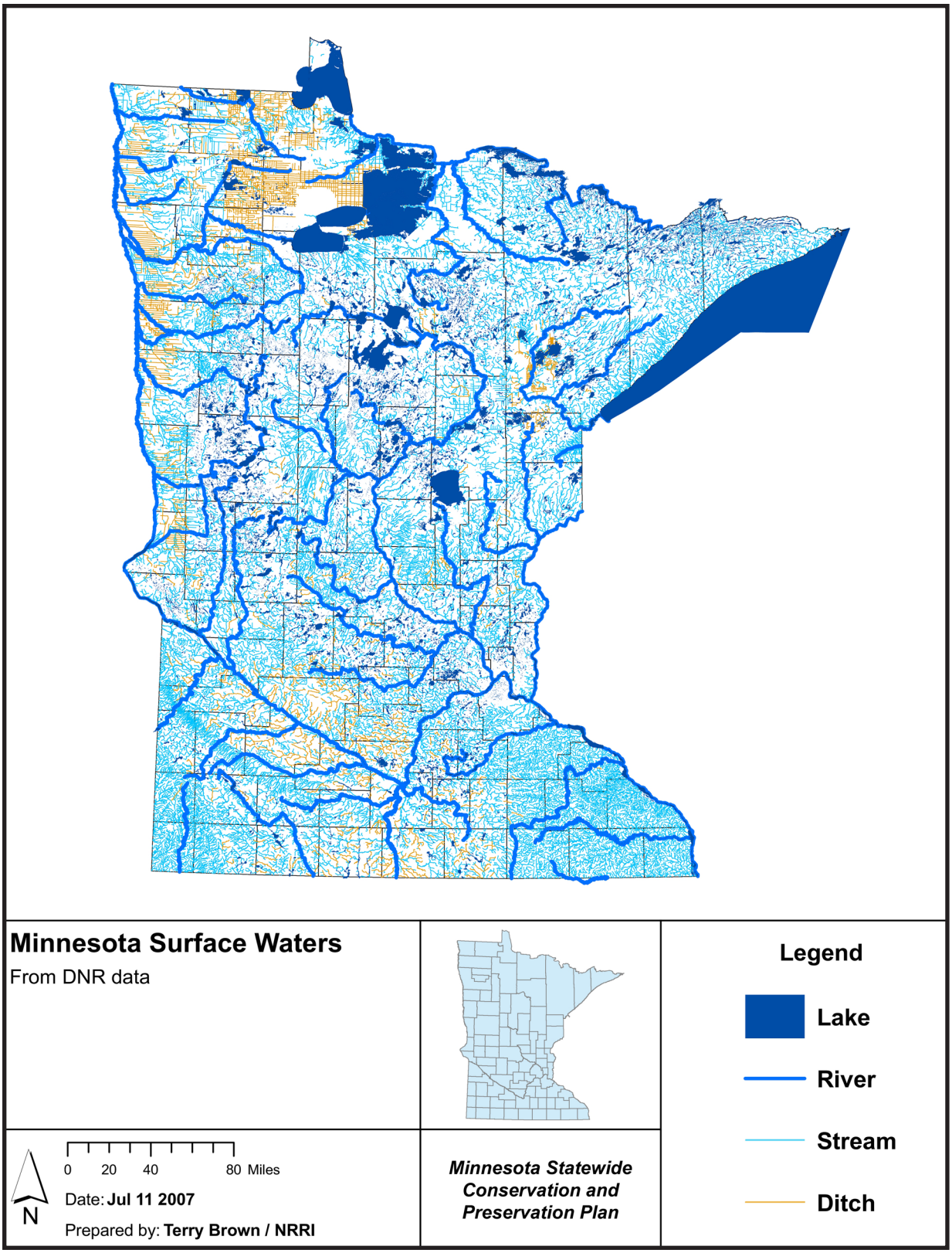


Figure H25. Surface waters in Minnesota. Credit: Terry Brown, NRRI.

