Chapter 7

Methods and Analyses

This chapter describes the methods of technical assessment used in *Tomorrow's Habitat for the Wild and Rare: An Action Plan for Minnesota Wildlife* (referred to in this document as Minnesota's Comprehensive Wildlife Conservation Strategy or CWCS). We first explain the problem analysis for each of the 292 species in greatest conservation need (SGCN), examining the factors that led to their rarity, vulnerability, or decline. Habitat loss and degradation emerged as the predominant reasons for the designation. With this in mind, and factoring in the large number of species involved and the statewide scope of the plan, the project's technical team determined that a sound approach to better manage these species would be to identify the key habitats they use by Ecological Classification System (ECS) subsection. The bulk of this chapter describes the methods used for determining these key habitats.

Focusing the attention and resources of CWCS partners on key habitats provides an efficient and effective approach to benefit the greatest number of SGCN for each conservation dollar spent. This will need to be coupled with a fine-filter species approach for those SGCN that do not benefit from conservation actions targeted at key habitats.

Species Problem Assessment

Each of the 292 species in greatest conservation need was evaluated to determine the factors influencing their rarity, vulnerability, or decline, using several sources of information, including Nature Serve Explorer; Revision Notes for Minnesota Endangered, Threatened, Special Concern Listing; Minnesota Rare Species Guide; and Partners in Flight, as well as various other published materials.

Each species was given a score of 0 to 3 across 9 categories based on the influence that each category has on the status of that species (Table 7.1). Each influence score (Table 7.2) was also given a level of confidence score from 1 to 3 (Table 7.3). Any category given an influence score of zero received a confidence score of 1. If no information was available about any influences, as was the case with some of the aquatic insects, then all categories were scored with a question mark ("?").

Table 7.1. Species Influence Categories

Category	Description
Habitat loss in Minnesota	Loss of habitat in Minnesota
Habitat degradation in Minnesota	Degradation of habitat in Minnesota, including loss of diversity, fragmentation, disruption of critical processes such as fire; also includes water quality degradation due to pollutant chemicals, nutrient input, or sedimentation/siltation
Habitat loss/degradation outside of Minnesota	Habitat loss or degradation outside of Minnesota that affects the population of the species within Minnesota; mainly applies to migratory species
Alien species and competition	Non-native invasive species or native species with populations outside of the natural range that occurred historically that affect the populations of species in greatest conservation need
Pollution	Contaminants such as pesticides, herbicides, and heavy metals; also includes sedimentation or siltation in river and stream systems.
Social tolerance/ persecution/exploitation	Recreational or commercial overexploitation, killing of individuals due to some perceived undesirable quality (such as large snakes thought to be venomous)
Disease	Introduced diseases or native diseases that are outside the natural range that occurred historically
Food source limitations	Predator species that rely on fluctuating prey cycles, or prey species that are influenced by fluctuating predator cycles
Other	Any factor that influences the species population that does not fall into the above categories (example: prescribed burning effects on prairie insects, road kills)
Peripheral (Y/N/E/D)	Species distribution in Minnesota relative to its entire range. Y = peripheral; N = not peripheral; E = endemic; D = disjunct (see Appendix K, Glossary of Terms, for a description of these designations)

Table 7.2. Species Influence Scores

Influence Score	Description
0	No indication of having an influence on species vulnerability/decline
1	Some indication of having an influence on species vulnerability/decline
2	Moderate influence on species vulnerability/decline
3	High influence on species vulnerability/decline
?	No information available about the species

Table 7.3. Confidence Scores

Confidence Score	Description
0	Not applicable
1	Some anecdotal evidence
2	Some published studies or general expert agreement
3	Several published studies or strong expert agreement
?	No information available about the species

The species assessment shows that the overwhelming influence on species vulnerability and decline is the loss or degradation of habitat in Minnesota (Table 7.4). A few species have other, specific issues that need individual attention.

Table 7.4. Results of the Species Assessment

	Percentage of Species with a Score of				
Influence Category	**3**	**2**	**1**	**0**	**?**
Habitat loss in Minnesota	10	33	33	14	10
Habitat degradation in Minnesota	18	37	28	7	10
Habitat loss/degradation out of Minnesota	1	8	15	71	5
Alien species and competition	2	10	12	70	6
Pollution	0	4	28	60	8
Social tolerance/persecution/exploitation	1	8	12	73	6
Disease	0	1	2	91	6
Food source limitations	0	1	2	91	6
Other	0	2	17	76	5

Note: Species were assigned an influence score from 0 to 3, or "?" if no information was available.

Key Habitat Analysis

The results of the assessment of the species in greatest conservation need clearly indicate the importance of identifying and conserving the habitats they use. Minnesota's 292 SGCN occupy a variety of habitats and are distributed across the entire state. Such a large number of species with a wide variety of needs poses the difficult task of developing strategies that benefit all. Given this challenge of managing for 292 species, CWCS conservation priorities focus primarily on a coarse-filter approach to conserving key habitats used by the SGCN.

