The Northern Tallgrass Prairie Ecoregion: A River and Stream Conservation Portfolio

Citation: Gagnon, P., P. Gerla, B. Schreurs, M. Cornett, M. Khoury, J. Hall. 2004. The Northern Tallgrass Prairie Ecoregion: A River and Stream Conservation Portfolio. The Nature Conservancy.

The Nature Conservancy's mission is to preserve the plants, animals and natural commuities that represent the diversity of life on Earth by protecting the lands and waters they need to survive.

The Nature Conservancy
Worldwide Office
4245 North Fairfax Drive, Suite 100
Arlington, VA 22203-1606
703-841-5300
www.nature.org

Funding for this project was generously provided by the Cox Family Fund for Science and Research and The Nature Conservancy of Minnesota.

The Northern Tallgrass Prairie Ecoregion: A River and Stream Conservation Portfolio

Paula Gagnon
Aquatic Ecologist
The Nature Conservancy
pgagnon@tnc.org; 708.484.3594

Phil Gerla
Conservation Hydrologist
The Nature Conservancy of Minnesota
and Associate Professor, Department of Geology and Geological Engineering
University of North Dakota
phil.gerla@mail.und.nodak.edu; 701.777.3305

Brian Schreurs
GIS Analyst
The Nature Conservancy of Minnesota
bschreurs@tnc.org; 612.331.0733

Meredith Cornett
Director of Conservation Science
The Nature Conservancy of Minnesota
mcornett@tnc.org; 612.331.0758

Mary Khoury
Aquatic Ecologist
The Nature Conservancy
mkhoury@tnc.org; 312.759.8017

Jennifer Hall
Conservation Planner
The Nature Conservancy
jhall@tnc.org; 734.213.7066

Acknowledgements

We appreciate the financial support generously provided by The Nature Conservancy of Minnesota and the Cox Family Fund for Science and Research. This document's greatest value lies in the collective knowledge provided by numerous scientists, resources specialists, ecologists, and biologists in the Northern Tallgrass Prairie Ecoregion. We gratefully acknowledge the expert advice and review provided by the following individuals.

Luther Aadland, River Ecologist, Stream Habitat Program, MN Department of Natural Resources

Roy Bartholomay, District Chief, US Geological Survey, Huron, SD

Bethany Bolles, Senior Research Manager, Energy and Environmental Research Center

Lisa Botnen, Research Scientist, Energy & Environmental Research Center

Helen Cozzetto, Project Manager, Red River State Recreation Area, MN Department of Natural Resources

George Cunningham, Private Consultant, Eco-Centrics

Andre Delorme, Professor, Valley City State University

Doug Dieterman, Fisheries Research Biologist, Lake City Area Fisheries Office, MN DNR

Bruce Ehresman, Wildlife Biologist, Wildlife Diversity Program, Iowa Department of Natural Resources

Bill Franzin, Research Scientist, Environmental Science Division, Fisheries and Oceans Canada

Randy Gjestvang, Red River Water Resource Engineer, ND State Water Commission

Tom Groshens, Natural Resources Specialist, MN Department of Natural Resources

Cary Hamel, Assistant Biologist, Manitoba Conservation Centre

Jay Hatch, Associate Professor, University of Minnesota

Matt Hubers, Wildlife Biologist, SD Department of Game, Fish and Parks

Patrick Isakson, Non-Game Biologist, ND Game and Fish

Todd M. Koel, Aquatic Section Leader, Yellowstone Center for Resources

Richard L. Kroger, Conservation Ag Advisor, Clean Up the River Environment

Eric Laux, Biologist, US Army Corps of Engineers, Omaha, NE

Scott Moats, Director of Stewardship, The Nature Conservancy of Iowa

Bruce Paakh, Water Quality Specialist, MN Pollution Control Agency

Dane Ralston, ND TMDL/Watershed Liasion Program (East), ND Department of Health

Kory Richardson, District Manager, US Fish & Wildlife Service, Arrowwood NWR Complex

Isaac Schlosser, Professor, University of North Dakota Department of Biology

Lynn Schlueter, ND Game and Fish

Jeff Shearer, Aquatic Ecologist, SD Natural Heritage Program

Cindy Steele, Environmental Engineer, Natural Resources Conservation Service

Dan Svedarsky, Professor, University of Minnesota, Crookston, MN

Lan Tornes, Hydrologist, US Geological Survey

Henry VanOffelen, Natural Resource Scientist, MN Center for Environmental Advocacy

Steven Wall, Resource Biologist, Wildlife and Fisheries Department, SD State University

Ernie Watson, Biologist, Fisheries and Oceans Canada

Brian Winter, Program Director, Northern Tallgrass Prairie Ecoregion, The Nature Conservancy

Table of Contents

Executive Summary

To promote the future health and sustainability of the streams and rivers of the Northern Tallgrass Prairie Ecoregion (NTPE), The Nature Conservancy (TNC; the Conservancy) and conservation partners have conducted a comprehensive assessment of the status of stream and river biological diversity and identified priority areas for aquatic conservation in the region. Participating in this assessment were 36 aquatic biologists, hydrologists and conservation experts representing 24 agencies, universities, and private organizations in the NTPE. The assessment team reviewed past and present research on streams and rivers of the ecoregion, gathered existing spatial and biological data, analyzed these data on a regional basis to identify the areas of greatest biodiversity significance, and developed a set of priority stream and river reaches to recommend for protection, restoration, or both. The resulting conservation portfolio map is a set of priority river and stream systems representing the best opportunities for conservation of the ecoregion's river and stream biological diversity.

The NTPE straddles a continental divide, encompassing portions of the Missouri and Mississippi basins, which drain into the Gulf of Mexico, and the Red River, which drains into Lake Manitoba. The extreme northwest portion of the ecoregion also encompasses the lower Assiniboine River basin and crosses several small streams that drain directly to Lake Manitoba. As such, stream and river drainage patterns and natural character, including species diversity, habitat characteristics, and biological productivity vary dramatically across the region. The NTPE drainage system harbors unique natural communities populated with species that have entered the area only as recently as 15,000 years ago.

The rivers and streams of the NTPE have been significantly altered. Major threats to freshwater biological diversity throughout the NTPE include habitat alteration and degraded water quality. For example, over 95% of the original native prairie, savanna, and transition habitats have been converted to agriculture in large portions of the ecoregion. Incompatible agriculture and forestry practices, channelization of rivers or streams, operation of dams or reservoirs, excessive groundwater withdrawal, and invasive/alien species were identified by experts as the top contributors to the decline of biological diversity in the region. Nonetheless, these streams and rivers host imperiled species and provide important ecological and societal services. Currently, thirty aquatic animal species of international, federal, or sub-federal protected status occur within the NTPE.

A total of 27 stream systems in Minnesota, South Dakota, North Dakota, Iowa, and Manitoba were included in the conservation portfolio as priorities for conservation through the assessment process. These systems include locations hosting at least 78 target species and assemblages, including eleven G1-G3 taxa. Key portfolio areas in the Red River basin include the Otter Tail /Pelican River watershed and Red Lake River on the east side of the basin, and the lower Assiniboine, Sheyenne, Lower Pembina and Turtle Rivers on the west side of the basin. In the portion of the Missouri River basin that crosses the NTPE, key portfolio areas include the northeastern tributaries and mainstem of the Big Sioux River, the mainstem of the Missouri River, and the lower mainstem and tributaries of the James River basin. In the Upper Mississippi River Basin, the largest portfolio systems are the mainstem

Minnesota River and numerous tributary basins, including the Pomme de Terre, Chippewa, Yellow Bank, Yellow Medicine, Redwood River and Blue Earth River basins. The lower mainstems of the LeSeur and Cottonwood Rivers are also key portfolio sites in the Minnesota River watershed. In the southeastern extreme of the ecoregion, the headwaters of the Iowa River, the Boone River basin, portions of the North and Middle Raccoon basins and the West branch and mainstem of the Des Moines River constitute the portfolio river and stream reaches.

The portfolio areas identified through this assessment serve as an addendum to terrestrial and bird conservation areas identified through prior NTPE conservation assessments (The Nature Conservancy 1998; Chapman et al. 1998). Among the first steps following the completion of this report will be a detailed review of the integrated maps of terrestrial, bird, and aquatic priorities, along with development of strategies based on work already underway by TNC and partners in "priority landscapes" of the NTPE. In the following years, TNC will develop specific strategies for conservation at each of the priority sites highlighted in the assessment. These plans will detail the specific targets, goals, and management activities that TNC will undertake with partners in each conservation area as appropriate.

Maps and data developed through the conservation assessment process may be used to launch further ecological investigations. For example, logical next steps for research might include 1) characterizing the relationship between stream physical classes and biological data; 2) testing the sensitivity of sub-watersheds to changes in key watershed factors and processes; 3) and estimating the degree to which key watershed processes have been altered in each sub-watershed.

In addition to directing the conservation and research activities of TNC, we hope that this conservation portfolio may guide and inform the actions of our conservation partners and friends in the ecoregion. By working collaboratively in these locations, we can achieve efficient, lasting protection of all types of aquatic biodiversity in the ecoregion.

Chapter 1.0 Introduction

1.1. Overview of the Northern Tallgrass Prairie Ecoregion

The Northern Tallgrass Prairie Ecoregion (NTPE) occupies the northeastern edge of the North American Great Plain. The ecoregion lies in a narrow band that is more than 1,100 km long from southern Manitoba, along the Dakotas - Minnesota border, and into central Iowa (Omernik and Gallant 1988). It ranges in width from about 100 km in the north to a maximum of about 275 km at the latitude of the Minnesota - Iowa border (Figure 1.1). On the west boundary of the NTPE, tallgrass prairie grades into mixed grass prairie. The eastern side of the NTPE marks the modern transition zone from tallgrass prairie to savannah and northern mixed forest ecosystems; however, this transition zone has shifted through time with changes in herbivory, fire, and drought (Fitzgerald et al. 1998).

The NTPE straddles the Missouri, Mississippi, and Red River watersheds, and therefore includes a continental divide (Figure 1.1). The river and stream system in the ecoregion displays significant variation in species diversity, habitat characteristics, and biological productivity. The physical features of the region

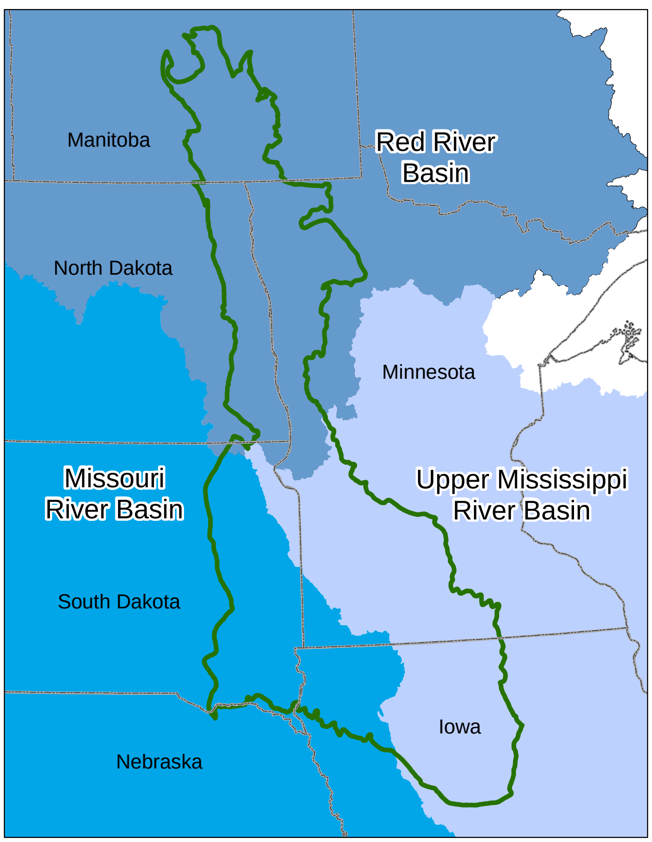


Figure 1.1. The location of the Northern Tallgrass Prairie Ecoregion (green line), and the Missouri, Red River, and Upper Mississippi River basins in the US and Canada.

are largely a result of recent glaciation (Bennett and Glasser 1997), and the relatively young and non-integrated drainage system hosts unique natural communities populated with species that have entered the area only as recently as 15,000 years ago.

In their current state, the rivers and streams of the NTPE constitute an ecosystem that has been significantly changed. For example, over 95% of the original native prairie, savanna, and prairie/forest of the southern and Red River Valley parts of the NTPE have been converted to agricultural uses (National Audubon Society 2000; Stoner et al. 1993), with drastic effects on both terrestrial and aquatic species and communities. Agricultural development, and concomitant alteration of the natural hydrologic regime, has led to an overall loss in native aquatic diversity and ecosystem resiliency (e.g., Benke 1990; Karr et al. 1985; Uri 1999; Whiles et al. 2000). This high degree of alteration, and downward trends in the status of aquatic species and communities creates a compelling need to examine what remains of the basin's native biodiversity and the issues that must be addressed to ensure the future health and sustainability of the Northern Tallgrass Prairie aquatic ecosystem.

1.2. The Status of Conservation Planning in the Northern Tallgrass Prairie Ecoregion

The Nature Conservancy's work is guided by the goal of providing for "the long-term survival of all viable native species and community types through the design and conservation of portfolios of sites within ecoregions" (The Nature Conservancy 1996). We aim to achieve this goal through a four-step cycle: setting priorities, developing strategies, taking action, and measuring success (Figure 1.2).

Figure 1.2. The Nature Conservancy's conservation approach.

The first of these steps, setting priorities, is the ecoregional planning process. This is the step in the conservation process where we define where we work. The following steps define what we do when we get there: planning for, implementing and measuring conservation strategies at conservation sites. During the ecoregional planning process, we conduct a detailed assessment of an ecoregion's biotic heritage and identify the priority conservation areas for that ecoregion. These areas and the methods used to select them have been variously called conservation assessments, plans, portfolios and networks. Despite the variations in name, all ecoregional assessments have the same objective: to identify the suite of sites within an ecoregion that represents the best opportunities for conservation of all types of biodiversity contained in that ecoregion.

A couple of ecoregional planning efforts have already been completed for the NTPE. In 1998, The Nature Conservancy and partners developed a terrestrial ecoregional plan, which was intended to lay the foundation for terrestrial conservation action for five to ten years (TNC 1998). Later that year, planners and experts identified important bird conservation sites in the NTPE (Chapman et al. 1998). In 2003, the Freshwater Initiative of the Nature Conservancy, NatureServe and partners developed a plan for the conservation of freshwater systems of the Upper Mississippi River Basin (UMRB; Weitzell et al. 2003), which overlaps a large segment of the NTPE. As a result, the freshwater conservation needs of much of the southeastern portion of the NTPE were identified and mapped.

Our goal in developing an NTPE river/stream conservation plan was to complete an assessment of the riverine conservation needs in the part of the ecoregion that lies outside of the UMRB, and merge this plan with the previous three plans. *Accordingly, this assessment will focus on the natural systems and biodiversity of the portions of the Red River and Missouri River basins that overlap the NTPE. We will limit our discussion to the methods, data, and strategies used to develop a river/stream conservation portfolio for the portion of these basins that lie within the ecoregion.* We will describe the freshwater conservation analysis of the UMRB portion of the ecoregion only briefly, but will incorporate the NTPE portions of the UMRB into our final presentation of NTPE river/stream portfolio sites and the map of conservation areas that represent the overlap of the NTPE terrestrial and aquatic conservation plans (Chapter 3).

The integration of the terrestrial and aquatic plans (Chapter 3) will serve as a basis for immediate and future conservation action by The Nature Conservancy in the Northern Tallgrass Prairie. We also hope that it provides guidance to and informs the actions of our conservation partners and friends in the ecoregion. By galvanizing conservation efforts around the portfolio of sites identified in these plans, we aim to achieve efficient, lasting protection of all types of biodiversity in the ecoregion.

1.3. Physiography of the Northern Tallgrass Prairie Ecoregion

1.3.1. Landforms and Soils

Surface geology and topography strongly influence the biota and hydrological character of streams and rivers. Relief in the region ranges from 230 m to 610 m. All of the NTPE lies within surficial geological materials that were derived either directly or indirectly from Pleistocene glaciations. The thickness of glacial deposits ranges from zero to more than 200 meters. Most of the region is directly underlain by glacial till of Wisconsin age. Tills consist of poorly sorted substrates of variable sizes, including clay, silt, sand, and gravel, with variable amounts of cobbles and boulders. The relative proportion of each substrate size depends on source, with finer till derived from sedimentary bedrock and coarser till from crystalline rock.

Although tills are common throughout the region, glacial sediments vary greatly in texture and composition. In the Red River Valley region, the glacial Lake Agassiz Plain consists of thick homogeneous silty clay sediments deposited during the existence of the lake from about 12,000 until 8,000 years before present (Teller and Clayton 1983). Significant thickness of organic soils formed in poorly drained areas, while thick, organic-rich A-horizon mollisols developed in drier sites. In some areas such as ice contact deposits, glacial outwash, and glacial lake beach ridges, coarse sediments occur interspersed with till. The heterogeneity of surficial geological deposits leads to abrupt changes and variations in aquatic habitats within the region.

1.3.2. Climate and Runoff

Climatic conditions in the NTPE vary greatly across the ecoregion as a result of mid-continental climatic regimes and the significant latitudinal gradient the ecoregion crosses. On the north (latitude 49.9°), Winnipeg's average temperature ranges from 19.5 °C in July to -17.8 °C in January. In contrast, the average temperature at Storm Lake, Iowa (latitude 42.6°), 900 km to the south, in July and January ranges from 22.4 °C to -9.4 °C. Precipitation varies significantly across the NTPE, ranging from as little as 450 mm to as much as 850 mm from locations in the west-northwest to those in the east-southeast, respectively (data from Environment Canada, High Plains Regional Climate Center, and Midwest Regional Climate Center). In all areas, summer convective rainfall greatly exceeds winter precipitation, although spring runoff provides significant flow during almost all years.

Because of a large gradient of temperature, humidity, and precipitation from east to west across the region, the moisture balance varies significantly from east to west. Watersheds on the east tend to have greater runoff per unit area than those on the west. For example, both Baldhill Creek near Dazey, North Dakota and the North Raccoon River, at Sac City, Iowa have watersheds covering about 700 square miles. The mean flow in Baldhill Creek (1956-2003) closely tracks the *minimum* monthly flow for the North Raccoon River (1959-2003) (Figure 1.3). The discharge records also show greater sustained flow in the summer for the North Raccoon River, where convective summer precipitation leads to high stream discharge. Flow in Baldhill Creek drops quickly during the summer, but rebounds slightly during late summer and fall senescence.

Rapid snowmelt in the spring, convective precipitation, and soils of generally low permeability throughout the region also lead to large natural variation of stream discharge. Peak yearly flow (Figure 1.4) generally occurs during the period immediately following spring runoff. Although most precipitation during the growing season is quickly lost to evapotranspiration, unusually large and sustained rainfall occasionally leads to summer season floods. The area has experienced devastating floods in the past, most recently in 1993 in the upper Mississippi basin and 1997 along the Red River. Flooding has been exacerbated by land use changes, such as agricultural drainage and cropping, that make surface runoff from upland areas even flashier.

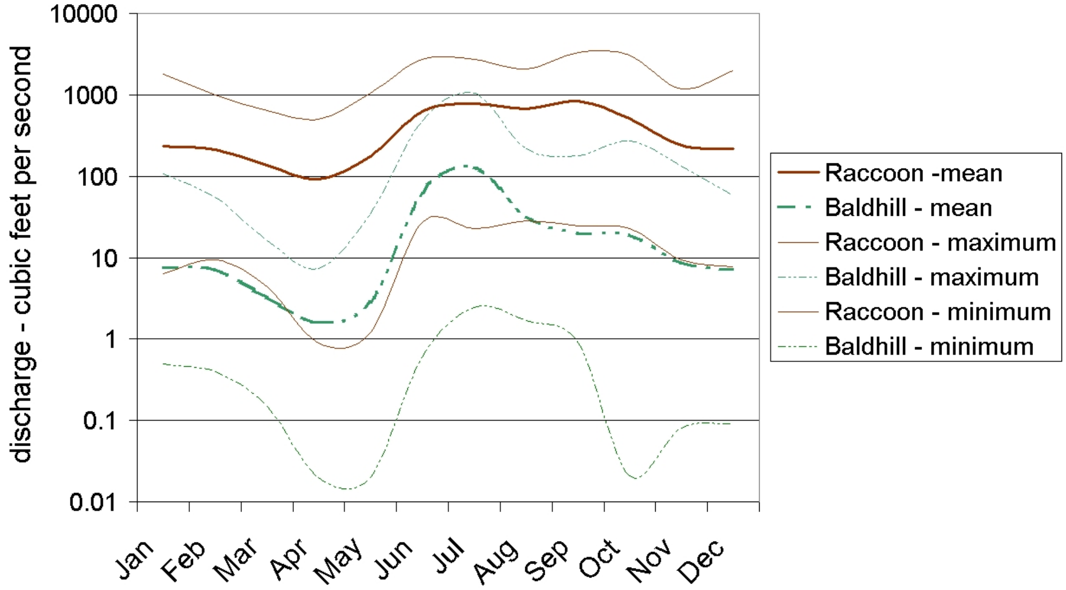


Figure 1.3. Difference in maximum, minimum, and average monthly discharge (cubic feet / second) for the North Raccoon River near Sac City, Iowa and Baldhill Creek near Dazey, North Dakota (data from Nalley et al. 2003 and Robinson et al. 2003).

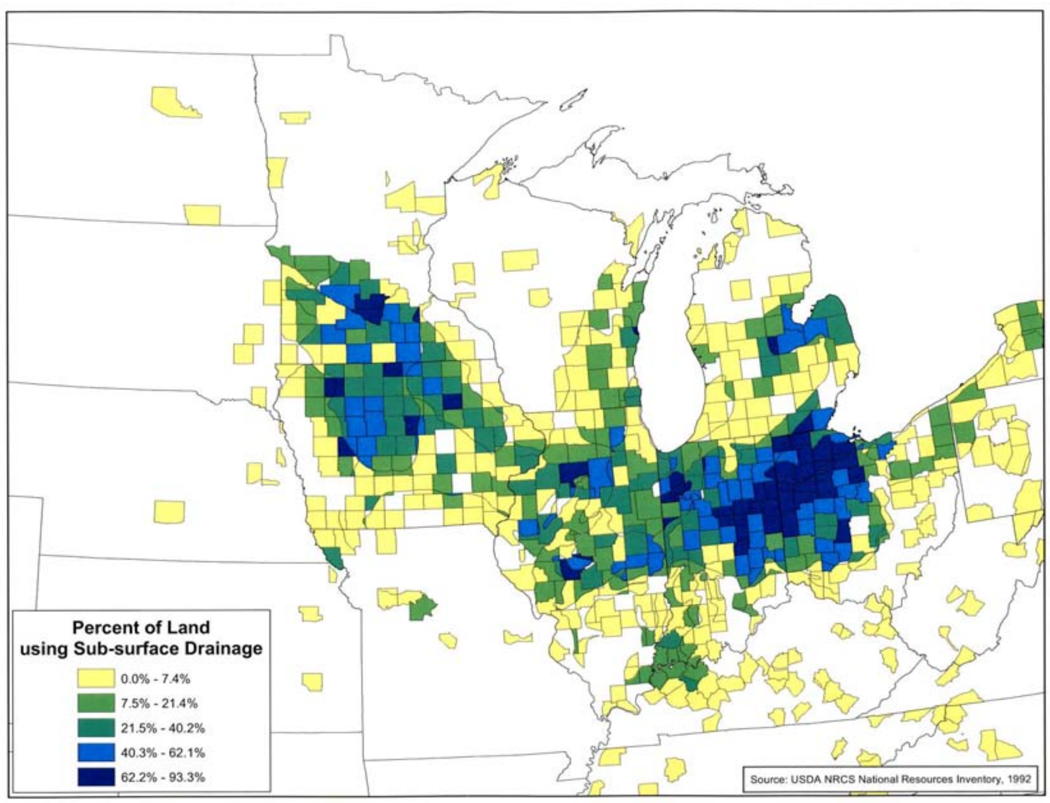


Figure1.4. Map of the upper Midwest US showing the distribution of tile drainage.

1.3.3. Vegetation and Agriculture

Prior to the agricultural development that began in the latter part of the nineteenth century, the NTPE was characterized by extensive tracts of tallgrass prairie and emergent wetlands, with scattered areas of riparian woodland, oak savanna, and aspen parkland.

Currently, only 4% of the original upland ecosystem remains, much of which is strongly fragmented (Samson and Knopf 1994). Except for a few urban centers, nearly the entire area has been converted to agriculture, consisting of corn and soybeans in the south and wheat and barley in the north. With the advent of new short growing season varieties, corn and soybeans are becoming more important crops to the north. Potatoes, and especially sugar beets, are grown in the Red River Valley. Grazing is locally important in areas of light, less productive soils.

1.3.4. Major Watersheds

The NTPE comprises portions of three major watersheds: the Red River on the north, a small part of the Missouri River on the southwest, and the upper Mississippi in the southeast (Figure 1.1). The extreme northwest portion of the ecoregion lies in the lower Assiniboine River basin and crosses several small streams that drain directly to Lake Manitoba. The natural character and drainage pattern of these basins varies dramatically across the region.

Natural drainage of the landscape in discrete channels was non-existent in many areas of the region. Recently developed glacial and glacial lake basin topography combined with gentle slopes led to a water budget characterized by precipitation input and evapotranspiration as the strongly dominant output. Agricultural development has led to an extensive ditch system that now conveys water much faster and maintains a lower water table, especially in the Red River basin. Tile drainage has been installed throughout the southern Minnesota and Iowa portions of the NTPE (Figure 1.4), with some counties exceeding 2/3 of their area drained by tile.

1.4. Overview of Systems and Biota of the Northern Tallgrass Prairie Ecoregion

In the Missouri River drainage, portions of the James, Vermillion, Big Sioux and Little Sioux River basins are captured in the NTPE. These rivers flow from north to south through gently rolling ground moraines interspersed with occasional drift. Historically, streams in these basins were predominantly shallow, low gradient channels with low banks and flat, wide floodplains, or no apparent floodplain at all. Sand, gravel and “muck” were the predominant bottom substrates (Coker and Southhall 1915). This portion of the Missouri basin straddles a substantial east-west climatic gradient; the Big and Little Sioux basins lie in a sub-humid climate, and the westernmost James River basin is situated in a semi-arid climate zone (Milewski et al. 2001). Stream discharges peak in April and June and return to baseflow in October through February. Tributary streams in the James River basin are remarkable for their flashy runoff patterns (due to moderate to steep slopes and small drainage areas) and the frequency of springs and seeps. During dry phases, many tributaries in the James and Vermillion rivers become intermittent.

On a geologic timescale, biotic assemblages of the Missouri basin streams and rivers have only recently occupied these habitats, having populated these drainages following the glacial advances of the Pleistocene. Fauna spread to these systems from southern refuges in the lower portions of the Missouri basin, and from headwater stream capture between streams in the upper portions of the Big Sioux basin and the Upper Minnesota River basin in the Upper Mississippi River drainage (Cross et al. 1986). Approximately 50 fish species reside in the Missouri basin portion of the NTPE, with cyprinids (minnows), catostomids (suckers), and ictalurids (catfish) among the most dominant taxa (Berry et al. 1993, Dieterman and Berry 1998; Hatch et al. 2003). Historically mussel richness in these basins may have ranged from 11 species in the Big Sioux River and Vermillion Rivers to 16 species in the mainstem James River (Coker and Southhall 1915; Perkins and Backlund 2000).

In the Red River basin, the NTPE encompasses the northward-flowing Red River mainstem and the lower portions of tributary watersheds draining both the east and west sides of the basin. Underlying many of the streams and rivers of this area is the thick silty-clay bottom sediments of glacial Lake Agassiz. As such, stream channels are typically low-gradient meandering runs underlain by sand, silt and clay. Headwaters of eastern and western drainages outside of the ecoregion are typically higher gradient and dominated by coarse gravel and cobble substrate. As in the Missouri basin, the Red River basin spans a considerable east-west climatic gradient, resulting in much lower runoff and discharge from western-side streams versus eastern-side streams and rivers; 75% of the flow of the mainstem Red River is contributed by eastern drainages (Tornes and Brigham 1994). Much of the streamflow occurs during the spring and summer months when spring snowmelts and rainfall can cause severe flooding.

As in the Missouri basin, Red River basin stream and river assemblages are relatively young in a geologic time scale. With the retreat of the last Pleistocene glaciers, the area that is now occupied by the Red River basin alternately drained to the Upper Mississippi river system, Lake Superior, and Hudson Bay. As a result, stream and river fish fauna resemble that of both the Upper Mississippi and Great Lakes basins (Aadland et al. 2004). In recent times, fauna of the Upper Mississippi and Red River have been connected through purportedly navigable marshlands that spanned the continental divide near Lake Traverse (in the Red River drainage) and Big Stone Lake (Minnesota River drainage) (Dyke and Prest 1987; Aadland et al. 2004). Currently, 84 species of fish occupy the basin, with cyprinids (minnows), percids (darters, perches, walleye and sauger), centrachids (sunfishes), catostomids (suckers) and ictalurids (catfishes) dominating (Koel and Peterka 1998). Approximately 12 species of mussels are thought to be present in the basin (Jenson et al. 2001).

Currently, 30 aquatic species found within the rivers and streams that cross the NTPE have been provided special conservation status through international, federal, and state or provincial listing programs (Table 1.1).

Table 1.1. Conservation status of NTPE aquatic fauna with protected status under international, federal and sub-federal programs. Appendix 2 provides descriptions of codes.

Common Name	Scientific Name	G-RANK	USESA	CA-SARA	State or Provincial Status
Chestnut lamprey	*Ichthyomyzon castaneus*	G4		SC	
Lake sturgeon	*Acipenser fulvescens*	G3G4			MB-S2S3; MN-SC
Pallid sturgeon	*Scaphirhynchus albus*	G1	LE		SD-SE; ND-ST; IA-E
Paddlefish	*Polyodon spathula*	G4			ND-WATCH; MN-T
Longnose gar	*Lepisosteus osseus*	G5			SD-S3
Shortnose gar	*Lepisosteus platostomus*	G5			ND-PERIPHERAL
Bowfin	*Amia calva*	G4			SD-SE/S1; ND-PERIPHERAL; IA-T
Largescale stoneroller	*Campostoma anomalum*	G5			ND-WATCH
Sicklefin chub	*Macrhybopsis meeki*	G3			SD-ST/S1; ND-WATCH
Silver chub	*Macrhybopsis storeriana*	G5		SC	MB-SC
Sturgeon chub	*Macrhybopsis gelida*	G3			SD-ST/S2; ND-WATCH
Topeka shiner	*Notropis Topeka*	G3	LE		SD-S2; MN-SC; IA-T
Bigmouth buffalo	*Ictiobus cyprinellus*	G3G4		SC	SD-SA; ND-EXT; MN-SC; IA-E
Quillback carpsucker	*Carpiodes cyprinus*	G5			SD-S3
Blue sucker	*Cycleptus elongates*	G3G4			SD-S3; ND-WATCH; MN-SC
Greater redhorse	*Moxostoma valenciennesi*	G4			ND-PERIPHERAL
Flathead catfish	*Pylodictis olivaris*	G5			ND-PERIPHERAL
Bankcreeper	*Strophitus undulates*	G5			SD-S3
Black sandshell	*Ligumia recta*	G5			SD-S1; MN-SC
Creek heelsplitter	*Lasmigona compressa*	G5			SD-S1; MN-SC
Deertoe	*Truncilla truncate*	G5			SD-S2
Higgins eye	*Lampsilis higginsii*	G1	LE		
Mapleleaf	*Quadrula quadrula*	G5			SD-S2
Pink heelsplitter	*Potamilus alatus*	G5			SD-S3
Wabash pigtoe	*Fusconaia flava*	G5			SD-S1
Winged mapleleaf	*Quadrula fragosa*	G1	LE,XN		
River otter	*Lontra Canadensis*	G5			SD-ST;
Blanding's turtle	*Emydoidea blandingii*	G4			SD-SE
False map turtle	*Graptemys pseudogeographica*	G5			SD-ST; ND-PERIPHERAL
Northern leopard frog	*Rana pipiens*	G5		SC	

1.5. Major Threats to Diversity

1.5.1. Habitat Alteration

Ward and Tockner (2001) suggest that species diversity in lotic ecosystems varies with disturbance, ecotone density, patch size, and connectivity. Diversity will reach a maximum at an intermediate state for each parameter. For example, minimal fluvial dynamics in systems that have low connectivity will not sustain a diversity of successional stages in the stream corridor. In contrast, excessive connectivity will impart sufficient energy to maintain pioneer stages throughout the system. Identifying the intermediate state for each of these parameters becomes the challenge in evaluating the effect of human disturbance on biodiversity.

Human adaptations and changes to streams and rivers in the NTPE have modified their natural fluvial dynamics and ecology. Low-head dams in the mainstem of the Red River isolated upstream spawning reaches of the lake sturgeon (*Acipenser fulvescens* Rafinesque) in the early part of the twentieth century. Efforts are underway to remove channel obstructions and reintroduce the fish. Drainage ditches and tiles have strongly altered the natural fluvial dynamics and hence natural habitats by greatly increasing peak flow in the spring and following heavy rainfall. Under natural hydrological conditions, evapotranspiration will generally constitute the largest output term in the water budget, suggesting that rates of infiltration and recharge in unaltered systems would be less than those in extensively drained watersheds. Therefore, enhanced baseflow may result from tiles and ditches intersecting and continuously lowering the water table in drained cropland.

Because of the severe fragmentation of the original natural terrestrial ecosystem, few, if any, fragments encompass a significant, functional watershed that is greater than first or second order. Fragmentation of channels and floodplains leads to complex changes and relationships in lotic ecosystems (Bornette et al. 1998). Unfortunately, there has been little research directed toward understanding the original and current aquatic ecosystem of prairie streams (Dodds et al. 2004). These streams and rivers, however, host imperiled species and provide important ecological and societal functions.

The pervasive development of drainage ditches in the Red River basin and tile drainage in the Iowa and Minnesota parts of the NTPE (Figure 1.5) have greatly altered the stream and river flow regime throughout the region. Tiles tend to function as sources for stream baseflow, and shunt water from processes that would lead to loss by evapotranspiration. Drainage ditches tend to convey water quickly from the landscape, thereby increasing the magnitude of peak flow and decreasing the time of concentration. Some have argued that ditches, however, mitigate flood potential by lowering the water table and decreasing the potential for runoff (e.g. Ross 1997); therefore, effects on ecology are uncertain.

1.5.2. Water Quality

The physical, chemical, hydrological, and biological characteristics that compose the environmental setting of streams and rivers in the NTPE affect water quality. Physical factors relate to the nature of the geological deposits at the base of the stream, and the dissolution, erosion, and transport of this substrate material. The chemical composition of stream water, derived from surface runoff, groundwater discharge, and direct channel precipitation, will approach equilibrium with the atmosphere and the substrate. Hydrological conditions will influence water quality by controlling sediment and dissolved load through stream velocity. Finally, biological conditions and processes will affect water quality by controlling temperature along shaded and unshaded reaches, input of organic compounds, and biological productivity, among others.

Streams flowing through agricultural land in the upper Midwest vary greatly in their chemical and ecological characteristics, although agricultural land use is highly intensive throughout most of the region. These contrasting characteristics likely are attributable to differences in riparian vegetation, soil properties, and hydrology (Porter et al. 2001)

Human activity and land use strongly influence the water quality of streams and rivers in the region (Stark et al., 2000). The dominant use of land for agriculture throughout the NTPE has greatly altered the water quality of streams and rivers in the region. The conditions and problems associated with degradation and threat to water quality because of agriculture are both diffuse (non-point) and universal (e.g. Haygarth and Jarvis 2001). In addition to degradation of streams from surface runoff, the contribution of both natural and agricultural contaminants from aquifers is known to occur in some areas (Lawrence and Sando 1991; Strobel and Gerla 1992). Although there is only one large metropolitan area (Winnipeg) and a few small urban centers in the NTPE (Fargo and Sioux Falls), they have a profound effect on the water quality of stream runoff (e.g., Tornes and Brigham 1994). Management of water quality in streams and rivers adversely affected by urban runoff has improved greatly in recent years (American Society of Civil Engineers 2001) through municipal, state, and federal programs.

Section 303(d) of the federal Clean Water Act, administered by the US EPA, requires that all states develop a list of impaired waters that do not meet clean water standards. The total maximum daily load (TMDL) is used to evaluate water quality based on specified designated use(s) of the water body. Because water quality can change rapidly both spatially and temporally, the TMDL unit provides a way to assess stream reaches and lakes in a way that considers overall water quality of a water body, rather than occasional anomalous values. In a sense, a TMDL Total Maximum Daily Load (TMDL) is the amount of a particular pollutant that a particular stream, lake, estuary or other body of water can accommodate without violating state water quality standards.

TMDL reports from Minnesota, Iowa, and North and South Dakota, indicate that water quality impairment in the NTPE region results primarily from elevated fecal coliform, methyl-mercury, turbidity, nutrients, and low oxygen. All of these, except for methyl mercury, relate primarily to non-point agricultural sources. The most likely source of methyl mercury, which can easily accumulate in fish tissues, is atmospheric deposition.

1.5.2.1. Erosion, Suspended Load, and Sedimentation

Although erosion, transport, and sedimentation occur under natural conditions, agriculture and other human activities greatly enhance these physical processes (e.g., Toy et al. 2002). Many streams of the NTPE are young in the sense that the basins drained are at most a few tens of thousands of years old, having been formed by continental glaciation during the latter part of the Pleistocene era. Natural channel systems and flood plains in the region are therefore developing at a rapid geomorphological rate. Many streams and rivers of the region have a large suspended load and turbidity, especially because of the fine texture of glacial substrates.