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-

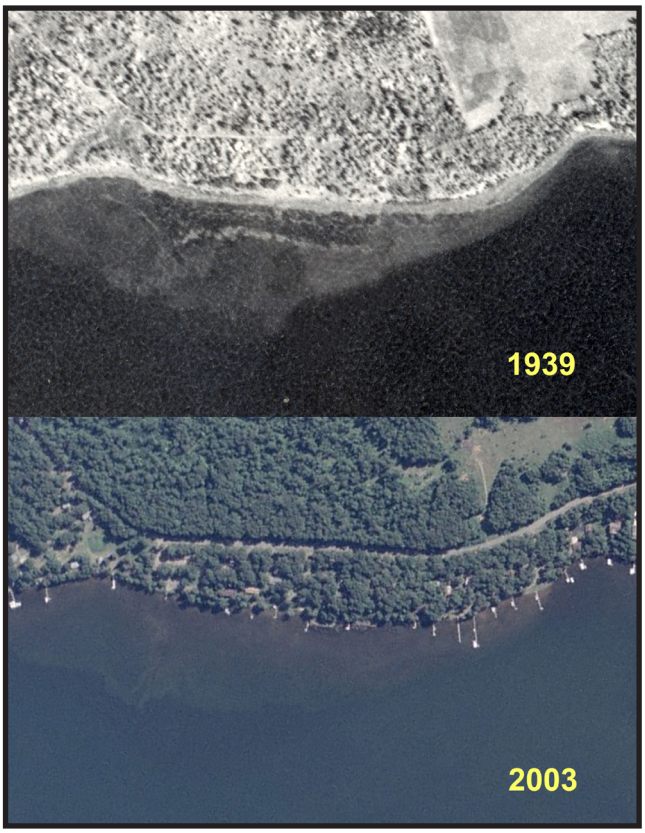


Figure H26. Aerial photographs show the same shore of a Minnesota lake 64 years apart. Note the disappearance of aquatic vegetation along the lakeshore in the 2003 photo.
Credit: 1939, USDA; 2003, USDA Farm Service Agency.

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.

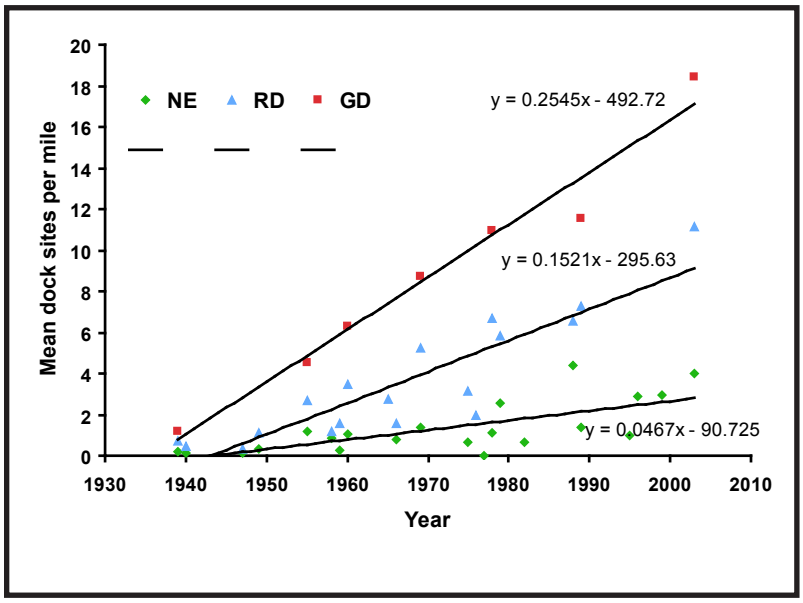


Figure H27. Development around north-central Minnesota lakes, as dock sites per mile, from DNR aerial photos. General development (GD) lakes have a faster rate of development than recreational development (RD) lakes, whereas natural environment (NE) lakes are just beginning to be developed. In 2003, 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

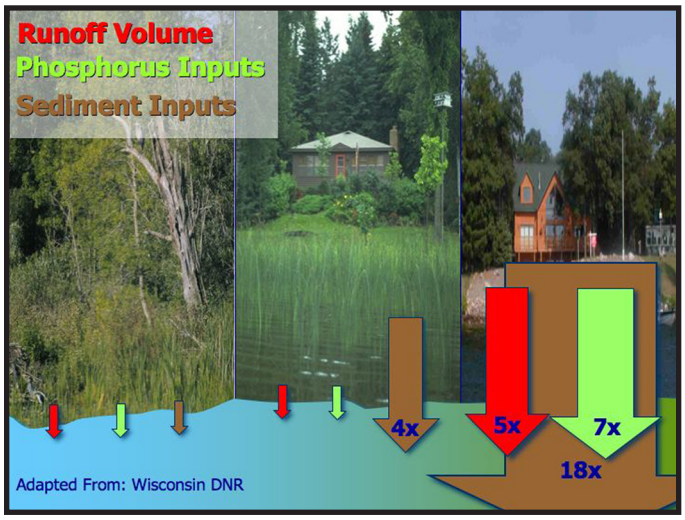


Figure H28. Increasing size of the arrows indicate increasing volume of runoff and nutrients as shorelines. Credit: DNR Waters.