Key habitats were identified using the following three methods, which are discussed below:

1. Species habitat use
2. Major changes in land cover
3. Identification of priority stream reaches based on analyses by The Nature Conservancy

Aquatic and terrestrial habitats were analyzed separately given that they differ in the type and availability of information, system characteristics, and associated species. Differences between the aquatic and terrestrial analyses are described as they arise in the sections below.

Species Habitat Use

In order to analyze habitat use by SGCN, we first needed to determine species–habitat relationships and species distributions. For this purpose, we adopted the approach developed by the MN GAP Analysis Program for terrestrial vertebrates and made several modifications and additions.

Species–Habitat Relationships

The GAP Level 4 land cover classes (49 categories; see Appendix D) were modified by the CWCS project. The nonforested wetlands portion of the GAP classes was matched to the Cowardin Wetland Classification used in the National Wetland Inventory (Wetlands classes 1 to 5; Table 7.5), including the NWI category, "Seasonally flooded basin or flat," which did not have a GAP equivalent. The addition of eight lake classes (Tables 7.5 and 7.6; Valley et al. 2004) and seven river classes (Tables 7.5 and 7.7) expanded the GAP Level 4 "aquatic" category. Specific terrestrial habitats that did not have a GAP equivalent were also included and are "cliff/talus slope," "shoreline/dune," "oak savanna," "oak woodland," and "jack pine woodland." River classes were developed using data on stream and watershed size from the Minnesota Pollution Control Agency (Scott Nemela, personal communication). Linear regression of drainage area versus stream size for streams with drainage areas less than 200 square miles was run to determine reasonable break points for the classifications and the average stream widths (Figure 7.1). The approach described here resulted in a total of 70 classes of habitat that were related to the SGCN.

Relating the invertebrate and aquatic species to the 70 CWCS habitat classes was accomplished using a variety of published materials and expert consultation. We made some modifications to the terrestrial species–habitat relationships, originally created by the GAP analysis project. These species-habitat relationships were developed for use in GIS models using buffers and adjacency of nonprimary habitat, whereas the CWCS species–habitat relationships were based on presence/absence in the primary habitat(s) used by species for breeding (or main migratory habitat for migrating shorebirds). The CWCS Feedback Teams (see chapter 2) reviewed all of the species–habitat relationships, and further changes were made following those reviews.

Table 7.5. CWCS–GAP Level 4 Habitat Categories

GAP 4 ID	GAP Level 4	CWCS Level 4
1	Mixed development	Mixed development
2	High-intensity urban	High-intensity urban
3	Low-intensity urban	Low-intensity Urban
4	Transportation	Transportation
5	Barren	Barren
6	Cropland	Cropland
7	Grassland	Grassland
8	Prairie	Prairie
9	Upland shrub	Upland Shrub
10	Lowland deciduous shrub	Lowland deciduous shrub
11	Lowland evergreen shrub	Lowland evergreen shrub
12	Water	Lake-Small, Shallow, not alkaline
12	Water	Lake-Large, Shallow, not alkaline
12	Water	Lake-Small, Shallow, alkaline
12	Water	Lake-Large, Shallow, alkaline
12	Water	Lake-Small, Deep, not alkaline
12	Water	Lake-Large, Deep, not alkaline
12	Water	Lake-Small, Deep, alkaline
12	Water	Lake-Large, Deep, alkaline
12	Water	River-Headwater, cold
12	Water	River- Moderate, cold
12	Water	River-Large, cold
12	Water	River-Headwater, warm
12	Water	River-Moderate, warm
12	Water	River-Large, warm
12	Water	River-Very large, warm
12	Water	Shallow open water
14	Sedge Meadow	Wet meadow
15	Broadleaf Sedge/Cattail	Shallow marsh
15	Broadleaf Sedge/Cattail	Deep marsh
16	Jack Pine	Jack Pine
17	Red/White Pine	Red/White Pine
18	Red Pine	Red Pine
19	White Pine mix	White Pine mix
20	Balsam Fir mix	Balsam Fir mix
21	White Spruce	White Spruce
22	Upland Black Spruce	Upland Black Spruce
23	Upland Northern White Cedar	Upland Northern White Cedar
24	Red cedar	Red cedar
25	Upland Conifer	Upland Conifer
26	Lowland Black Spruce	Lowland Black Spruce
27	Stagnant Black Spruce	Stagnant Black Spruce
28	Tamarack	Tamarack
29	Stagnant Tamarack	Stagnant Tamarack
30	Lowland Northern White-Cedar	Lowland Northern White Cedar
31	Stagnant Northern White-Cedar	Stagnant N White Cedar
32	Stagnant Conifer	Stagnant Conifer
33	Aspen/White Birch	Aspen/White Birch
34	White/red Oak	White/Red Oak
35	Bur/White Oak	Bur/White Oak
36	Red Oak	Red Oak
37	Northern Pin Oak	Northern Pin Oak
38	Maple/Basswood	Maple/Basswood
39	Upland Deciduous	Upland Deciduous mix
40	Black Ash	Black Ash
41	Silver Maple	Silver Maple
42	Cottonwood	Cottonwood
43	Lowland Deciduous	Lowland Deciduous Mix
44	Upland Coniferous-Deciduous mix	Upland Conifer/Deciduous Mix Forest
45	Jack Pine-Deciduous mix	Jack Pine-Deciduous mix
46	Red/White Pine-Deciduous mix	Red/White Pine-Deciduous mix
47	Spruce/Fir-Deciduous mix	Spruce/Fir-Deciduous mix
48	Redcedar-Deciduous mix	Red cedar-Deciduous mix
49	Lowland Conifer-Deciduous mix	Lowland Conifer/Decid. Mix Forest
NA	NA	Cliff/talus slope
NA	NA	Shoreline/dune
NA	NA	Seasonally flooded basin or flat
NA	NA	Jack pine woodland
NA	NA	Oak savanna
NA	NA	Oak woodland