An unknown amount of the turbidity in streams of the ecoregion, particularly in the Red River basin, is derived from ditches and field scrapes that have been excavated to enhance agricultural drainage. Sedimentation in the ditches results in the near-universal need for periodic ditch "clean-outs," which aggravate the turbidity problem. Livestock grazing in riparian areas, especially in the Big Sioux and James River basins, also constitutes a significant source of turbidity and suspended sediment in streams of the region (Roy Bartholomay, personal comm. 2004). In the Red River basin, sediments transported in the system are ultimately deposited in Lake Winnipeg, where studies have indicated significant increases in the rate of sedimentation following development of agriculture (Brunskill et al. 1983; Henderson and Last 1998).

1.5.2.2. Nutrients, Pesticides and Other Contaminants

Between 1991 and 2001, the US Geological Survey conducted an extensive assessment of water quality parameters in the Red River basin under the NAWQA program (National Water Quality Assessment). Because such extensive and consistent data are not available for NTPE streams outside of the Red River basin, we will focus our discussion on the Red River basin, although conditions in other NTPE streams and rivers are likely to be similar in most respects.

For the Red River basin, nutrients (nitrogen and phosphorus) have been shown to have the greatest concentration in the main stem of the river near urban centers such as Fargo-Moorhead (Tornes and Brigham 1994). Pesticides are used extensively in the largely agricultural Red River basin, but only small amounts were routinely detected in samples collected in the NAWQA study. Tornes and Brigham (1995) showed that the pesticides detected comprise less than 2 percent of the amount applied, when integrated with the discharge of streams sampled. Results also indicated that pesticides usually are at concentrations far less than established drinking water standards. Sources near the headwaters in the southern part of the basin appear to contribute most of the detected pesticides. Flat land slope, organic soils, pesticide management, and degradation all may limit pesticide contamination that reaches Red River basin streams.

The most common pesticides detected in the Red River basin are atrazine, cyanazine, metolachlor, and triallate (Tornes and Brigham 1995). These are commonly used on corn and soybean crops, which have occupied increasingly more acreage in the northern Red River Valley as the availability of genetically engineered varieties requiring shorter growing seasons increases.

Results from work by Goldstein (1995) on contaminant concentrations in fish from the Red River indicated that most trace elements and organochlorine compounds present in tissues were not at levels toxic to fish or humans. Minnesota and North Dakota, however, have issued a fish consumption advisory based on levels of mercury and PCBs bound in some species.

Chapter 2.0. The Portfolio Selection Process

2.1. General Methodology

The goal of the ecoregional conservation planning process is to identify a set of areas that collectively represent the best opportunities for protection of the full array of freshwater species, natural assemblages and ecosystems within an ecoregion. The process is complex and iterative, requiring extensive analysis of aquatic systems of the region and the knowledge and recommendations of regional experts. Details about the NTPE conservation assessment are provided in the following sections. Additional information about the assessment methodology can be found in *Designing a Geography of Hope: A Practitioner's Handbook to Ecoregional Conservation Planning* (TNC 2000).

The conservation planning process starts with the identification of the important elements of biological diversity that will be used to select the final portfolio of conservation areas. These important elements, or **conservation targets**, represent critical biological resources at many scales. They include:

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

After the conservation targets are selected, numeric **conservation goals** are established for each target. The goal represents the number of viable occurrences, *and* the spatial distribution of a target across the region that is needed to maintain the population or system over the next 100 years.

The aquatic ecological systems that encompass the most viable occurrences of the conservation targets are mapped as **Areas of Biodiversity Significance (ABS)**. The final **portfolio** includes areas that most effectively meet the conservation goals. Following the portfolio selection process, the Conservancy and its partners develop a specific plan of action for each portfolio site.

2.2. Data Collection and Preparation: Expert Meetings, Biological Data Search, and Aquatic Systems Classification

Analysis of the relative viability and importance of river and stream reaches for conservation relies heavily on biological survey data, a standardized aquatic system classification for the region, and expert knowledge and information about the region's aquatic biodiversity. In the following paragraphs, we describe the data collection and aquatic system classification efforts that underpinned our planning assessment of the ecoregion.

2.2.1. Aquatic Species and Assemblage Data

Digitally georeferenced data marking the locations of freshwater species and assemblages were obtained from academics, state and federal agencies, and NatureServe between 2003 and 2004 (Table 2.1). We sought records of the occurrences of river and stream-dwelling fishes, crayfish, mussels, invertebrates, mammals, reptiles and amphibians using any survey or observation method. All data were transferred into a standardized data format and imported into a GIS.

These data formed the basis of our assessment of target species occurrences and goals attainment.

Table 2.1. Data sources for species occurrence records.

Data Code	Taxa Group	Title	Source/Contact	Coverage
CA01	fish, reptiles, amphibians, birds, mollusks	Manitoba Natural Heritage data for Lower Assiniboine	Nicole Firlotte - Manitoba Conservation	Assiniboine basin
IA01/UMR12	fish, mussel, crayfish, reptiles, amphibians, aquatic insects	IA Natural Heritage Dataset	IA Natural Heritage Program	IA - statewide
IA02	fish	IA Baseline Fish Survey (Paragamian Study)	Clay Pierce - IA STATE	Upper Mississippi River basin
IA03	mussels	IA Mussels Dataset	John Downing - IA STATE	Upper Mississippi River basin
IA05	fish and inverts	IA DNR (1/2 of the Iowa Contemporary Dataset)	Tom Wilton - IA DNR	IA - statewide
IA06	fish	Manchester dataset (1/2 of the "Iowa Contemporary Fish Dataset"	Greg Gellwicks - IA STATE	IA - statewide
IA08	Topeka Shiner	IA Nat Heritage Topeka Shiner	Daryl Howell and Kathryne Clark - IA DNR	IA - statewide
MN01	fish	PCAFish	Scott Nimela - MN PCA	St. Croix, Minnesota, and Upper Mississippi River Drainages
MN02	mussels	MN Mussel Data (DNR)	Mike Davis - MN DNR	Cedar, Des Moines, Minnesota, St. Croix, and Upper MS River systems
MN03	fish	Schmidt Dataset	Konrad Schmidt - MN DNR	MS, St. Croix, MN, Des Moines River drainages
MN08	fish	Lake Surveys	Konrad Schmidt - MN DNR	MN - statewide

Table 2.1. (continued) Data sources for species occurrence records.

Data Code	Taxa Group	Title	Source/Contact	Coverage
MN13/UMR12	fish, mussel, crayfish, reptiles, amphibians, aquatic insects	MN Heritage Dataset	MN Natural Heritage Program	MN - statewide
MN14	fish	Schmidt MS River Pool 1-9	Konrad Schmidt - MN DNR	pools 1-9 on MS river
ND02	fish	ND Fishes database	Steven W. Kelsch - UND	ND - statewide
ND03	fish, mollusks,..etc.	ND Natural Heritage data	ND Natural Heritage	ND - statewide
ND05	fish	Koel Dataset	Todd M. Koel - NDSU (Koel and Peterka 2003)	Red River Basin
SD01	fish	Backlund Dataset	Chad Kopplin - SD Aquatic GAP	SD - statewide
SD02	fish	Dietermann Dataset	Chad Kopplin - SD Aquatic GAP	Upper Mississippi River basin of SD
SD03	fish	Bailey and Allum Dataset	Chad Kopplin - SD Aquatic GAP	eastern half of SD
SD05/UMR12	fish, mussel, crayfish, reptiles, amphibians, aquatic insects	SD Natural Heritage data	Dave Ode - SD Natural Heritage Program	SD - statewide
SD07	fish	Topeka Shiner Locations from SD GAP	Steven Wall - SD Aquatic GAP	SD - statewide
UMR12	fish, mussel, crayfish, reptiles, amphibians, aquatic insects	Natureserve Aquatic Element Occurences for IA, IL, IN, MN, MO, SD and WI	NatureServe	IA, IL, IN, MN, MO, SD and WI
UMR13	mussel	Natureserve Aquatic Element Occurences for IA, IL, IN, MN, MO, SD and WI	NatureServe	IA, IL, IN, MN, MO, SD and WI

2.2.2. Aquatic Ecological System Classification

In preparation for the ecoregional planning process, we also developed a hierarchical classification for the river and stream systems of the ecoregion. The classification we employed successively divides the surficial hydrologic landscape into Aquatic Subregions, Ecological Drainage Units (EDUs), Aquatic Ecological Systems (AESs; also referred to as systems), and Macrohabitats (Higgins et al. in press). This classification serves as the organizing structure for our conservation assessment of the ecoregion. Details on the classification of NTPE rivers and streams are provided in Appendix 1.

2.2.3. Expert Meetings

Much of the data underpinning the NTPE plan was gleaned from meetings held with aquatic biologists and ecologists on March 18-19, 2004, in Grand Forks, ND and March 23-24, 2004, in Brookings, SD. Over the course of two days, experts were queried on the conservation status, location, viability, and threats to aquatic taxa and systems in the rivers and streams of the NTPE. They provided detailed information about aquatic taxa and systems of conservation importance at locations around the region (Figure 2.1). Experts developed target species and assemblage lists and identified conservation goals for the targets. They reviewed and provided suggestions for improving our river/stream classification system and offered comments on a proposed approach to select priority conservation areas for the NTPE. Information and suggestions offered at these meetings were adopted and incorporated into the portfolio assembly strategies. Additional experts reviewed these materials and provided comments on previous versions of this document.

In the following sections we describe the methods used to select and define conservation targets, establish conservation goals, and assemble the portfolio.

2.3. Conservation Targets

Conservation targets serve as the focal elements of the planning process (The Nature Conservancy 2000). For each conservation target, we set goals for the amount and distribution of each target we hope to conserve in the ecoregion, and strive to include multiple occurrences of every target in our conservation portfolio, or design a portfolio that provides habitat for targets in all of their life history stages. Locations where targets occur and areas that are needed for viable persistence of each target form the building blocks for the portfolio map. Finally, targets are used to measure the effectiveness of our conservation strategies; we assess our conservation success by monitoring the health and viability of targets.

Targets include both coarse scale (ecological system) and fine scale (species and assemblages) elements of biodiversity. Conservation planning aimed at both coarse and fine filter targets is thought to provide complementary and comprehensive protection strategies for the full range of biodiversity of an ecoregion (Groves et al. 2003). By including coarse scale targets in our conservation portfolio, we provide for the protection of whole ecological systems and their component biodiversity. By including fine scale elements, we provide for the protection of taxa that may escape conservation protection if we were to use only a coarse-filter approach. Such taxa might include species that are rare, endangered, endemic, on the periphery of their range, wide-ranging, or declining. The key to the effective use of the coarse/fine filter strategy is to carefully select targets that include the full array of ecological systems in an ecoregion and represent a range of taxa and their ecological needs.

In NTPE freshwater systems, coarse-scale targets were the AES types (i.e., system types) that make up the ecoregion. System types are groups of drainages that have similar physical habitat conditions, such as geology, stream size, flow

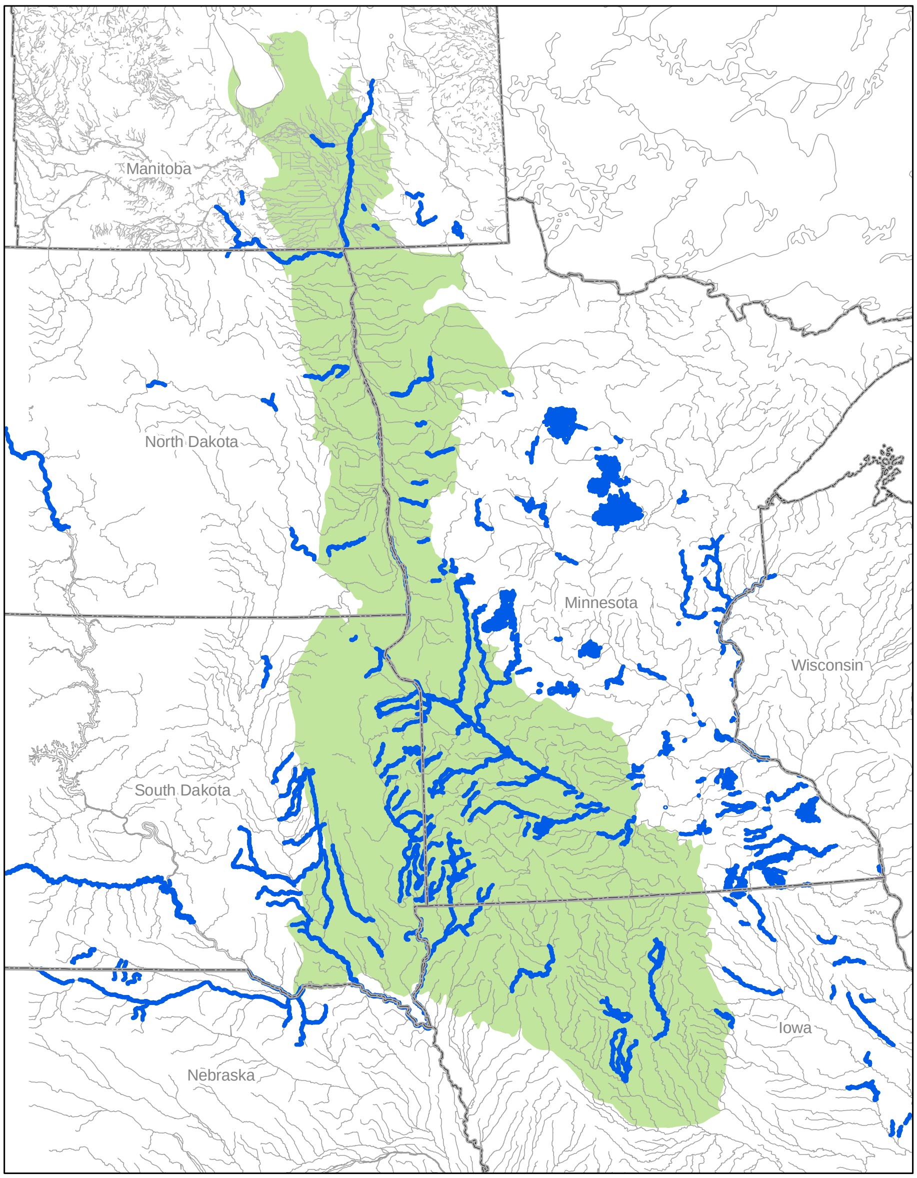


Figure 2.1. Locations (in blue) of expert information about aquatic taxa and systems in the NTPE and nearby vicinities. Expert information from locations in the Upper Mississippi River basin was acquired through the UMRB planning process from 2002 to 2003 (Weitzell et al. 2003). Other locations were identified during the NTPE expert meetings in March 2004.

permanence, flow network position, climate, and proximity to lakes – all factors known to influence the distribution of biota. Each AES type is thought to represent a unique ecological setting, with a distinctive combination of geophysical processes, disturbance regimes, biological species composition, and physical conditions. System types are the intermediate-scale units in the hierarchical classification of NTPE rivers and streams (Appendix 1).

Every AES type found in the NTPE was considered a conservation target. By including representative examples of each system type in the final conservation portfolio, we hoped to ensure protection of the full range of river/stream ecological settings found in the NTPE, and the elements of biodiversity commonly found within them.

NTPE fine-scale targets included fish, mussel, crayfish, mammal, reptile and amphibian species or assemblages that are rare, endemic, declining, disjunct, wide-ranging, or on the periphery of their range (Appendix 2). Species targets were selected on an EDU by EDU basis (to recognize differences in the status or distribution of taxa across EDUs), or were assigned to a group of EDUs within a large drainage basin. Assemblage targets for the NTPE included characteristic native species assemblages that are rare or declining in the ecoregion (Appendix 3). A total of 95 species and assemblage targets were identified for EDUs that cross the NTPE (Table 2.2).

Table 2.2. Number of species and assemblage targets by Ecological Drainage Unit for the NTPE.

Target Type	**Red River West EDU**	**Red River East EDU**	**Assini-Boine EDU**	**James River EDU**	**Big Sioux EDU**	**UMRB EDUs**
crayfish species	2	2	2			
fish species	15	22	11	7	9	12
fish assemblage	1	1	1	4	4	
herp species	5	5	5	1	1	2
invert assemblage	1					
mammal species	1	1	1	1	1	
mussel species				2	1	21
mussel assemblage	2	2	2	2	2	
turtle assemblage				1		

2.4. Conservation Goals

In building a conservation portfolio for the NTPE, we adopted four primary objectives (Groves 2003) for the structure and composition of the portfolio sites.

> Representative – Portfolio sites within the ecoregion should represent the biological features of the ecoregion and the range of environmental conditions under which they occur.

Resilient – Conservation targets occurring within the rivers and streams identified as portfolio sites should be resilient to both natural and human-caused disturbances.

Redundant – To avoid extinction or endangerment caused by both naturally occurring stochastic events (e.g., disease, predation, floods, fires) and human-related threats, conservation targets should be represented multiple times within a system of portfolio areas.

Restorative – In areas where conservation targets are not sufficiently represented to meet conservation goals, portfolio sites should include areas where occurrences of conservation targets are not viable or lack ecological integrity, but may be feasibly restored to appropriate levels of viability and integrity within the ecoregion.

To address representation and redundancy objectives, we aimed to include occurrences of every species, assemblage and system type in the portfolio, and we established specific goals for the amount and distribution of target occurrences we sought to include in the portfolio map. The goal for systems targets was to include at least one occurrence of each system type in the portfolio network. Species and assemblage goals were defined on an individual basis, with the aim of delineating the number and spatial distribution of target occurrences required to ensure the persistence of that target for the next 100 years (Appendix 2). For example, experts identified *Phoxinus erythrogaster* (Southern Redbelly Dace) as a species target and set its conservation goal at three occurrences within the Big Sioux EDU. Experts defined a target occurrence location as a stream or river segment inhabited by a target species or used during its life history. Each target occurrence location should be in a spatially distinct watershed or basin.

To address our resiliency and restorative objectives, we included the most viable (and presumably most resilient) examples of our targets in the locations identified as Areas of Biodiversity Significance (ABS), and completed the network of portfolio sites with lower-viability restoration locations that provided connectivity and movement routes for aquatic biota. Details on the process of assembling the portfolio to meet the four objectives are provided in the following sections.

2.5. Threats, Viability and Integrity Assessments

Prior to beginning work on the NTPE conservation portfolio, no consistent, comprehensive assessment of aquatic system viability, threats, and integrity to these systems had been conducted. However, extensive work had been done to understand the types of anthropogenic factors impacting these systems and the species composition of many stream and river reaches in the ecoregion. This work informed the development of our measures of aquatic system quality.

Our goal through these assessments was to acquire standardized information on the relative quality and suitability of aquatic systems for conservation protection as well as to understand the ecoregion-level condition of aquatic systems and the kinds of threats that may need to be addressed for effective conservation of these systems. We also aimed to use methods and metrics that were simple, applicable to a wide variety of systems, and efficient.

2.5.1. Expert Viability Assessment

The viability assessment was designed to provide information on the status of aquatic system composition, structure, and function at expert-identified target occurrences in the ecoregion. It was a qualitative assessment of target status based on expert field experience and knowledge.

Three factors contribute to the viability of any given target occurrence, whether it is a species, assemblage or AES (TNC 2000).

> *Size* is the area or abundance of the conservation target's occurrence, relative to other known, and/or presumed viable, examples. For ecological systems and assemblages, size is simply a measure of the occurrence's patch size or geographic coverage. For target species and assemblages, size is a relative ranking based on the area of occupancy and number of individuals within the target occurrence.
>
> *Condition* is the quality of the immediate habitat and biophysical conditions necessary to promote survival and reproduction. This includes factors such as the presence of exotic invasives, population age structure, physical structure (e.g., bank structure, or local point source input), and biotic interactions (e.g., levels of competition, predation, and disease).
>
> *Landscape context* is the quality of the landscape factors required to provide appropriate conditions for habitat maintenance, genetic exchange, migration,and escape from disturbance. Factors might include the dominant environmental regimes and processes that establish and maintain the target occurrence (e.g., hydrologic regimes, surficial and groundwater chemistry, geomorphic processes, climatic regimes) and the degree to which targets have lateral and longitudinal movement (i.e., connectivity). Connectivity includes such factors as species targets having access to habitats and resources needed for life cycle completion, fragmentation of ecological assemblages and systems, and the ability of any target to respond to environmental change through dispersal, migration, or re-colonization.

During the experts meetings in Brookings and Grand Forks, participants assigned a rank of Very Good, Good, Fair, or Poor to each viability factor for each target occurrence they identified. Details on the criteria used to evaluate viability and assign ranks are provided in Appendix 3. During the portfolio selection process, viability assessment information was used to rate and select portfolio sites.

2.5.2. Expert Threat Assessment

The threats assessment (also called the "sources of stress assessment") was designed to identify the suite of factors affecting expert-identified target occurrences and the relative magnitude of these stressors. At the experts meetings, attendees listed the top three threats to the integrity of the target occurrences. Threat assessment data were used to inform the portfolio selection process and identify potential conservation strategies for portfolio sites.

2.5.3. Landscape-Scale Aquatic Ecological System Integrity Assessments

To provide consistent, quantitative information about AES integrity across the ecoregion, we assessed the relative magnitude of various stressors to aquatic systems using digital landscape-scale information in a GIS. For each AES, we calculated five metrics:

- percent of system covered by non-natural landcover, excluding urban areas and roads (Data source: National Land Cover Database - USGS 1992)
- percent of system covered by urban and road land cover (Data source: National Land Cover Database - USGS 1992)
- number of dams per linear kilometer of stream length (Data source: National Inventory of Dams - USACE 1999)
- average stream sinuosity (Data source: National Hydrography Data - USGS 1999)
- number of point source polluters per linear kilometer of stream length (Data source: BASINS - USEPA 2001)

Landscape integrity data were used to inform the portfolio selection process and provide greater information on threats to and potential conservation strategies needed at portfolio sites.

2.6. Selecting River/Stream Areas of Biodiversity Significance and Assembling the Network of Portfolio Sites

The NTPE river/stream conservation portfolio was assembled using AESs as the building blocks of the map (for explanation of how AESs were delineated, see Appendix 1). Prior to beginning the selection process, we created a database that included available information about target occurrences, threats and viability for each AES. Each AES was attributed with the following data:

- species and assemblage target types found within the system;
- AES type code;
- landscape quality metrics, including percent natural cover, percent non-natural cover, percent urban/road cover, average stream sinuosity, density of dams, density of point source polluters.

In addition, where an AES encompassed a location at which experts provided detailed information about target occurrences (Figure 2.1), the AES was attributed with two additional pieces of information:

- expert ranking of the relative viability of the target occurrences;
- expert identification of the threats to the targets.

Based on the data compiled, each AES was assigned a portfolio category using the criteria outlined in Table 2.3. Portfolio categories A, B and C denoted systems which housed the best examples of species and assemblage target occurrences. Portfolio categories D and E denoted AESs that were the highest known quality examples of AES types. AESs that could be assigned to multiple portfolio categories were given the lower alphabetical letter. For example, one AES might house a high-quality occurrence of target species X (therefore earning a rating of portfolio category A), and also have been identified as a high-quality example of

AES type Y (portfolio category D). The AES would be assigned the portfolio category of A.

After assigning each AES to a portfolio network category, our next step was to assemble an NTPE portfolio network that met our conservation goals for target occurrences by selecting a group of AESs from among the systems assigned to portfolio categories A through G. Usually, this is an iterative process, in which we progressively add systems to the network based on their conservation value, and periodically assess our progress toward achieving our conservation goals. However, we quickly learned that our conservation goals could not be met using only a subset of the systems identified in priority categories A through G. Because there were so few high quality examples of species, assemblage and system target occurrences in the NTPE, it was necessary to include *all* systems that fell into portfolio categories A through G in our portfolio network.

After assembling the portfolio network, systems were assigned to one of two Area of Biodiversity Significance (ABS) classes based on their portfolio category. *Confirmed ABSs* (ABSs assigned portfolio categories A, D and F) are those AESs that encompass the most viable occurrences of targets in the ecoregion and represent the most important places for conservation and protection of targets. They also provide connectivity and movement corridors between and among ABSs (including terrestrial and aquatic ABSs). Confirmed ABSs form the core elements of the full network of systems included in the NTPE river/stream conservation portfolio. Confirmed ABSs were primarily those nominated by experts and identified as having the highest quality occurrences of target elements.

The remaining portfolio areas are considered *possible ABSs* (portfolio categories B,C,E and G), and include systems that provide a variety of functions in the conservation network and serve multiple conservation goals, including supporting lower quality target occurrences, or representing unique system types and restoration opportunities.

The criteria and methods used to assemble the portfolio network were developed through review and discussion at the expert meetings. They were designed to promote achievement of the conservation goals using the most efficient and viable arrangement of AESs.

Table 2.3. Portfolio network categories and ABS classes for the NTPE. Each AES was assigned to one category, and the portfolio network was assembled by selecting AESs from each category until the conservation goals were met.

Portfolio Network Category and ABS Cass	Description	Source of information for rating	Selection Details
A (confirmed ABS)	Systems with very high and high quality occurrences of target species/assemblages	Expert opinion and/or biotic indicators	AESs containing target occurrences that were expert-rated as "Good" or "Very Good" for any of the three species/assemblage target viability metrics
B (possible ABS)	Systems with fair to poor quality occurrences of target species/assemblages	Expert opinion and/or biotic indicators	AESs containing target occurrences that were expert-rated as "Fair" or "Poor" for any of the three species/assemblage target viability metrics
C (possible ABS)	Systems with high frequency but unknown quality of target species/assemblage occurrences	Post-1995 Survey data and expert opinion	AESs with the highest number of target occurrences in any of these categories: all mussel targets, all fish targets, all herp targets, all invert targets, all assemblage targets and all species and assemblage targets combined; or AESs with target species occurrence data (provided by experts) but no quality information attributed to the target occurrences
D (confirmed ABS)	Very good and good quality examples of AES types	Expert opinion	AESs with "very good" or "good" expert-rated system viability
E (possible ABS)	Fair, poor and unrated quality examples of AES types	Expert opinion	AESs with "fair," "poor," or "unknown/unrated" expert-rated system viability
F (confirmed ABS)	Systems that connect aquatic ABSs	GIS Analysis	AESs that provide movement corridors connecting confirmed ABSs
G (possible ABS)	Systems belonging to AES types that are unrepresented in portfolio categories A through F but have high landscape quality indicators	GIS analysis/ landscape quality metric	AESs that represent unique types that were not captured in previous categories but have a high proportion of upland natural cover for their AES type
X	All other systems		AESs that did not meet any of the above criteria

Chapter 3.0. The NTPE River/Stream Conservation Portfolio

3.1. River/Stream Portfolio Network

The portfolio selection process resulted in a suite of AESs that represent the best opportunities for conservation of the river and stream biological diversity of the NTPE (Figure 3.1). Among all NTPE rivers and streams, these systems are thought to best serve our conservation goals and capture and link the most viable occurrences of target species, assemblages and AES types. Because there were so few high quality examples of coarse and fine filter target occurrences in the NTPE, the portfolio includes target occurrences representing a large degree of variability in viability and condition. In addition, despite our best efforts to do so, several species targets are not represented in this network due to our inability to identify locations where these targets occur. Further details on how well our portfolio meets our conservation goals are provided in Section 3.3.

In combination with the map of ABSs identified through the UMRB conservation assessment (Weitzell et al. 2003), a total of 261 AESs within all of the EDUs of the NTPE were selected for the portfolio network (Figure 3.2). Full descriptions of the systems captured in this map are provided in Appendix 4.

In the Red River basin, key ABSs include the Otter Tail watershed and Red Lake River on the east side of the basin, and the Sheyenne, Lower Pembina and Turtle Rivers on the west side of the basin. Numerous smaller tributaries on both the western and eastern sides of the Red River mainstem make up the remainder of the portfolio network. These tributaries include the Buffalo, Wild Rice, Rush and Forest Rivers. Significant areas in these smaller tributaries are the beach ridge zones of the former Lake Agassiz.

In the portion of the Missouri River basin that crosses the NTPE, key ABSs include the northeastern tributaries and mainstem of the Big Sioux River, Turkey Ridge Creek and the West Fork and mainstem of the Vermillion River. The lower mainstem of the James River basin and numerous tributaries in the lower portion of this basin are also captured in the portfolio network. In the south-central portion of the ecoregion, the mainstem and headwater portions of the Little Sioux River basin is the dominant portfolio area.

In the Upper Mississippi River Basin, the largest portfolio systems are the mainstem Minnesota River and numerous tributary basins, including the Pomme de Terre, Chippewa, Yellow Bank, Yellow Medicine, Redwood River and Blue Earth River basins. The lower mainstems of the LeSeur and Cottonwood Rivers are also key portfolio sites in the Minnesota River watershed. In the southeastern extreme of the ecoregion, the headwaters of the Iowa River, the Boone River basin, portions of the North and Middle Raccoon basins and the West branch and mainstem of the Des Moines River constitute the portfolio river and stream reaches.

3.2. Integrated NTPE Terrestrial, Bird and River/Stream Conservation Portfolios

As described in the Introduction (Section 1.5 of Chapter 1), the NTPE river and stream conservation portfolio consists of a suite of locations that must be integrated with previous conservation areas identified in the ecoregion. Figure 3.3

depicts the locations of NTPE terrestrial ABSs (TNC 1998), NTPE bird conservation areas (Chapman et al. 1998), UMRB ABSs and Priority Areas (Weitzell et al. 2003) and the Priority Landscapes identified by the MN chapter of The Nature Conservancy (TNC 2004).

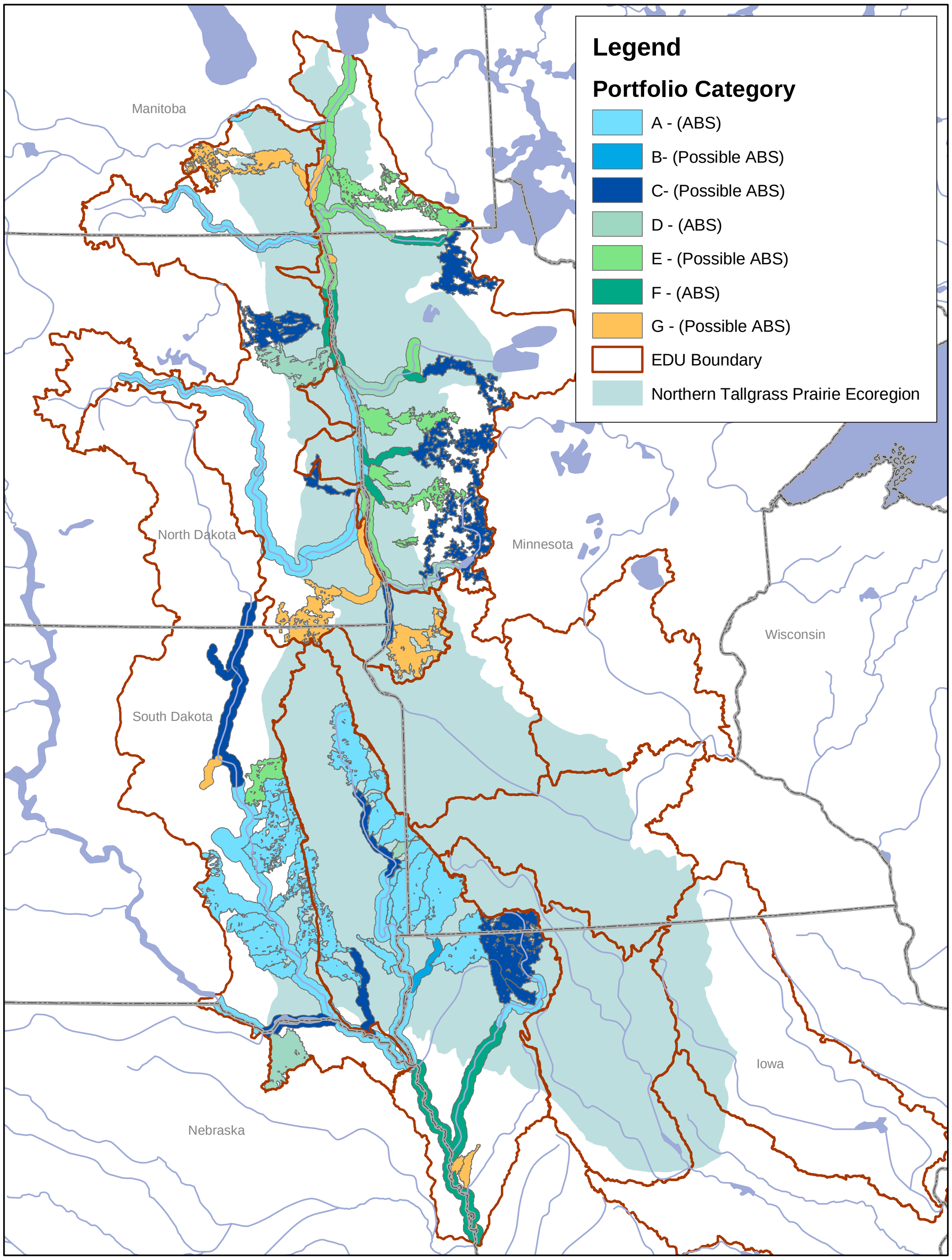


Figure 3.1. The NTPE river/stream conservation portfolio in the Missouri River and Red River basins. Each portfolio AES is color-coded by portfolio category. For portfolio category descriptions, see Table 2.3 in Chapter 2.

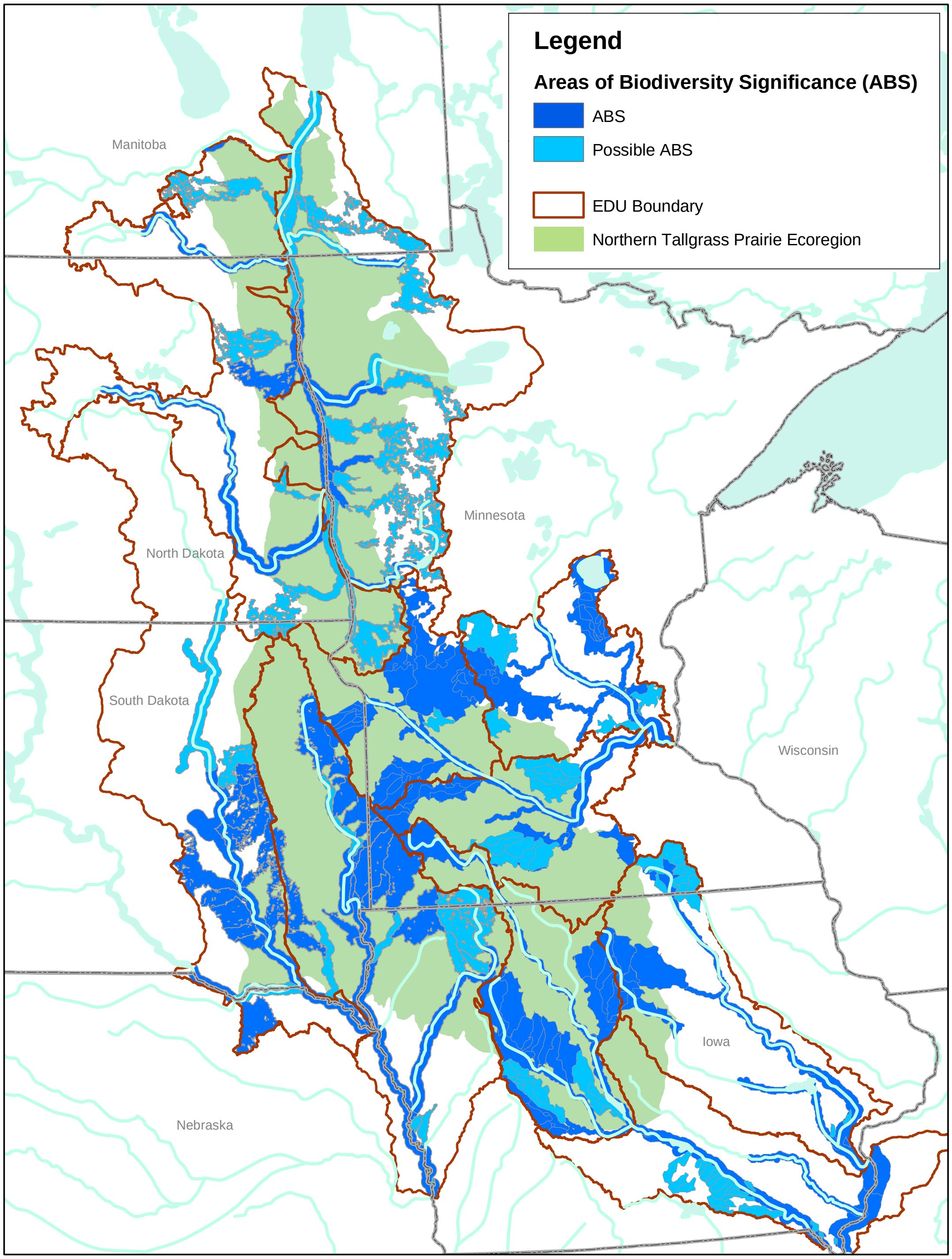


Figure 3.2. The river/stream conservation portfolio network in the NTPE. AESs have been color-coded to reflect the ABS class to which each system belongs. Further information about the AESs that comprise the portfolio network is provided in Appendix 4.