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

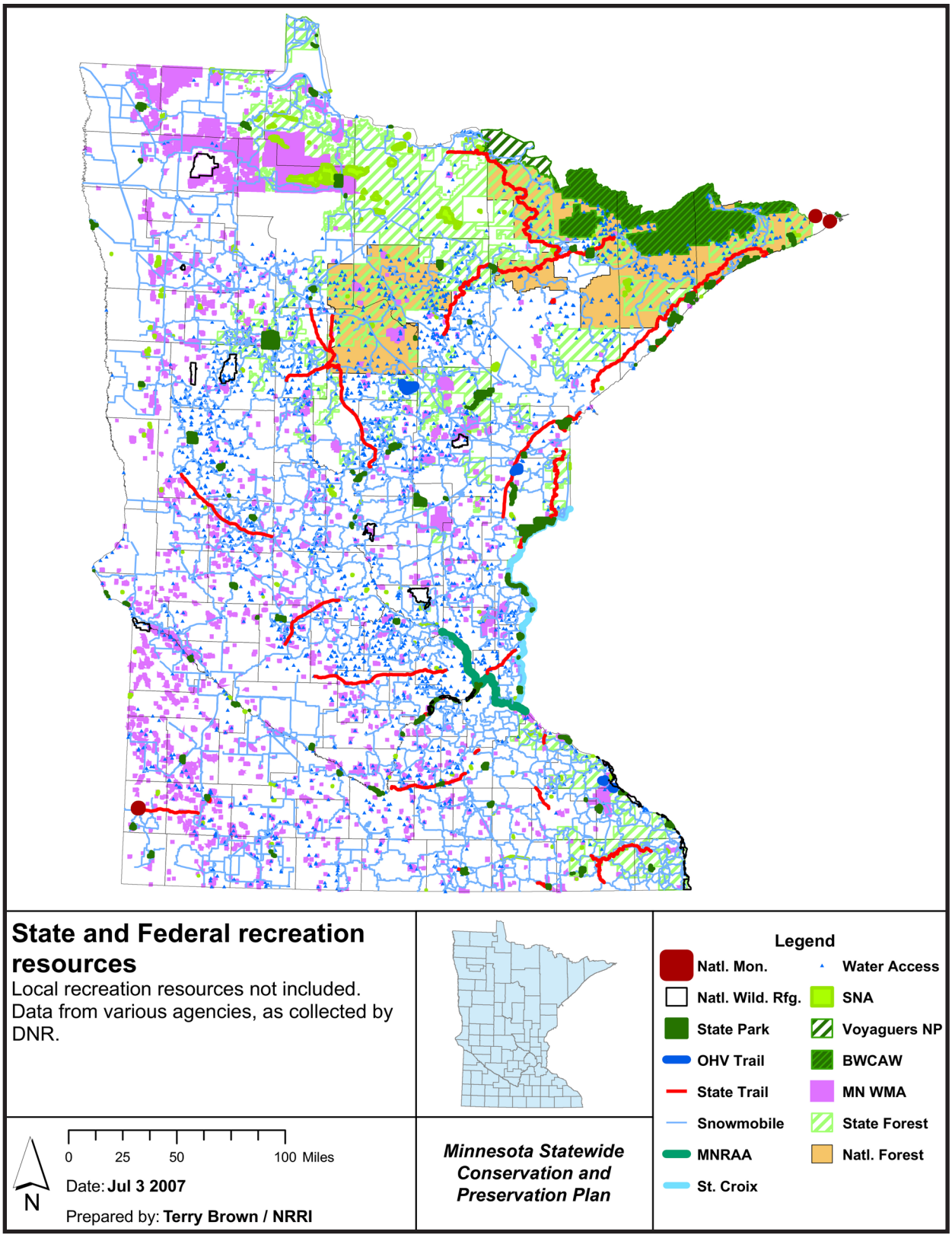


Figure H30. State and federal recreation resources available in Minnesota. Credit: Terry Brown, NRRI.

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.