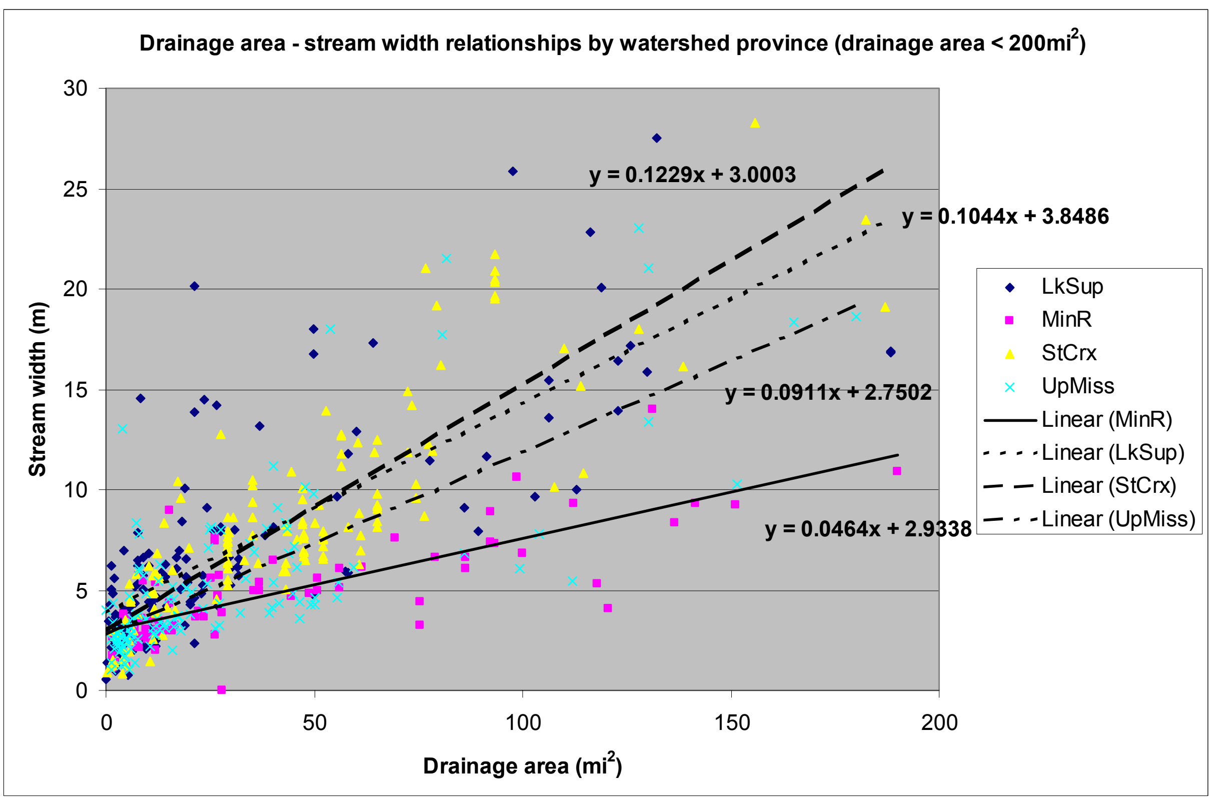
Table 7.6. Lake Parameter Descriptions

Parameter	Descriptions	
Area	Small: < 500 acres (200 hectares)	Large: > 500 acres (200 hectares)
Depth	Shallow: < 15 ft (5m) or > 80% littoral	Deep: > 15 ft (5 m) or < 80% littoral
Alkalinity	Alkaline: > 100 ppm mg/L $CaCO_3$	Not alkaline: < 100 ppm mg/L $CaCO_3$

Table 7.7. River Size Descriptions

Stream Size	Watershed Area	Maximum Width
Headwater	< 25 mi^2 (65 km^2)	averages ~ 13 ft (4 m) across, varies from ~ 3–23 ft (1–7 m)
Moderate	25–200 mi^2 (65–520 km^2)	averages ~ 33 ft (10 m) across, varies from ~ 16–50 ft (5–15 m)
Large	> 200 mi^2 (520 km^2)	averages ~ 100 ft (30 m) across, varies from ~ 50–150 ft (15–45 m)
Very large	Large rivers with backwater systems, as well as large, hybrid lake/river systems. These are the Lower Mississippi and Lake Pepin, lower St. Croix and Lake St. Croix, and lower Minnesota.	