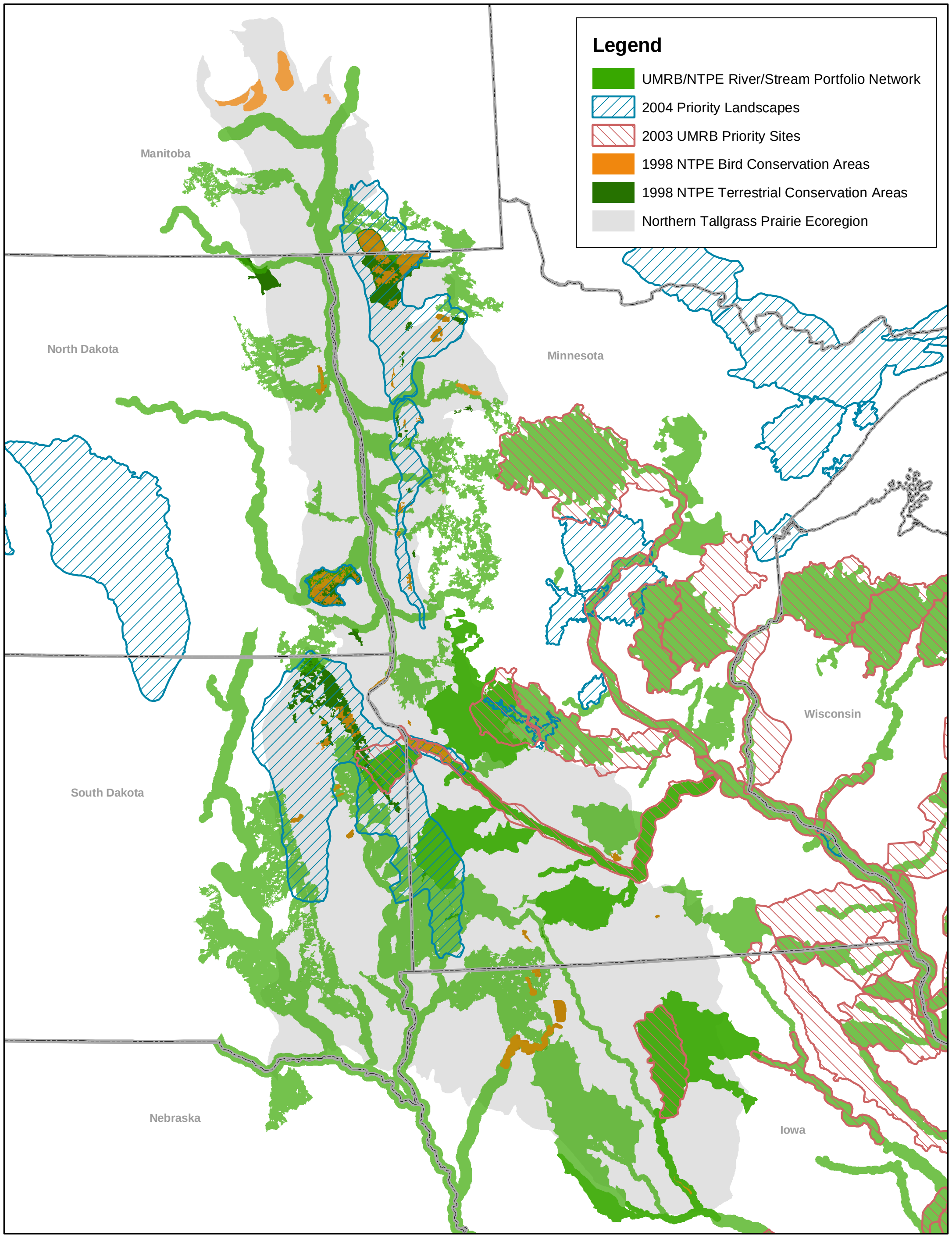


Figure 3.3. Overlap of identified terrestrial and aquatic priority conservation areas around and within the NTPE.

3.3. Progress Toward Conservation Goals

One measure of the success of our conservation planning process is the degree to which the river/stream portfolio meets our conservation planning goals and objectives. In the following paragraphs, we detail how we measured our progress toward and success in meeting our representation and redundancy goals for species, assemblages and AESs.

As described in Chapter 2, among our primary goals was our intent to include a minimum of one occurrence of each AES type in the portfolio network. In this effort we were successful. Across the entire NTPE (including the Missouri, Red River and Upper Mississippi River basins), at least one example of every AES type was captured in the portfolio network; furthermore, many system types were represented with multiple examples. Those AES types represented multiple times were typically ones that housed many targets species and assemblages. AES types that were only represented with one example were typically those in agriculturally-dominated areas where instream habitats are highly altered and few target species persist. By number, smaller systems (headwaters and creeks) make up the bulk of the portfolio network. But larger systems (large and big rivers)are proportionally better represented; almost all large and big river occurrences are included in the network by virtue of their role in providing connectivity, representing unique habitat types, and providing unique habitat for target species (Table 3.1).

Table 3.1. System goals met by the portfolio network. Data reflect systems in the Missouri, Red River and Upper Mississippi EDUs.

AES Size Class	Number of AESs in portfolio network	Number of AESs in all EDUs	Percent of AESs captured in portfolio network	Percent of AES types captured in portfolio network
Headwater (Size 1)	776	4920	16%	100%
Headwater-Creek (Size 1-2)	113	855	13%	100%
Creek (Size 2)	182	1365	13%	100%
Small River (Size 3)	69	402	17%	100%
Medium River (Size 4)	33	80	41%	100%
Large River (Size 5)	28	30	93%	100%
Big River (Size 6)	7	7	100%	100%

In Chapter 2, we also described the goals established for representation and redundancy in target species and assemblages. During the NTPE experts meetings, participants established target species and assemblage conservation goals in terms of the minimum number of “occurrences” that needed to be captured in the portfolio network (Appendix 2). Experts agreed that ideally these occurrences would be viable populations observed within the past five years and each occurrence would be located in separate drainages or watersheds within an EDU.

Assessing the degree to which we met our species conservation goals was challenging, given the limitations of our database. Despite over 8000 target location records, many species were unrepresented in our database, and only a limited number had records dating from the past five years. Records of assemblage locations were even more rare or dated. And expert viability assessments were missing for the vast majority of target locations. To assess the number of target occurrences captured by our portfolio network, we needed to devise a more practical, measurable definition of a target occurrence.

For the purposes of providing a cursory assessment of our progress toward attaining the conservation planning goals, each AES in which a target was observed since 1994 was considered a target occurrence. A target occurrence was counted as captured if the AES in which it resided was included in the portfolio network. An AES could only be counted once for each target; multiple records of a target within an AES did not qualify as separate target occurrences even if the records were spatially or temporally distinct. Headwater (size 1) and creek basins (size 2) nested within small river systems (size 3) were not included in this analysis so as not to repeatedly count the same target occurrences.

Admittedly, this approach was likely to capture and count many non-viable (or possibly even no longer inhabited) locations of targets. But because it grouped spatially and temporally distinct records within a system and recognized occurrences only at the system scale, we felt it would minimize overestimates of the number of occurrences captured, and thereby minimize overstatements of our progress toward achievement of our goals.

In total, conservation goals were met for 49 of the 94 (52%) NTPE target species and assemblages (Table 3.2; Appendix 2). However, we did not have target occurrence records for 15 species and assemblages. Out of the 79 species and assemblages for which we had post-1994 spatial occurrence records, 78 (98%) were represented at least once in the portfolio network. Targets for which we did not meet our conservation goals included extirpated species, taxa that have very

Table 3.2. Species and assemblage goals met by portfolio network. Data reflect species target occurrences in the Missouri, Red River and Upper Mississippi River NTPE EDUs.

Target Type	Total number of targets	Percent of targets that met goal	Percent of targets for which at least one occurrence was captured in portfolio network	Percent of targets for which there were no occurrence records in post-1994 dataset
fish assemblages	8	75%	100%	0%
invert assemblages	1	100%	100%	0%
mussel assemblages	4	20%	80%	20%
turtle assemblages	1	100%	100%	0%
crayfish	2	50%	50%	50%
fish	46	43%	85%	13%
herpetofauna	9	22%	56%	44%
mammals	2	50%	50%	50%
mussels	23	79%	92%	8%

limited occurrences or groups that are undersampled. Our ability to meet goals was most notably hampered by the limited amount of data for many mammals, herpetofauna and crayfish.

3.4. Threats to Rivers and Streams of the NTPE

At many of the locations where experts provided information on target occurrences, they also identified the top three threats impacting the targets found there. Table 3.3 summarizes the results of this assessment. Out of 224 sites where experts provided information on target occurrences (Figure 2.1, Chapter 2), 84 included threats assessments. Within this set of 84 sites, general agricultural activities, including all types of management and production practices related to agriculture industries, were identified most frequently in the list of top threats. Invasive species and incompatible water management in the form of groundwater withdrawals, stream channelization and dam operations were also commonly selected as major threats to the systems and targets. Although these data represent only a fraction of systems selected for inclusion in the conservation portfolio, they provide good insight into the types of threats most frequently facing aquatic systems in the ecoregion. And they suggest what types of conservation strategies might effectively serve to enhance aquatic biodiversity in the ecoregion.

In particular, it appears that conservation strategies aimed at addressing impacts to aquatic systems derived from crop production activities and grazing practices would be among the most widely effective and important measures conservation organizations could employ in this ecoregion. Although experts did not always specifically indicate the types of agriculture activities causing impairment to aquatic systems, they may include non-point source pollution (of sediments and agricultural nutrients and chemicals), water diversions and withdrawals, and filling and draining. Conservation activities such as riparian buffer enhancement, conservation easements and producer education have proven to be effective tools in addressing these concerns. Many conservation organizations and county, state, provincial and federal programs are actively addressing these resource concerns and pursing these strategies in the ecoregion.

For example, the Natural Resources Conservation Service in SD, in partnership with local, state, and other Federal agencies, provides technical and financial assistance for individual landowners to voluntarily conserve natural resources on privately owned agricultural land. Utilizing established conservation programs and practices, NRCS assists landowners to identify and address the soil, water, air, plant, animal, and human resource concerns associated with agriculture (Cindy Steele, personal communication).

The threats assessment also indicates that conservation strategies aimed at mediating the effects of incompatible dam operations and management for invasive/alien species are among the top strategies necessary to protect aquatic system integrity in this ecoregion. Again, multiple public agencies and private organizations within the ecoregion are already active in addressing these issues. For example, in the Red River Basin, several local, state and federal agencies and private organizations, including the US Army Corps of Engineers, MN Department of Natural Resources, City of Fargo, City of Moorhead, Buffalo and Red River Watershed Boards, ND Department of Game and Fish, and River Keepers are participating in a project called "Reconnect the Red," which will make all of the dams along the Red River of the North (from Winnipeg, Canada to Fergus Falls, MN) passable to fish (Luther Aadland, personal communication).

Further analysis and close collaboration with conservation partners in the region are necessary to develop a comprehensive plan for abating threats to aquatic ecological systems within the portfolio network. However, this preliminary assessment indicates key areas of concern and points to potential conservation strategies needed in the ecoregion.

Table 3.3. Threat categories and frequency of occurrence at 84 expert-identified locations of target occurrences. Frequency values represent the percent of sites in which a threat was listed among the top three threats facing the targets at that site. All values greater than 0.15 have been highlighted in bold lettering.

Threat	Code	Frequency
Incompatible Agriculture and Forestry	A	**0.39**
Crop production practices	A1	**0.31**
Livestock production practices	A2	0.12
Grazing practices	A3	**0.23**
Forestry practices	A4	0
Other	A5	0
Incompatible Land Development	B	0
Primary home development	B1	0.06
Secondary home/resort development	B2	0.01
Commercial/industrial development	B3	0
Road/utility development	B4	0.01
Conversion to agriculture or silviculture	B5	0.06
Other	B6	0.01
Incompatible Water Management	C	0.01
Dam construction	C1	0.02
Construction of ditches, dikes, drainage or diversion systems	C2	0.06
Channelization of rivers or streams	C3	**0.17**
Operation of dams or reservoirs	C4	**0.18**
Operation of drainage or diversion systems	C5	0.02
Excessive groundwater withdrawal	C6	**0.32**
Bank stabilization	C7	0.05
Large woody debris removal	C8	0.01
Other	C9	0.01
Point Source Pollution	D	0.01
Industrial facility discharge	D1	0
Wastewater treatment plant discharge	D2	0.04
Landfill	D3	0
Other	D4	0
Resource Extraction	E	0
Mining	E1	0.01
Oil or gas drilling	E2	0
Commercial harvesting	E3	0
Poaching or collecting	E4	0
Other	E5	0
Incompatible Recreation	F	0
Recreational vehicles	F1	0
Overfishing, collecting or hunting	F2	0
Other	F3	0
Land/Resource Management	G	0
Fire suppression	G1	0
Incompatible management of/for select species	G2	0.01
Other	G3	0
Biological	H	0
Parasites/Pathogens	H1	0
Invasive/Alien species	H2	**0.21**

Chapter 4.0. Putting the Portfolio into Action

4.1. Use and Application of the NTPE River/Stream Conservation Portfolio

TNC aims to use the NTPE river/stream portfolio in combination with previous ecoregional conservation assessments to guide conservation efforts in the ecoregion for the next 10 years. Our greatest hope is that this assessment will also help to focus and define the conservation activities of our conservation partners and friends. By working collaboratively in these locations, we believe that we can achieve lasting conservation of all types of biodiversity found in the NTPE.

This conservation assessment is intended to be revisited periodically to update targets, goals and portfolio sites as new information becomes available, conservation theories and management practices develop, and conditions in the ecoregion evolve and change. As such, this is considered a working document through which we may improve and refine our strategies for large-scale conservation of all elements biodiversity in the ecoregion. If you have thoughts or concerns about the conservation portfolio, we welcome them as an opportunity to improve upon this effort.

Among the first steps following completion of this report is careful review of the integrated maps of terrestrial, bird, and aquatic priorities and development of strategies based on the overlap of all ABSs. TNC conservation efforts are already underway in “priority landscapes” of the NTPE, as is conservation action in myriad forms by numerous local, state and federal agencies and private organizations. By integrating terrestrial and aquatic conservation activities at the locations where ABSs overlap, we may achieve more efficient and effective conservation action across the entire landscape.

In the coming years, TNC will develop specific strategies for conservation at each of the portfolio areas highlighted in this assessment. These plans will detail the specific targets, goals and management activities that TNC hopes to undertake in each of the conservation areas in which it works.

4.2. Improving Future Iterations

Although the NTPE river/stream conservation portfolio has been developed with careful effort, it must be recognized as an organic document, subject to change and improvement as social and economic factors exert new pressures on these systems and our knowledge of them develops and expands.

Among the information that would significantly improve and refine this document is further studies of macroinvertebrate taxa in NTPE rivers and streams. As in many places in the world, our understanding of invertebrate composition, structure and function in the NTPE lags far behind that of large, conspicuous river and stream organisms despite the extremely critical role that invertebrates play in energy and nutrient transport and cycling. Our lack of understanding of how to protect the integrity of invertebrate communities and thereby preserve stream energy process and nutrient cycles may result in inadequate conservation efforts despite our best intentions.

In the NTPE, our conservation planning efforts are also hampered by the geographic and temporal limitations of species and community occurrence records. Despite the generous help and data provided by many academics and state and federal agencies, our knowledge of the locations and *viability* of target taxa in the ecoregion is still very limited. Ideally, conservation planning takes place under an umbrella of regular, systematic survey efforts that routinely monitor the viability of target species and populations throughout the ecoregion. Until this ideal can be met, our conservation plans will fall somewhat short of their potential.

Our conservation planning efforts for NTPE rivers and streams could be greatly improved by higher quality digital hydrologic data. In preparing for this assessment, members of our team invested great effort in correcting and repairing digital stream networks, particularly in the Red River Basin. However, this effort is far from complete. In regions such as the NTPE where the natural flow network is commonly intersected by drainage ditches and canals, much remains to be understood about where and how water is flowing. This information is essential to building sound conservation plans for systems impacted by altered flow regimes.

Another area for which we see room for improvement in this plan is that of the threats assessment. The current threats assessment is a cursory effort, and could be improved by further querying experts regarding the stresses (e.g., sedimentation) and sources of stress (e.g., lack of riparian buffer zones) to aquatic systems. Better understanding threats "pathways" and developing a clearer understanding of the relative magnitude of these threats is essential to developing conservation strategies for the ecoregion and providing appropriate conservation protection for these river and stream systems within it.

A shortfall common to most conservation planning efforts, including this one, is our limited understanding of and ability to quantify target occurrence viability, including factors such as size, condition and landscape context. More exact and quantifiable measures of target viability would greatly improve our ability to establish conservation goals and measure conservation success in all of our ecoregional conservation efforts.

Finally, despite an exceptional group of experts and participation of over 24 conservation partners, our conservation planning efforts could be made far more effective by even greater participation in and strategy development with stakeholders and partners in the ecoregion. In developing this plan, NTPE team members initiated numerous valuable relationships with conservation partners in the ecoregion. These relationships need to be further cultivated and more created in order to develop and implement efficient and effective conservation strategies in the ecoregion.

4.3. Acquiring Data Used In and Developed Through this Assessment

The datasets and report developed for the purpose of this assessment will be made publicly available online.

Full text of the NTPE report and associated appendices are available from Conserve Online (www.conserveonline.org). To access the report, select "Browse

Library" and navigate to the "general subjects" and then "ecoregional planning" sections.

GIS and tabular datasets developed through this project will also be available online. Contact the Minnesota chapter of The Nature Conservancy to obtain access to these datasets:

GIS Data Layers:

- Improved NHD layers with physical attributes
- River/Stream Classification Units: EDUs, AESs
- NTPE Ecoregion boundary

Conservation Databases:

- Conservation Planning Tool (A standardized Microsoft Access database with full ecoregional planning datasets, including information related to targets, target occurrences, AESs and portfolio sites.)

5.0. Literature Cited

Aadland, L.P., T. M. Koel, W. G. Franzin, K.W. Stewart, and P. Nelson. In press. Changes in fish assemblage structure of the Red River of the North, in "Historical Changes in Fish Assemblages of Large American Rivers." American Fisheries Society, Bethesda, MD.

Abell, R.A., D.M. Olson, E. Dinerstein, P.T. Hurley, J.R. Diggs, W. Eichbaum, S. Walters, W. Wettengel, T. Allnutt, C.J. Loucks, and P. Hedao. 2000. Freshwater ecoregions of North America: a conservation assessment. World Wildlife Fund – US, Island Press, Washington, D.C.

American Society of Civil Engineers. 2001. A Guide for Best Management Practice Selection in Urban Developed Areas. 51 p.

Bailey, R.G. 1995. Description of the Ecoregions of the United States. U.S. Forest Service Miscellaneous Publication 1391 (Revised), With Separate Map At A Scale of 1:7,500,000, Washington, D.C.

Bailey, R.G., P.E. Avers, T.King, and W.H. McNab, *eds.* 1994. Ecoregions and Subregions of the United States (map). Washington, DC, U.S. Geological Survey. Scale 1:750,000; colored. Accompanied by a supplementary table of map unit descriptions compiled and edited by W.H. McNab and R.G. Bailey. Prepared for the U.S. Department of Agriculture, Forest Service.

Benke, A.C. 1990. A perspective on America's vanishing streams. J. North American Benthological Society 9:77-88.

Bennett, M.R., and N.F. Glasser. 1997. Glacial Geology : Ice Sheets and Landforms. John Wiley and Sons, Inc. 376 p.

Berry, C.R., W. Duffy, R. Walsh, S. Kubeny, D. Schumacher, and G. VanEeckhout. 1993. The James River of the Dakotas. Pp. 70-86 in L. Hesse, C. Stainaker, N. Benson and J. Zuboy, *eds*. Restoration planning for the rivers of the Mississippi River ecosystem. National Biological Survey, Biological Report 19. Washington, D.C.

Bornette G., C. Amoros, and N. Lamouroux. 1998. Aquatic plant diversity in riverine wetlands: the role of connectivity. Freshwater Biology 39:267-283.

Brunskill, G.J., P. Wilkinson, and S.E.M. Elliott. 1983. Recent sedimentation and mercury accumulation in the south basin of Lake Winnipeg, Manitoba, Canada. EOS, Transactions, American Geophysical Union. 64(52): 1096.

Chapman, K., K. Hiller, and J. Haferman. 1998. Identification of important bird sites in the Northern Tallgrass Prairie ecoregion: a step in ecoregion-based conservation. The Nature Conservancy, Minnesota Chapter. Minneapolis, MN.

Coker, R.E., J.B. Southall. 1915. Mussel resources in tributaries of the upper Missouri River. US Bureau of Fisheries Document No. 812. (Available from the SD State Historical Society, Pierre, SD).

Cross, F.B., R.L. Mayden, J.D. Stewart. 1986. Fishes in the western Mississippi Basin (Missouri, Arkansas and Red Rivers). In Hocutt, C.H. and E.O. Wiley (editors). The zoogeography of North American freshwater fishes. John Wiley and Sons, New York, USA. 866 pp.

Dieterman, D., and C.R. Berry. 1998. Fish community and water quality changes in the Big Sioux river. The Prairie Naturalist 30(4):199-223.

Dodds, W.K., K. Gido, M.R. Whiles, K.M. Fritz, and W.J. Matthews. 2004. Life on the edge: the ecology of Great Plains streams. BioScience 54(3): p. 205-216.

Dyke, A.S., and V.K. Prest. 1987. Paleogeography of northern North America, 18,000 – 5,000 years ago. Geological Survey of Canada Map 1703A, scale 1:12,500,000, Sheets 1-3.

Environment Canada. 1971-2000 averages (http://www.climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html)

Fitzgerald, J., D.N. Pashley, S.J. Lewis, and B. Pardo. 1998. Partners in Flight: Bird Conservation Plan for the Northern Tallgrass Prairie (Physiographic Area 40). American Bird, P.O. Box 249, The Plains, VA 20198. 49 pp.

Goldstein, R.M. 1995. Aquatic communities and contaminants in fish from streams of the Red River of the North basin, Minnesota and North Dakota. U.S. Geological Survey Water-Resources Investigations Report 95-4047, 34 p.

Groves, C.R. 2003. Drafting a conservation blueprint: a practitioner's guide to regional planning for biodiversity. Contributors M.W. Beck, J.V. Higgins, and E.C. Saxon. Island Press, Washington, D.C.

Hatch, J.T., K.P. Schmidt, D.P. Siems, J.C. Underhill, R.A. Bellig, and R.A. Baker. 2003. A new distributional checklist of Minnesota fishes, with comments on historical occurrence. Journal o the Minnesota Academy of Science 67:1-17.

Haygarth, P.M., and S.C. Jarvis. 2001. Agriculture, Hydrology and Water Quality. CABI Publishing, 416 p.

Henderson, P.J., and W.M. Last.1998. Holocene sedimentation in Lake Winnipeg, Manitoba, Canada: implications of compositional and textural variations. Journal of Paleolimnology 19(3):265-284.

Higgins, J.V., M.T. Bryer, M.L. Khoury, T.W. FitzHugh. In press. A Freshwater Classification Approach for Biodiversity Conservation Planning. Conservation Biology.

High Plains Regional Climate Center. 1961-1990 normal precipitation and temperature (http://hprcc.unl.edu/normals/raw_norm_txt.html)

Hocutt, C.H., and E.O. Wiley, editors. 1986. The zoogeography of North American freshwater fishes. John Wiley and Sons, New York.

Jenson, W.F., R.L. Kreil, S.R. Dyke, J.D. Schumacher, and M.G. McKenna. 2001. Distribution, relative abundance, and species diversity of freshwater mussels in the Sheyenne and Red Rivers of eastern North Dakota. ND Game and Fish Department Report Number 42.

Karr, J. R., L. A. Toth and D. R. Dudley. 1985. Fish communities of midwestern rivers: a history of degradation. BioScience 35: 90-95.

Koel, T.M., and J.J. Peterka. 2003. Stream fish communities and environmental correlates in the Red River of the North, Minnesota and North Dakota. Environmental Biology of Fishes 67:137-155.

Lawrence, S.J., and S.K. Sando. 1991. Quality of water from surficial-outwash aquifers in the Big Sioux River basin, eastern South Dakota. U.S. Geological Survey Water-Resources Investigations Report 89-4170, 81 p.

Manitoba Conservation. Unpublished Material. Watershed and Drain Indexing Maps. Manitoba Conservation, Land Information Division, Remote Sensing Centre, Digital Mapping Applications. http:// www.gov.mb.ca/natres

Maxwell, J.R., C.J. Edwards, M.E. Jensen, S.J. Paustain, H. Parrot, and D.M. Hill. 1995. A hierarchical framework of aquatic ecological units in North America (Nearctic Zone). General Technical Report NC-176. United States Department of Agriculture Forest Service, North Central Forest Experimental Station, St. Paul, Minnesota.

McCune, B., and M.J. Mefford. 1995. PC-ORD. Multivariate analysis of ecological data. Version 2.0. MjM Software Design, Gleneden Beach, Oregon.

McNab, W.H., and P.E. Avers, compilers. 1994. Ecological subregions of the United States: section descriptions. United States Department of Agriculture, Forest Service, Washington, D.C.

Midwestern Regional Climate Center. 1971-2000 NCDC averages (http://mcc.sws.uiuc.edu/html/MWclimate_data_summaries.htm#)

Milewski, C.L., C.R. Berry, D. Dieterman. 2001. Use of the index of biological integrity in eastern South Dakota rivers. The Prairie Naturalist 33(3):135-151.

Nalley, G.M., J.G. Gorman, R.D. Goodrich, and V.E. Miller. 2003. Water Resources Data Iowa --- Water Year 2003, Volume 1. Surface Water and Precipitation. U.S. Geological Survey Water-Data Report IA-03-1.

NASA. 2002. Shuttle Radar Topography Mission (SRTM) Elevation Dataset. US Geological Survey. Sioux Falls, SD.

National Audubon Society. 2000. The changing face of the UMR Basin. Agriculture: Selected profiles of farming and farm practices. National Audubon Society, Upper Mississippi River Campaign, St. Paul, Minnesota. 126pp.

Omernik, J.M., and A.L. Gallant. 1988. Ecoregions of the upper Midwest states. U.S. Environmental Protection Agency. EPA/600/3-88/037, Corvallis, Oregon. 56 p.

Perkins, K., and D.C. Backlund. 2000. Freshwater mussels of the Missouri National Recreation River below Gavins Point Dam, South Dakota and Nebraska. SD Game Fish and Parks Report 2000-1.

Porter, S.D., M.A. Harris, and S.J. Kalkhoff. 2001. Influence of natural factors on the quality of Midwestern streams and rivers. U.S. Geological Survey Water Resources Investigations Report 00-4288.

Robinson, S.M., R.F. Lundgren, B.A. Sether, S.W. Norbeck, and J.M. Lambrecht. 2003. Water Resources Data --- North Dakota Water Year 2003, Volume 1. Surface Water U.S. Geological Survey Water-Data Report ND-03-1.

Ross, G. 1997. Do ditches cause floods? Red Lake News 1(7). (Newsletter of the Red lake Watershed District, Thief River Falls, MN).

Samson, F.B., and F.L. Knopf. 1994. Prairie conservation in North America. BioScience 44:418-421.

Stark, J.R., P.E. Hanson, R.M. Goldstein, J.D. Fallon, K.E. Fong, A.L. Lee, S.E. Kroening, and W.J. Andrews. 2000. Water quality in the upper Mississippi River basin, Minnesota, Wisconsin, South Dakota, Iowa, and North Dakota, 1995–98: U.S. Geological Survey Circular 1211, 35 p.

Stoner, J.D., D.L. Lorenz, G.J. Wiche, and R.M. Goldstein. 1993. Red River of the North Basin, Minnesota, North Dakota, and South Dakota. Water Resources Bulletin 29(4): 575-615.

Strobel, M.L., and P.J. Gerla. 1992. Effects of saline ground-water discharge on water quality in the Red River of the North, northeastern North Dakota: Preliminary observations of the hydrologic setting: North Dakota Water Quality Symposium Proceedings, 1992, Bismarck, ND, p. 60-82.

Teller, J.T., and L. Clayton. 1983. Glacial Lake Agassiz. Geological Association of Canada Special Paper 26, Department of Geology, Memorial University of Newfoundland, St. John's, Nlfd., Canada. 451 p.

TNC. 1996. Conservation by design: A framework for mission success. The Nature Conservancy, Arlington VA.

TNC. 1998. Ecoregional planning in the Northern Tallgrass Prairie ecoregion. The Nature Conservancy, Midwest Regional Office, Minneapolis, MN, 208 p.

TNC. 2000. Designing a Geography of Hope: A Practitioner's Handbook to Ecoregional Conservation Planning. The Nature Conservancy, Arlington, Virginia.

TNC. 2004. The Nature Conservancy in Minnesota and the Dakotas: Preserves, Active Landscapes, Ecoregions and Offices (Map). The Nature Conservancy of Minnesota. Minneapolis, MN.

TNC-FWI. 2000. Tools for GIS Analysis. Available from www.freshwaters.org and http://www.freshwaters.org/info/large/documents.shtml#gis

TNC Prairie Forest Border Ecoregional Planning Team. 2000. The Prairie-Forest Border Ecoregion: a conservation plan. The Nature Conservancy, Madison, WI.

Tornes, L.H., and M.E. Bringham. 1994. Nutrients, suspended sediment, and pesticides in waters of the Red River of the North basin, Minnesota, North Dakota and South Dakota, 1970-1990. US Geological Survey Water-Resources Investigations Report, 93-4231, 62 p.

Tornes, L.H., and M.E. Brigham. 1995. Pesticide amounts are small in streams in the Red River of the North basin, 1993-94. U.S. Geological Survey Open-File Report 95-283, 2 p.

Toy, T.J., G.R. Foster, and K.G. Renard. 2002. Soil Erosion : Processes, Prediction, Measurement, and Control. John Wiley and Sons, 352 p.

USACE. 1999. National Inventory of Dams, Water Control Infrastructure. U.S. Army Corps of Engineers in cooperation with FEMA's National Dam Safety Program. http://crunch.tec.army.mil/mid/webpages/nid.cfm.

USEPA. 2001. BASINS, v. 3.0. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC. http://www.epa.gov/OST/BASINS/

USGS. 1992. National Land Cover Data 1992. National Land Cover Characterization Project. Http://landcover.usgs.gov/nationallandcover.html.

USGS. 1999. National Hydrography Dataset (NHD) – Medium resolution. US Geological Survey. Reston, VA.

Uri, N.D. 1999. Protecting soil and water quality: The impact of conservation practices. International Journal of Environmental Studies A and B 57:33-51.

Ward, J.V., and K. Tockner. 2001. Biodiversity: towards a unifying theme for river ecology. Freshwater Biology 46:807-819.

Weitzell, R.E., M.L. Khoury, P. Gagnon, B. Schreurs, D. Grossman, and J. Higgins. 2003. Conservation Priorities for Freshwater Biodiversity in the Upper Mississippi River Basin. NatureServe and The Nature Conservancy. 90 pp.

Whiles, M.R., B.L. Brock, A.C. Franzen, S.C. Dinsmore. 2000. Stream invertebrate communities, water quality, and land-use patterns in an agricultural drainage basin of northeastern Nebraska, USA. Environmental Management, 26:563-576.

Appendix 1. River/Stream Classification for the NTPE

A1.1. Aquatic Classification Framework

One of the goals of the ecoregional planning process is to develop a strategy to protect ecosystems and habitats on a systematic basis. In many ecoregions, it is difficult to achieve this objective due to the lack of a consistent classification of aquatic ecological systems, which allows us to identify, distinguish and map the types of freshwater habitats and ecological settings within an ecoregion. Prior to beginning work on the NTPE conservation portfolio, a river/stream classification was only available for the UMRB portion of the ecoregion (Weitzell et al. 2003). No aquatic classification was available for the systems in the Missouri and Red River portions the ecoregion, although much had been done to understand the biodiversity and ecology of these watersheds. Our objective was to apply TNC's aquatic classification framework to the Missouri and Red River systems, identify the river/stream ecological system types that occur in this part of the ecoregion and include them as coarse-filter targets in our conservation plan.

The first step in the Nature Conservancy's river/stream classification approach is to successively divide the surficial hydrologic landscape into Aquatic Subregions, Ecological Drainage Units (EDUs), Aquatic Ecological Systems (AESs; also called systems) and Macrohabitats. Once the boundaries of these areas have been drawn, the macrohabitats and AESs are grouped into macrohabitat types and AES types, respectively, based on similarities in the physical habitat parameters that make up the individual AESs and macrohabitats. These habitat parameters include physical features of aquatic systems that are known to influence the composition and abundance of biota in the region.

A1.1.1. Aquatic Subregions

At the largest geographic scale are the Aquatic Subregions. These are large drainage regions that generally correspond to the Aquatic Zoogeography of North America, as defined by the United States Forest Service (Maxwell et al. 1995) and the Aquatic Subregions of North America as defined by the World Wildlife Fund (Abell et al., 2000). Boundaries of these units are based on fish zoogeography, physiography, climate and drainage pattern history. The NTPE crosses three subregions: the Missouri Subregion, the Arctic Subregion, and the Southern Plains Subregion (Figure A1.1).

A1.1.2. Ecological Drainage Units (EDUs)

Ecological Drainage Units are aggregates of hydrologic units (usually 8-digit United States Geological Survey Hydrological Units - HUCs) that share finer-scale physiographic and zoogeographic properties. We defined 11 EDUs for the NTPE ecoregion (Figure A1.2, Table A1.1), using physiographic and zoogeographic data provided in Bailey (1995) and Hocott and Wiley (1986).

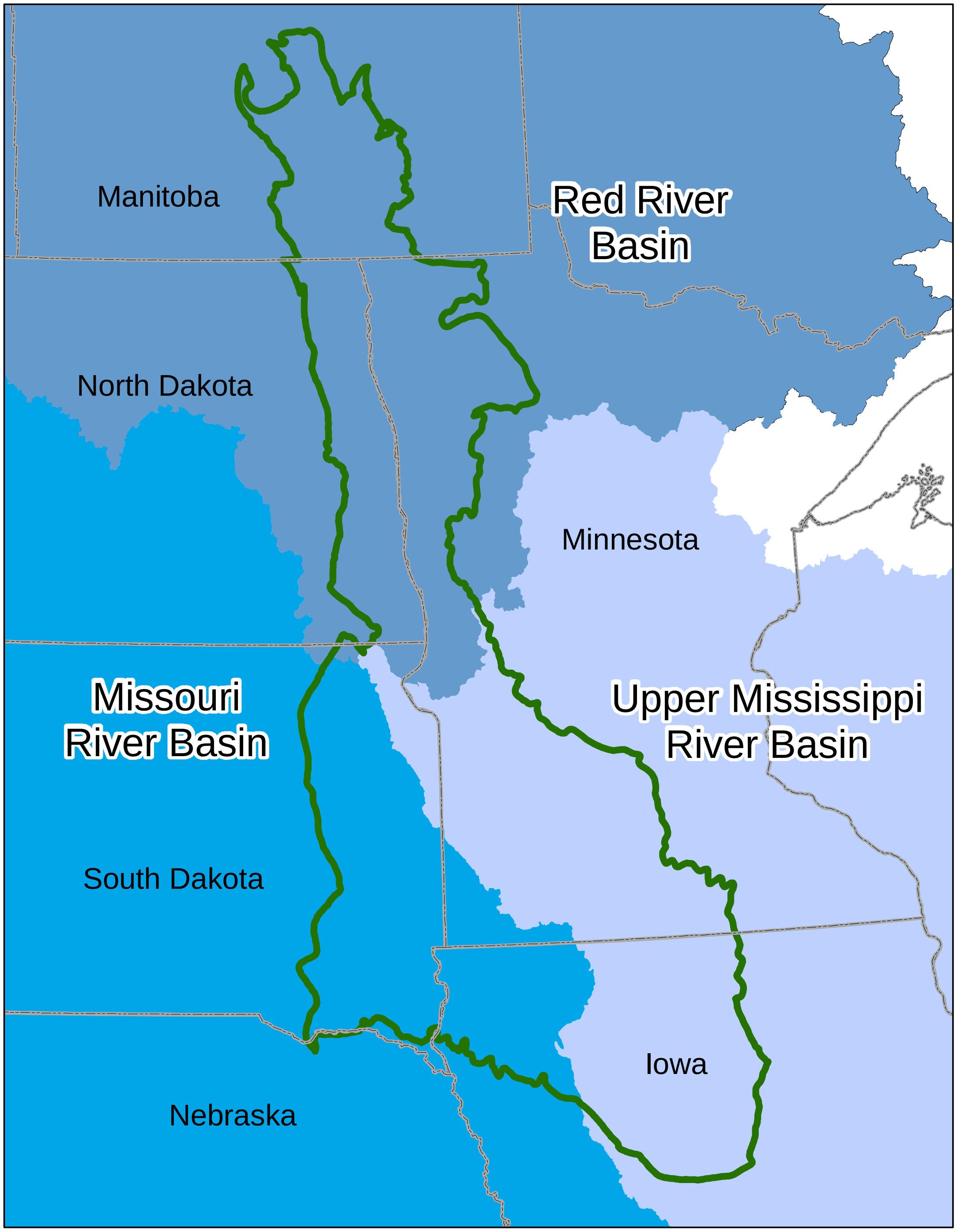


Figure A1.1. Aquatic Subregions of the Northern Tallgrass Prairie Ecoregion. The Upper Mississsippi River River basin is the Southern Plains subregion,tThe Missouri River basin is the Missouri subregion, and the Red River basin is the Arctic subregion.