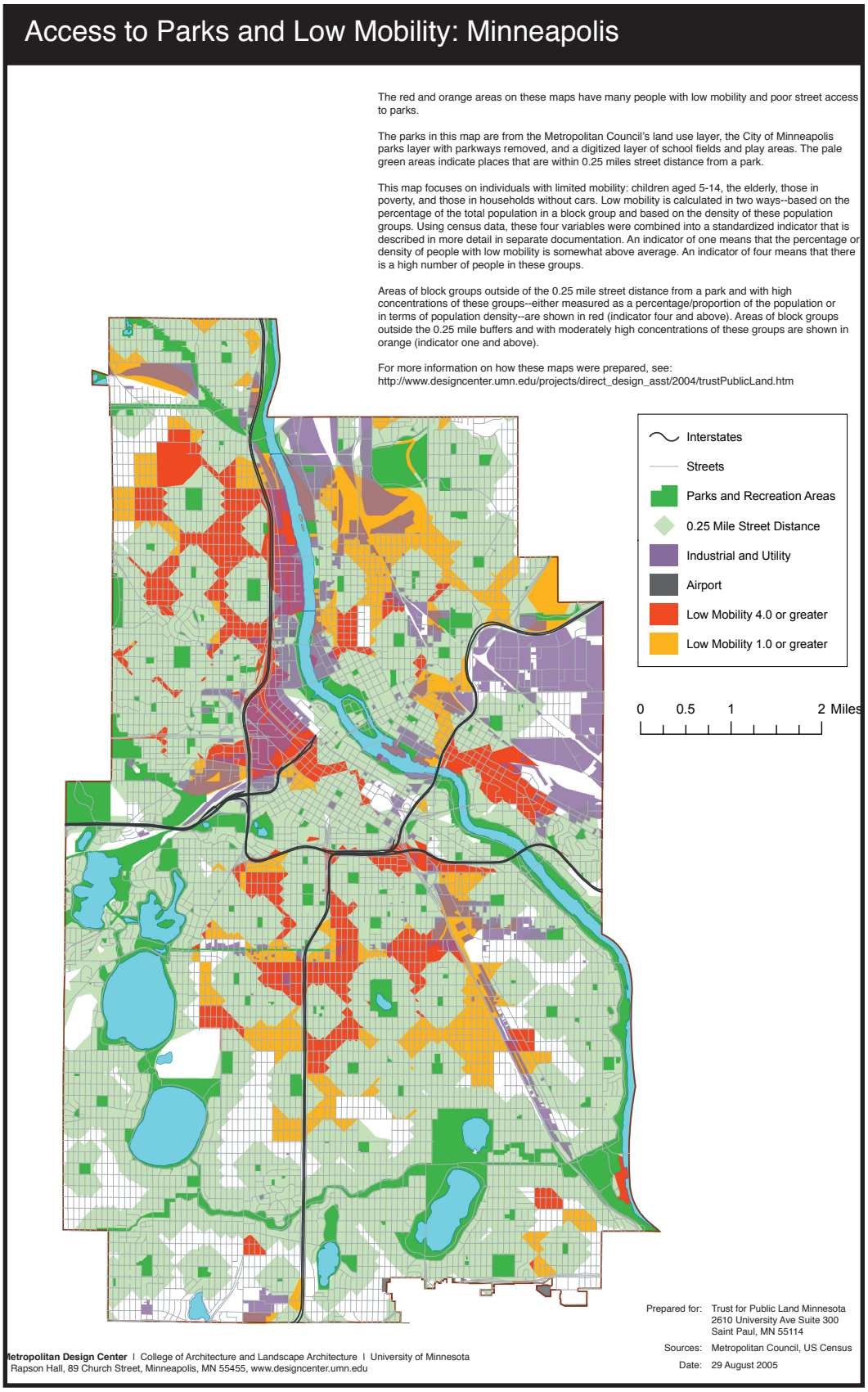


Figure H31. Access to parks and low mobility, Minneapolis.
Credit: Trust for Public Land with assistance from the Metropolitan Design Center, UM.

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-

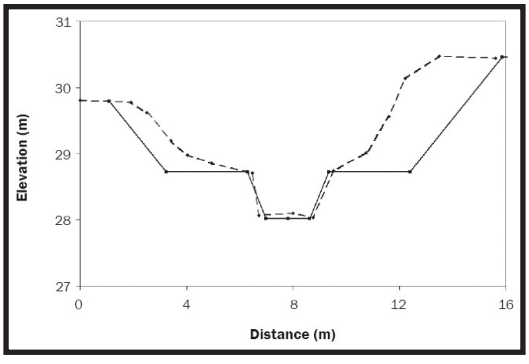


Figure H33. Cross-section of two-stage channel (solid line) constructed within a channelized stream (dashed line). Existing geometry shown in dashed lines and proposed two-stage channel dimensions based on the regional curve shown in solid lines.
Credit: Powell et al 2007.