Figure 7.1. Watershed Area and Stream Width Relationships of Streams with Drainage Areas < 200 Square Miles by Watershed Province (LkSup = Lake Superior province, MinR = Minnesota River province, StCrx = St. Croix River province, UpMiss = Upper Mississippi River province)

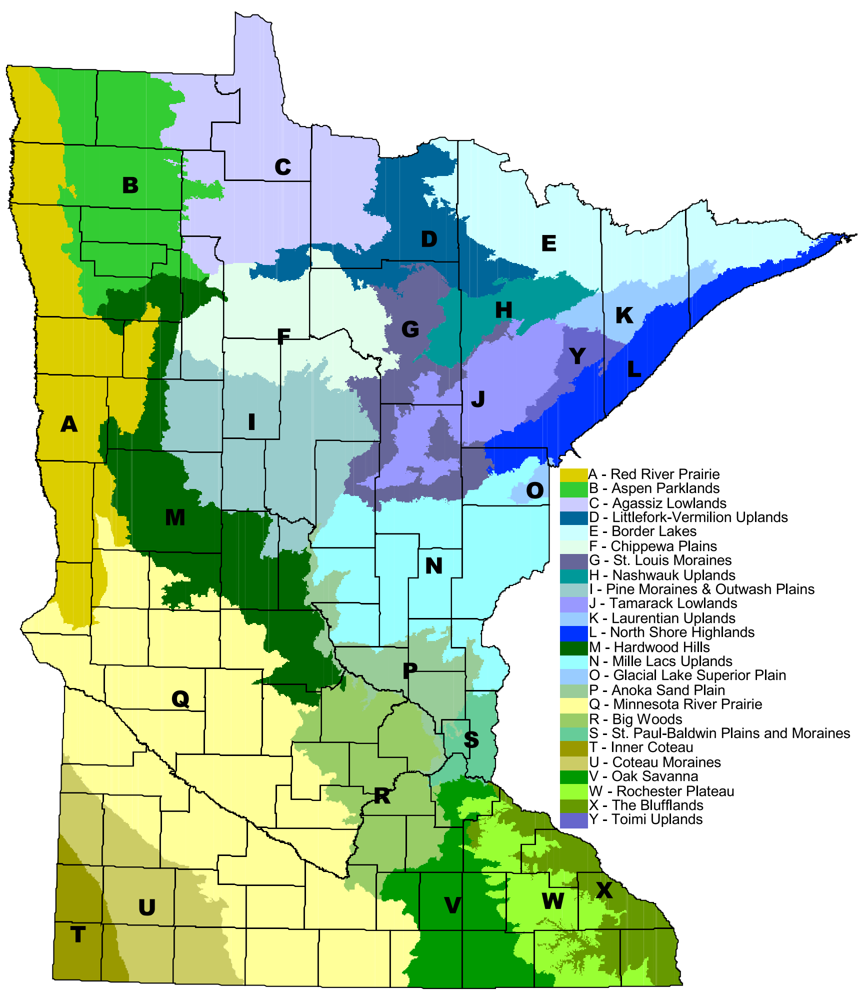


Species Distribution

To determine species distribution, we again used the data and process from the MN GAP Analysis Project and assigned each species a presence or absence in each of the 25 ecological subsections in Minnesota (Figure 7.2). Aquatic and invertebrate species were added, and a few adjustments to the existing terrestrial vertebrate distributions were made. Terrestrial vertebrates mapped at a detail finer than the subsection were scaled up to the subsection level. Aquatic species were first assigned to the eight major watersheds in Minnesota (Hatch et al., 2003). Intersecting the watersheds with the ecological subsections allowed assignment of aquatic species distribution to the ecological subsections. In some cases, a subsection included only a small part of a major watershed where the aquatic species was recorded to occur. For these cases, we checked the distribution of spatially located species occurrence records collected from a variety of surveys to determine whether the aquatic species had been found in that subsection. While there is not perfect overlap between the subsections and major watersheds, the distribution scores are sufficient for working at the scale of the state of Minnesota.

Upon completing the presence/absence scores for habitat and distribution, we then summed the number of species in each habitat in each subsection. This calculation resulted in a species use value for each habitat in a particular subsection, which was used to guide selection of key habitats.