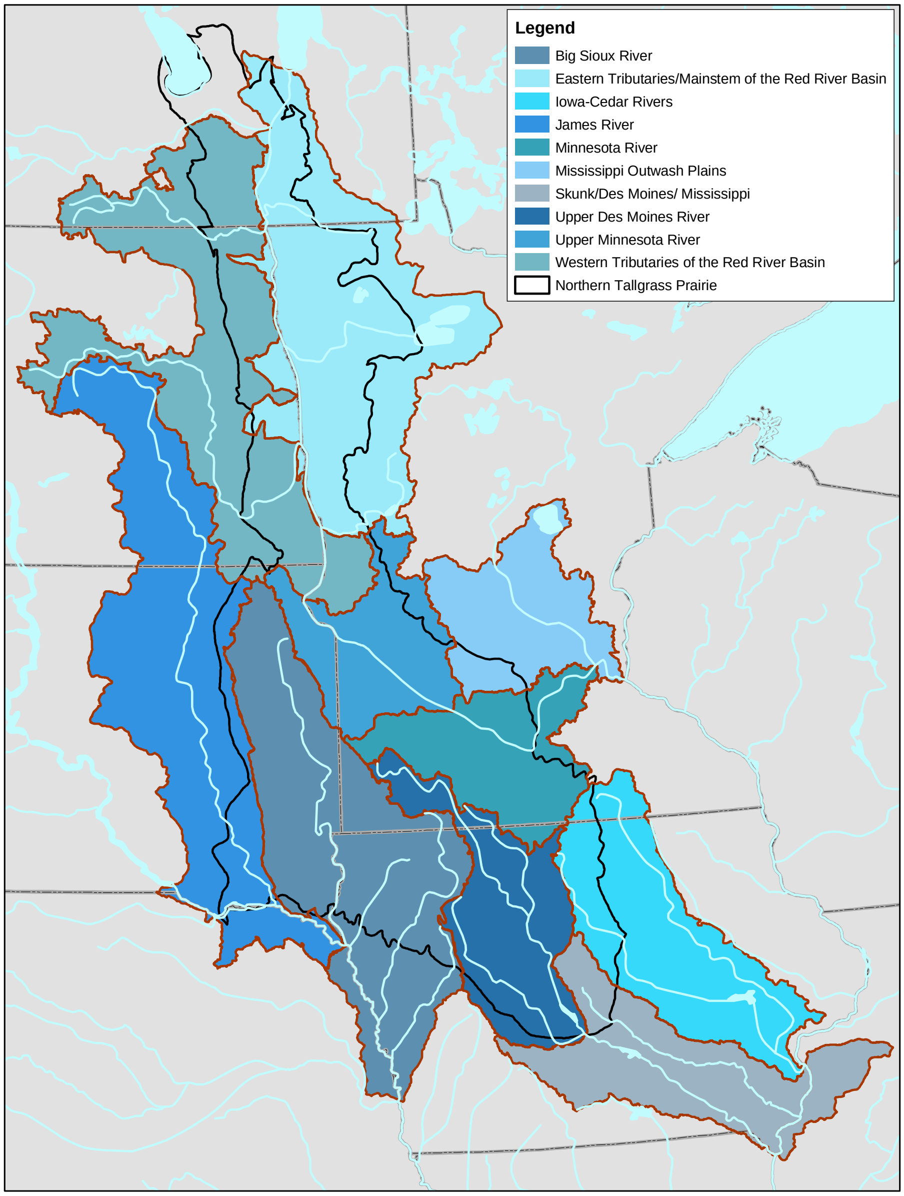


Figure A1.2. Ecological Drainage Units of the NTPE.

A1.1.3. Aquatic Ecological Systems (AESs)

Aquatic ecological systems are the surface hydrologic units (e.g., lake basins, stream basins or large river segments) nested within EDUs. AES boundaries are mapped using protocols and GIS tools developed by the Nature Conservancy's Freshwater Initiative (Higgins et al. In press; TNC-FWI 2000). Using the National Hydrologic Dataset (NHD; USGS 1999), Manitoba Watershed and Drain Indexing Maps (MWDI; Manitoba Conservation Unpublished Material)[1] and SRTM (NASA

[1] The Manitoba Watershed and Drain Indexing Maps were digitally altered to correct discontinuities in the drainage network. In general, the flow network was reduced those flow paths that were

2002), we drew boundaries around the drainage areas for five size classes of streams and rivers: headwaters (size 1), creeks (size 2), and small (size 3), medium (size 4), and large rivers (size 5). The minimum and maximum drainage areas encompassed by each of these size classes differed slightly depending on the aquatic subregion to which the streams and rivers belonged (Table A1.2). For our conservation planning purposes, we use maps of the full drainage areas for size 1 through 3 systems as our conservation planning units (Figures A1.3 – A1.5). For size 4 and 5 systems, the conservation planning units encompass the river reach and the area 3 km and 5 km, respectively, on either side of the river reach. Each large river system (size 5) is divided into segments representing functional and/or geomorphic breaks in the river continuum (Figure A1.6)

A1.1.4. Macrohabitats

A macrohabitat is an individual arc segment the NHD and the Manitoba Watershed and Drain Index. The boundaries of each arc segment are usually marked by the confluence of two or more stream/river segments.

A1.1.5. AES and Macrohabitat Classification

Once the AES and macrohabitat boundaries were established, they were grouped into AES and macrohabitat types according to similarities in persistent, natural attributes that could be mapped at a fairly coarse resolution. Attributes included surface geology, drainage network position, slope, proximity to lakes, and climatic region. Each attribute consisted of several classes that distinguished potentially biologically meaningful thresholds in the environmental gradients of each attribute (Table A1.2).

Each macrohabitat arc segment was assigned a combination of macrohabitat attribute classes by overlaying digital environmental spatial data on the NHD in a geographic information system. Groups of macrohabitats that shared a similar series of attribute conditions were considered a macrohabitat type.

After all macrohabitats were attributed with the appropriate macrohabitat attribute class, we calculated the total extent of each attribute class in all of the macrohabitats that comprised each AES. We then used hierarchical agglomerative cluster analysis in PCOrd (McCune 1995) to group AESs into AES types based on the relative proportions of macrohabitat attributes found in each system. Therefore, an AES type (also called “system type”) or macrohabitat type is thought to represent a unique ecological setting, with a distinctive combination of macrohabitat attributes and corresponding geophysical processes, disturbance regimes, biological species composition, and potential natural state. Every system type identified for the NTPE is described in Table A1.3.

---

described as natural streams. Where the flow was interrupted between natural streams, we developed an automated process to connect flow networks using intervening canal/ditch reaches.

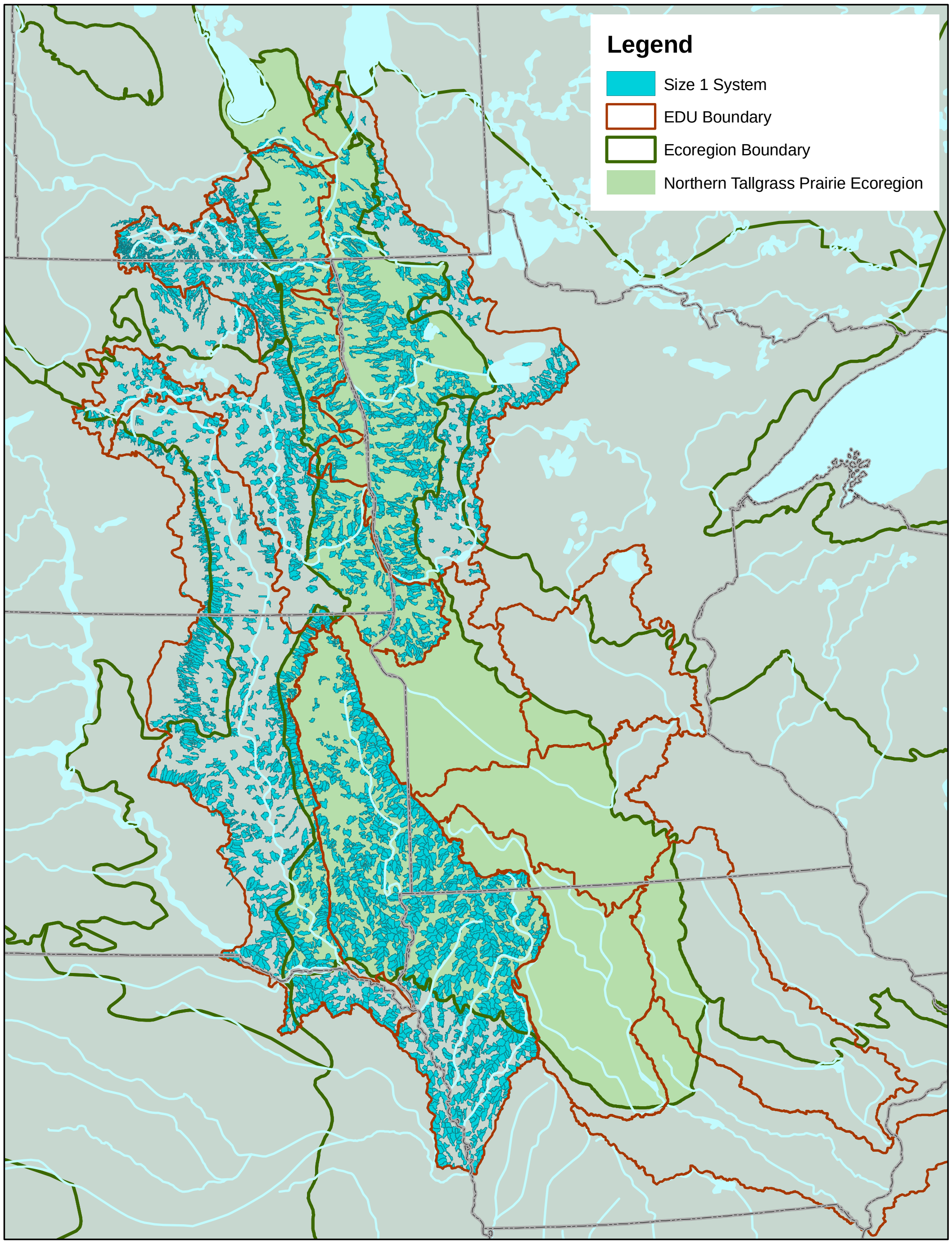


Figure A1.3. Map of headwater (size 1) AESs in the Missouri and Red River basin EDUs of the NTPE.

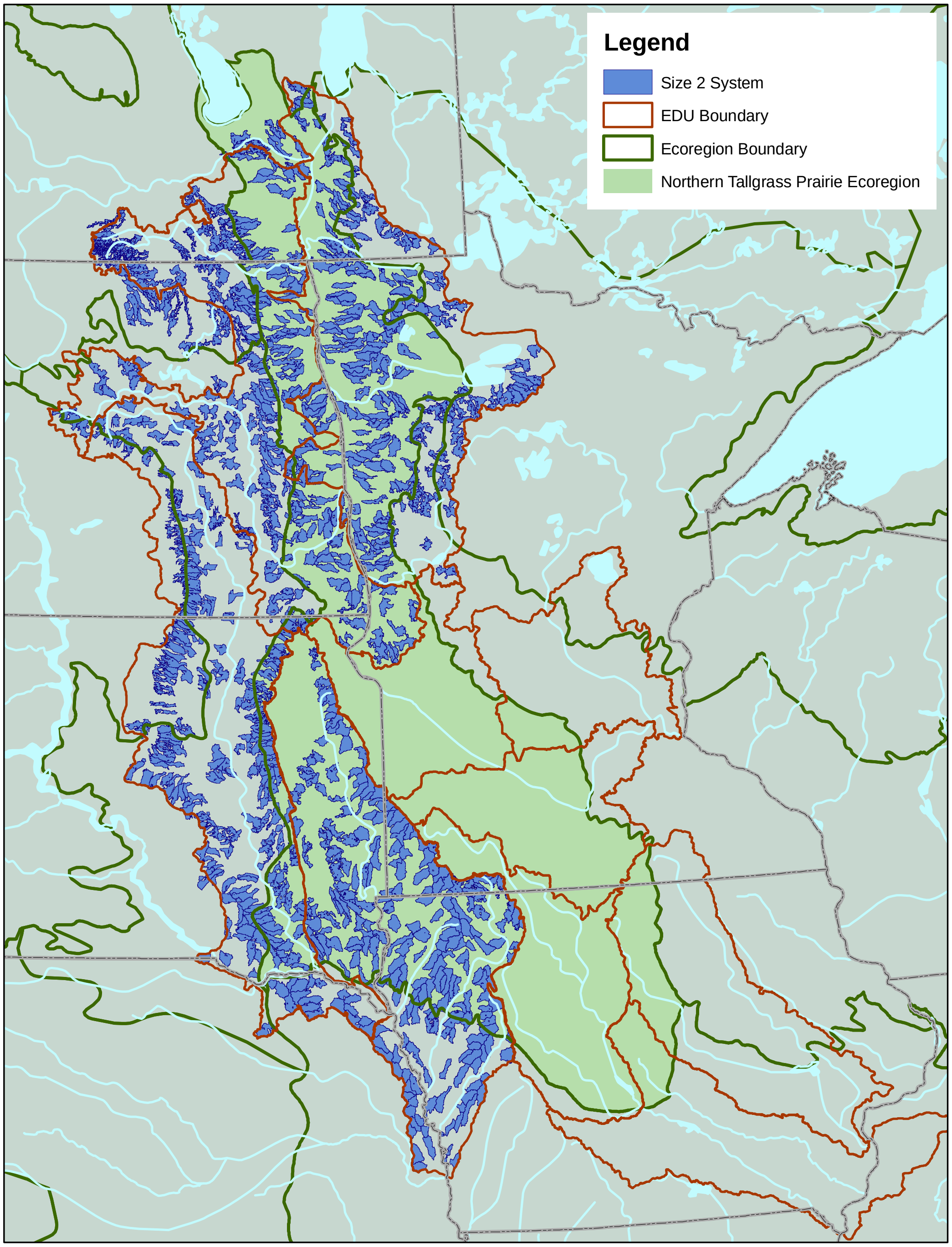


Figure A1.4. Map of creek (size 2) AESs in the Missouri and Red River basin EDUs of the NTPE.

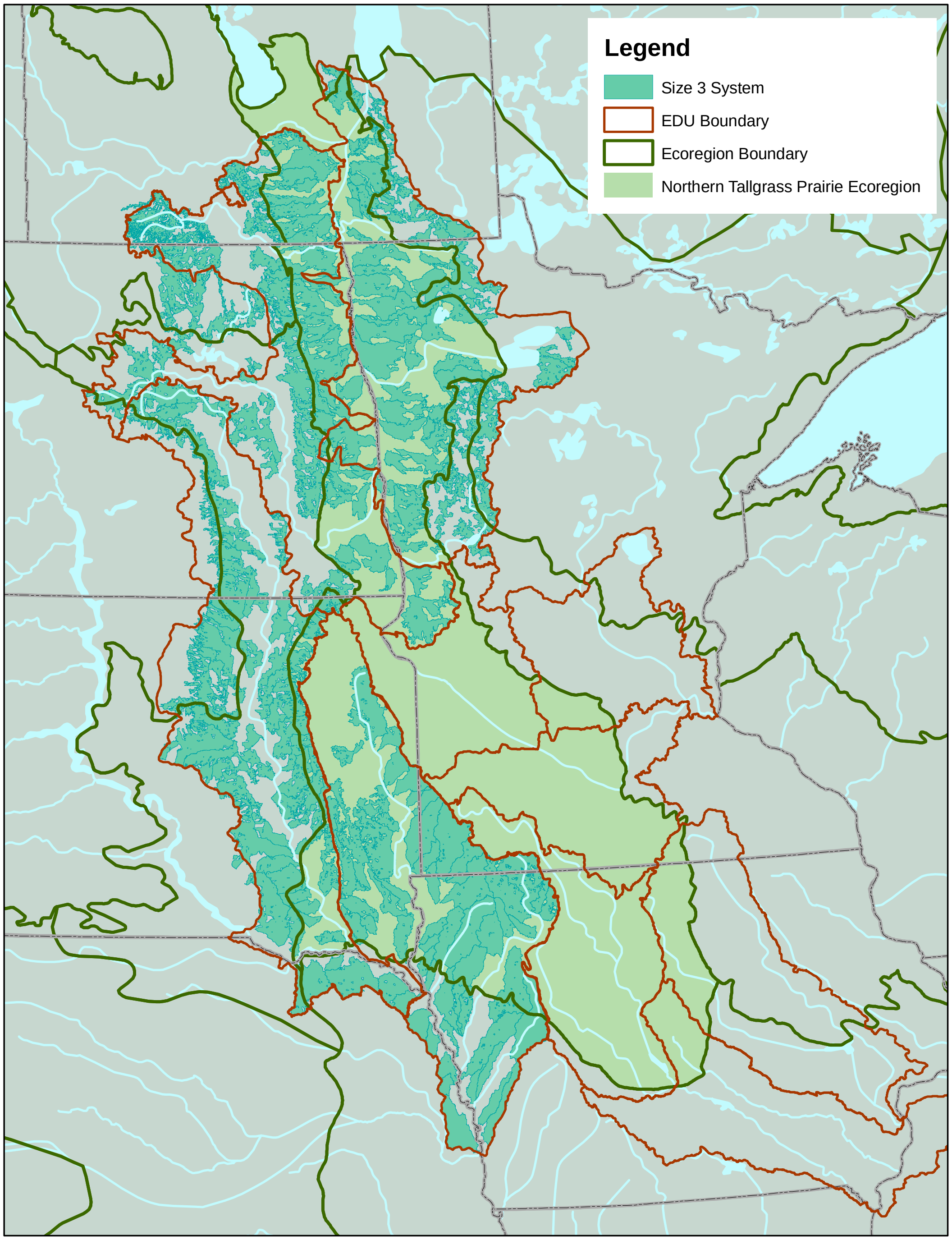


Figure A1.5. Map of small river (size 3) AESs in the Missouri and Red River basin EDUs of the NTPE.

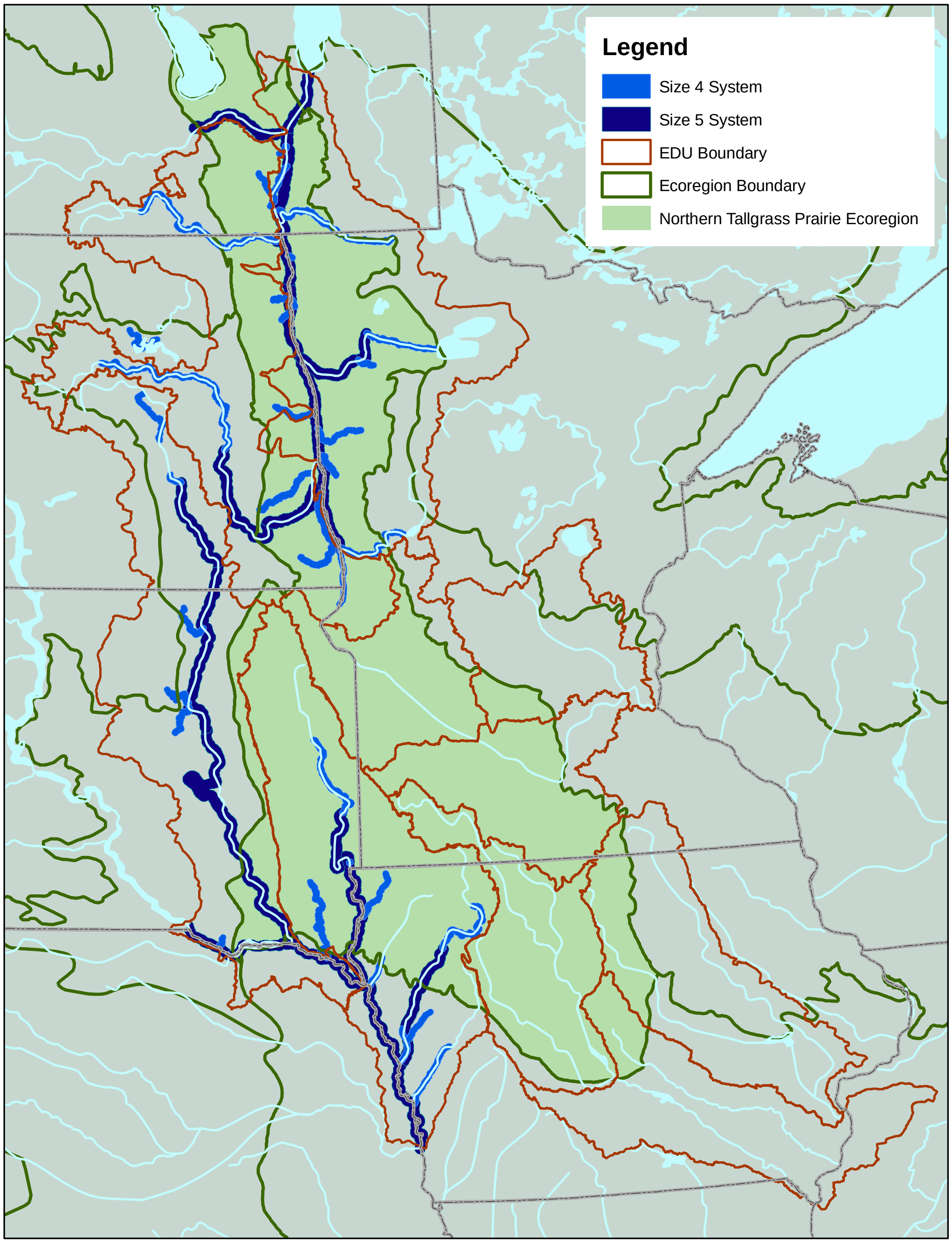


Figure A1.6. Map of medium and large river (sizes 4 and 5) AESs in the Missouri and Red River basin EDUs of the NTPE.

Table A1.1. Ecological Drainage Units (EDUs) of the NTPE.

EDU	**Terrestrial Ecoregions** (EPA Level III)	**Geomorp-hology** (Bailey et al. 1994)	**Geology** (Bailey et al. 1994)	**Climate** (Bailey et al. 1994)	**Zoogeo-graphy** (Hocutt and Wiley 1986; and Maxwell et al. 1995)	**General Description**
Upper Minnesota River	Northern Glaciated Plains, Western Corn Belt Plains, North Central Hardwood Forests	Level to rolling till plain dissected by morainal ridges	Till, stratified drift and lacustrine sand and clay covering shale, limestone and sandstone	Annual precipitation averages 20-33". Mean annual temperature is 40-48° F.	Upper Mississippi Subregion	Level to gently rolling plains formed on glacial till. Bluestem prairie historically covered the uplands, with a narrow corridor of northern floodplain forests along the Minnesota River. Drainages include the upper Minnesota River and its tributaries.
Minnesota River	Northern Glaciated Plains, Western Corn Belt Plains, North Central Hardwood Forests	Level to rolling till plain	Till, stratified drift and lacustrine sand and clay covering shale, limestone, sandstone and some crystalline bedrock	Annual precipitation averages 20-33". Mean annual temperature is 40-48° F.	Upper Mississippi Subregion	Level to gently rolling plains formed on glacial till. Bluestem prairie historically covered the uplands, with a narrow corridor of northern floodplain forests along the Minnesota River. Drainages include the Minnesota River and its tributaries.
Mississippi Outwash Plains	Western Corn Belt Plains, North Central Hardwood Forests, Northern Lakes and Forests	Level plains and low irregular hills	Approximately 30-500 ft of glacial drift, till, and outwash sands and gravels cover granite, greenstone and metasediments.	Precipitation averages 25-33". Mean annual temperature is 39-48° F.	Upper Mississippi Subregion	Ecotone between western plains and the forested woodlands of the upper Midwest. The Mississippi headwaters and its tributaries form the primary drainage.

EDU	**Terrestrial Ecoregions** (EPA Level III)	**Geomorphology** (Bailey et al. 1994)	**Geology** (Bailey et al. 1994)	**Climate** (Bailey et al. 1994)	**Zoogeography** (Hocutt and Wiley 1986; and Maxwell et al. 1995)	**General Description**
Iowa – Cedar Rivers	Western Corn Belt Plains	Level plains and low irregular hills	Approximately 30-500 ft of glacial drift, till, and outwash sands and gravels cover intermittently exposed sandstone, shale, and dolomite.	Precipitation averages 25-33”. Mean annual temperature is 39-48° F.	Upper Mississippi Subregion	Ecotone between western plains and the forested woodlands of the upper Midwest. The Iowa and Cedar Rivers and their tributaries form the primary drainages.
Skunk/Des Moines/Mississippi	Western Corn Belt Plains, Central Irregular Plains, Central Corn Belt Plains, Interior River Valleys and Hills	Moderately dissected, glaciated, flat to rolling plains sloping gently to the Mississippi and Missouri River valleys	Up to 25 ft of loess mantles most of the uplands; till and drift up to 300 ft thick underlie the loess, and shale, limestone and carbonate form the bedrock	Precipitation averages 30-40”. Mean annual temperature is 50-56° F.	Upper Mississippi Subregion	A mosaic of bluestem prairie and oak-hickory forest covered most of the historic landscape of this EDU. Drainages include the Skunk, Des Moines and Mississippi Rivers.
Upper Des Moines River	Western Corn Belt Plains	Level to rolling till plain	Till, stratified drift and lacustrine sand and clay covering shale, limestone and sandstone	Annual precipitation averages 20-33”. Mean annual temperature is 40-48° F.	Upper Mississippi Subregion	Level to gently rolling plains formed on glacial till. Bluestem prairie historically covered the uplands, with a narrow corridor of northern floodplain forests along the Minnesota River. Drainages include the Upper Des Moines River and its tributaries.

EDU	**Terrestrial Ecoregions** (EPA Level III)	**Geomorphology** (Bailey et al. 1994)	**Geology** (Bailey et al. 1994)	**Climate** (Bailey et al. 1994)	**Zoogeography** (Hocutt and Wiley 1986; and Maxwell et al. 1995)	**General Description**
Big Sioux River	Northern Glaciated Plains and Western Corn Belt Plains	Level to rolling till plain	Mostly till, stratified drift and lacustrine sand and clay covering Cretaceous shale, limestone and sandstone, including a few small outcrops of Proterozoic quartzite.	Annual precipitation averages 20-33". Mean annual temperature is 40-48° F.	Missouri; Missouri Subregion	Level to gently rolling plains formed on glacial till. Bluestem prairie historically covered the uplands, with a narrow corridor of northern floodplain forests along the Minnesota River. Drainages include the Big Sioux River and its tributaries.
James River	Western Glaciated Plains, Northeastern Glaciated Plains, North-Central Glaciated Plains	Level to rolling till plain	Glacial till underlain by Cretaceous shale. Areas of ablation potholes, moraines and glacial lake plains.	Cold continental climate with hot, humid summers. Annual precipitation averages 14-24". Mean annual temperature is 39-43° F.	Missouri; Missouri Subregion	Flat to rolling landscape formed on glacial till, lateral and end moraines. Drainages include the James River Basin and a portion of the mainstem Missouri River (from the Fort Randall Dam to Sioux City, IA). Uplands consist of mixed-grass prairie with semi-permanent and seasonal pothole wetlands.

EDU	**Terrestrial Ecoregions** (EPA Level III)	**Geomorphology** (Bailey et al. 1994)	**Geology** (Bailey et al. 1994)	**Climate** (Bailey et al. 1994)	**Zoogeography** (Hocutt and Wiley 1986; and Maxwell et al. 1995)	**General Description**
Lower Assiniboine*	Eastern Prairies, Northern Glaciated Plains	Level to undulating till cut by glacial channels. Includes portions of glacial Lake Agassiz deposits and more recent lake sediments.	Glacial till and lacustrine deposits overlie Early Paleozoic carbonates and shale	Cold continental climate with warm summers. Precipitation averages 15-20”. Temperature averages 35-40° F. Evapotranspiration and precipitation approximately balanced.	Red River/ Hudson; Saskatchewan Subregion	Flat to gently rolling landscape developed on glacial till and lake plains sediments. Drainage includes a few small tributaries to the main stem Assiniboine River, and extends northward to Lake Manitoba.
Eastern Red River Basin	Lake Agassiz Plain, Northern Lakes and forests, North Central Hardwood Forests, Northern Minnesota Wetlands	Level to gently rolling plains bisected by the Red River Valley. Includes the eastern part of the Lake Agassiz plain and beach deposits.	Level lacustrine plains in the west, beach and morainal ridges grade into upland till and peat/muck in the east. Up to 400 feet of glacial sediments overlie Precambrian crystalline bedrock in most areas.	Precipitation averages 18-23”. Mean annual temperature is 36-45° F. Evapotranspiration and precipitation approximately balanced.	Red River/ Hudson; Saskatchewan Subregion	This EDU spans a broad ecotone: the western half of the EDU intersects with the glacial Lake Agassiz plain, which was historically covered by tallgrass prairie. In the eastern half of the EDU, boreal forests, lakes and swamps occur in the north and hardwood forests occur in the south. Drainages include the eastern tributaries and mainstem of the Red River.

EDU	**Terrestrial Ecoregions** (EPA Level III)	**Geomorphology** (Bailey et al. 1994)	**Geology** (Bailey et al. 1994)	**Climate** (Bailey et al. 1994)	**Zoogeography** (Hocutt and Wiley 1986; and Maxwell et al. 1995)	**General Description**
Western Red River Basin	Lake Agassiz Plain, Northern Glaciated Plains	Level to undulating till cut by glacial channels. Includes the western part of the Lake Agassiz plain and beach deposits.	Glacial till and lacustrine deposits. Outwash and alluvium in the fans and major river valleys. Areas of ablation potholes, moraines and glacial lake plains overlie Cretaceous and Paleozoic sedimentary bedrock.	Cold continental climate with warm summers. Precipitation averages 15-20". Temperature averages 36-45° F. Evapotranspiration exceeds precipitation.	Red River/ Hudson; Saskatchewan Subregion	Flat to gently rolling landscape developed on glacial till and lake plains sediments. Drainage includes the western tributaries of the Red River. Historically, transitional tallgrass to mixed-grass prairie occurred in the uplands.

* Assiniboine EDU data from the Atlas of Canada (http://atlas.gc.ca/site/english/index.html

Table A1.2. Macrohabitat attributes for Ecological Drainage Units (EDUs) of the NTPE.

Attribute	Attribute Classes for Missouri River EDUs	Attribute Classes for Red River EDUs	Data Source(s)
Watershed Size/Shreve Link Magnitude	1- 10-50 km2 headwater 2- 50-150 creek 3- 150-1500 small river 4- 1500-5000 medium river 5- >5000 large river	1- 10-50 km2 headwater 2- 50-150 creek 3- 150-1500 small river 4- 1500-5000 medium river 5- >5000 large river	NHD/MWDI/SRTM* analysis using TNC Tools for Freshwater Classification (TNC-FWI 2000)
Flow Permanence	1- perennial 2- intermittent	1- perennial 2- intermittent	"fcode" field in NHD
Network Position/ Connectivity/ Size Discrepancy	0 – no size discrepancy (next downstream segment is not a larger size-class stream) 1 – size discrepancy (next downstream segment is a larger size-class stream)	1 – little to no size discrepancy(stream order of subject reach differs from order of downstream reach by 0 to 3) 2 – moderate to large size discrepancy (stream order of subject reach differs from order of downstream reach by 4 to 7)	Link/order number calculated from NHD/MWDI/SRTM* using TNC Tools for Freshwater Classification (TNC-FWI-2000)
Lake Connections	1- no lake connection 2- lake connection	1- no lake connection 2- lake connection	NHD/MWDI/SRTM* analysis with TNC Tools
Gradient	1 - low (<0.0005) 2 - moderate (0.0005-0.0010) 3 - high (>0.0010)	1- low (<0.0003) 2 - moderate (0.0003 - 0.0010) 3 - high (>0.0010)	NHD/MWDI/SRTM* analysis with TNC tools
Surface Geology	1- Coarse Quaternary Substrates (alluvium, outwash, eolian sand, till composed primarily of sand through boulder-sized substrates) 2- Fine Quaternary Substrates (silt, loam, loess/silt, till primarily of silt or loam, or till overlain by loess) 3- Lake Plains 4- Badlands 5- Hard Bedrock (granite) 6- Soft Bedrock (shale, limestone, siltstone) 7- Peat and muck	1- alluvium and lake shore deposits 2- silt and clay lake deposits 3- peat and muck 4- coarse outwash, ice contact and eolian deposits 5- till 6- water	State surficial geology maps

Attribute	Attribute Classes for Missouri River EDUs	Attribute Classes for Red River EDUs	Data Source(s)
Climate Zone/ Temperature	1- North 2- North-Central 3- South-Central 4- South	1- Northwest 2- Northeast 3- Southwest 4- Southeast	American Horticulture Society/USDA Hardiness zone map; State trout stream coverages

* NHD is the National Hydrologic Dataset (USGS 1999); MWDI is the Manitoba Watershed and Drain Indexing Maps; SRTM is the Shuttle Radar Topography Mission Elevation Dataset (NASA 2002).

Table A1.3. Aquatic Ecological System (AES types of the NTPE.