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.

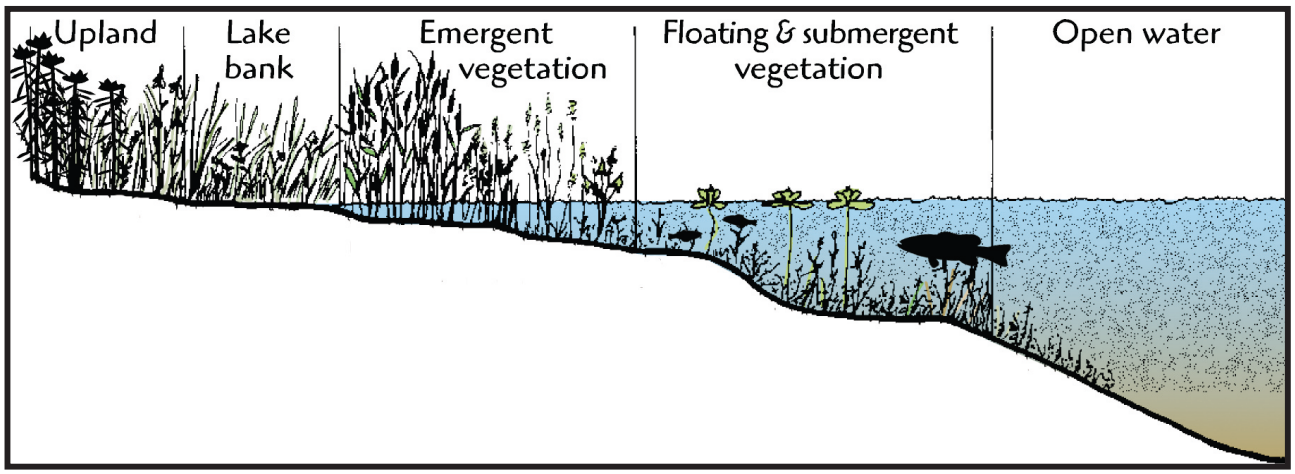


Figure H35. Floating, emergent, and natural vegetation along the shoreline provides habitat for fish and wildlife. Credit: DNR Waters.

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.

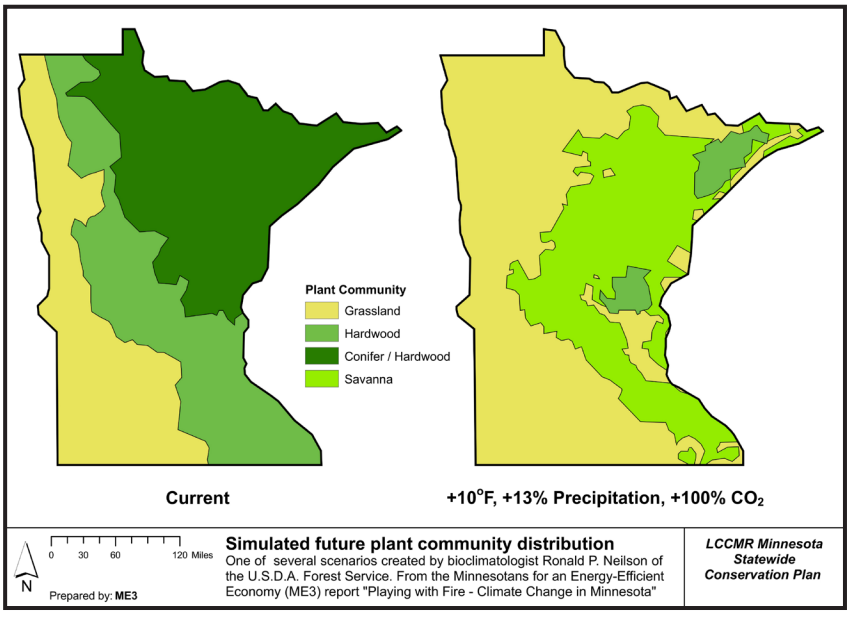


Figure H38: This map projects what Minnesota vegetation cover might look like if average temperatures in the state rise 10 degrees F and precipitation increases 13% at double historical CO_2 levels. This is one of several scenarios created by bioclimatologist Ronald P. Neilson of the USDA Forest Service.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