Figure 7.2. Minnesota's ECS Subsections



Selection of Key Habitats Based on Habitat Use

Prior to selecting key habitats, we combined 66 of the 70 CWCS habitat classes (CWCS Level 4) into coarser categories (CWCS Level 2, Table 7.8). These categories were developed in order to have a manageable number of categories, to be able to compare them with the Marschner pre-1890s vegetation classes (see the section "Analysis of Major Changes in Land Cover," later in this chapter, for a description) used in the land cover change analysis, and to depict ecologically and managerially meaningful categories. Four of the categories, "upland coniferous/deciduous mix forest," "lowland coniferous/deciduous mix forest," "red cedar," and "red cedar-deciduous mix," were not included as they created some problematic categories when they were combined to a higher level. Careful examination showed that leaving these categories out of the Level 2 categories did not change any results. That is, no species was uniquely associated with any of the four omitted land cover categories.

Table 7.8. CWCS Level 2 Compared to CWCS Level 4

CWCS Level 2	CWCS Level 4	
Forest-Upland Deciduous (Aspen)	- Aspen/White Birch	
Forest-Upland Deciduous (Hardwood)	- White/Red Oak - Bur/White Oak - Red Oak	- N Pin Oak - Maple/Basswood - Upland Deciduous mix
Forest-Upland Conifer	- Jack Pine - Red/White Pine - Red Pine - White Pine mix - Balsam Fir mix - White Spruce	- Upland Black Spruce - Upland N White Cedar - Upland Conifer - Jack Pine-Deciduous mix - Red/White Pine-Deciduous mix - Spruce/Fir-Deciduous mix
Shrub/woodland-Upland	- Upland Shrub - Jack Pine woodland	- Oak Savanna - Oak Woodland
Prairie	- Prairie	
Forest-Lowland Deciduous	- Black Ash - Silver Maple	- Cottonwood - Lowland Deciduous Mix
Forest-Lowland Conifer	- Lowland Black Spruce - Stagnant Black Spruce - Tamarack - Stagnant Tamarack	- Lowland N White Cedar - Stagnant N White Cedar - Stagnant Conifer
Shrub-Lowland	- Lowland deciduous shrub - Lowland evergreen shrub	
Wetland-Nonforest	- Seasonally flooded basin or flat - Wet meadow - Shallow marsh	- Deep marsh - Shallow open water
Grassland	- Grassland	
Shoreline-dunes-cliff/talus	- Barren - Cliff/talus slope	- Shoreline/dunes
Cropland	- Cropland	
Developed	- Mixed Development - High-intensity Urban	- Low-intensity Urban - Transportation
Lake-Shallow	- Lake-Small, Shallow, not alkaline - Lake-Large, Shallow, not alkaline	- Lake-Small, Shallow, alkaline - Lake-Large, Shallow, alkaline
Lake-Deep	- Lake-Small, Deep, not alkaline - Lake-Large, Deep, not alkaline	- Lake-Small, Deep, alkaline - Lake-Large, Deep, alkaline
River-Headwater to Large	- River-Headwater, cold - River-Moderate, cold - River-Large, cold	- River-Headwater, warm - River-Moderate, warm - River-Large, warm
River-Very Large	- River-Very large, warm	

Terrestrial Habitats

Key terrestrial habitats used by species in greatest conservation need were identified using two methods: substantial habitat use and specialist habitat use. For both methods, habitats were included for analysis only if they made up at least 1 percent of the subsection, either historically or currently.

To determine habitats that have the most substantial number of species ("substantial habitat use"), we used a one-tailed z-test on the number of species in each habitat and subsection. This should not be considered a statistical test of significance; rather, it is a consistent method that considers the number of species by habitat "array" to determine a cutoff line for designating key habitats. The array of number of species by habitat followed roughly a normal distribution, thus validating the use of standard statistical sampling techniques. To guide the identification of key habitats, we chose to identify only those habitats with a $p < 0.01$ of the z-distribution (Table 7.9). Only those habitats that met the *p*-value cutoffs and made up more than 5 percent of the subsection, either historically or currently, were selected as a key habitat.

Table 7.9. Substantial Habitat Use Example from the Anoka Sand Plain Subsection

CWCS Level 2 Habitat	Number of Species	*p*
Forest-Upland Deciduous (Aspen)	15	0.9884
Forest-Upland Deciduous (Hardwood)	22	0.3270
Forest-Upland Conifer	22	0.3270
Shrub/woodland-Upland	30	0.0002
Prairie	34	0.0000
Forest-Lowland Deciduous	17	0.9324
Forest-Lowland Conifer	10	1.0000
Shrub-Lowland	19	0.7634
Wetland-Nonforest	36	0.0000
Grassland	31	0.0000
Shoreline-dunes-cliff/talus	15	0.9884
Cropland	11	0.9999
Developed	9	1.0000

Note: Z-test based on number of species in greatest conservation need using a particular habitat. **Gray-bold** indicates habitats that meet the $p < 0.01$ cutoff.