Red River / Assiniboine River Basins

AES Type Code	Size Class	AES Description	Examples	Total Number
AS 1 - 1	(1) Headwater	Headwater basins in till and alluvium and beach sediment, with silt/clay lake deposits, peat, and sandy outwash; generally intermittent flow; variable gradient; infrequently connected to lakes; northeast climate zone; infrequent large size discrepancy to downstream systems. Assiniboine EDU.		7
AS 2 - 38	(2) Creek	Creek basins in till, silt/clay lake deposits, and peat; generally perennial flow; moderate to low gradient; generally unconnected to lakes; northeast climate zone; infrequent large size discrepancy to downstream system; Assiniboine EDU.		7
AS 5 - 1	(5) Large River	Assiniboine River from Portage la Prairie to the Red River		1
RE 1 - 1	(1) Headwater	Headwater basins in till and alluvium and beach sediment, with silt/clay lake deposits, peat, and sandy outwash; generally intermittent flow; variable gradient; often connected to lakes; northeast climate zone; infrequent large size discrepancy to downstream systems. Red River East EDU.		312
RE 1 - 2	(1) Headwater	Headwater basins in till and sandy outwash, with alluvium and beach sediments; generally intermittent flow; variable gradient; often connected to lakes; northwest climate zone; infrequent large size discrepancy to downstream system; Red River East EDU		52

AES Type Code	Size Class	AES Description	Examples	Total Number
RE 1 - 31	(1) Headwater	Headwater basins in alluvium, beach sediments, and till, with silt/clay lake sediments; mostly intermittent flow; moderate gradient; unconnected to lakes; generally in south climate zones; consistent large size discrepancy to downstream system; Red River East EDU		23
RE 1 - 4	(1) Headwater	Headwater basins in silt/clay lake deposits, with alluvium, beach sediments, and sandy outwash; mostly intermittent flow; moderate gradient; occasionally connected to lakes; northwest climate zone; occasional large size discrepancy to downstream system; Red River East EDU		76
RE 1 - 49	(1) Headwater	Headwater basins in till, alluvium, and beach sediments, with sandy outwash; generally intermittent flow; variable gradient; often connected to lakes; southeast climate zone; no large size discrepancy to downstream system; Red River East EDU		107
RE 1 - 64	(1) Headwater	Headwater basins in till, alluvium, and beach sediments, with silt/clay lake sediment and sandy outwash; generally intermittent flow; variable gradient; occasionally connected to lakes; southwest climate zone; no large size discrepancy to downstream systems; Red River East EDU		47
RE 2 - 1	(2) Creek	Creek basins in mostly till and alluvial/beach deposits; generally intermittent flow; moderate gradient; generally unconnected to lakes; mostly in the southeast climate zone; no large size discrepancy to downstream system; Red River East EDU		40
RE 2 - 15	(2) Creek	Creek basins in till with sand and outwash, with some silt/clay lake deposits; mostly intermittent flow; moderate gradient; generally unconnected to lakes; southwest climate zone; no large size discrepancy to downstream system; Red River East EDU		15
RE 2 - 2	(2) Creek	Creek basins in mostly till and silt/clay lake deposits; mostly intermittent flow; moderate gradient; generally unconnected to lakes; northwest climate zone; infrequent large size discrepancy to downstream system; Red River East EDU		35
RE 2 - 22	(2) Creek	Creek basins in till and silt/clay lake deposits; mostly intermittent flow; moderate to low gradient; unconnected to lakes; northeast and south climate zones; consistent large size discrepancy to downstream system; Red River East EDU		7
RE 2 - 38	(2) Creek	Creek basins in till, silt/clay lake deposits, and peat; generally perennial flow; moderate to low gradient; generally unconnected to lakes; northeast climate zone; infrequent large size discrepancy to downstream system; Red River East EDU		96

AES Type Code	Size Class	AES Description	Examples	Total Number
RE 3 - 1	(3) Small River	Small river basins in mostly till and silt/clay lake deposits, with beach deposits; mostly intermittent flow; moderate gradient; generally unconnected to lakes; northeast and northwest climate zones; no large size discrepancy to downstream system; Red River East EDU		11
RE 3 - 25	(3) Small River	Small river basins in till and silt/clay lake deposits, with beach deposits; mostly intermittent flow; moderate gradient; generally unconnected to lakes; southwest climate zone; no large size discrepancy to downstream system; Red River East EDU		4
RE 3 - 32	(3) Small River	Small river basins in mostly till with outwash and alluvial deposits; generally intermittent flow; moderate to low gradient; occasionally connected to lakes; southeast climate zone; no large size discrepancy to downstream system; Red River East EDU		6
RE 3 - 6	(3) Small River	Small river basins in mostly till and silt/clay lake deposits, with beach and peat deposits; generally perennial flow; moderate to low gradient; occasionally connected to lakes; northeast climate zone; infrequent large size discrepancy to downstream systems; Red River East EDU		23
RE 4 - 1	(4) Medium River	Medium river basins in mostly till with some silt/clay lake and sand deposits; mostly intermittent flow; medium gradient; generally unconnected to lakes; northwest transitional to northeast climate zone; no large size discrepancy to downstream system; Red River East EDU		2
RE 4 - 2	(4) Medium River	Medium river basins in till with some silt/clay lake, peat, and sand deposits; mostly perennial flow; medium gradient; generally unconnected to lakes; northeast climate zone; no large size discrepancy to downstream system; Red River East EDU		4
RE 4 - 3	(4) Medium River	Medium river basins in mostly till with some sand deposits; generally intermittent flow; medium gradient; occasionally connected to lakes; southeast climate zone; no large size discrepancy to downstream system; Red River East EDU		4
RE 5 - 2	(5) Large River	Red River from the Drayton Dam to the confluence of the Roseau River		1
RE 5 - 3	(5) Large River	Red River from the confluence of the Red Lake River to Drayton Dam		1
RE 5 - 4	(5) Large River	Red River from the confluence of the Otter Tail and Bois de Sioux to the confluence with the Sheyenne		1

AES Type Code	Size Class	AES Description	Examples	Total Number
RE 5 - 5	(5) Large River	Red River from the confluence of the Sheyenne to the confluence of the Red Lake River		1
RE 5 - 6	(5) Large River	Red Lake River from the confluence of the Clearwater River to the confluence with the Red River		1
RE 5 - 7	(5) Large River	Red Lake River from the confluence of the Thief River to the confluence with the Clearwater River		1
RE 5 - 8	(5) Large River	Red River from the confluence with the Roseau to the confluence with the Assiniboine		1
RE 5 - 9	(5) Large River	Red River from the confluence with the Assiniboine to Lake Winnipeg		1
RW 1 - 1	(1) Headwater	Headwater basins in till and alluvium and beach sediment, with silt/clay lake deposits, peat, and sandy outwash; generally intermittent flow; variable gradient; often connected to lakes; northeast climate zone; infrequent large size discrepancy to downstream systems; Red River West EDU		49
RW 1 - 2	(1) Headwater	Headwater basins in till and sandy outwash, with alluvium and beach sediments; generally intermittent flow; variable gradient; often connected to lakes; northwest climate zone; infrequent large size discrepancy to downstream system; Red River West EDU		239
RW 1 - 31	(1) Headwater	Headwater basins in alluvium, beach sediments, and till, with silt/clay lake sediments; mostly intermittent flow; moderate gradient; unconnected to lakes; generally in south climate zones; consistent large size discrepancy to downstream system; Red River West EDU		29
RW 1 - 4	(1) Headwater	Headwater basins in silt/clay lake deposits, with alluvium, beach sediments, and sandy outwash; mostly intermittent flow; moderate gradient; occasionally connected to lakes; northwest climate zone; occasional large size discrepancy to downstream system; Red River West EDU		83
RW 1 - 49	(1) Headwater	Headwater basins in till, alluvium, and beach sediments, with sandy outwash; generally intermittent flow; variable gradient; often connected to lakes; southeast climate zone; no large size discrepancy to downstream system; Red River West EDU		66

AES Type Code	Size Class	AES Description	Examples	Total Number
RW 1 - 64	(1) Headwater	Headwater basins in till, alluvium, and beach sediments, with silt/clay lake sediment and sandy outwash; generally intermittent flow; variable gradient; occasionally connected to lakes; southwest climate zone; no large size discrepancy to downstream systems Red River West EDU		203
RW 2 - 1	(2) Creek	Creek basins in mostly till and alluvial/beach deposits; generally intermittent flow; moderate gradient; generally unconnected to lakes; mostly in the southeast climate zone; no large size discrepancy to downstream system; Red River West EDU		16
RW 2 - 15	(2) Creek	Creek basins in till with sand and outwash, with some silt/clay lake deposits; mostly intermittent flow; moderate gradient; generally unconnected to lakes; southwest climate zone; no large size discrepancy to downstream system; Red River West EDU		69
RW 2 - 2	(2) Creek	Creek basins in mostly till and silt/clay lake deposits; mostly intermittent flow; moderate gradient; generally unconnected to lakes; northwest climate zone; infrequent large size discrepancy to downstream system; Red River West EDU		94
RW 2 - 22	(2) Creek	Creek basins in till and silt/clay lake deposits; mostly intermittent flow; moderate to low gradient; unconnected to lakes; northeast and south climate zones; consistent large size discrepancy to downstream system; Red River West EDU		5
RW 2 - 38	(2) Creek	Creek basins in till, silt/clay lake deposits, and peat; generally perennial flow; moderate to low gradient; generally unconnected to lakes; northeast climate zone; infrequent large size discrepancy to downstream system; Red River West EDU		20
RW 3 - 1	(3) Small River	Small river basins in mostly till and silt/clay lake deposits, with beach deposits; mostly intermittent flow; moderate gradient; generally unconnected to lakes; northeast and northwest climate zones; no large size discrepancy to downstream system; Red River West EDU		15
RW 3 - 25	(3) Small River	Small river basins in till and silt/clay lake deposits, with beach deposits; mostly intermittent flow; moderate gradient; generally unconnected to lakes; southwest climate zone; no large size discrepancy to downstream system; Red River West EDU		16
RW 3 - 32	(3) Small River	Small river basins in mostly till with outwash and alluvial deposits; generally intermittent flow; moderate to low gradient; occasionally connected to lakes; southeast climate zone; no large size discrepancy to downstream system; Red River West EDU		3

AES Type Code	Size Class	AES Description	Examples	Total Number
RW 3 - 6	(3) Small River	Small river basins in mostly till and silt/clay lake deposits, with beach and peat deposits; generally perennial flow; moderate to low gradient; occasionally connected to lakes; northeast climate zone; infrequent large size discrepancy to downstream systems; Red River West EDU		5
RW 4 - 1	(4) Medium River	Medium river basins in mostly till with some silt/clay lake and sand deposits; mostly intermittent flow; medium gradient; generally unconnected to lakes; northwest transitional to northeast climate zone; no large size discrepancy to downstream system; Red River West EDU		6
RW 4 - 2	(4) Medium River	Medium river basins in till with some silt/clay lake, peat, and sand deposits; mostly perennial flow; medium gradient; generally unconnected to lakes; northeast transitional to northwest climate zone; no large size discrepancy to downstream system; Red River West EDU		2
RW 4 - 3	(4) Medium River	Medium river basins in mostly till with some sand deposits; generally intermittent flow; medium gradient; occasionally connected to lakes; southeast climate zone; no large size discrepancy to downstream system; Red River West EDU		1
RW 4 - 5	(4) Medium River	Medium river basins in till with minor sand and silt/clay lake deposits; generally perennial flow; medium gradient; generally unconnected to lakes; southwest climate zone; no large size discrepancy to downstream system; Red River West EDU		3
RW 5 - 8	(5) Large River	Sheyenne River from Baldhill Creek (Lake Ashtabula) to the upper end of the Sheyenne delta		1
RW 5 - 9	(5) Large River	Sheyenne River from the upper end of the Sheyenne delta to the confluence with the Red river		1

Missouri River Basin

AES Type Code	Size Class	AES Description	Examples	Total Number

AES Type Code	Size Class	AES Description	Examples	Total Number
BS 1 - 1	(1) Headwater	Headwater systems in fine and coarse quaternary substrates; intermittent flow; low to high gradient; infrequent connections to lakes and wetlands; no size discrepancy to downstream systems; located in northeast and southwest portions of the Big Sioux EDU.		75
BS 1 - 2	(1) Headwater	Headwater systems predominantly in fine and coarse quaternary substrates with minor amounts of hard bedrock, lake plains sediments and peat and muck; intermittent flow; generally high gradient; occasional connections to lakes and wetlands; no size discrepancy to downstream systems; Big Sioux EDU		456
BS 1 - 234	(1) Headwater	Headwater systems predominantly in coarse quaternary substrates; predominantly intermittent flow; generally low gradient; occasional connections to lakes and wetlands; no size discrepancy to downstream systems; located in the central portions of the Big Sioux EDU		43
BS 1 - 43	(1) Headwater	Headwater systems predominantly in fine quaternary substrates with lesser amounts of coarse quaternary substrates; predominantly intermittent flow; generally high gradient; infrequent connections to lakes and wetlands; no size discrepancy to downstream systems; Big Sioux EDU		372
BS 1 - 5	(1) Headwater	Headwater systems in mixture of fine and coarse quaternary substrates; intermittent flow; high gradient; occasional connections to lakes and wetlands; frequent size discrepancy to downstream systems; located in the northern two-thirds of the Big Sioux EDU		105
BS 2 - 1	(2) Creek	Creek basins predominantly in fine and coarse quaternary substrates with minor amounts of hard bedrock, lake plains sediments and peat and muck; high gradient, intermittent flow throughout most of basins; occasional connections to lakes and wetlands; infrequent size discrepancy to downstream systems; Big Sioux EDU		138
BS 2 - 11	(2) Creek	Creek basins predominantly in fine quaternary substrates with lesser amounts of coarse quaternary substrates; high gradient, intermittent flow throughout most of basins; occasional connections to lakes and wetlands; infrequent size discrepancy to downstream systems; Big Sioux EDU		78

AES Type Code	Size Class	AES Description	Examples	Total Number
BS 2 - 40	(2) Creek	Creek basins in coarse quaternary substrates; headwaters and creeks are usually low gradient with intermittent and perennial flow; occasional connections to lakes and wetlands; infrequent size discrepancy to downstream systems; located in the central part of the Big Sioux EDU		5
BS 3 - 1	(3) Small River	Small river basins predominantly in fine and coarse quaternary substrates with minor amounts of hard bedrock, lake plains sediments and peat and muck; high gradient, intermittent flow throughout most of basins; occasional connections to lakes and wetlands; Big Sioux EDU		28
BS 3 - 3	(3) Small River	Small river basins in mixture of fine and coarse quaternary substrates; basin streams mostly high gradient with intermittent flow; infrequent connections to lakes and wetlands; located in the southern two-thirds of the Big Sioux EDU.		23
BS 3 - 7	(3) Small River	Small river basins predominantly in coarse quaternary substrates with lesser amounts of fine quaternary substrates; basin streams a mixture of low and high gradient with intermittent and perennial flow; infrequent connections to lakes and wetlands; Big Sioux EDU		3
BS 4 - 1	(4) Medium River	Medium river basins predominantly in fine and coarse quaternary substrates with minor amounts of hard bedrock, lake plains sediments and peat and muck; high gradient, intermittent flow throughout most of basins; located in the northern two thirds of the Big Sioux EDU.		4
BS 4 - 4	(4) Medium River	Medium river basins in fine and coarse quaternary substrates; high gradient, intermittent flow throughout most of basins; located in the southern two thirds of the Big Sioux EDU.		5
BS 5 - 1	(5) Large River	Big Sioux River - Sioux Falls to Missouri Confluence		1
BS 5 - 2	(5) Large River	Little Sioux River		1
BS 5 - 3	(5) Large River	Missouri River from Sioux City, Iowa to the Platte River confluence		1
BS 5 - 4	(5) Large River	Big Sioux River – from Egan to Sioux Falls		1
JR 1 - 1	(1) Headwater	Headwater stream systems predominantly in fine quaternary substrates, with some coarse substrates and soft bedrock; intermittent flow; frequently connected to lakes and/or wetlands; central and southern portions of the James River EDU		217

AES Type Code	Size Class	AES Description	Examples	Total Number
JR 1 - 12	(1) Headwater	Headwater stream systems in soft bedrock and fine and coarse quaternary substrates; intermittent flow; unconnected to lakes and/or wetlands, but frequently connected to river mainstems; found throughout the James River EDU		73
JR 1 - 17	(1) Headwater	Headwater stream systems predominantly in fine and coarse quaternary substrates with some soft bedrock; mostly intermittent flow; unconnected to lakes and/or wetlands; found throughout the James River EDU		92
JR 1 - 2	(1) Headwater	Headwater stream systems predominantly in fine quaternary substrates, with some coarse substrates, lake plains sediments and soft bedrock; intermittent flow; frequently connected to lakes and/or wetlands; northern and central portions of the James River EDU		212
JR 1 - 5	(1) Headwater	Headwater stream systems predominantly in fine and coarse quaternary substrates with some soft bedrock; intermittent flow; frequently connected to lakes and/or wetlands; central portions of the James River EDU		93
JR 2 - 1	(2) Creek	Creek basins predominantly fine quaternary substrates with lesser amounts of coarse quaternary substrates, lake plains sediments and soft bedrock; headwaters and creeks are mostly intermittent; low to high gradient streams throughout systems; James River EDU		74
JR 2 - 10	(2) Creek	Creek basins predominantly in coarse and fine quaternary substrates with some lake plains sediments and soft bedrock; headwaters and creeks are mostly intermittent; generally higher gradient streams throughout systems; occasional connections to lakes/wetlands; James River EDU		94
JR 2 - 20	(2) Creek	Creek basins predominantly in soft bedrock and coarse quaternary substrates with some fine quaternary substrates and lake plains sediments; headwaters and creeks are mostly intermittent; generally higher gradient streams throughout systems; infrequent connections to lakes/wetlands; James River EDU		15
JR 2 - 46	(2) Creek	Creek basins in coarse and fine quaternary substrates with some lake plains sediments and soft bedrock; headwaters and creeks are mostly intermittent; generally high to moderate gradient streams throughout systems; infrequent connections to lakes/wetlands; James River EDU		21

AES Type Code	Size Class	AES Description	Examples	Total Number
JR 3 - 1	(3) Small River	Small river basins in coarse and fine quaternary substrates with some lake plains sediments and soft bedrock; headwaters and creeks are mostly intermittent; generally high to moderate gradient streams throughout systems; occasional connections to lakes/wetlands; James River EDU		22
JR 3 - 13	(3) Small River	Small river basins in a mixture of coarse and fine quaternary substrates; headwaters and creeks are mostly intermittent; generally high to moderate gradient streams throughout systems; occasional connections to lakes/wetlands; occasionally large size discrepancy to downstream systems; James River EDU		22
JR 3 - 2	(3) Small River	Small river basins in soft bedrock, with lesser amounts of fine and coarse quaternary substrates; headwaters and creeks are mostly intermittent; generally high to moderate gradient streams throughout systems; infrequent connections to lakes/wetlands; James River EDU		5
JR 3 - 44	(3) Small River	Small river basins predominantly in coarse quaternary substrates with some fine quaternary substrates; headwaters and creeks are generally intermittent; high to low gradient streams throughout systems; occasional connections to lakes/wetlands; usually no size discrepancy; James River EDU		5
JR 4 - 1	(4) Medium River	Medium river basins in fine quaternary substrates, soft bedrock and coarse quaternary substrates; headwaters and tributaries mostly intermittent flow, but mainstems include a mixture of perennial and intermittent channels; mainstem mostly low gradient; James River EDU		2
JR 4 - 2	(4) Medium River	Medium river basins in fine and coarse Quaternary substrates; intermittent flow throughout headwaters and tribs, but mainstem systems are mostly perennial; mainstems mostly low gradient, with mostly high gradient headwaters and tribs; frequent interconnections to lakes/ wetlands; James River EDU		3
JR 4 - 3	(4) Medium River			1
JR 5 - 2	(5) Large River	Lower James River – from the Beadle/Spink county line in SD to the confluence with the Missouri River		1
JR 5 - 3	(5) Large River	Middle James River – Dakota Lake Plain segment – from Oakes, ND to the Beadle/Spink county line		1
JR 5 - 4	(5) Large River	Upper James River from Oakes to Jamestown, ND		1

AES Type Code	Size Class	AES Description	Examples	Total Number
JR 5 - 7	(5) Large River	Missouri River/Lewis and Clarke Lake – from Niobrara confluence to Gavins Point Dam		1
JR 5 - 8	(5) Large River	Missouri River (1) from Gavins Point Dam to confluence with the Big Sioux River in Sioux City, IA		1
JR 5 - 9	(5) Large River	Missouri River (2) from Fort Randal Dam to the confluence with the Niobrara River		1

Upper Mississippi River Basin

AES Type Code	Size Class	AES Description	Examples	Total Number
12_1B 149	(1-2) Headwater-Creek	Perennial creek systems, low gradient with low to moderate gradient headwaters of mixed intermittency, in fine ground and end moraines, with localized areas of outwash, sand, and alluvium along the main channels.		15
12_1B 3	(1-2) Headwater-Creek	Perennial headwater systems, low gradient, with moderate to high gradient tributaries, in fine ground and end moraines, the extreme lower reaches in outwash, sand alluvium, and colluvium.		1
12_1B 62	(1-2) Headwater-Creek	Perennial creek systems, low gradient, with moderate to high gradient, intermittent headwaters, in fine ground and end moraines, the lower reaches of many systems in outwash and alluvium.		232
12_2C 10	(3) Small River	Perennial small rivers, low to moderate gradient with moderate to high gradient, largely intermittent tributaries, in fine ground and end moraines, the lower main channel in alluvium, outwash, and sand.		20

AES Type Code	Size Class	AES Description	Examples	Total Number
12_2C 8	(3) Small River	Perennial small rivers, low gradient with low to moderate gradient, largely intermittent tributaries, in fine ground and end moraines, the main channel in outwash.		5
12_3C 5	(4) Medium River	Perennial medium rivers, low gradient with moderate to high gradient, largely intermittent tributaries, in coarse ground moraine with areas of dune sand, the main channels in alluvium.	West Fork Cedar River; English River.	2
12_3C 6	(4) Medium River	Perennial medium rivers, low to moderate gradient with low to moderate gradient, largely intermittent tributaries, in coarse ground moraine, the upper reaches of the main channels in coarse outwash, the lower reaches in alluvium.	Lower reach of the Shell Rock; Upper middle reach of the Cedar River; Iowa River	3
12_W2472	(5) Large River	Perennial large river, low gradient with moderate to high gradient, largely intermittent tributaries, in coarse ground moraine, the main channel in alluvium, with a short stretch of colluvium in the middle reaches.	Iowa River, from the mouth of Otter Creek, Tama County, IA, downstream to the mouth of the Cedar River.	1
12_W2474	(5) Large River	Perennial large river, low gradient with few low to moderate gradient, largely intermittent tributaries, in coarse ground moraine with isolated areas of dune sand, the main channel in alluvium.	Middle reaches Cedar River, from just upstream of Janesville, Bremer County, IA, downstream to the mouth of Big Creek, Linn County, IA.	1
13_1B 149	(1-2) Headwater-Creek	Perennial creek systems, low gradient with moderate gradient headwaters of mixed intermittency, in fine ground and end moraines, with areas of outwash, sand, and alluvium in lower reaches.		41

AES Type Code	Size Class	AES Description	Examples	Total Number
13_1B 24	(1-2) Headwater-Creek	Perennial creek systems, low to moderate gradient, with moderate to high gradient, intermittent headwaters, in fine ground and end moraines, the lower reaches in colluvium and alluvium.		8
13_1B 3	(1-2) Headwater-Creek	Perennial headwater system, low to moderate gradient, with moderate to high gradient headwaters, in fine ground and end moraines, the extreme lower reaches in outwash and colluvium. Occurrences along the Des Moines River, below the mouth of the Boone River		51
13_2C 3	(3) Small River	Perennial small rivers, low to moderate gradient with moderate to high gradient, largely intermittent tributaries, in fine ground and end moraines, the lower main channel in outwash.		2
13_2C 36	(3) Small River	Perennial small rivers, low gradient, with low to moderate gradient, largely intermittent tributaries, in fine ground and end moraine with isolated areas of lake sand and clay, the main channels in outwash.		5
13_2C 6	(3) Small River	Perennial small river, low to moderate gradient, with moderate to high gradient tributaries, in fine ground moraine, the main channel in alluvium.		1
13_3C 1	(4) Medium River	Perennial medium river, low to moderate gradient with moderate to high gradient, largely intermittent tributaries, in fine ground and end moraines, the main channel in outwash and alluvium.	Middle reach of the South Raccoon River; Lower reach of the Middle Raccoon River	1

AES Type Code	Size Class	AES Description	Examples	Total Number
13_3C 15	(4) Medium River	Perennial medium rivers, low to moderate gradient, with low to high (mostly moderate) gradient tributaries of mixed intermittency, in fine ground and end moraines, the main channels in coarse outwash.	Upper Des Moines River; Lower North Raccoon River	2
13_W2888	(5) Large River	Perennial large river, low gradient with moderate to high gradient, largely intermittent tributaries, in fine ground and end moraines, with areas of lake sand, the upper main channel in colluvium, the lower in coarse outwash. Des Moines River.		1
14_1B 149	(1-2) Headwater-Creek	Perennial creek systems, low gradient, with moderate to high gradient, intermittent headwaters, in fine ground and end moraines, the lower main channels with isolated areas of outwash, alluvium, and sand.		90
14_1B 3	(1-2) Headwater-Creek	Perennial headwater system, low to moderate gradient, with moderate to high gradient tributaries, in fine ground and end moraines, the extreme downstream reaches in outwash, alluvium, and sand.		172
14_2C 10	(3) Small River	Perennial small rivers, low to moderate gradient, with moderate to high gradient, intermittent tributaries, in fine ground and end moraines, the lower mainstems in outwash and alluvium, with isolated areas of loess.		26
14_3C 6	(4) Medium River	Perennial medium rivers, low to moderate gradient with moderate to high gradient, largely intermittent tributaries, in fine ground and end moraines, the main channels in alluvium and outwash, with isolated areas of sand and loess.	Lower reach of the North Skunk River; Lower reaches of the North River, Middle River, White Breast Creek, and Cedar Creek in Iowa	10

AES Type Code	Size Class	AES Description	Examples	Total Number
14_W2758	(5) Large River	Perennial large river, low gradient with moderate to high gradient, intermittent tributaries, in fine ground moraine in the upper reaches, fine end moraine in the lower reaches, the main channel in alluvium.	South Skunk River; Skunk River	1
2_1A 1	(1-2) Headwater-Creek	Perennial creeks, low gradient with moderate gradient, intermittent headwaters, in fine, calcareous ground moraine.		1
2_1A 18	(1-2) Headwater-Creek	Perennial creek systems, low gradient with moderate gradient, intermittent headwaters, in coarse ground moraine, with local areas of outwash, peat and muck.		7
2_1A 191	(1-2) Headwater-Creek	Low density, perennial creek systems, low gradient with low to moderate gradient, intermittent headwaters, in fine, calcareous ground and end moraines, with isolated areas of coarse, calcareous outwash.		2
2_1A 2	(1-2) Headwater-Creek	Perennial, low density creek systems, low gradient with low to moderate gradient headwaters, in ground and end moraines of mixed texture and chemistry, with localized areas of calcareous outwash, peat, and muck.		81
2_1A 207	(1-2) Headwater-Creek	Perennial low density creek system, low gradient with low to moderate gradient headwaters, in ground and end moraines of varying texture and chemistry, with localized areas of calcareous outwash, peat and muck.	Essentially, the Lake Mille Lacs watershed.	1
2_1A 234	(1-2) Headwater-Creek	Perennial creek system, low gradient with low gradient, lake-dominated headwaters, in fine, calcareous end moraine and outwash.		1

AES Type Code	Size Class	AES Description	Examples	Total Number
2_1A 3	(1-2) Headwater-Creek	Perennial, lake-dominated creek systems, low gradient with low gradient headwaters, in coarse outwash, with isolated areas of ground and end moraines of mixed chemistry .		1
2_1A 4	(1-2) Headwater-Creek	Perennial creek systems, low gradient with low to moderate gradient, mostly perennial headwaters, in coarse outwash, fine ground moraine, and isolated peat and muck.		3
2_2A 1	(3) Small River	Perennial small river, low gradient, with low to moderate gradient tributaries, in outwash and non-calcareous end moraines, with isolated areas of alluvium, peat and muck.		4
2_2A 2	(3) Small River	Perennial small river, low gradient, with few moderate gradient, intermittent tributaries, in coarse outwash and alluvium .	A very small portion of the extreme lower Coon River.	1
2_2A 3	(3) Small River	Perennial, low gradient small river, originating in fine ground and end moraines, terminating in coarse outwash. Tributaries largely intermittent, low to moderate gradient, in similar geology.	The upper mainstem Sauk River	1
2_2A 6	(3) Small River	Perennial, low gradient small rivers, in fine ground and end moraines, and coarse outwash. Tributaries intermittent, low to moderate gradient, in similar geology.	North and South Forks, Crow River.	2
2_3A 14	(4) Medium River	Perennial medium rivers, low gradient with few moderate gradient, mostly intermittent tributaries, the mainstem in coarse outwash, the tributaries in fine ground and end moraines.	North Fork, South Fork, and lower mainstem Crow River (MN)	1

AES Type Code	Size Class	AES Description	Examples	Total Number
2_3A 2	(4) Medium River	Perennial medium river, low gradient with low to moderate gradient tributaries, upper reaches of the mainstem in alluvium, the lower reaches and tributaries in coarse outwash, with areas of fine ground and end moraines.	Lower Rum River (MN).	1
2_3A 9	(4) Medium River	Perennial medium river, low gradient with low to moderate gradient tributaries, mainstem in coarse outwash, with areas of ground and end moraine of various texture and chemistry.	Lower Sauk River (MN)	1
3_1A 1	(1-2) Headwater-Creek	Perennial creeks, low gradient with moderate to high gradient, intermittent headwaters, in fine, calcareous ground and end moraines.		21
3_1A 191	(1-2) Headwater-Creek	Perennial creek systems, low gradient with low to moderate gradient, intermittent headwaters, in fine, calcareous ground and end moraines, with isolated areas of coarse, calcareous outwash.		7
3_1A 2	(1-2) Headwater-Creek	Intermittent and perennial creek systems, low gradient with low to moderate gradient headwaters, in fine, calcareous end and ground moraines, with localized areas of lake sands, lake clays, and calcareous outwash.		47
3_1A 234	(1-2) Headwater-Creek	Perennial, low-density creek systems, low gradient with low to moderate gradient, intermittent headwaters, in fine, calcareous end moraine, with the lowest reaches in calcareous outwash.		2

AES Type Code	Size Class	AES Description	Examples	Total Number
3_1A 4	(1-2) Headwater-Creek	Perennial creek systems, low gradient with low to moderate gradient, southern systems with highly intermittent headwaters, in coarse, calcareous ground moraine.		1
3_2A 3	(3) Small River	Perennial, low-gradient small rivers, originating in fine ground and end moraines, terminating in coarse outwash. Tributaries intermittent, low to moderate gradient, in fine ground and end moraines.		6
3_2A 6	(3) Small River	Perennial, low gradient small rivers, in coarse outwash and alluvium. Tributaries generally intermittent, low to moderate gradient, in fine ground and end moraines, lake silt and clay.	Pomme de Terre River, Chippewa River, Hawk Creek.	3
3_3A 19	(4) Medium River	Perennial medium river, low gradient with few low to moderate gradient, intermittent tributaries, in alluvium with isolated areas of lake sands and fine ground moraines.	Upper Minnesota River (from the MN/SD border to the mouth of the Lac Qui Parle River) and lower Lac Qui Parle River, MN.	1
3_3A 9	(4) Medium River	Perennial medium river, low gradient with low to moderate gradient, perennial tributaries, mainstem in coarse outwash and alluvium, with tributaries in lake silt and clays.	Lower Chippewa River (MN).	1
4_1A 1	(1-2) Headwater-Creek	Perennial creek systems, low gradient with moderate to high gradient, intermittent headwaters, in fine, calcareous ground and end moraines, the larger creek mainstems in coarse outwash and alluvium.		12

AES Type Code	Size Class	AES Description	Examples	Total Number
4_1A 191	(1-2) Headwater-Creek	Perennial creek systems, low gradient with low to moderate gradient, intermittent headwaters, in fine, calcareous ground and end moraines, the southeastern systems with their lower reaches in lake clays.		6
4_1A 2	(1-2) Headwater-Creek	Perennial creek systems, low gradient with low to moderate gradient, intermittent headwaters, in fine, calcareous end and ground moraines, with localized areas of lake sand, lake clay, and calcareous outwash.		44
4_1A 234	(1-2) Headwater-Creek	Perennial creek systems, low gradient with low to moderate gradient, intermittent headwaters, in fine, calcareous ground and end moraines, the lower reaches in outwash and alluvium.		8
4_2A 15	(3) Small River	Perennial small river, low gradient with low to moderate gradient, mostly intermittent tributaries, in lake sands and clays, the main channels in alluvium.		1
4_2A 3	(3) Small River	Perennial, low to moderate gradient small rivers, originating in fine ground and end moraines, terminating in alluvium. Tributaries intermittent, low to moderate gradient, in fine ground and end moraines.		2
4_2A 6	(3) Small River	Perennial, low to moderate gradient small rivers, originating in fine ground and end moraines, terminating in alluvium or coarse outwash. Tributaries generally intermittent, moderate to high gradient, in similar geology.	Rush River, Sleepy Eye Creek, High Island Creek, Sand Creek	4

AES Type Code	Size Class	AES Description	Examples	Total Number
4_3A 14	(4) Medium River	Perennial medium rivers, low gradient with very few moderate gradient, intermittent tributaries, the mainstem in alluvium, the tributaries in sands, lake clays, and fine ground moraines.	Lower Blue Earth River (MN).	1
4_3A 9	(4) Medium River	Perennial medium river, low gradient with low to moderate gradient tributaries of mixes mixed intermittency, mainstem in coarse outwash and alluvium, with tributaries in lake silt and clays.	Lower Cottonwood River (MN).	1
4_W107	(5) Large River	Perennial larger river, low gradient with moderate to high gradient, largely intermittent tributaries, the mainstem in outwash and alluvium, the tributaries in fine ground and end moraines.	Minnesota River (from just below the mouth of the Redwood River, downstream to the mouth of the Blue Earth River.)	1
GR1	(6) Big River	Perennial big river, low gradient with few moderate to high gradient tributaries of mixed intermittency, the main channel in alluvium, the tributaries in ground and end moraines of mixed texture and chemistry, with areas of outwash and colluvium.	Pools 1 - 3	3
GR1.1	(6) Big River			1
GR2.1	(6) Big River			1
GR5	(6) Big River	Perennial big river, low gradient with moderate to high gradient tributaries, the main channel in alluvium and outwash, the tributaries in mixed geology, including fine end moraines, lake silts and clays, colluvium, and loess.	Pools 14 - 17	1
GR6	(6) Big River	Perennial big river, low gradient with few moderate to high gradient, intermittent tributaries, the main channel in alluvium, the tributaries in fine end moraine.	Pools 18 - 19	2

AES Type Code	Size Class	AES Description	Examples	Total Number
GR6.1	(6) Big River			1
GR7	(6) Big River	Perennial big river, low gradient with low to high gradient tributaries, the main channel in alluvium, the tributaries in mixed geology, including fine ground moraines of mixed chemistry, loess, and a few isolated calcareous bedrock outcrops.	Pools 20 - 22	1
GR7.1	(6) Big River			1

Appendix 2. Species and Assemblage Targets and Goals.

Table A2.1. NTPE Species and Assemblage Targets and conservation status under national and subnational programs.

Arctic Subregion (Red River / Assiniboine EDUs)

Assemblage	Ecological Drainage Units (EDUs)*	Common Name	Scientific Name	GRANK**	USESA** And *CASARA*	AFS**	State or Provincial Status**
(No Assemblage – Single Species Target)	RW, RE, AS	Northern Leopard frog	*Rana pipiens*	G5	*SC*		
	RW, RE, AS	Plains spadefoot toad	*Spea bombifrons*	G5			
	RW, RE, AS	Mudpuppy	*Necturus maculosus*	G5			
	RW, RE, AS	Calico crayfish	*Orconectes immunis*	G5			
	RW, RE, AS	Virile crayfish	*Orconectes virilis*	G5			
	RW, RE, AS	Northern water shrew	*Sorex palustris*	G5			
	RW, RE, AS	Western painted turtle	*Chrysemys picta*	G5			
	RW, RE, AS	Snapping turtle	*Chelydra serpentina*	G5			
	RW, RE, AS	Chestnut lamprey	*Ichthyomyzon castaneus*	G4	*SC*		
	RE	Silver lamprey	*Ichthyomyzon unicuspis*	G5			
	RW, RE, AS	Lake sturgeon	*Acipenser fulvescens*	G3G4			
	RE	Bowfin	*Amia calva*	G4			SD-SE/S1; ND-PERIPHERAL; IA-T
	RW, RE, AS	Finescale dace	*Phoxinus neogaeus*	G5			
	RW, RE, AS	Northern redbelly dace	*Phoxinus eos*	G5			
	RW, RE, AS	Pearl dace	*Margariscus margarita*	G5			
	RW, RE, AS	Hornyhead chub	*Nocomis biguttatus*	G5			
	RW, RE	Central stoneroller	*Campostoma anomalum*	G5			

Assemblage	Ecological Drainage Units (EDUs)*	Common Name	Scientific Name	GRANK**	USESA** And *CASARA*	AFS**	State or Provincial Status**
	RW, RE	Largescale stoneroller	*Campostoma oligolepis*	G5			
	RW; RE	Flathead chub	*Platygobio gracilis*	G5			
	RE, AS	Silver chub	*Macrhybopsis storeriana*	G5	*SC*		MB-SC
	RW, RE	Rosyface shiner+	*Notropis rubellus*	G5	*T*		
	RW, RE, AS	River shiner	*Notropis blennius*	G5			
	RW, RE	Blacknose shiner	*Notropis heterolepis*	G4			
	RE	Pugnose shiner	*Notropis anogenus*	G3			
	RW, RE	Bigmouth buffalo	*Ictiobus cyprinellus*	G3G4	*SC*	T	SD-SA; ND-EXT; MN-SC; IA-E
	RE	Northern hog sucker	*Hypentelium nigricans*	G5			
	RW, RE	Greater redhorse	*Moxostoma valenciennesi*	G4			ND-PERIPHERAL
	RW, RE, AS	Burbot	*Lota lota*	G5			
	RW, RE, AS	Banded killifish	*Fundulus diaphanus*	G5			
	RE	Rainbow darter	*Etheostoma caeruleum*	G5			
	RE	Least darter	*Etheostoma microperca*	G5			
Lower Sheyenne River Ephemeroptera and Tricoptera Assemblage	RW	Armored mayflies	*Baetiscidae Baetisca*				
	RW	Burrowing mayflies	*Ephemeridae Pentagenia*				
	RW	The Netspinners	*Hydropsychidae Potamyia*				
	RW	The Microcaddisflies	*Hydroptilidae Neotrichia*				
	RW	Pale burrowers	*Polymitarcidae Ephoron*				
	RW	The Hacklegills	*Potomanthidae Anthopotamus*				
Small Stream Mussel Assemblage	RE, RW, AS	Cylindrical papershell	*Anodontoides ferussacianus*	G5		CS	
	RE, RW, AS	Creeper	*Strophitus undulatus*	G5			
Medium River Mussel	RE, RW, AS	Wabash pigtoe	*Fusconaia flava*	G5		CS	SD-S1
	RE, RW, AS	Threeridge	*Amblema plicata*	G5			

Assemblage	Ecological Drainage Units (EDUs)*	Common Name	Scientific Name	GRANK**	USESA** And *CASARA*	AFS**	State or Provincial Status**
Assemblage	RE, RW, AS	White heelsplitter	*Lasmigona complanata*	G5			
	RE, RW, AS	Plain pocketbook	*Lampsilis cardium*	G5			
	RE, RW, AS	Black sandshell	*Ligumia recta*	G5		SC	SD-S1; MN-SC
	RE, RW, AS	Mucket	*Actinonaias ligamentina*	G5			
	RE, RW, AS	Fluted shell	*Lasmigona costata*	G5			
	RE, RW, AS	Creeper	*Strophitus undulatus*	G5			
Large River Mussel Assemblage	RW, RE, AS	Threeridge	*Amblema plicata*	G5			
	RW, RE, AS	Wabash pigtoe	*Fusconaia flava*	G5		CS	SD-S1
	RW, RE, AS	Pink heelsplitter	*Potamilus alatus*	G5		CS	SD-S3
	RW, RE, AS	Mapleleaf	*Quadrula quadrula*	G5		CS	SD-S2

Missouri Subregion (Missouri River EDUs)

Assemblage	Ecological Drainage Units (EDUs)*	Common Name	Scientific Name	GRANK**	USESA** And *CASARA*	AFS**	State or Provincial Status**
	JR	Mudpuppy	Necturus maculosus	G5			
	BS	Blanding's turtle	Emydoidea blandinsii	G4			SD-SE
	JR	Scaleshell	Leptodea leptodon	G1	LE		
	JR, BS	Winged mapleleaf	Quadrula fragosa	G1	(LE,XN)		
	JR, BS	River otter	Lontra canadensis	G5			SD-ST;
	JR, BS	Pallid sturgeon	Scaphirhynchus albus	G1	LE	E	SD-SE; ND-ST; IA-E
	JR	Sicklefin Chub	Macrhybopsis meeki	G3		T	SD-ST/S1; ND-WATCH
	JR	Sturgeon Chub	Macrhybopsis gelida	G3		SC	SD-ST/S2; ND-WATCH
	JR, BS	Paddlefish	Polyodon spathula	G4		SC	ND-WATCH; MN-T

Assemblage	Ecological Drainage Units (EDUs)*	Common Name	Scientific Name	GRANK**	USESA** And *CASARA*	AFS**	State or Provincial Status**
	BS	Southern redbelly dace	Phoxinus erythrogaster	G5			
	JR, BS	Topeka shiner	Notropis topeka	G3	LE		SD-S2; MN-SC; IA-T
	JR, BS	Blue sucker	Cycleptus elongatus	G3G4		SC	SD-S3; ND-WATCH; MN-SC
	BS	Trout perch	Percopsis omiscomaycus	G5			
	BS	Plains topminnow	Fundulus sciadicus				
	JR, BS	Sauger	Sander canadense	G5			
	BS	Blackside darter	Percina maculata	G5			
Large River Turtle Assemblage	JR	Smooth Softshell	Apalone mutica	G5		NA	
	JR	Spiny Softshell	Apalone spinifera	G5		NA	
	JR	False Map Turtle	Graptemys pseudogeographica	G5		NA	SD-ST; ND-PERIPHERAL
Headwater/Stream Native Mussel Assemblage	JR, BS	Threeridge	Amblema plicata	G5			
	JR, BS	Cylindrical Papershell	Anodontoides ferussacianus	G5		CS	
	JR, BS	Wabash Pigtoe	Fusconaia flava	G5		CS	SD-S1
James and Big Sioux River Native Mussel Assemblage	JR, BS	Creek Heelsplitter	Lasmigona compressa	G5		CS	SD-S1; MN-SC
	JR, BS	Black Sandshell	Ligumia recta	G5		SC	SD-S1; MN-SC
	JR, BS	Pink Heelsplitter	Potamilus alatus	G5		CS	SD-S3
	JR, BS	Mapleleaf	Quadrula quadrula	G5		CS	SD-S2
	JR, BS	Bankcreeper	Strophitus undulatus	G5		CS	SD-S3
	JR, BS	Deertoe	Truncilla truncata	G5		CS	SD-S2
James and Big Sioux River Native Fish Assemblage	JR, BS	Longnose Gar	Lepisosteus osseus	G5			SD-S3
	JR, BS	Shortnose Gar	Lepisosteus platostomus	G5			ND-PERIPHERAL
	JR, BS	Goldeye	Hiodon alosoides	G5			
	JR, BS	Quillback Carpsucker	Carpiodes cyprinus	G5			SD-S3

Assemblage	Ecological Drainage Units (EDUs)*	Common Name	Scientific Name	GRANK**	USESA** And *CASARA*	AFS**	State or Provincial Status**
	JR, BS	Smallmouth Buffalo	Ictiobus bubalus	G5			
	JR, BS	River Carpsucker	Carpiodes carpio	G5			
	BS	Silver Chub	Macrhybopsis storeriana	G5	*SC*		MB-SC
	JR, BS	Topeka Shiner	Notropis topeka	G3	LE		SD-S2; MN-SC; IA-T
	JR, BS	Blue Sucker	Cycleptus elongatus	G3G4		SC	SD-S3; ND-WATCH; MN-SC
	JR, BS	Flathead Catfish	Pylodictis olivaris	G5			ND-PERIPHERAL
	JR, BS	Freshwater Drum	Aplodinotus grunniens	G5			
Perennial Flow/Groundwater Contact Native Fish Assemblage	JR, BS	Creek Chub	Semotilus atromaculatus	G5			
	JR, BS	Central Stoneroller	Campostoma anomalum	G5			ND-WATCH
	JR, BS	Brassy Minnow	Hybognathus hankinsoni	G5			
	JR, BS	Common Shiner	Luxilus cornutus	G5			
	JR, BS	Bigmouth Shiner	Notropis dorsalis	G5			
	JR, BS	Stonecat	Noturus flavus	G5			
	JR, BS	Johnny Darter	Etheostoma nigrum	G5			
	BS	Iowa Darter	Etheostoma exile	G5			
Mainstem Lower Missouri River Native Fish Assemblage (Shallow Water)	JR, BS	Sicklefin Chub	Macrhybopsis meeki	G3		T	SD-ST/S1; ND-WATCH
	JR, BS	Flathead Chub	Platygobio gracilis	G5			
	JR, BS	Sturgeon Chub	Macrhybopsis gelida	G3		SC	SD-ST/S2; ND-WATCH
	JR, BS	Silver Chub	Macrhybopsis storeriana	G5	*SC*		MB-SC
	JR, BS	Western Silvery Minnow	Hybognathus argyritis	G4			
	JR, BS	Plains Minnow	Hybognathus placitus	G4			
Mainstem Lower Missouri River Native Fish Assemblage	JR, BS	Pallid Sturgeon	Scaphirhynchus albus	G1	LE	E	SD-SE; ND-ST; IA-E
	JR, BS	Paddlefish	Polyodon spathula	G4		SC	ND-WATCH; MN-T
	JR, BS	Bigmouth Buffalo	Ictiobus cyprinellus	G3G4	*SC*	T	SD-SA; ND-EXT; MN-SC; IA-E

Assemblage	Ecological Drainage Units (EDUs)*	Common Name	Scientific Name	GRANK**	USESA** And *CASARA*	AFS**	State or Provincial Status**
(Deep Water)	JR, BS	Quillback Carpsucker	Carpiodes cyprinus	G5			SD-S3
	JR, BS	Smallmouth Buffalo	Ictiobus bubalus	G5			
	JR, BS	Blue Sucker	Cycleptus elongatus	G3G4		SC	SD-S3; ND-WATCH; MN-SC
	JR, BS	Blue Catfish	Ictalurus furcatus	G5			
	JR, BS	Flathead Catfish	Pylodictis olivaris	G5			ND-PERIPHERAL
	JR, BS	Walleye	Sander vitreum	G5			
	JR, BS	Sauger	Sander canadense	G5			

Southern Plains Subregion (Upper Mississippi River EDUs)

Assemblage	Ecological Drainage Units (EDUs)*	Common Name	Scientific Name	GRANK**	USESA** And *CASARA*		
	UMRB	Lake sturgeon	Acipenser fulvescens	G3G4			
	UMRB	Pallid sturgeon	Scaphirhynchus albus	G1	LE		
	UMRB	Paddlefish	Polyodon spathula	G4			
	UMRB	American eel	Anguilla rostrata	G5			
	UMRB	Skipjack herring	Alosa chrysochloris	G5			
	UMRB	Sicklefin chub	Macrhybopsis meeki	G3			
	UMRB	Sturgeon chub	Macrhybopsis gelida	G3			
	UMRB	Topeka shiner	Notropis topeka	G3	LE		
	UMRB	Pugnose shiner	Notropis anogenus	G3			
	UMRB	Blue sucker	Cycleptus elongatus	G3G4			

Assemblage	Ecological Drainage Units (EDUs)*	Common Name	Scientific Name	GRANK**	USESA** And *CASARA*		
	UMRB	Greater redhorse	Moxostoma valenciennesi	G4			
	UMRB	Western Sand Darter	Ammocrypta clara	G3			
	UMRB	Blanding's turtle	Emydoidea blandingii	G4			
	UMRB	Yellow mud turtle	Kinosternon flavescens	G5			
	UMRB	Elktoe	Alasmidonta marginata	G4			
	UMRB	Flat floater	Anodonta suborbiculata	G5			
	UMRB	Rock pocketbook	Arcidens confragosus	G4			
	UMRB	Purple Wartyback	Cyclonaias tuberculata	G5			
	UMRB	Butterfly	Ellipsaria lineolata	G4			
	UMRB	Elephantear	Elliptio crassidens	G5			
	UMRB	Spike	Elliptio dilatata	G5			
	UMRB	Ebonyshell	Fusconaia ebena	G4G5			
	UMRB	Plain pocketbook	Lampsilis cardium	G5			
	UMRB	Higgins eye	Lampsilis higginsii	G1	LE		
	UMRB	Yellow sandshell	Lampsilis teres	G5			
	UMRB	Scaleshell	Leptodea leptodon	G1	LE		
	UMRB	Black sandshell	Ligumia recta	G5			
	UMRB	Pondmussel	Ligumia subrostrata	G4G5			
	UMRB	Round pigtoe	Pleurobema sintoxia	G4			
	UMRB	Winged mapleleaf	Quadrula fragosa	G1	(LE,XN)		
	UMRB	Monkeyface	Quadrula metanevra	G4			
	UMRB	Wartyback	Quadrula nodulata	G4			
	UMRB	Salamander mussel	Simpsonaias ambigua	G3			
	UMRB	Pistolgrip	Tritogonia verrucosa	G4			
	UMRB	Ellipse	Venustaconcha ellipsiformis	G3G4			

+ within it's Manitoba range this species is now considered to be the Carmine Shiner (*Notropis percobromus*)(Wood, R.M., R.L. Mayden, R.H. Matson, B.R. Kuhajda, and S.R. Layman. 2002. Systematics and biogeography of the Notropis rubellus species group (Teleostei: Cyprinidae). Bulletin Alabama Museum of Natural History 22:37-80)

* EDU Codes: RE = Red River East; RW = Red River West; AS = Assiniboine; JR = James River; BS = Big Sioux; UMRB = Upper Mississippi Basin EDUs

**Conservation Status Codes

Grank (Natural Heritage Network Global Ranks)

The Global (G) Rank of a species or natural community is based on the *range-wide* status of that species or community. The rank is regularly reviewed and updated by experts, and takes into account such factors as number and quality/condition of occurrences, population size, range of distribution, population trends, protection status, and fragility.

Definitions of ranks:

G1:	Critically imperiled globally because of extreme rarity (5 or fewer occurrences, or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction. (Critically endangered throughout its range).
G2:	Imperiled globally because of rarity (6 to 20 occurrences), or because of other factors demonstrably making it very vulnerable to extinction throughout its range. (Endangered throughout its range).
G3:	Very rare or local throughout its range or found locally in a restricted range (21 to 100 occurrences).
G4:	Apparently secure globally, though it might be quite rare in parts of its range, especially at the periphery.
G5:	Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
GX:	Presumed extinct.
GU:	Unable to assign rank due to lack of available information.
G(#)?:	Indicates uncertainty about the assigned global rank.
GQ:	Indicates uncertainty about taxonomic status.
G(#)T(#):	Trinomial (T) rank for subspecies or varieties; these taxa are T-ranked using the same definitions as the G-ranks above.

USESA (US Federal Status under the Endangered Species Act)

E – Federally Endangered
T - Federally Threatened
P – Proposed for listing as Endangered or Threatened
C – Candidate for listing, but no proposal to list has yet been published in the Federal Register

CASARA (Status under the Canadian Species at Risk Act)

X - extirpated species - wildlife species that no longer exist in the wild in Canada, but exist elsewhere in the wild
E - endangered species - wildlife species that are facing imminent extirpation or extinction
T - threatened species - wildlife species that are likely to become endangered species if nothing is done to reverse the factors leading to their extirpation or extinction
SC - species of special concern - wildlife species that may become threatened or endangered species because of a combination of biological characteristics and identified threats

AFS (American Fisheries Society Rank)

E – Endangered
E* - Endangered, possibly extinct
T - Threatened
SC – Special Concern
CS – Currently stable throughout range
U - Undetermined

State Status (Official State Listing Status or State Natural Heritage Program Rank)

ND – (State Listing, according to http://www.npwrc.usgs.gov/resource/othrdata/rareone/index.htm)
- E - Extinct
- T - Threatened
- P – Peripheral
- W - Watch

SD – (Official State Listing or State Natural Heritage Program Rank, according to http://www.state.sd.us/gfp/DivisionWildlife/Diversity/TES.htm)

SE – State Endangered

ST – State Threatened

S1 – (Similar to G1 Global Heritage Rank, except with respect to South Dakota)

S2 - (Similar to G2 Global Heritage Rank, except with respect to South Dakota)

S3 - (Similar to G3 Global Heritage Rank, except with respect to South Dakota)

MN – (State listing, according to http://www.revisor.leg.state.mn.us/stats/84/0895.html)

E - Endangered

T - Threatened

S - Special Concern

MB – (Provincial listing, according to the Manitoba Endangered Species Act http://web2.gov.mb.ca/laws/statutes/ccsm/e111e.php)

E – Endangered

T – Threatened

EP – Extirpated

EX – Extinct

SC- Special Concern

IA – (State listing, according to http://www.state.ia.us/dnr/organiza/ppd/t&e.htm#definitions)

E – Endangerd

T - Threatened

Table A2.2. Target Goals and Goals Achievement

Arctic Subregion (Red River / Assiniboine EDUs)

Scientific Name	Common Name	Conservation Goal (# of occurrences in each EDU of historic range)	Goal Met	Reason Not Met*	Amount Captured (# of system or functional occurrences captured in network)	Ecological Drainage Units (EDUs) in which target occurs*
Rana pipiens	Northern Leopard frog	3	no	only 1 occurrence record in database	1	RW; RE; AS
Spea bombifrons	Plains spadefoot toad	3	no	no occurrence records in post-'95 database		RW; RE; AS
Necturus maculosus	Mudpuppy	3	no	no occurrence records in post-'95 database		RW; RE; AS
Orconectes immunis	Calico crayfish	3	yes		3	RW; RE; AS
Orconectes virilis	Virile crayfish	3	no	no occurrence records in post-'95 database		RW; RE; AS
Sorex palustris	Northern water shrew	3	no	no occurrence records in post-'95 database		RW; RE; AS
Chrysemys picta	Western painted turtle	2	no	no occurrence records in post-'95 database		RW; RE; AS
Chelydra serpentina	Snapping turtle	2	no	only 1 occurrence record in database	1	RW; RE; AS
Ichthyomyzon castaneus	Chestnut lamprey	3	no	only 1 occurrence record in database	1	RW; RE; AS
Ichthyomyzon unicuspis	Silver lamprey	3	no	no occurrence records in post-'95 database		RE
Acipenser fulvescens	Lake sturgeon	1	yes		5	RW; RE; AS
Amia calva	Bowfin	3	no	one record in post-'95 data; 150+ pre-'95 records	1	RE

Scientific Name	**Common Name**	**Conservation Goal (# of occurrences in each EDU of historic range)**	**Goal Met**	**Reason Not Met***	**Amount Captured (# of system or functional occurrences captured in network)**	**Ecological Drainage Units (EDUs) in which target occurs***
Phoxinus neogaeus	Finescale dace	3	no	all records concentrated in a single system		RW; RE; AS
Phoxinus eos	Northern redbelly dace	3	no	partial attainment in RW and RE; no records in AS	3	RW; RE; AS
Margariscus margarita	Pearl dace	3	no	partial attainment in RE	1	RW; RE; AS
Nocomis biguttatus	Hornyhead chub	3	no	partial attainment in RE and RW	2	RW; RE; AS
Campostoma anomalum	Central stoneroller	3	no	no records in post-'95 database; 30 records pre-'95 data		RW; RE
Campostoma oligolepis	Largescale stoneroller	3	no	partial attainment for RW	1	RW; RE
Platygobio gracilis	Flathead chub	3	no	no occurrence records in post-'95 database		RW; RE
Macrhybopsis storeriana	Silver chub	3	no	partial attainment in RE; most records are pre-1995	2	RE; AS
Notropis rubellus	Rosyface shiner	3	no	no records post '95		RW; RE
Notropis blennius	River shiner	3	no	met goal for RE and RW; partial achievement in AS	1	RW; RE; AS
Notropis heterolepis	Blacknose shiner	3	yes		5	RE
Notropis anogenus	Pugnose shiner	1	yes		2	RE
Ictiobus cyprinellus	Bigmouth buffalo	3	no	only 1 record in post-'95 database		RW; RE
Hypentelium nigricans	Northern hog sucker	3	no	no records in post-'95 database		RE

Scientific Name	Common Name	Conservation Goal (# of occurrences in each EDU of historic range)	Goal Met	Reason Not Met*	Amount Captured (# of system or functional occurrences captured in network)	Ecological Drainage Units (EDUs) in which target occurs*
Moxostoma valenciennesi	Greater redhorse	3	no	partial attainment in RE; too few records in data	1	RW; RE
Lota lota	Burbot	3	no	partial attainment in RW; too few records in data	1	RW; RE; AS
Fundulus diaphanus	Banded killifish	3	no	met goal for RE; too few records for AS	4	RW; RE; AS
Etheostoma caeruleum	Rainbow darter	3	no	partial attainment	2	RE
Etheostoma microperca	Least darter	3	no	partial attainment	1	RE
	Lower Sheyenne River Ephemeroptera and Tricoptera Assemblage	1	yes		1	RW
	Small Stream Mussel Assemblage	3	no	no records in database		RE; RW; AS
	Medium River Mussel Assemblage	3	no	too few records; partial attainment in RW	1	RE; RW; AS
	Large River Mussel Assemblage	3	no	only one record in data; partial attainment in AS	1	RW; RE; AS

Missouri Subregion (Missouri River EDUs)

Scientific Name	Common Name	Conservation Goal (# of occurrences in each EDU of historic range)	Goal Met	Reason Not Met*	Amount Captured (# of system or functional occurrences captured in network)	Ecological Drainage Units (EDUs)
Necturus maculosus	Mudpuppy	0	no	extirpated		JR
Emydoidea blandingii	Blanding's turtle	1	yes		5	BS
Leptodea leptodon	Scaleshell	0	no	extirpated		JR
Quadrula fragosa	Winged mapleleaf	1	no		1	JR, BS
Lontra canadensis	River otter	1	yes		8	JR, BS
Scaphirhynchus albus	Pallid sturgeon	1	yes		8	JR, BS
Polyodon spathula	Paddlefish	1	no	no records in BS EDU; all other EDU goals met	5	JR, BS
Phoxinus erythrogaster	Southern redbelly dace	3	yes		3	BS
Notropis topeka	Topeka shiner	12	yes		32	JR, BS
Cycleptus elongatus	Blue sucker	1	yes		9	JR, BS
Percopsis omiscomaycus	Trout perch	1	yes		5	BS
Fundulus sciadicus	Plains topminnow	5	no	all 7 records in one system of the upper Big Sioux	1	BS
Sander (Stizostedion) canadense	Sauger	1	no	no records in JR EDU; BS EDU goal met	1	JR, BS
Percina maculata	Blackside darter	2	yes		4	BS
Macrhybopsis gelida	Sturgeon chub	1	yes		4	JR
Macrhybopsis meeki	Sicklefin chub	1	yes		4	JR
	James and Big Sioux River Native Mussel Assemblage	1	yes		5	JR, BS
	James and Big Sioux River Native Fish Assemblage	1	yes		2	JR, BS

Scientific Name	Common Name	Conservation Goal (# of occurrences in each EDU of historic range)	Goal Met	Reason Not Met*	Amount Captured (# of system or functional occurrences captured in network)	Ecological Drainage Units (EDUs)
	Perennial Flow/Groundwater Contact Native Fish Assemblage	6	yes		24	JR, BS
	Mainstem Lower Missouri River Native Fish Assemblage (Deep Water)	1	no	no records in BS; other EDU goals met	3	JR, BS
	Mainstem Lower Missouri River Native Fish Assemblage (Shallow Water)	1	yes		5	JR, BS
	Large River Turtle Assemblage	1	yes		1	JR
	Headwater/Stream Native Mussel Assemblage	3	no	no occurrence records in BS EDU; goal met in JR	10	JR, BS

Southern Plains Subregion (Upper Mississippi River EDUs)

Scientific Name	Common Name	Conservation Goal (# of occurrences in each EDU of historic range)	Goal Met	Reason Not Met*	Amount Captured (# of system or functional occurrences captured in network)	Ecological Drainage Units (EDUs) in which target occurs*
Acipenser fulvescens	Lake sturgeon	3	yes		15	UMRB EDUs
Scaphirhynchus albus	Pallid sturgeon	3	yes		3	UMRB EDUs
Polyodon spathula	Paddlefish	3	yes		3	UMRB EDUs
Anguilla rostrata	American eel	3	no		1	UMRB EDUs

Scientific Name	**Common Name**	**Conservation Goal (# of occurrences in each EDU of historic range)**	**Goal Met**	**Reason Not Met***	**Amount Captured (# of system or functional occurrences captured in network)**	**Ecological Drainage Units (EDUs) in which target occurs***
Alosa chrysochloris	Skipjack herring	3	no		2	UMRB EDUs
Macrhybopsis meeki	Sicklefin chub	2	yes		2	UMRB EDUs
Macrhybopsis gelida	Sturgeon chub	2	yes		3	UMRB EDUs
Notropis topeka	Topeka shiner	13	no		1	UMRB EDUs
Notropis anogenus	Pugnose shiner	5	yes		10	UMRB EDUs
Cycleptus elongatus	Blue sucker	3	yes		8	UMRB EDUs
Moxostoma valenciennesi	Greater redhorse	5	yes		38	UMRB EDUs
Ammocrypta clara	Western Sand Darter	7	yes		56	UMRB EDUs
Emydoidea blandingii	Blanding's turtle	5	yes		338	UMRB EDUs
Kinosternon flavescens	Yellow mud turtle	18	no		2	UMRB EDUs
Alasmidonta marginata	Elktoe	7	yes		58	UMRB EDUs
Anodonta suborbiculata	Flat floater	7	yes		9	UMRB EDUs
Arcidens confragosus	Rock pocketbook	7	yes		21	UMRB EDUs
Cyclonaias tuberculata	Purple Wartyback	7	yes		8	UMRB EDUs
Ellipsaria lineolata	Butterfly	7	yes		17	UMRB EDUs
Elliptio crassidens	Elephantear	7	yes		10	UMRB EDUs
Elliptio dilatata	Spike	7	yes		38	UMRB EDUs
Fusconaia ebena	Ebonyshell	7	yes		18	UMRB EDUs
Lampsilis cardium	Plain pocketbook	7	yes		84	UMRB EDUs
Lampsilis higginsii	Higgins eye	7	yes		12	UMRB EDUs
Lampsilis teres	Yellow sandshell	7	yes		31	UMRB EDUs
Leptodea leptodon	Scaleshell	7	no		4	UMRB EDUs
Ligumia recta	Black sandshell	7	yes		83	UMRB EDUs
Ligumia subrostrata	Pondmussel	7	no		2	UMRB EDUs
Pleurobema sintoxia	Round pigtoe	7	yes		56	UMRB EDUs

Scientific Name	Common Name	Conservation Goal (# of occurrences in each EDU of historic range)	Goal Met	Reason Not Met*	Amount Captured (# of system or functional occurrences captured in network)	Ecological Drainage Units (EDUs) in which target occurs*
Quadrula fragosa	Winged mapleleaf	13	no		5	UMRB EDUs
Quadrula metanevra	Monkeyface	7	yes		27	UMRB EDUs
Quadrula nodulata	Wartyback	7	yes		30	UMRB EDUs
Simpsonaias ambigua	Salamander mussel	7	yes		9	UMRB EDUs
Tritogonia verrucosa	Pistolgrip	7	yes		33	UMRB EDUs
Venustaconcha ellipsiformis	Ellipse	13	yes		25	UMRB EDUs

* EDU Codes: RE = Red River East; RW = Red River West; AS = Assiniboine; JR = James River; BS = Big Sioux; UMRB = Upper Mississippi Basin EDUs

Appendix 3. Viability Analysis Criteria and Ranking System

Table A3.1. Guidelines for ranking target viability factors in the DMGP.

Size Viability Guidelines

Rank	General Guidelines	**Single Species Target** Consider the population abundance and density and the spatial extent of appropriate habitat for life history needs	***Assemblage/System Targets*** Consider the spatial extent (linear and lateral) of appropriate habitat for life history needs of most species and refugia during disturbance events. Assess the home range needs of key species (top predator, characteristic species), and the minimum dynamic area in terms of likely extent of largest natural disturbance (e.g., the area needed to ensure survival and recolonization after a 500 year flood event)
Very Good (A)	Population or occurrence size is greater than or equal to size of other known (and presumed viable) examples.	Population appears sufficient to recover from major disturbances that would cause high mortality. All habitats needed for life history functions appear available.	Habitats suitable for reproduction, rearing and feeding of all species (including wide-ranging taxa). Upstream/downstream and floodplain habitats sufficient for species to find refugia from major disturbances and recolonize
Good (B)	Population or occurrence size may be smaller than other known (and presumed viable) examples, but appears to be maintaining population numbers or occurrence extent.	Population would likely survive low to moderate levels of disturbance. Habitats are generally available, but may be impaired.	Habitats suitable for life history needs of most species. Refugia available for most species.
Fair (C)	Population or occurrence size is smaller than other known (and presumed viable) examples. Low numbers or small size is a threat to the viability of the target.	Population would not likely survive low to moderate levels of disturbance. Habitats limited and impaired.	Some habitats for life history needs of some species not available. Access to refugia limited for most species.
Poor (D)	Population or occurrence size is smaller than other known (and presumed viable) examples, and is highly vulnerable to extirpation due to small size.	Population may not be sufficient to sustain itself in the face of disturbances. Habitats highly impaired or absent.	Habitats highly impaired or absent. Vulnerable to natural disturbance because refugia are lacking.
Unknown (E)		No knowledge of population size or habitat conditions.	No knowledge of habitat conditions, life history needs or refugia.

Condition Viability Guidelines

Rank	**General Guidelines**	**Single Species Target** Consider the composition, structure (age classes), success and regularity of reproduction, presence/absence of competitors/predators and exotics, and the degree of local anthropogenic impacts	**Assemblage/Systems Targets** Consider the viability of individual populations, the ecological interactions among species (e.g., competition, predation), the presence and viability of rare, indicator, keystone, exotic and wide-ranging species, the presence of biological legacies (e.g., coarse woody debris) and the level of local anthropogenic impacts
Very good (A)	Population/occurrence is self-sustaining and would persist if protection from threats were provided	Viable (self sustaining)	Most or all of species targets are viable (very good or good), none are non-viable (poor); ecological interactions appear to mimic historic conditions; anthropogenic impacts absent
Good (B)	Population/occurrence is self-sustaining, but conservation intervention is needed to maintain	Viable (self sustaining but some impairment present)	Most of the species targets are viable (very good or good); none are non-viable (poor); ecological interactions among species are functional but may be impaired
Fair (C)	Restorable	Marginal (could recover is threats are removed)	Less than half of the species targets are viable; ecological interactions impaired
Poor (D)	Non-restorable	Non-viable (would not recover if threats are removed, unless augmented with reintroductions)	Few of the species targets are viable; ecological interactions non-functional
Unknown (E)		No knowledge of population interactions and anthropogenic threats	No knowledge of ecological interactions, anthropogenic threats and general condition

Landscape Context Viability Guidelines

Rank	*General Guidelines*	*Single Species/ Assemblages/ Systems* Consider the intactness of large-scale natural ecological processes and environmental regimes (flow, sediments, flood, drought, etc.) and the levels of fragmentation and species access between and among suitable habitats for metapolulation processes
Very good (A)	Part of an intact natural ecosystem or embedded in a natural matrix	Highly connected to other unimpaired lotic habitats, natural flow and sediment transport regimes intact; >20% natural vegetation in watershed (prairie, wetland, ungrazed grassland - not necessarily original); non-point source impairment not present.
Good (B)	Part of a highly functioning (but not necessarily natural) ecosystem	Moderately connected, hydrologic regime mostly intact (e.g., regulated releases mimic natural flow regime, i.e., allow peak flows and/or prevent unnaturally low flows; <20% natural vegetation in the watershed, but very low levels of urban development; non-point source pollution present, but very low.
Fair (C)	Part of a functioning ecosystem (not very natural)	Moderately fragmented, hydrologic regime restorable but currently altered by retention of peak flow and/or consumption of water causes periodic too low flows; <20% natural vegetation in watershed with moderate amounts of urban development; point source impairment present, moderate levels.
Poor (D)	Part of a non-natural, poorly functioning ecosystem	Highly fragmented, hydrologic regime altered; <20% natural vegetation in watershed with high amounts of urban development; water quality not meeting designated uses under the Clean Water Act (on 303(d) list).

Appendix 4. Aquatic Ecological Systems in the NTPE River/Stream Portfolio Network.

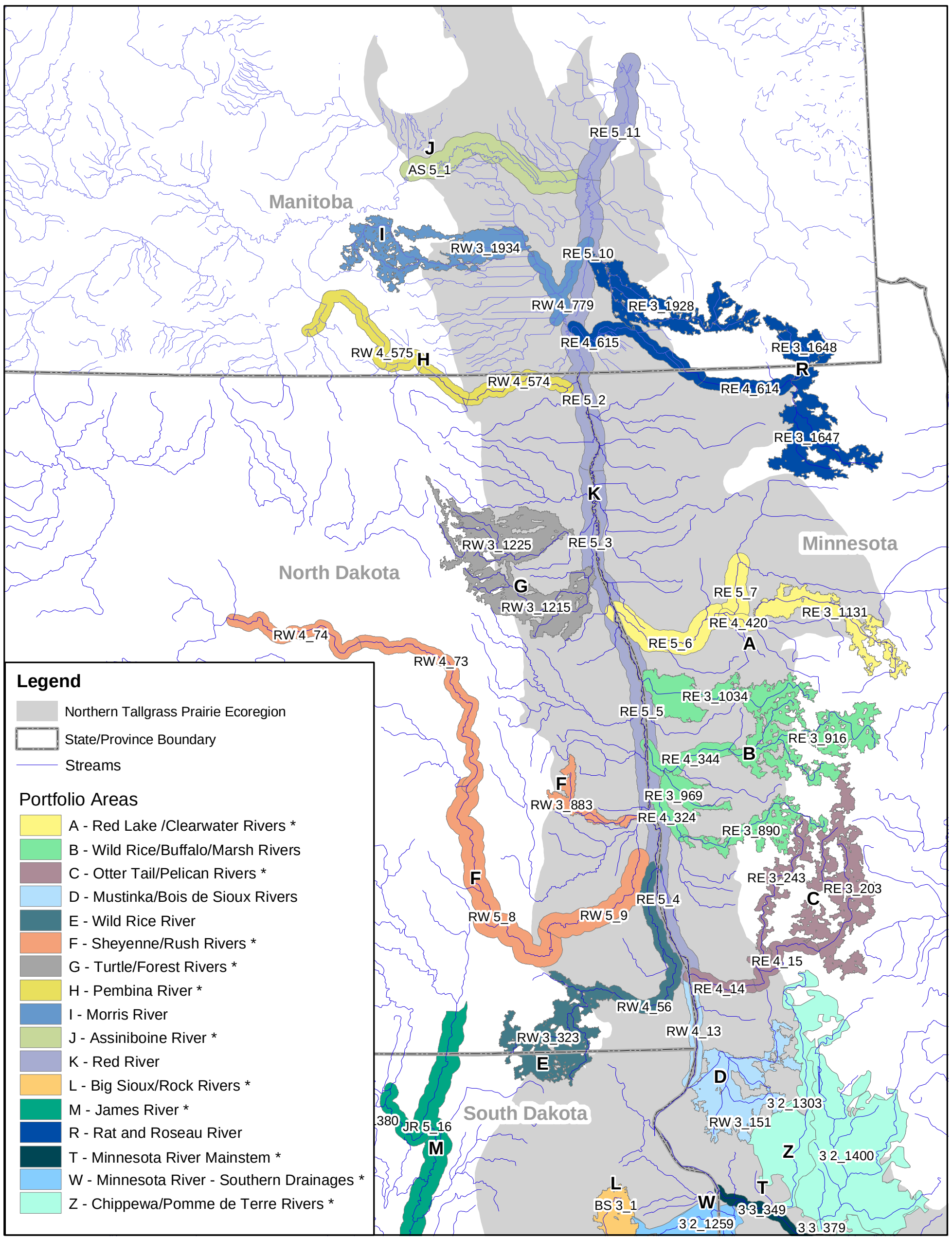


Figure A4.1 AESs selected for inclusion in the NTPE portfolio network (northern portion). AESs have been merged into groups called "portfolio areas." Asterisks indicate the portfolio areas in which 50% or more of the component AESs are ABS class "1" (confirmed ABSs). Details about each portfolio area are provided in the following sections.

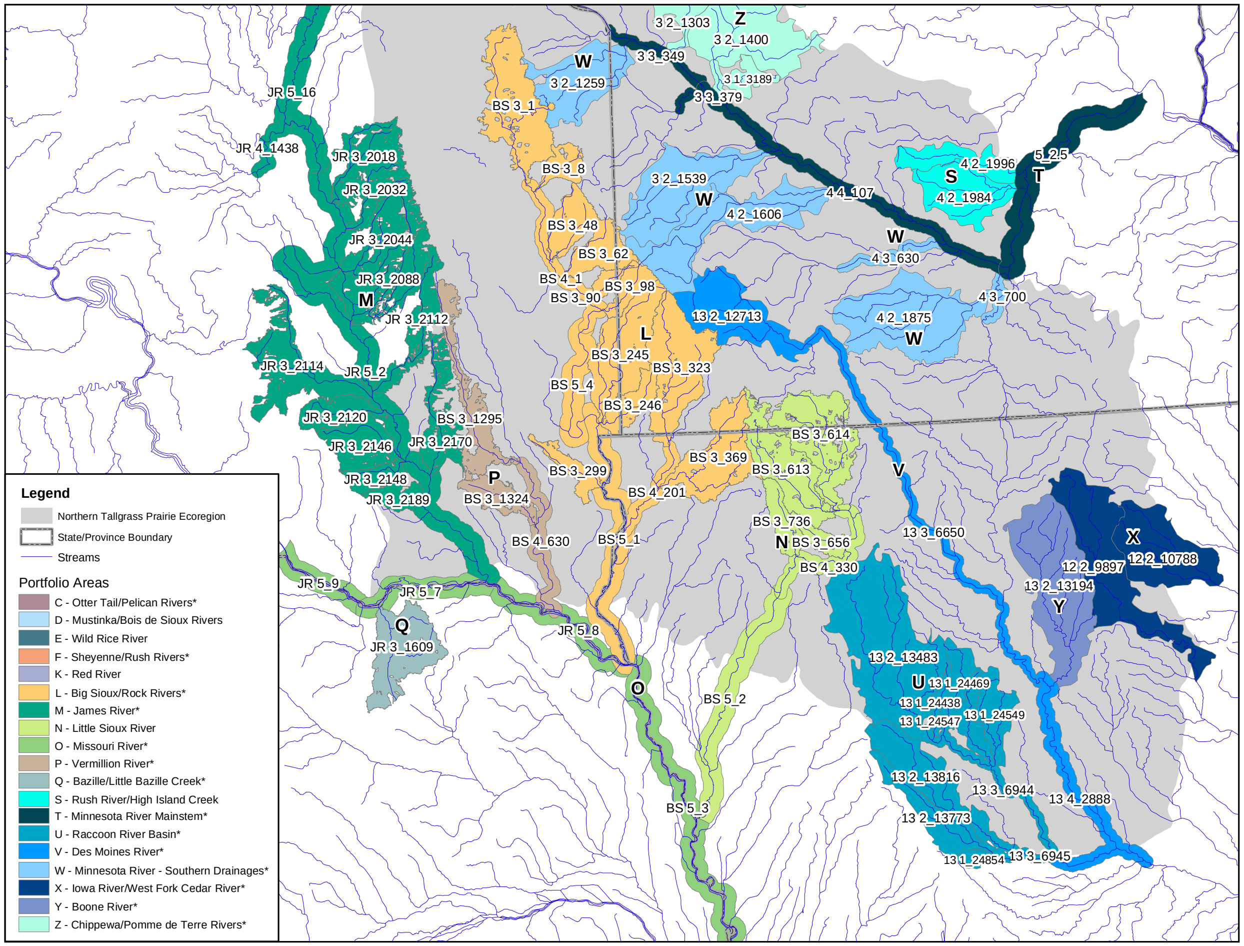
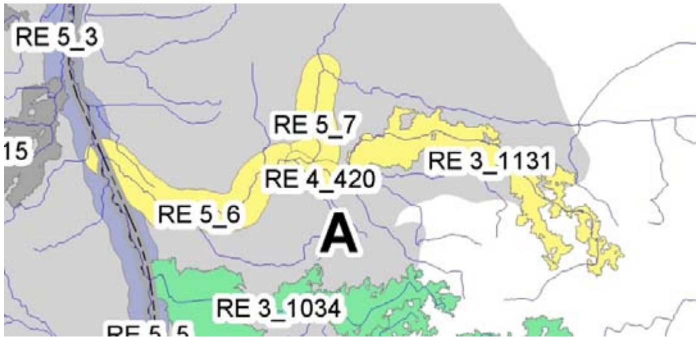


Figure A4.2 AESs selected for inclusion in the NTPE portfolio network (southern portion). AESs have been merged into groups called "portfolio areas." Asterisks indicate the portfolio areas in which 50% or more of the component AESs are ABS class "1" (confirmed ABSs). Details about each portfolio area are provided in the following sections.

Northern Tallgrass Prairie
River and Stream
Portfolio Area Descriptions

A Red Lake /Clearwater Rivers



The **Red Lake / Clearwater River** watershed lies in the eastern Red River ecological drainage unit. The entire Clearwater river basin is encompassed in this portfolio area. However, only the mainstem of the Red Lake River and a 5-km area on either side of the channel is included in the portfolio area. The Red Lake/Clearwater River portfolio area spans a major ecotone. Peat bogs, boreal forest, and lakes cover the headwaters area to the north and east. The headwaters area is underlain by glacial till and outwash up to 400 feet thick. As the Red Lake River flows west it transects beach ridges of glacial Lake Agassiz before flowing across silty clay glacial lake sediments. Historically, this area was covered by tallgrass prairie. Hardwood to mixed northern forest occurs in the south. Elevations range from about 1200 feet in the Itasca Moraine in the southeast to 820 feet at the confluence of the Red Lake River with the mainstem Red River. Evapotranspiration and precipitation are approximately balanced with average precipitation ranging from 18-24 inches.

Targets occurring in this portfolio area include *Acipenser fulvescens* (Lake sturgeon) and two species of the medium river mussel assemblage target, *Ligumia recta* (Black sandshell) and *Lampsilis cardium* (Plain pocketbook). The boulder riffle in channels near the Red Lake and Clearwater confluence create arguably the most important Lake sturgeon-spawning habitat in the basin. Upstream of Red Lake Falls, Minnesota, the Red Lake River has diverse habitat with numerous species. Headwater areas have narrow, forested reaches with gravelly and rocky riffle habitat containing deep pools.