A second factor used in the identification of key habitats based on species habitat use was their importance to species that are habitat specialists. Habitat specialists were defined as those using two or fewer habitats (CWCS Level 2). The logic for including the second factor is that habitat specialists are both more vulnerable to habitat change and more likely to benefit greatly from conservation of their key habitats. The rule for selecting key habitats based on the number of specialist species depended on both the total number of species in a given habitat and the percentage that are "specialists." Habitats with at least 15 species of which at least 20 percent are specialists were selected as key habitats (Table 7.10). Again, habitats were selected only if they made up more than 5 percent of the subsection, either historically or currently.

Table 7.10. Unique Terrestrial Habitat Use Example from the Anoka Sand Plain Subsection

CWCS Level 2 Habitat	Number of Species	Percentage of Species Using ≤ 2 Habitats
Forest-Upland Deciduous (Aspen)	15	0
Forest-Upland Deciduous (Hardwood)	22	9
Forest-Upland Conifer	22	5
Shrub/woodland-Upland	30	13
Prairie	34	**21**
Forest-Lowland Deciduous	17	6
Forest-Lowland Conifer	10	10
Shrub-Lowland	19	5
Wetland-Nonforest	36	**44**
Grassland	31	6
Shoreline-dunes-cliff/talus	15	**60**
Cropland	11	0
Developed	9	22

Note: **Gray-bold** indicates habitats that have > 15 SGCN and at 20 percent "specialists" that make up more than 5 percent of the subsection, either currently or historically.

Aquatic Habitats

Because there are only four categories of aquatic habitats, it was not feasible to analyze among habitat types for each subsection as was done with the terrestrial habitats. Also, the broad habitat categories did not allow for a specialist aquatic habitat use analysis. Stream habitats are considered a priority in all subsections because generally they are highly imperiled and their condition is reflective of the condition of terrestrial habitats surrounding them. Priority stream reaches were identified using results from The Nature Conservancy's Ecoregional Assessments (see below, "Identification of Priority Stream Reaches"). However, preliminary examination of the data revealed that some subsections are clearly more important in terms of the number of species in greatest conservation need that potentially occur in aquatic habitats. Therefore, we conducted an analysis between subsections for each of the four aquatic habitat types.

For the analysis of aquatic habitats between subsections, we used the number of species in a habitat for each subsection. A standard z-test was then run, and subsections with $p < 0.0001$ were highlighted as having a substantial potential number of species in greatest conservation need for that particular habitat (Table 7.11). The strict p-value cutoff was used to keep the number of subsections with designated priority habitats to a minimum.

Table 7.11. Aquatic Substantial Habitat Use Analysis

Ecological Subsections	River-Very large		River-Headwater to large		Lake-Deep		Lake-Shallow	
	No. of Species	*p*	No. of Species	*p*	No. of Species	*p*	No. of Species	*p*
Agassiz Lowlands	5	0.9903	10	0.9967	5	0.7999	12	0.0463
Anoka Sand Plain	13	0.3221	16	0.3022	6	0.1422	15	0.0000
Aspen Parklands	5	0.9903	7	1.0000	5	0.7999	19	0.0000
Big Woods	38	0.0000	26	0.0000	7	0.0014	17	0.0000
Blufflands	51	0.0000	35	0.0000	4	0.9970	10	0.6824
Border Lakes	3	0.9988	8	0.9999	9	0.0000	5	1.0000
Chippewa Plains	3	0.9988	12	0.9495	7	0.0014	11	0.2730
Coteau Moraines	8	0.9011	14	0.7127	2	1.0000	13	0.0029
Glacial Lake Superior Plain	3	0.9988	7	1.0000	2	1.0000	7	0.9999
Hardwood Hills	7	0.9493	14	0.7127	7	0.0014	18	0.0000
Inner Coteau	9	0.8258	14	0.7127	2	1.0000	10	0.6824
Laurentian Uplands	2	0.9996	5	1.0000	3	1.0000	3	1.0000
Littlefork-Vermilion Uplands	3	0.9988	8	0.9999	4	0.9970	6	1.0000
Mille Lacs Uplands	24	0.0000	34	0.0000	11	0.0000	10	0.6824
Minnesota River Prairie	16	0.0653	17	0.1451	7	0.0014	18	0.0000
Nashwauk Uplands	3	0.9988	6	1.0000	3	1.0000	6	1.0000
North Shore Highlands	4	0.9964	12	0.9495	11	0.0000	8	0.9957
Oak Savanna	14	0.2084	25	0.0000	3	1.0000	8	0.9957
Pine Moraines & Outwash Plains	4	0.9964	14	0.7127	7	0.0014	11	0.2730
Red River Prairie	5	0.9903	8	0.9999	4	0.9970	13	0.0029
Rochester Plateau	14	0.2084	27	0.0000	3	1.0000	5	1.0000
St. Louis Moraines	3	0.9988	10	0.9967	8	0.0000	8	0.9957
St. Paul-Baldwin Plains	50	0.0000	32	0.0000	7	0.0014	15	0.0000
Tamarack Lowlands	3	0.9988	8	0.9999	5	0.7999	9	0.9397
Toimi Uplands	2	0.9996	7	1.0000	4	0.9970	4	1.0000
Mean	11.68		15.04		5.44		10.44	
Standard error	2.86		1.85		0.52		0.93	