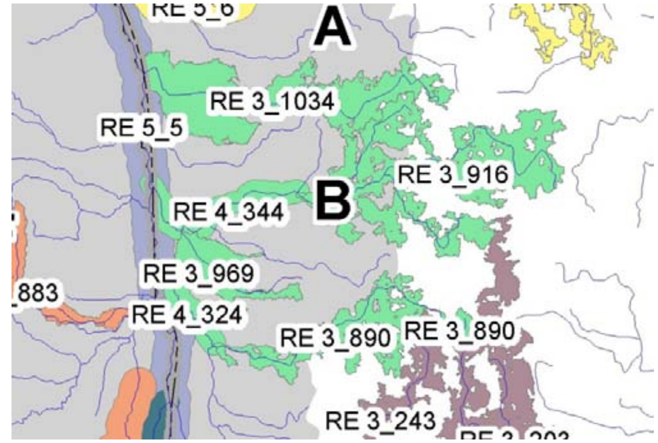
Currently, experts view dam operations as the greatest threat to this portfolio area. However, efforts are currently underway to modify dam structures and operations in ways that would benefit aquatic biodiversity. (For more information, see Chapter 3, Section 3.4).

Detailed information about Red Lake/Clearwater River portfolio area AESs:

Port-folio Area ID	**Aquatic Ecological System (AES) ID**	**System Name**	**Aquatic Ecological System (AES) Type**	**Total Area (HA)**	**Expert Site ID**	**Total Number of Species and Assemblage Targets (post 1994)**	**Percent of Upland in Natural Cover**	**Portfolio Network Category**	**ABS Class (1=con-firmed ABS; 2= possible ABS)**
A	RE 5_7	Red Lake River from the confluence of Thief River to the confluence with the Clearwater River	RE 5 - 7	38424	RE-10	0	12	e	2
A	RE 5_6	Red Lake River from the confluence of the Clearwater River to the confluence with the Red River	RE 5 - 6	78385	RE-10	3	10	d	1
A	RE 4_420	Clearwater River	RE 4 - 2	14566		0	18	f	1
A	RE 3_1131	Clearwater River	RE 3 - 6	80383		2	43	c	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

B Wild Rice/Buffalo/Marsh Rivers (Minnesota)



The **Wild Rice/Buffalo/Marsh River** portfolio area covers the central part of the eastern Red River ecological drainage unit. The portfolio area encompasses portions of the upper basins and lower mainstems of the Sand Hill, Wild Rice, Buffalo, and Marsh Rivers and Felton Creek in Minnesota. Similar geomorphic and hydrologic processes tie these areas together. The poorly integrated headwaters of these basins lie in northern hardwood and mixed northern forest characterized by abundant lakes and wetlands. Farther west, tributaries to these systems coalesce and form discrete channels within the glacial Lake Agassiz plain. Originally, drainage of the lake plain portion of the watershed was nonintegrated, but is now effectively drained by an extensive rectilinear ditch system developed for agriculture. All three of the rivers begin in a forested lake and pothole region developed on glacial till and outwash, transect the complex glacial Lake Agassiz beach ridge system, and then meander across the silty clay glacial lake sediments that were historically covered in tallgrass prairie. Elevations range from over 2000 feet, the highest elevation in western Minnesota, to about 850 feet at the confluence with the Red River. Evapotranspiration and precipitation are approximately balanced with average precipitation ranging from 18-24 inches.

Targets in this portfolio area include *Phoxinus eos* (Northern redbelly dace), *Phoxinus neogaeus* (Finescale dace), *Nocomis biguttatus* (Hornyhead chub), *Notropis heterolepis* (Blacknose shiner), *Notropis anogenus* (Pugnose shiner), and *Fundulus diaphanous* (Banded killifish). Experts particularly noted the biodiversity significance of the portions of rivers and streams in this portfolio area that intersect the beach ridge zones of the former Lake Agassiz. These areas are significant for their coarse substrates and the associated habitat conditions that they provide.

A 1000-year flood damaged the lower reach of the Wild Rice River recently. Headcutting is now occurring from the channelized portion upstream. Farther upstream there is forested corridor, which is in very good condition where the river transects White Earth Indian Reservation.

Between Hawley, Minnesota and the confluence with its south branch, the Buffalo River flows within a unique non-channelized reach. Restoration of lake sturgeon is underway in this reach. Restoration activities in this reach of the river include the removal of a dam at Buffalo River State Park several years ago.

Felton Creek is coldwater spring-fed stream with 20+ species of fish, including Finescale dace and Brook trout. Experts regard this stream as one with significant restoration potential and good prospects for reintroducing much of the native biodiversity.

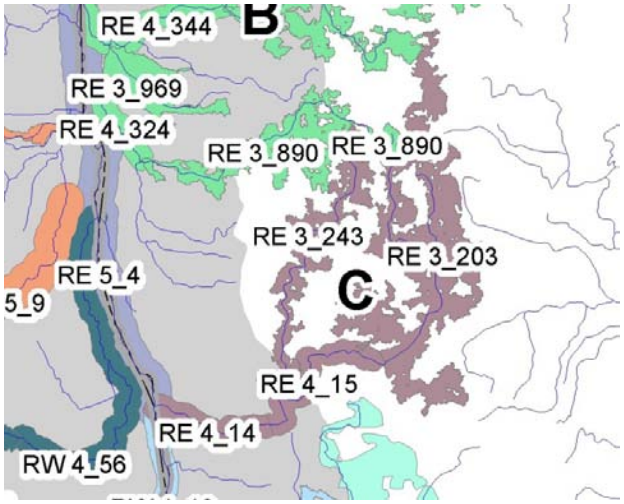
The middle reaches of the Sand Hills River historically networked into a wetland complex, effectively obliterating a mainstem channel. In the past century, five check dams were installed to contain flow. All are currently targeted for modification or removal by local, state and federal agencies. Experts hope that alterations to dams will improve access to headwaters, which have excellent potential for supporting native biodiversity.

Detailed information about Wild Rice/Buffalo/Marsh River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
B	RE 4_344	Wild Rice River	RE 4 - 3	38997		0	10	f	1
B	RE 4_324	Buffalo River	RE 4 - 3	21985		0	7	f	1
B	RE 3_1034	Sand Hill River	RE 3 - 1	102157	RE-17	0	10	e	2
B	RE 3_890	Buffalo River	RE 3 - 32	60368	RE-13	1	22	e	2
B	RE 3_916	Wild Rice River/Marsh River	RE 3 - 6	142513	RE-15	4	49	c	2
B	RE 3_969	Felton Creek	RE 3 - 25	28796	RE-14	1	4	e	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

C Otter Tail/Pelican Rivers



The **Otter Tail and Pelican Rivers** portfolio area hosts the greatest biodiversity in the Red River basin. The two rivers lie in the eastern Red River ecological drainage unit, flowing through relatively intact northern hardwood forest before joining near Fergus Falls, MN. Lakes and wetlands abound in the watershed, with the largest, Otter Tail Lake, covering an area of 13,725 acres and extending to a depth of 120 feet. Numerous chains of lakes and wetlands along the course of the streams and rivers in the watershed provide mixed habitat and ecological conditions that are unique for the Red River watershed. Except for a short reach upstream of the confluence with the Red River, the Otter Tail River and nearly all of its tributaries flow on outwash and irregular glacial till. Because it lies in the southeastern portion of the Red River EDU, this region receives greater yearly rainfall (20-24 inches) than other areas of the basin, and may experience a small surplus of rainfall over evapotranspiration. Elevations range from about 1400 feet in the vicinity of Otter Tail Lake to about 945 feet at the confluence with the Bois de Sioux River at Wahpeton-Breckenridge.

Six target species are known to occur in this portfolio area: *Amia calva* (Bowfin), *Notropis heterolepis* (Blacknose shiner), *Notropis anogenus* (Pugnose shiner), *Fundulus diaphanous* (Banded killifish), *Etheostoma caeruleum* (Rainbow darter), and *Etheostoma microperca* (Least darter).

In the headwaters, the Otter Tail River between Big Pine Lake and Hubble Pond flows in a natural sinuous channel that likely provided historical spawning habitat for Lake sturgeon. Stocking in Otter Tail Lake is expected to result in Lake sturgeon reinvading this stretch of stream for spawning.

A second important section of the Otter Tail is the 20-mile natural flow reach between Fryberg Dam and Central Dam in Fergus Falls. In this reach, diversity increases in downstream direction: least darter, rainbow darter, pugnose shiner, northern hogsucker, bowfin occur, which are unique to the basin.

Experts recognize the Lower Ottertail between Orwell Reservoir and the start of the lower channelized reaches as being among the most important conservation targets in the greater Red River basin. This portion of river hosts a diverse fish and mussel community, including Rainbow darter, Pugnose shiner, Lake sturgeon, and most mussel species. Riparian buffer protection and restoration are considered among the most important conservation measures that need to be taken for protection of this reach. Below this stretch, the river is channelized and highly degraded.

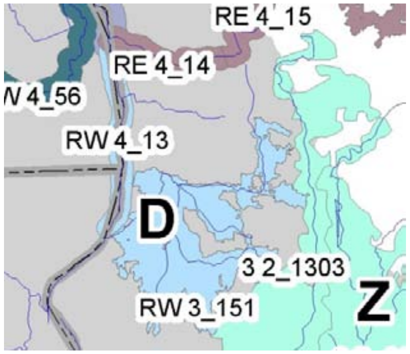
The lower Pelican River, just above the confluence with the Otter Tail has high gradient reaches and boulder and riffle habitat that are thought to provide spawning habitat for Lake sturgeon. Additional data on species composition of this stretch of river are limited.

Detailed information about Otter Tail/Pelican River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
C	RE 4_15	Otter Tail River from Otter Tail Lake to Orwell Dam	RE 4 - 3	31437	RE-07	0	29	d	1
C	RE 4_14	Otter Tail River from Orwell Dam to the confluence with the Red River	RE 4 - 3	24650	RE-09	4	6	d	1
C	RE 3_203	Upper Otter Tail River	RE 3 - 32	149850	RE-06	5	58	d	1
C	RE 3_243	Pelican River	RE 3 - 32	51075	RE-08	4	45	c	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

D Mustinka/Bois de Sioux Rivers



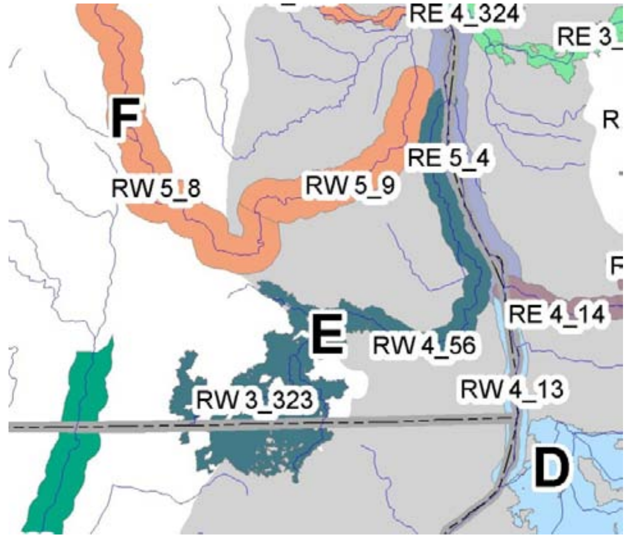
The **Mustinka/Bois de Sioux Rivers** lie in the southern portion of the Red River basin and extend over an area of about 170,000 ha. The Mustinka River, which is a tributary to the Bois de Sioux, has its headwaters in the prairie pothole area of Minnesota. Numerous lakes, ponds, and wetlands with poorly integrated drainage characterize this area. The lower part of the Mustinka basin, along with the Bois de Sioux River, occupy the southernmost part of the glacial Lake Agassiz plain. Much of this area has been ditched for agriculture. Members of the medium river mussel assemblage target group, including *Lampsilis cardium* (Plain pocketbook), and *Ligumia recta* (Black sandshell), have been recorded in this portfolio area. This portfolio area also represents unique system types not otherwise represented in the portfolio. Experts note that if restored and water quality impacts are mitigated, the Mustinka/Bois de Sioux Rivers could provide significant aquatic biodiversity and a unique conservation resource. This region receives greater yearly rainfall (20-24 inches) than other areas of the Red River basin, and may experience a small surplus of rainfall over evapotranspiration in most years.

Detailed information about Mustinka/Bois de Sioux portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
D	RW 4_13	Bois De Sioux River from the confluence with the Mustinka River to the Red River	RW 4 - 3	37031	RW-10	2	17	c	2
D	RW 3_151	Mustinka River	RW 3 - 32	133055		0	5	g	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

E Wild Rice River



The **Wild Rice River (North Dakota)** watershed straddles the central western boundary of the northern tallgrass prairie and the easternmost mixed grass prairie. The portfolio area encompasses only the buffered portions of the river. The headwaters of the Wild Rice River lie in the prairie pothole area of southeastern North Dakota where drainage is poorly integrated and glacial till underlies numerous small lakes, ponds, and wetlands. The river also drains the southern portion of the Sheyenne delta, a large area of fine sand and silt deposited in glacial Lake Agassiz during the latter part of the Pleistocene. The river flows flows north onto the glacial Lake Agassiz plain where it parallels the Red River for about 30 miles before entering the Red River a few miles south of Fargo. The basin covers more than 200,000 ha and receives, on average, about 18-20 inches of precipitation annually.

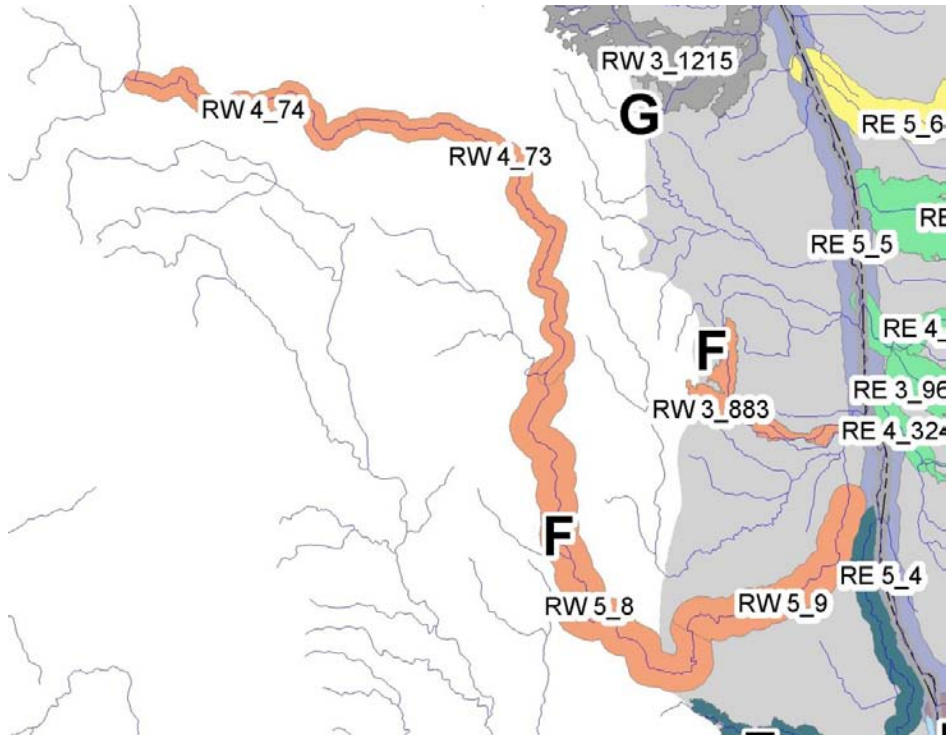
Although no species and assemblage level targets were found in these systems, they were included in the portfolio because they represented unique system types otherwise not captured in the portfolio. In addition, this system forms a linkage between two landscape priority areas (Otter Tail and Prairie Coteau) identified in previous ecoregional plans.

Detailed information about Wild Rice River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
E	RW 4_56	Wild Rice River from the confluence with Elk Creek to the Red River	RW 4 - 5	72267		0	3	g	2
E	RW 3_323	Upper Wild Rice River	RW 3 - 25	132964		0	21	g	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

F Sheyenne/Rush Rivers



The **Sheyenne River** flows in a narrow watershed, with headwaters in the Northern Mixed Grass Prairie in the westernmost portion of the region. The Sheyenne River basin covers about 360,000 ha, making it the largest watershed that contributes to the Red River, although the average flow of the river is smaller than several other tributaries. Only the channel and adjacent buffered areas constitute the portfolio area. Since the Pleistocene, the Sheyenne River has incised a prominent valley through the eastern North Dakota till plain, with up to 300 feet of relief in some areas. The river flows much less now, having at prior times carried glacial melt water and flow from the expansive Devils Lake basin. Sediments transported by the river and deposited in glacial Lake Agassiz as an underflow fan created the Sheyenne delta, a terrestrial portfolio landscape. The Sheyenne River has cut down into Cretaceous-age shale that underlies Pleistocene glacial sediments and flows through much of its course on recent alluvial deposits. The baseflow of the river increases significantly from spring discharge that occurs where the river transects the extensive unconfined aquifer that underlies the Sheyenne delta. Near Kindred, North Dakota, the river enters the glacial Lake Agassiz plain and parallels the Red River for about 50 miles before its confluence at Argusville. Average annual rainfall ranges from 16 inches in the upper western end of the watershed to more than 20 inches in the Red River Valley. Evapotranspiration exceeds rainfall throughout the basin. The Rush River watershed is much smaller (33,000 ha) and covers only areas in the Northern Tallgrass Prairie Ecoregion. Nearly the entire Rush River basin lies within the glacial Lake Agassiz plain.

Three targets are found in the portfolio area: *Phoxinus eos* (Northern redbelly dace), the Lower Sheyenne River Ephemeroptera and Tricoptera assemblage, and the Medium River Mussel assemblage.

West of the Spirit Lake Indian Reservation, the upper Sheyenne has good stream habitat with pools and flow between pools in most years. This upper reach has prairie banks that are generally not farmed because of rocky, steep slopes. Further downstream the

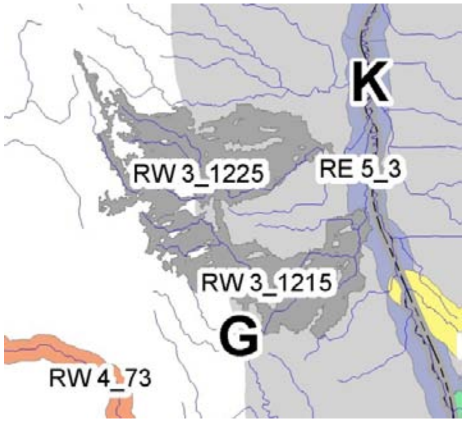
Sheyenne flows are regulated by Lake Ashtabula, and cropland runoff, grazing, and wastewater discharge diminish water quality. The Sheyenne River between Fort Ransom and Lisbon provides the best representative reach of the middle Sheyenne. The valley of the Sheyenne River through the Sheyenne delta hosts some of largest and best hardwood forest of North Dakota, although high sediment load, BOD, and nutrients affect water quality.

Detailed information about Sheyenne/Rush River portfolio area AESs:

Port-folio Area ID	**Aquatic Ecological System (AES) ID**	**System Name**	**Aquatic Ecological System (AES) Type**	**Total Area (HA)**	**Expert Site ID**	**Total Number of Species and Assemblage Targets (post 1994)**	**Percent of Upland in Natural Cover**	**Portfolio Network Category**	**ABS Class (1=con-firmed ABS; 2= possible ABS)**
F	RW 5_9	Sheyenne River from the upper end of the Sheyenne delta to the confluence with the Red River	RW 5 - 9	79625	RW-12	0	24	a	1
F	RW 5_8	Sheyenne River from Baldhill Creek (Lake Ashtabula) to the upper end of the Sheyenne delta	RW 5 - 8	143908	RW-09	0	15	a	1
F	RW 4_74	Sheyenne River from the confluence with Big Coulee Creek to Warwick Dam	RW 4 - 1	52683	RW-14	1	31	a	1
F	RW 4_73	Sheyenne River from Warwick Dam to the confluence with Baldhill Creek (Lake Ashtabula)	RW 4 - 1	80634	RW-15	1	11	a	1
F	RW 3_883	Rush River	RW 3 - 25	32754		1	2	c	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

G Turtle/Forest Rivers



The **Turtle/Forest River** watersheds lie in the western Red River ecological drainage unit. These small basins cover about 250,000 hectares and have poorly integrated drainage that has its headwaters in the glacial till plain of eastern North Dakota. About two-thirds of the watersheds lie within the Northern Tallgrass Prairie Ecoregion, with the balance within the eastern margin of the Northern Mixed Grass Ecoregion. The rivers flow westward through a complex of deltas, underflow deposits, outwash, and beach ridges related to glacial Lake Agassiz. As the rivers flow across the glacial Lake Agassiz plain, they acquire dissolved salt from groundwater slowly discharged from underlying bedrock aquifers, for which the spatial extent of this process is unique for the Red River region. As in other areas of the western Red River ecological drainage unit, the Turtle/Forest River basins experience a small deficit of rainfall (about 17 inches per year) over evapotranspiration.

Targets found in this portfolio area include *Nocomis biguttatus* (Horneyhead chub) and *Campostoma oligolepis* (Largescale stoneroller). Although not considered extremely high quality, these drainages were selected for inclusion in the portfolio map because they are some of the best remaining examples of the system types they represent and they flow through large tracts of state parklands and preserves.

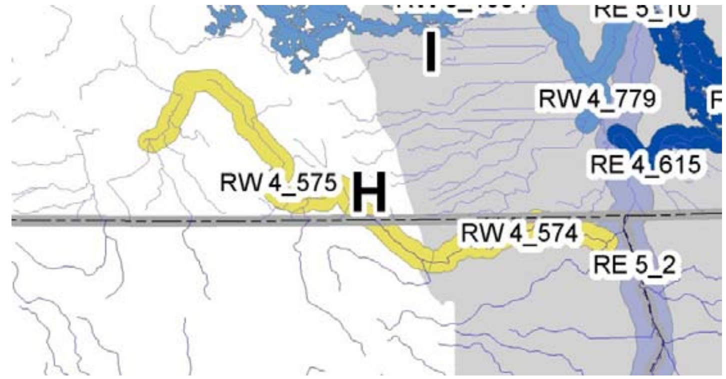
Detailed information about Turtle/Forest River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
G	RW 3_1225	Forest River	RW 3 - 1	125979		2	3	c	2
G	RW 3_1215	Turtle River	RW 3 - 1	120342	RW-07	0	5	d	1

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

H Pembina River

The **Pembina River** portfolio area extends along the buffered portion of the river's main stem from its confluence with the Red River to Rock Lake, Manitoba. The river flows through areas of diverse geology, with the upper portion in glacial tills of the prairie pothole region, the middle reach flowing through a narrow glacial outflow valley with up to 300 feet of relief, and final portion entering the glacial Lake Agassiz plain near the Red River. In its middle reach the Pembina River transects bedrock of Cretaceous shale and has sufficient gradient and discharge to form riffles and pools, thus creating an unique ecological niche for the region. Precipitation averages about 18 inches per year in the basin, with evapotranspiration slightly exceeding precipitation.



Conservation targets in this portfolio area include *Acipenser fulvescens* (Lake sturgeon) and *Lota lota* (Burbot). Experts noted that the conservation value of this system lies in the unique physical characteristics of the river, which sets it apart from other rivers in the region. In addition, the Pembina currently supports populations of threatened fish species and riparian areas support a number of provincially rare plant species. The lower parts of the river were historic spawning grounds of Lake sturgeon, and at one time likely hosted large species diversity. Portions of the watershed lie within state and provincially protected lands.

Water diversion in Canada reduces historical flows and diminishes the conservation potential of the Pembina River. In addition, the river is impaired by episodic sediment loading.

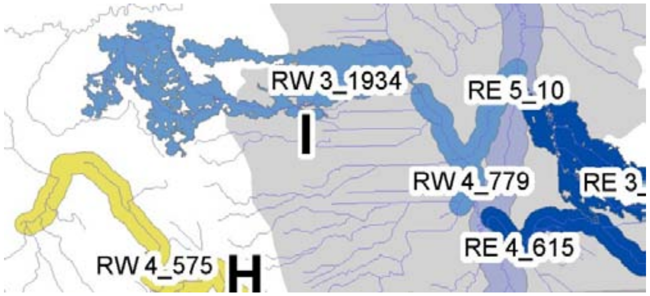
Detailed information about Pembina River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
H	RW 4_575	Pembina River from Rock Lake to the confluence with South Pembina River	RW 4 - 1	82218	RW-04	1	50	a	1

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
H	RW 4_574	Pembina River from the confluence with the South Pembina River to the Red River	RW 4 - 1	39058	RW-03	2	9	a	1

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

I Morris River



The **Morris River** has headwaters in the southcentral Manitoba till plain, which lies west of the Northern Tallgrass Prairie Ecoregion. To accommodate agriculture, drainage in the headwaters has been enhanced and integrated by ditches. To the east where the Morris River flows onto the glacial Lake Agassiz plain, both tributaries and the mainstem are straightened and channelized. The Morris River enters the Red River about 25 miles downstream from the U.S.-Canada border.

Although this system is highly altered and does not support any target species, it was selected for inclusion in the portfolio because it represented a unique system type otherwise not captured in the portfolio network. In addition, the portfolio area includes Lyle Creek, which was noted by experts for its conservation potential.

Detailed information about Morris River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
I	RW 4_779	Morris River from the confluence of the Boyne River to the Red River	RW 4 - 2	47718		0	11	g	2
I	RW 3_1934	Morris River headwaters including Lyle Creek	RW 3 - 6	133465	RW-01	0	19	g	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

J Assiniboine River

The **Assiniboine River** forms a large downstream tributary to the Red River, with the confluence of the two rivers at Winnipeg. The portfolio reach includes only the channel and buffered margins on 5 km on either side of the river as it flows through the Northern Tallgrass Prairie Ecoregion. The Assiniboine River has its headwaters far to the west in southeastern Saskatchewan and in the Riding Mountain region of southwestern Manitoba. Glacial till and outwash underlie most of the Assiniboine River watershed. The portfolio channel flows across the expansive Assiniboine delta near Portage la Prairie before entering the Lake Agassiz plain. Many parts of the Assiniboine delta are cultivated and irrigated. Rainfall averages about 18 inches per year in the region, with evapotranspiration approximately equal to rainfall.

Targets found in the portfolio area include *Rana pipens* (Northern leopard frog), *Chelydra serpentine* (Snapping turtle), *Ichthyomyzon castaneus* (Chestnut lamprey), *Acipenser fulvescens* (Lake sturgeon), *Macrhybopsis storeriana* (Silver chub), *Notropis blennius* (River shiner) and the Large River Mussel assemblage. The lower Assiniboine River probably hosts one of the last intact mussel assemblages in the river basin and contains existing walleye and sauger spawning habitat, along with potential sturgeon spawning/rearing habitat.

Dam operations and crop production practices were identified as the top threats to this system.

Detailed information about Assiniboine River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
J	AS 5_1	Assiniboine River from Portage la Prairie to the Red River	AS 5 - 1	121316	AS-02	7	19	a	1

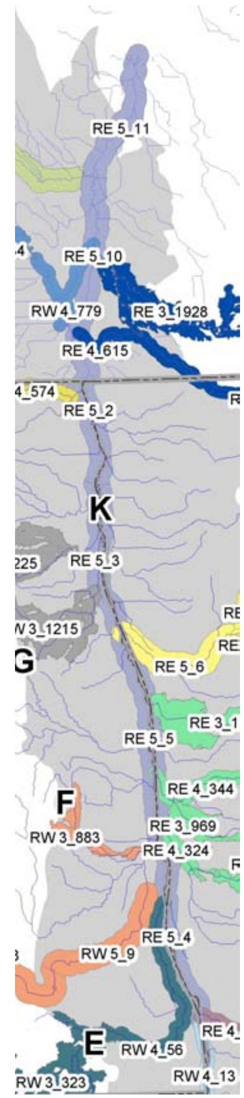
***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

K Red River

The entire buffered length of the **Red River** channel extending from southern North Dakota to southern Manitoba comprises a series of portfolio reaches. The river flows on silty clay sediments deposited by glacial Lake Agassiz during the Late Pleistocene, about 9,000 years ago. Hydraulic gradients north of Grand Forks become very small, falling to 1.5 inches per mile as the river enters Canada. The Red River transports a large suspended sediment load and meanders extensively within a very young and narrow flood plain. A large gradient in rainfall occurs across the basin and the river serves as the boundary between the Red River east and west ecological drainage units, as described in this report.

The upper reach of Red hosts boulder/rock habitat that supports numerous target and riffle species including stocked *Acipenser fulvescens* (Lake sturgeon), *Platygobio gracilis* (Flathead chub*), Moxostoma valenciennesi (Greater redhorse), Ichthyomyzon castaneus and* I. unicuspis (chestnut and silver lamprey), *Ictiobus cyprinellus* (Bigmouth buffalo), *Lota lota* (Burbot), and two mussel assemblage types. The middle Red River near Halstad has an unimpounded reach known as "Goose Rapids" that is characterized not by rapids, but larger substrate. This section of the river includes all mainstem Red River target species. Under low flow conditions there could be potential for reproduction of riffle species in this relatively rocky portion of the Red River. The lower reach of the Red River has the potential for the re-introduction of sturgeon runs.

Captured within the boundaries of the Red River portfolio area is the lower portion of the **Two Rivers** system**,** a system that lies within the extreme northwestern part of Minnesota and south and west of the Roseau River. Only a short segment and buffer zone near the river's confluence with the Red River is included as a portfolio reach. The Two Rivers basin has its headwaters in the beaches and shore deposits of eastern glacial Lake Agassiz. Much the The Nature Conservancy's Tallgrass Aspen Parkland Preserve lies in the upper part of the watershed. Drainage is poorly integrated in the headwaters, although agricultural ditches have connected and drained glacial interbeach marshes and bogs in many areas. Downstream, the rivers and tributaries on the glacial lake plain have been extensively straightened and channelized.



Detailed information about Red River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
K	RE 5_10	Red River from the confluence with the Roseau to the confluence with the Assiniboine	RE 5 - 8	83670	RE-22	4	13	e	2
K	RE 5_11	Red River from the confluence with the Assiniboine River to Lake Winnipeg	RE 5 - 9	74589	RE-22	2	54	e	2
K	RE 5_2	Red River from the Drayton Dam to the confluence of the Roseau River	RE 5 - 2	86723	RE-22	0	9	e	2
K	RE 5_3	Red River from the confluence of the Red Lake River to Drayton Dam	RE 5 - 3	82649		0	7	f	1
K	RE 5_4	Red River from the confluence of the Otter Tail and Bois de Sioux to the confluence with the Sheyenne	RE 5 - 4	100442.	RE-11	0	5	e	2
K	RE 5_5	Red River from the confluence of the Sheyenne to the confluence of the Red Lake River	RE 5 - 5	113305	RE-16	6	6	a	1

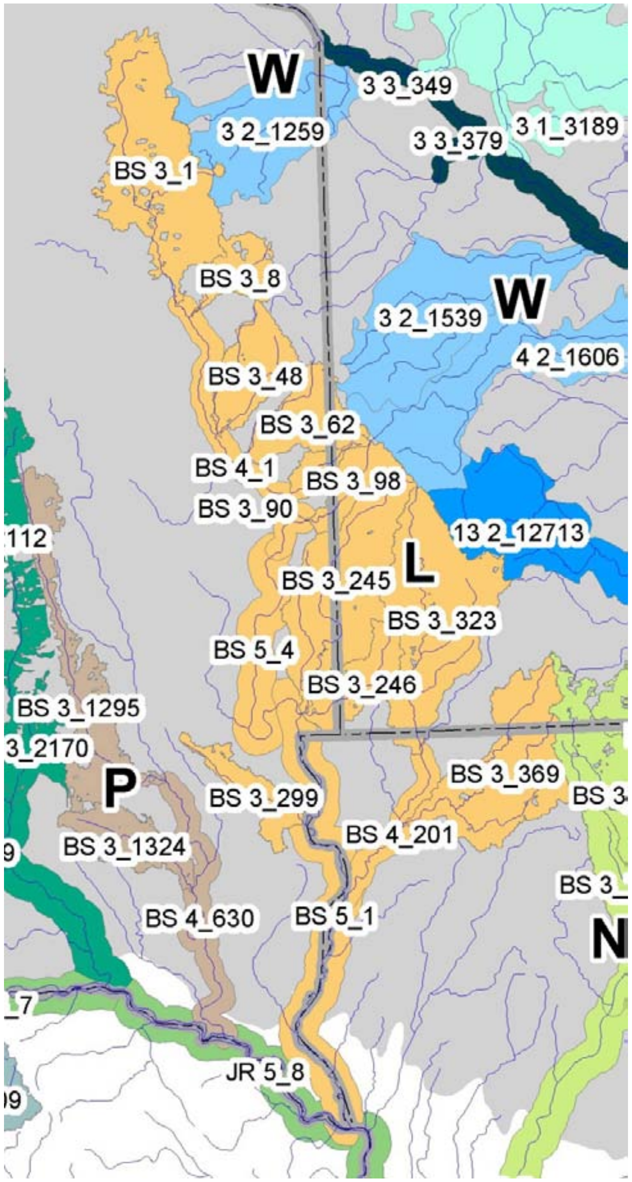
***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

L Big Sioux/Rock Rivers

This portfolio area includes the mainstems of the Big Sioux and Rock Rivers, and numerous tributary streams to these systems in southeastern South Dakota, southwestern Minnesota and northwestern Iowa. The streams and rivers of these basins flow primarily through coarse glacial till, occasionally interrupted by outcrops of Sioux quartzite. Stream substrates are primarily sand and silt with occasional rocky outcrops. A quartzite outcrop at Sioux Falls, South Dakota acts as a natural barrier to fish movement. Several low-head dams north of Sioux Falls, and the 5-m high Klondike dam south of Sioux Falls are also barriers to migration except during floods.

A total of 14 targets are captured in this portfolio area, including *Emydoidea blandingii* (Blanding's Turtle), six fish species, one mussel species, three fish assemblages and one mussel assemblage. Experts noted the important role this basin plays in supporting populations of the federally endangered *Notropis Topeka* (Topeka shiner). In addition, occurrences of *Phoxinus erythrogaster* (Southern Redbelly Dace) represent the extreme northwestern distribution of this species. Because these basins are heavily used for agriculture, less than 10% of most of these systems have natural vegetative cover (i.e., grasses and forbs) in the uplands. A narrow band of forest, frequently interrupted by pastures and cropland, marks riparian areas.

Experts noted that crop and livestock production practices, including stream channelization and groundwater withdrawal were the primary threats facing this portfolio area.



Detailed information about Big Sioux/Rock River portfolio area AESs:

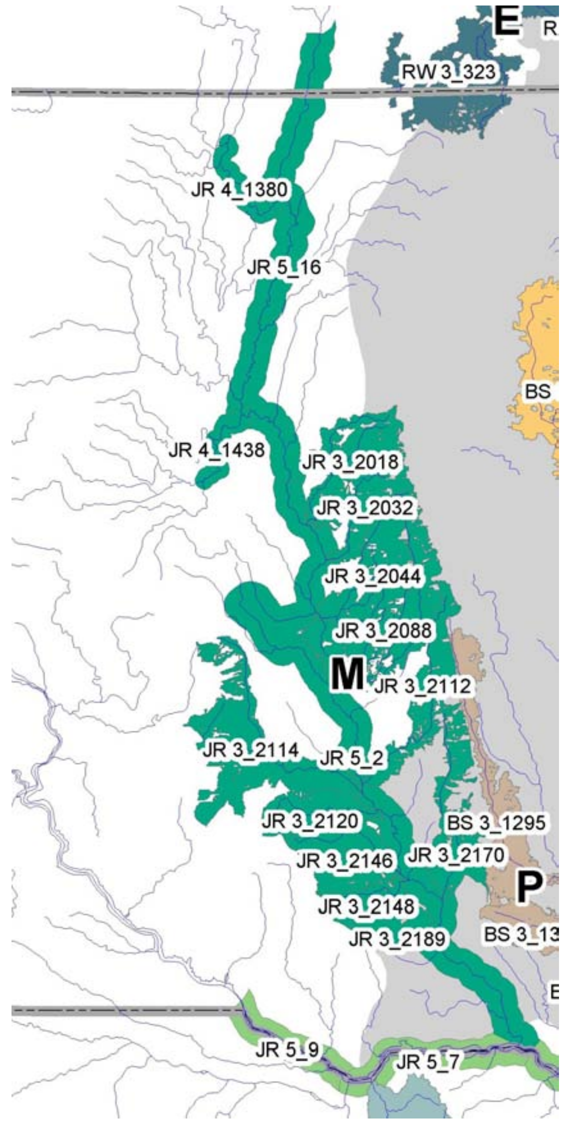
Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
L	BS 5_4	Upper Big Sioux River - from Egan to Sioux Falls	BS 5 - 4	74102	BS-01	3	5	a	1
L	BS 5_1	Lower Big Sioux River - from Sioux Falls to the confluence with the Missouri River	BS 5 - 1	166303	BS-19	10	18	a	1
L	BS 4_1	Big Sioux River	BS 4 - 1	63604	BS-01	4	11	c	2
L	BS 4_201	Rock River	BS 4 - 1	36588	BS-22	4	6	b	2
L	BS 3_323	Rock River Headwaters, Chanarambie Creek, Elk Creek, Poplar Creek	BS 3 - 1	146496	BS-20	8	3	a	1
L	BS 3_98	Willow Creek	BS 3 - 1	29848	BS-18	4	3	a	1
L	BS 3_90	Spring Creek	BS 3 - 1	16536	BS-17	2	3	d	1
L	BS 3_8	Hidewood Creek	BS 3 - 1	28636	BS-13	1	4	a	1
L	BS 3_299	Beaver Creek	BS 3 - 3	32122	BS-23	7	5	a	1
L	BS 3_62	Medary Creek, Deer Creek	BS 3 - 1	52041	BS-06	3	4	a	1
L	BS 3_369	Little Rock River	BS 3 - 1	120780	BS-21	6	1	a	1
L	BS 3_246	Beaver Creek, Lone Rock Creek	BS 3 - 1	41361	BS-10	2	2	a	1
L	BS 3_245	Split Rock Creek, Pipestone Creek, West Pipestone Creek	BS 3 - 1	126513	BS-07	6	3	a	1
L	BS 3_48	Sixmile Creek, North Deer Creek	BS 3 - 1	51295	BS-11	2	5	a	1
L	BS 3_1	Big Sioux Headwaters, Stray Horse Creek, Willow Creek, Gravel Creek	BS 3 - 1	148813	BS-14	4	7	a	1

M James River

The James River portfolio area encompasses most of the lower James River basin in eastern South Dakota. Flowing north to south through gently undulating ground moraines interspersed with drift, the drainage is bounded by the Missouri and Prairie Coteaus on the west and east sides of the basin, respectively. The Sand Lake National Wildlife Refuge lies in the northernmost reaches of the portfolio area, just south of the ND/SD border. At its lower end, the basin crosses into rich agriculture land used primarily for the production of wheat and corn. In most tributary systems, only about 3% of upland areas are in natural vegetative cover. Basin streams are mostly moderate gradient systems with flashy flows that may become intermittent in dry years. The mainstem of the lower James is a low gradient system, approximately 50 to 80 feet wide and 3 to 10 feet deep. Stream and river substrates are primarily sand, clay and gravel till. Springs along numerous tributary streams provide critical flow conditions and thermal refugia during adverse climatic conditions. Historically, spring flows were sufficient to provide perennial flow in most middle and lower basin tributaries.