Note: **Gray-bold** indicates those subsections where the number of species met the $p < 0.0001$ cutoff among all the subsections.

Analysis of Major Changes in Land Cover

The analysis of major changes in land cover is based on two premises:

1. The primary reason for the decline of the species in greatest conservation need is the loss of habitat (see earlier section titled "Species Assessments").
2. These habitats were once arrayed on the landscape in an amount and configuration that supported the full assemblage of species in Minnesota, including those species currently in greatest conservation need.

A comparison of the habitat distribution and acreage from the original Public Land Survey records to the GAP land cover highlights changes to the distribution of habitat elements that were present prior to settlement by people of European descent (for information about Public Land Surveys, see Almendinger 1997; Friedman and Reich 2005). We recognize that species distributions and abundances have ebbed and flowed over time across the landscape, but we assert that diverse communities of wildlife in the recent past included most of the species in greatest conservation need today. We also recognize that the landscape was already inhabited by humans prior to settlement by people of European descent and do not interpret pre-European settlement as meaning a "natural state" unmodified by humans. Finally, reverting to presettlement conditions is not feasible, nor in many cases is it desirable. Rather, this information serves as a valuable conservation tool that helps identify the major landscape elements that have experienced the greatest changes in the past 100 years and are depended on by species in greatest conservation need.

The analysis of major changes in land cover was done for terrestrial habitats only and used two main sources of information: the presettlement vegetation map by Marschner (1930) ("1890s vegetation") and the MN GAP land cover classification map ("1990s vegetation"). A different analysis used for wetlands is described further below in this section. Categories between the two maps were crosswalked to allow for direct comparison between the data layers (Table 7.12). For information on the accuracy and development of these two data layers, see the Web links listed in the references at the end of this chapter.

In addition, other sources of information were used to check the results of these comparisons and to provide more detail (Figure 7.3). The results of these other analyses of information were similar to the Marschner–GAP comparison and generally allowed for a more detailed habitat breakdown in terms of composition, age, structure, or quality (see Appendix C, Links to Other Plans).

The one-square-mile resolution of Public Land Office bearing trees was not fine enough to determine the amount of pre–European settlement wetlands because wetlands are and were often present as small, isolated depressions. To account for this, we used the analysis of Anderson and Craig (1984) examining the distribution of hydric soils. Since this analysis dates from 1984, it is a conservative estimate of wetlands loss today as drainage and conversion of wetlands has continued since that time.

The amount of habitat in the two time periods (1890s and 1990s) was calculated for each ecological subsection. Substantial habitat change was defined as a habitat that made up more than 5 percent of the subsection in the 1890s and had declined by more than 50 percent by the 1990s. The same cutoffs were used for the wetland analysis.

Table 7.12. CWCS Level 2–Marschner Crosswalk

CWCS Level 2	Marschner Classes
Forest-Upland Deciduous (Aspen)	- Aspen-Oak Land - Aspen-Birch (trending to hardwoods) - Aspen-Birch (trending to conifers)
Forest-Upland Deciduous (Hardwood)	- Big Woods-Hardwoods (Oak, Maple, Basswood, Hickory) - Mixed Hardwood and Pine (Maple, White Pine, Basswood, etc.)
Forest-Upland Conifer	- White Pine - Mixed White Pine and Red Pine - Pine Flats (Hemlock, Spruce, Fir, White Pine, Aspen)
Shrub/woodland-Upland	- Brush-prairie - Oak openings and barrens - Jack Pine barrens and openings
Prairie	- Prairie
Forest-Lowland Deciduous	- River bottom forest
Forest-Lowland Conifer/shrubland	- Conifer bogs and swamps
Wetland-Nonforest	- Wet prairie - Open muskeg
Water	- Lakes (open water)

Figure 7.3. Additional Sources of Historic and Current Land Cover

Historic land cover data sources

Range of Natural Variation Models

Comparisons of Bearing Trees and Forest Inventory and Analysis (FIA); Friedman and Reich, 2005; Almendinger and Hanson, 2004

Current land cover data sources

Minnesota County Biological Survey (MN DNR), 1987–present

HAPET models of Grassland Bird Conservation Areas

Identification of Priority Stream Reaches

In addition to the habitat use analysis, we identified additional key streams and rivers, with associated lakes and wetlands, by adapting freshwater ecoregional assessment methods developed by The Nature Conservancy (TNC) (Higgins et al., 2005). Specific stream reaches within TNC-identified Areas of Biodiversity Significance were chosen as key stream habitats. Since TNC's methodology explicitly focuses on the best examples of representative habitat intended to encompass all biological diversity, their identified stream habitats were not necessarily most important for species in greatest conservation need. Our analysis therefore identified additional stream reaches with concentrated SGCN occurrences. A description of TNC's process follows.

General Methodology for Freshwater Habitat Assessments

The goal of ecoregional conservation assessments is the identification of a set of areas that together represent the best opportunities to conserve a full array of freshwater species, natural assemblages, and ecosystems within an ecoregion (Groves, 2003).

Ecoregional assessments begin by identifying important elements of biological diversity that ultimately will be used to select a set of conservation areas. Such important elements represent priority biological resources at multiple scales and include:

- aquatic ecological systems
- species assemblages
- animal and plant species of special concern

Once elements are selected, numeric goals for conservation are established for each. Goals represent the number of viable occurrences and spatial distribution of each element across the region that is needed to maintain populations or systems over the time span of a century. Aquatic ecological systems that encompass the most viable occurrences for each element are mapped as Areas of Biodiversity Significance (ABS). A final portfolio is then selected that includes areas that best meet numeric conservation goals.

Classification Methods and Framework

The classification methods used to generate the set of priority stream and river habitats were based on both physical and biological criteria. The classification framework was developed to be applicable across a large region, provide a biodiversity context, and use data that are readily available, at an appropriate scale, and mappable (Higgins et al., 2005).

The hierarchical classification framework consists of four nested spatial scales: aquatic zoogeographic unit, ecological drainage unit (EDU), aquatic ecological system (AES), and macrohabitat (listed from coarsest to finest). These four levels constitute a minimum set to reflect ecological patterns. Zoogeographic units, the highest level in the classification, are the overall planning units, which are used to delineate the classification area. EDUs represent finer scales of physiographic and zoogeographic diversity allowing the stratification of rivers and lakes that are potential conservation priorities. AESs and macrohabitats generate the conservation elements (conservation targets) by considering how local distribution patterns of aquatic species are shaped by the physical environment (Higgins et al., 2005).

The classification framework works both for data-rich (bottom–up) and data-poor (top–down) regions. Examples of attributes used in the classification of AESs and macrohabitats for streams and rivers include gradient, size, local connectivity/drainage network position, and hydrologic regime. Among the products generated by the classification process is a spatially comprehensive inventory of classified and mapped units that may be used in the remote classification of regional patterns of AESs or aquatic habitat. (Higgins et al., 2005).

Selecting the Conservation Portfolio

Within a given region, the classification is used to select a conservation portfolio, using AESs as the building blocks. During the portfolio selection process, information is gathered about target occurrences, threats, and viability for each AES. Priority aquatic habitats, or ABSs, are selected using available information about target occurrences, threats, and viability for each AES (e.g., Gagnon et al. 2004). Among the attributes considered are species and assemblages, AES type, and landscape quality metrics, such as percentage cover in natural vegetation, percentage altered cover, percentage urban/road cover, stream sinuosity, point source pollution density, and dam density.

In addition to the data-based evaluations of each potential ABS, expert input is sought during the portfolio development process. For example, experts are often asked to rank the relative viability of species and assemblages. They further are asked to identify threats to each target occurrence. When available, expert opinion is integrated into the portfolio selection process.

The portfolio assembly process is iterative. Systems are progressively added to the network based on conservation value, and progress toward achieving numeric conservation goals is periodically assessed (Gagnon et al. 2004). In some instances, an ABS is included even if it has poor viability and few species or assemblage occurrences simply because it is the only representative example of that type within the classification.

How the TNC Aquatic Conservation Portfolios Appear in CWCS

Existing aquatic ecoregional assessments that included Minnesota were examined and merged to create a comprehensive, statewide layer of priority aquatic habitats. Information from five separate plans was integrated to provide a starting point for the Comprehensive Wildlife Conservation Strategy, including the following ecoregions: Northern Tallgrass Prairie, Prairie Forest Border, Superior Mixed Forest, and Great Lakes (The Nature Conservancy, Prairie Forest Border Ecoregional Planning Team 2000; Dephilip 2001; Superior Mixed Forest Ecoregional Planning Team 2002; Weitzell et al. 2003; Gagnon et al. 2004). Because TNC's methodology explicitly focuses on the best examples of representative habitat intended to encompass all biological diversity, not just SGCNs, the SGCNs were overlaid on the merged portfolio. Additional priority habitats were thus identified on the basis of concentrated SGCN occurrences alone. The results of this assessment are mapped and listed in the subsection profiles in chapter 5, An Ecological Assessment of Species in Greatest Conservation Need in Minnesota.