Eight targets are found in this portfolio site, including *Notropis topeka* (Topeka shiner), *Cycleptus elongatus* (Blue sucker), and *Lontra canadensis* (River otter). The other five targets are turtle, mussel and fish assemblages.

Again, experts identified crop production practices, including groundwater withdrawal, as the primary threat to these systems.

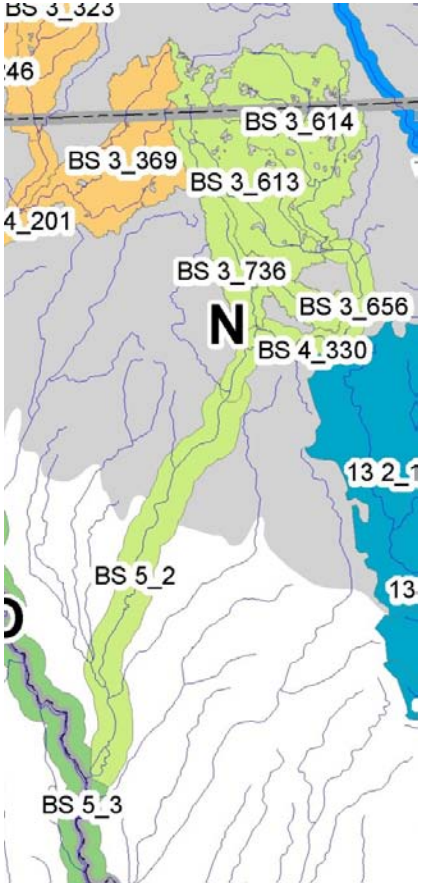


Detailed information about James River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
M	JR 5_16	Middle James River - Dakota Lake Plain segment - from Oakes, ND to the Beadle/Spink county line in SD	JR 5 - 3	198812	JR-16	0	11	c	2
M	JR 5_2	Lower James River - from the Beadle/Spink county line in SD to the confluence with the Missouri River	JR 5 - 2	309392	JR-01	6	9	a	1
M	JR 4_1438	Turtle Creek	JR 4 - 2	25473		0	11	g	2
M	JR 4_1380	Elm River	JR 4 - 1	30689		1	8	c	2
M	JR 3_2032	Shue Creek	JR 3 - 1	41882	JR-05	3	n/a	a	1
M	JR 3_2148	North Branch Dry Creek	JR 3 - 13	29581	JR-02	3	n/a	a	1
M	JR 3_2170	Wolf Creek	JR 3 - 13	70804	JR-13	4	6	a	1
M	JR 3_2044	Pearl Creek, Middle Pearl Creek, South Fork Pearl Creek	JR 3 - 44	73274	JR-10	3	n/a	a	1
M	JR 3_2112	Rock Creek	JR 3 - 13	62819	JR-04	3	n/a	a	1
M	JR 3_2189	Lonetree Creek	JR 3 - 13	26156	JR-06	3	n/a	a	1
M	JR 3_2120	Enemy Creek	JR 3 - 13	45608	JR-08	3	n/a	a	1
M	JR 3_2088	Redstone Creek	JR 3 - 44	107504	JR-12	3	n/a	a	1
M	JR 3_2146	Twelvemile Creek, Pony Creek	JR 3 - 13	69053	JR-11	3	n/a	a	1
M	JR 3_2114	Firesteel Creek	JR 3 - 13	133335	JR-07	3	n/a	a	1
M	JR 3_2018	Foster Creek	JR 3 - 1	73627	JR-17	0	n/a	e	2

N Little Sioux River

The Little Sioux River portfolio area includes the entire mainstem of the Little Sioux in northwest Iowa, and the mainstem and tributary streams in the uppermost part of the basin in northwest Iowa and southwest Minnesota. Three targets occur in this portfolio area: *Phoxinus erythrogaster* (Southern redbelly dace), the Large River Native Mussel Assemblage, and the Perennial Flow/Groundwater Contact Native Fish Assemblage. Experts noted that this system is relatively rich in mussel and fish fauna, noteworthy for its generally high water quality, and valuable for the associated calcareous fens in the riparian and upland areas. One expert identified this system as one of only three streams in western Iowa that possess characteristics for conservation. The primary threat to aquatic systems of this basin is non-point source pollution, including sediment and nutrient runoff, particularly in the upper basin. In addition, increased gravel mining in upland areas and increased production of genetically modified crops pose future threats.

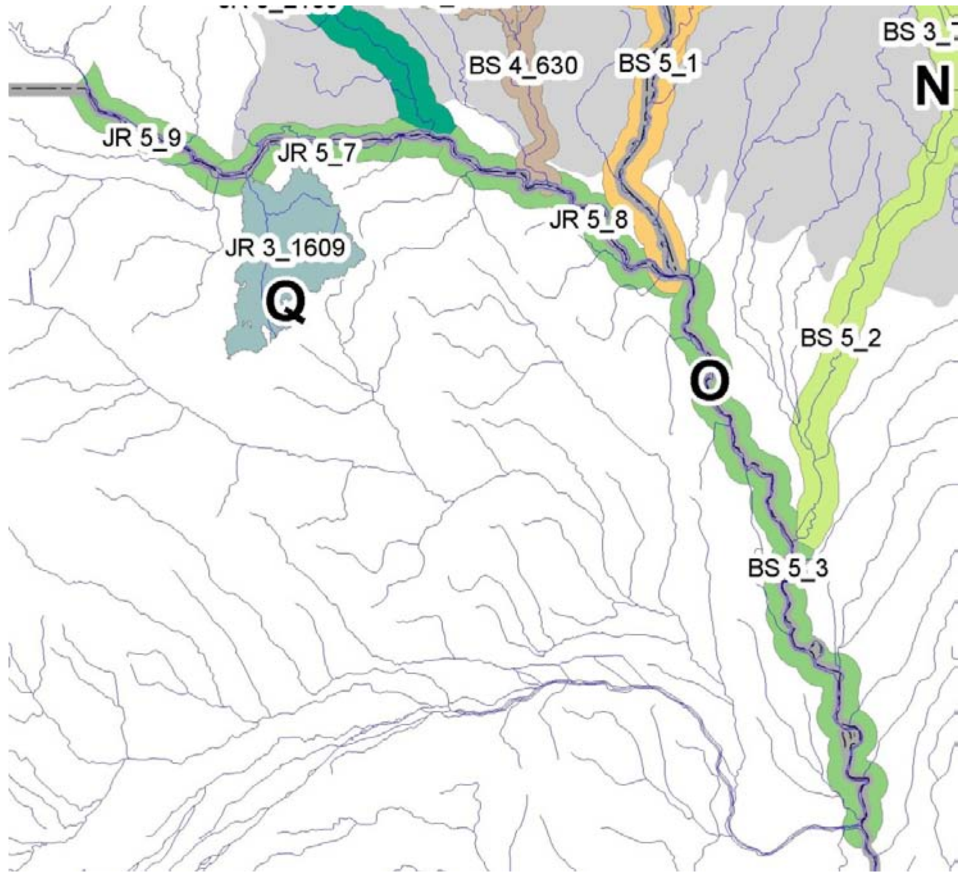


Detailed information about Little Sioux River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
N	BS 5_2	Little Sioux River	BS 5 - 2	133949		1	9	f	1
N	BS 4_330	Little Sioux River	BS 4 - 1	58667	BS-02	4	11	a	1
N	BS 3_613	Stony Creek	BS 3 - 1	108705		1	3	c	2
N	BS 3_614	West Fork Little Sioux River	BS 3 - 1	126185		2	9	c	2
N	BS 3_656	Willow Creek	BS 3 - 1	24332		1	1	c	2
N	BS 3_736	Waterman Creek	BS 3 - 1	36068		1	2	c	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

O Missouri River



The mainstem of the Missouri River borders the southwestern edge of the Northern Tallgrass Prairie Ecoregion. Flowing in a generally east/southeasterly direction, this section of the river includes Lewis and Clarke Lake, Gavins Point dam, a 50-mile unchanelized reach, and the beginning of the channelized portion of the lower Missouri River, near Sioux City, Iowa. As such, this section marks a zone of transition from the upper impounded portion of the river to the lower channelized portion of the river, and includes one of the least altered stretches of river remaining in the basin. In the section of the river between Gavins Point Dam and Sioux City (the unchannelized reach), nine species and assemblage targets are found: *Lontra canadensis* (river otter), *Scaphirhynchus albus* (pallid sturgeon), *Polyodon spathula* (paddlefish), *Cycleptus elongates* (blue sucker), *Macrhybopsis gelida* (sturgeon chub), *Macrhybopsis meeki* (sicklefin chub), the Large River Turtle Assemblage and the Mainstem Lower Missouri River Native Fish Assemblages (Shallow and Deep Water). The conservation value of this river includes its role in providing large river habitat for numerous native species, movement corridors between and among tributary streams, and its dual designation as a National Wild and Scenic River and the National Park Service's Missouri National Recreation River.

The primary threats to this portfolio area include dam and reservoir operations, bank stabilization efforts, primary home development, alien/invasive species and incompatible management for non-target species.

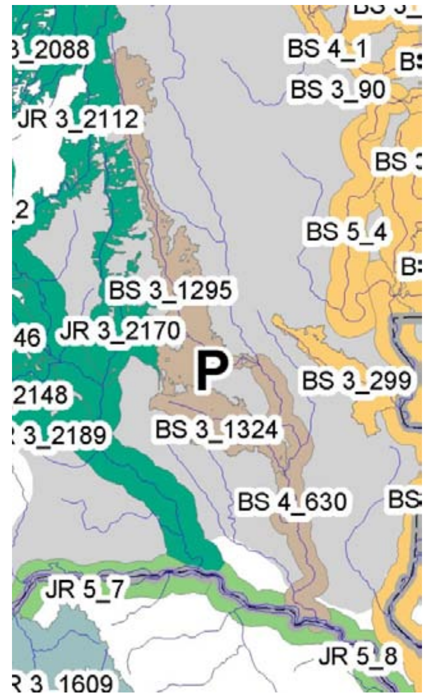
Detailed information about Missouri River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
O	BS 5_3	Missouri River - from Sioux City Iowa to the Platte River	BS 5 - 3	206719		2	18	f	1
O	JR 5_9	Missouri River (2) from Fort Randall Dam to the confluence with the Niobrara River	JR 5 - 9	49419	JR-15	9	67	a	1
O	JR 5_8	Missouri River (1) from Gavins Point Dam to confluence with the Big Sioux River in Sioux City, IA	JR 5 - 8	95515	JR-14	9	30	a	1
O	JR 5_7	Missouri River/Lewis and Clarke Lake - from Niobrara confluence to Gavins Point Dam	JR 5 - 7	71096		3	61	c	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

P Vermillion River

The Vermillion River portfolio area encompasses the West Fork of the Vermillion River, Turkey Ridge Creek, and the lower mainstem of the Vermillion River in southeastern South Dakota. Stream habitats in the basin are characterized as low to moderate gradient with substrates consisting of sand, clay and gravel. Predominant land use within the drainage is row crop agriculture and pastureland; less than 3% of the upland areas in the portfolio site are in natural vegetative cover. The Vermillion River mainstem is flood prone, possibly due to extensive drainage of basin wetland systems and channelization in the lower 20 miles of the mainstem river.



One target species and species assemblage occur in the basin: *Notropis topeka* (Topeka shiner) and the Perennial Flow/Groundwater Contact Native Fish Assemblage. In the portfolio area, the West fork of the Vermillion River and Turkey Ridge Creek were noted by experts for their value in providing habitat for a good population of headwater tributary fish species. Both were identified for the high frequency of Topeka shiner occurrences and both were considered very important to sustaining viable populations of this federally endangered species.

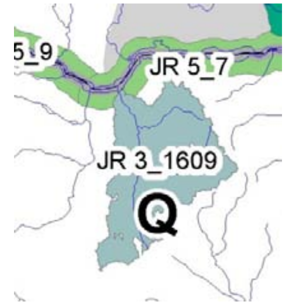
Predominant threats to this portfolio area include crop and livestock production practices including groundwater withdrawal, stream and river channelization, and conversion of untilled land to agriculture production.

Detailed information about Vermillion River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
P	BS 4_630	Vermillion River	BS 4 - 4	64770		1	11	c	2
P	BS 3_1324	Turkey Ridge Creek	BS 3 - 3	42230	BS-04	2	4	a	1
P	BS 3_1295	West Fork Vermillion River	BS 3 - 3	86515	BS-03	2	n/a	a	1

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

Q Bazille/Little Bazille Creek



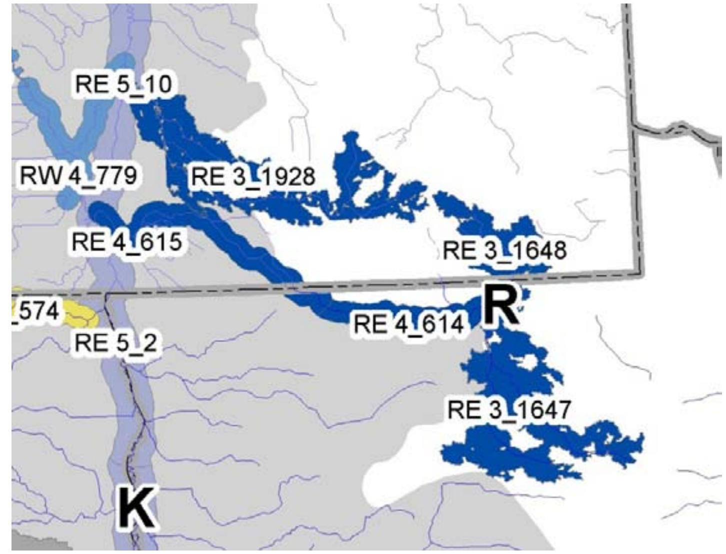
This portfolio area includes the entire Bazille Creek drainage, a small stream basin that drains in a northeasterly direction through northeastern Nebraska before emptying directly into the Missouri River at Lewis and Clarke Lake. This basin is unique in that the stream flows through a landscape consisting of partially untilled, native grassland. The Santee Sioux Indian Reservation straddles the lower half of the portfolio area. Stream substrates consist of coarser material than most streams in the area due to limestone and glacial geological features. Targets include *Notropis topeka* (Topeka shiner), *Percina maculata* (blackside darter), and the Perennial Flow/Groundwater Contact Native Fish Assemblage as well as the Lower Missouri River Native Fish Assemblage (Shallow Water). This system is also notable as a zone of sympatry for several non-target species, including *Rhinichthys atratulus* (Blacknose dace), *Rhinichthys cataractae* (Longnose dace), *Etheostoma exile* (Iowa darter) and *Etheostoma nigrum* (Johnny darter). This system has been impacted in the recent past by direct water withdrawal from the stream for irrigation.

Detailed information about Bazille/Little Bazille Creek portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
Q	JR 3_1609	Bazile Creek	JR 3 - 2	114001	JR-18	4	n/a	d	1

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

R Rat and Roseau Rivers



The **Roseau River** watershed lies in the northern part of the eastern Red River ecological drainage unit. Most of this portfolio basin covers areas outside the Northern Tallgrass Prairie Ecoregion, with its headwaters in glacial lake-plain wetlands, peat bog, and boreal forest. The entire basin, which covers about 200,000 hectares, overlies glacial sediments. These sediments consist mostly of glacial lake deposits, with some beach deposits, outwash, and till. Surface water gradients are very low throughout most of the watershed; the expansive Beltrami Island wetland area in the headwater region lies at an elevation of about 1200 feet. The confluence of the Roseau and Red River lies at about 775 feet.

The **Rat River** of southeastern Manitoba covers a contributing area of about 110,000 ha. The headwaters of the river lie in the beach ridge / interbeach basin area along the eastern margin of glacial Lake Agassiz and in the Sandilands area that is underlain by coarse outwash and kame deposits. Many of the interbeach areas consist of bog and marshes with poorly integrated drainage. Most channels of the Rat River watershed are ditched and straightened in the areas to the west where the joins the mainstem of the Red River near Ste. Agathe.

Targets in the Rat and Roseau River portfolio area include *Orconectes immunis* (Calico crayfish), *Phoxinus neogaeus* (Finescale dace), *Phoxinus eos* (Northern redbelly dace), and *Margariscus margarita* (Pearl dace). Within the portfolio area, the Roseau River rapids and lower mainstem, Upper Seine River watershed, Rat River headwaters, and Sprague creek headwater systems were identified by experts as having highest conservation value.

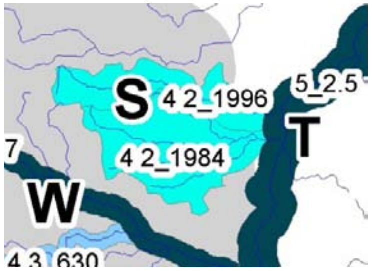
Detailed information about Rat/Roseau River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
R	RE 4_614	Middle Roseau River from the confluence with Hay Creek to the national border	RE 4 - 2	31990		2	60	f	1

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
R	RE 4_615	Lower Roseau River from the national border to the confluence with the Red River	RE 4 - 2	55039	RE-02	1	53	e	2
R	RE 3_1647	Upper Roseau River	RE 3 - 6	116913		5	50	c	2
R	RE 3_1648	Sprague Creek	RE 3 - 6	43205	RE-05	0	88	e	2
R	RE 3_1928	Rat River	RE 3 - 6	110973	RE-01, RE-04	0	68	e	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

S Rush River/High Island Creek



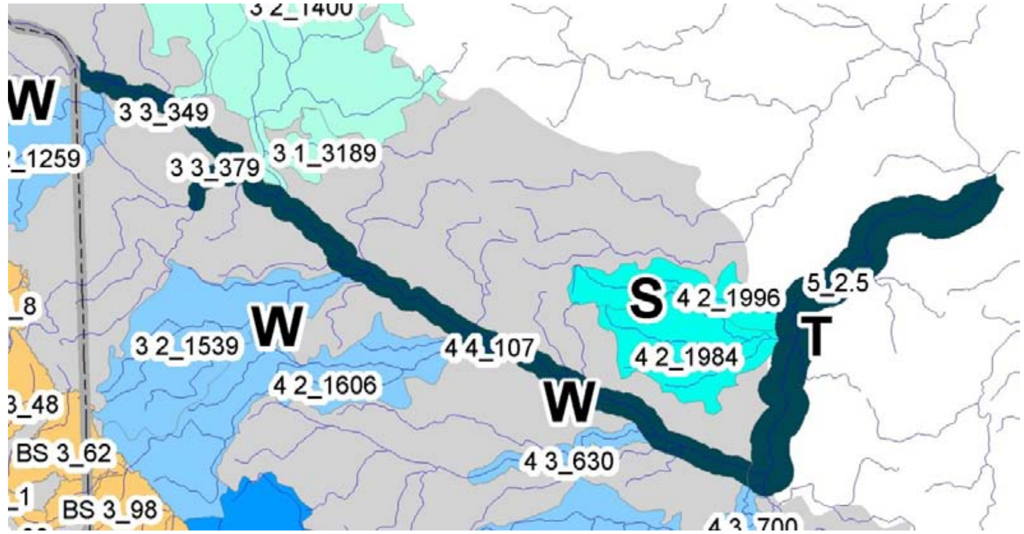
Located in south central Minnesota, this portfolio area includes the drainage basins of Rush River and High Island Creek. Both flow from west to east, draining into the Minnesota River near Le Sueur, Minnesota. Six percent of the Rush river basin and 13 percent of the High Island Creek basin persist in natural landcover, despite the extremely heavy agriculture pressure on these lands. These small watersheds are important refugia for fishes displaced from upper reaches of the watershed by agriculture and urbanization. They are also important as spawning areas for larger river fishes. One target is located in this portfolio area, *Lampsilis cardium* (Plain pocketbook).

Detailed information about Rush River/High Island Creek portfolio area AESs:

Port-folio Area ID	**Aquatic Ecological System (AES) ID**	**System Name**	**Aquatic Ecological System (AES) Type**	**Total Area (HA)**	**Expert Site ID**	**Total Number of Species and Assemblage Targets (post 1994)**	**Percent of Upland in Natural Cover**	**Portfolio Network Category**	**ABS Class (1=con-firmed ABS; 2= possible ABS)**
S	4 2_1984	Rush River	4_2A 6	n/a	Mnf15	0	6	n/a	2
S	4 2_1996	High Island Creek	4_2A 6	n/a	MNF14 a	0	13	n/a	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

T **Minnesota River Mainstem**
(from Weitzell et al., 2003)



This site includes the lower portion of Big Stone Lake, and the Minnesota River proper from the lake outlet, downstream to its confluence with the Mississippi River, just south of the Twin Cities, MN. The major aquatic systems represented by this area consist of perennial, low-gradient medium, large, and big river system types. Also included are the lower portions of many of the lateral tributaries, ranging from direct, moderate to high gradient headwaters and creeks, to low gradient small and medium sized rivers. The mainstem flows entirely through alluvium, with isolated areas of outwash along the margins. Tributary systems flow through varying geology, including a large area of lake sand in the upstream portion (associated with glacial Lake Agassiz), with the rest of the systems flowing through medium textured ground and end moraines, the lower courses of larger tributaries in outwash. The aquatic systems of this area are heavily impaired, with nearly 2/3 of the area converted to agricultural lands. Another 7.6% of the area consists of urban settings. Only about 22% remains in natural cover, mainly within the river floodplain and lower portions of tributary corridors, in high relief areas too steep for agriculture.

The Minnesota River was recognized in the Prairie-Forest Border ecoregional plan (TNC- Prairie Forest Border Ecoregional Planning Team 2000) as "one of the most important aquatic resources in southern Minnesota", yet it is also one of the most severely altered drainage basins of the state. Large-scale conversion to agriculture, and associated ditching, tiling, and chemical pollution have radically altered hydrologic and sediment regimes, degrading habitat and water quality throughout the basin.

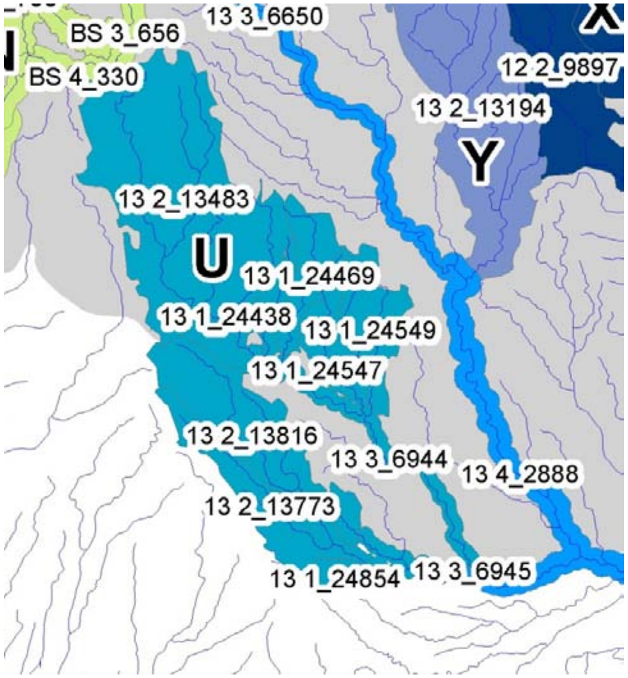
In the UMRB study (Weitzell et al. 2003), several areas along the river's mainstem were recommended by experts for high habitat quality and high fish and mussel species diversity. Within the river itself are several areas with coarser substrates, bedrock, cobble, and boulder rapids, providing important habitat for large river fishes. Throughout the floodplain are a number of disconnected backwaters, calcareous fens, and seepage wetlands. The small, high gradient lower reaches of the many small tributary systems along the mainstem Minnesota River are import refugia for fishes displaced from upper watershed by agriculture and urbanization, and serve as essential spawning areas for larger river fishes. In recent years, very high mayfly hatches have occurred in the river, between New Ulm and Redwood Falls, indicative of improving water quality. Post-1994 data indicate that the Minnesota River portfolio area harbors 7 target species. However, the UMRB study, which examined data prior to 1994, identified 21 target species, including 17 species of mussels, 5 fish, and one turtle species (*Emydoidea blandingii*).

Detailed information about Minnesota River portfolio area AESs:

Port-folio Area ID	**Aquatic Ecological System (AES) ID**	**System Name**	**Aquatic Ecological System (AES) Type**	**Total Area (HA)**	**Expert Site ID**	**Total Number of Species and Assemblage Targets (post 1994)**	**Percent of Upland in Natural Cover**	**Portfolio Network Category**	**ABS Class (1=con-firmed ABS; 2= possible ABS)**
T	5 2.5	Lower Minnesota River	GR2.1	n/a	MNF12	n/a	27	n/a	1
T	4 4_107	Minnesota River from just below the mouth of the Redwood River, downstream to the mouth of the Blue Earth River.	4_W107	n/a	MNF33	7	7	n/a	1
T	3 3_349	Upper Minnesota River (from the MN/SD border to the mouth of the Lac Qui Parle River) and lower Lac Qui Parle River, MN.	3_3A 19	n/a	MN25	2	8	n/a	1

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

U Raccoon River Basin



The Raccoon River basin portfolio area includes the headwaters and mainstems of the North, Middle and South branches of the Raccoon River. During the NTPE conservation planning process, this system was added to the UMRB ABS network (described in Weitzell et al. 2003) because of expert opinion and new survey data. This system is a tributary of the Des Moines River system in west-central Iowa. Most of the streams and tributaries of the Raccoon basin are low to moderate gradient channels underlain by thick deposits of fine ground and end moraines. The mainstem of the river flows through coarse outwash and alluvium. Over 90% of upland areas in this basin are cultivated. Despite unfavorable upland conditions, this basin is notable for the presence of fair quality off-channel habitats and a semi-natural flood regime. Four targets persist in the basin: *Notropis topeka* (Topeka shiner), *Lampsilis cardium* (Plain pocketbook), *Quadrula metanevra* (Monkeyface), and *Quadrula nodulata* (Wartyback). Experts particularly noted the conservation value of East and West Buttrick Creek and Hardin Creek. These three subbasins of the Raccoon provide some of the most stable populations of and critical habitat for the federally endangered Topeka Shiner. In addition, they serve as habitat for diverse mussel assemblages, although recent surveys were not able to document evidence of mussel recruitment. Finally, they also support a fairly good diversity of other fish species.

Detailed information about Raccoon River Basin portfolio area AESs:

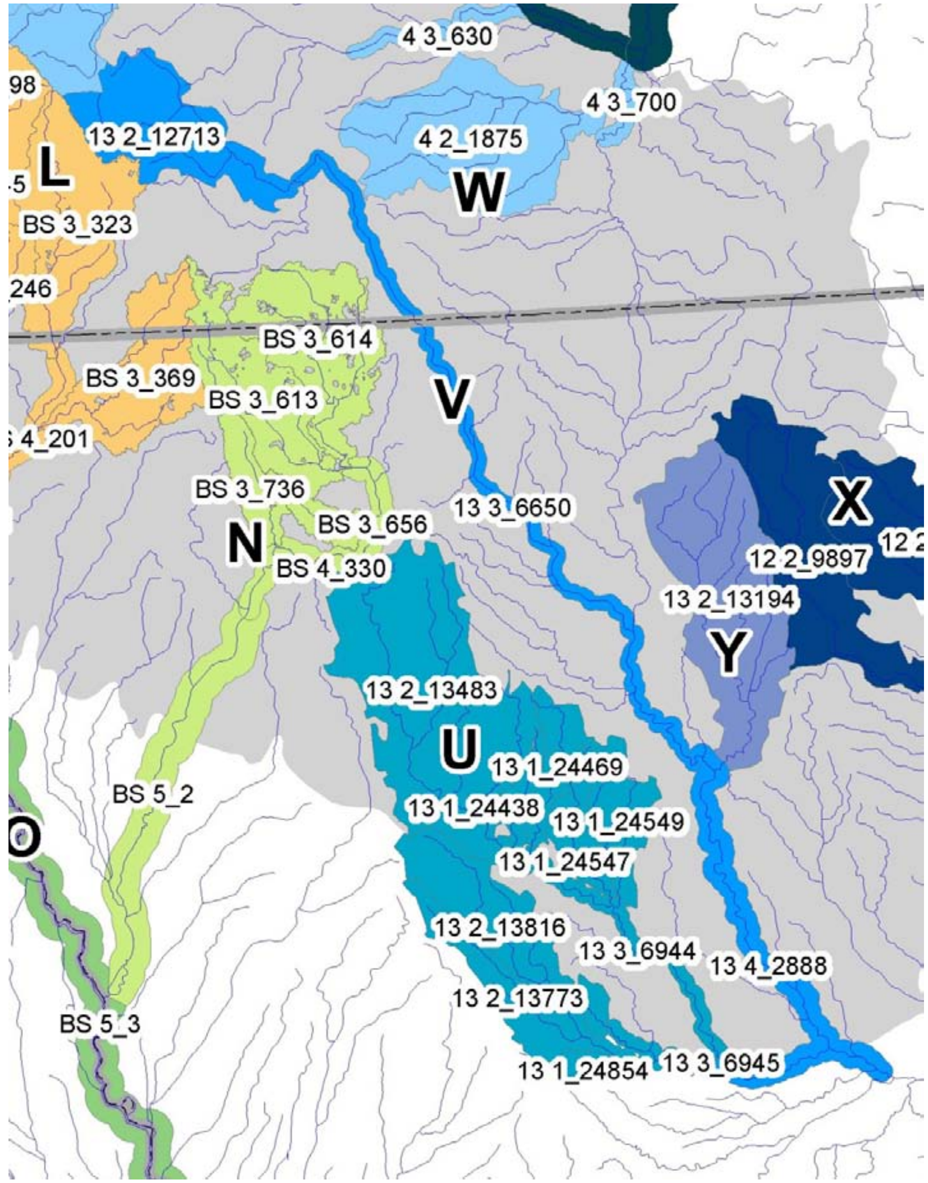
Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecologic al System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
U	13 3_6945	Middle reach of the South Raccoon River, from the mouth Beaver Creek, downstream to the mouth of the North Raccoon River.	13_3C 1	n/a	CA11; IN06	0	7	n/a	1
U	13 3_6944	Lower North Raccoon River, from the mouth of Purgatory	13_3C 15	n/a		4	4	n/a	1

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
		Creek, downstream to the confluence with the South Raccoon River.							
	13 2_13483	North Raccoon River	13_2C 36	n/a		2	2	n/a	1
	13 2_13816	Middle Raccoon River	13_2C 3	n/a			5	n/a	2
	13 2_13773	Brushy Creek	13_2C 6	n/a			6	n/a	1
	13 1_24854		13_1B 24	n/a			16	n/a	1
	13 1_24469	Cedar Creek	13_1B 149	n/a		1	2	n/a	1
	13 1_24549	West Buttrick Creek	13_1B 149	n/a	CA11	2	2	n/a	1
	13 1_24438	Purgatory Creek	13_1B 149	n/a		1	1	n/a	1
	13 1_24547	Hardin Creek	13_1B 149	n/a	IN06	4	2	n/a	1

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

V DesMoines River

The DesMoines River portfolio area includes the mainstem of the Des Moines River and its headwater drainages. During the NTPE conservation planning process, this system was added to the UMRB ABS network (described in Weitzell et al. 2003) because of expert opinion and new survey data. The river flows southeasterly through a narrow basin located in north-central Iowa and south-west Minnesota. The basin is consists primarily of fine ground and end moraines with some areas of outwash. More than 90% of upland areas are covered in row-crop agriculture. Experts noted the presence of high quality calcareous fens and isolated locations of high quality upland cover (mesic/gravel prairie systems) in this basin. In addition, experts felt that the riparian corridor of the Des Moines River was relatively good quality. Six targets (all mussel species) occur in the basin, but have only been noted in the northern-most reaches of the river: *Alasmidonta marginata* (Elktoe), *Elliptio dilatata* (Spike), *Lampsilis cardium* (Plain pocketbook), *Ligumia recta* (Black sandshell), *Pleurobema sintoxia* (Round pigtoe).

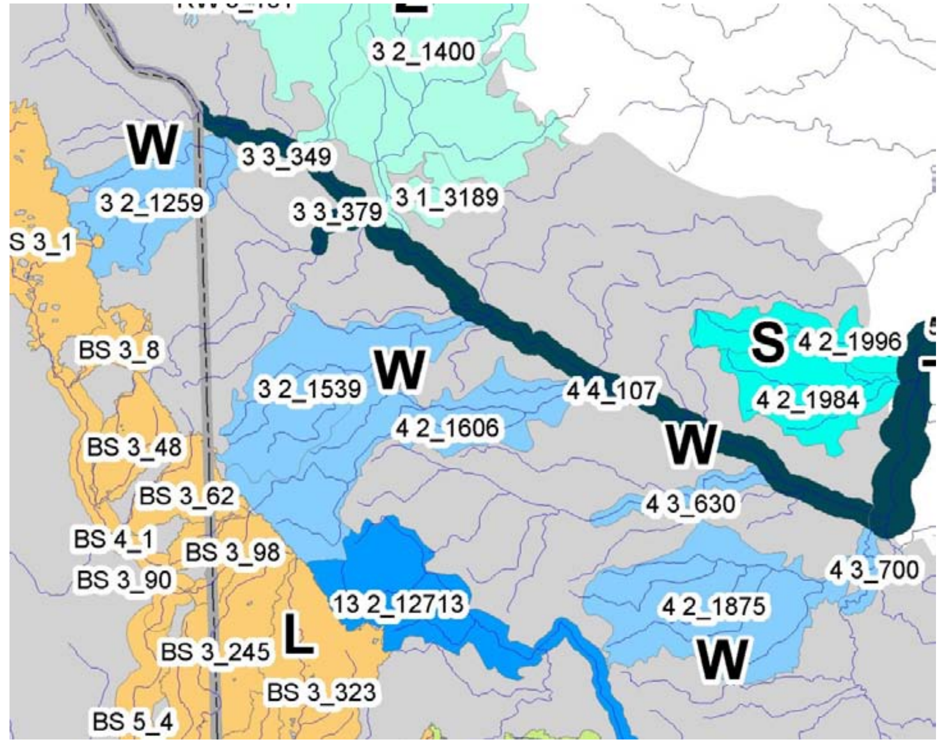


Detailed information about DesMoines River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
V	13 4_2888	Des Moines River, from the mouth of Brushy Creek, Webster County, IA, downstream to the mouth of the Raccoon River	13_W2888	n/a		2	6	n/a	1
V	13 3_6650	Upper Des Moines River, from the mouth of the Heron Lake Outlet, downstream to the confluence with the Boone River.	13_3C 15	n/a		6	4	n/a	1
V	13 2_12713	Des Moines River basin upstream of the Heron Lake outlet.	13_2C 36	n/a		0	6	n/a	1

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

W Minnesota River - Southern Drainages



The Minnesota River-Southern Drainages portfolio area encompasses five distinct medium river systems that drain into the Minnesota River from the southwestern Minnesota. The portfolio area includes the Yellow Bank, Yellow Medicine and Redwood Basins, the lower mainstem of the Cottonwood River, and portions of the Blue Earth River basin, including the Watonwan Basin and lower mainstem of the Blue Earth River. Most of these basins are underlain by fine, calcareous end and ground moraines, with localized areas of lake sands, lake clays, and calcareous outwash. The lower mainstems of the larger systems flow over alluvium. Eight targets are found in the portfolio area: one fish *Moxostoma valenciennesi* (Greater Redhorse) and seven mussel species. Experts noted the conservation value of the Blue Earth River system and the relatively good habitat and species diversity of the system. Although few target species have been documented in the system, experts believe that the river harbors populations of larger river target species. The Yellow Bank system was highlighted for its mussel diversity. The Yellow Medicine, Ramsey Creek and Cottonwood Rivers were also noted by experts for the high species and habitat diversity contained in these systems, the relatively high water quality of the systems, and the strong numbers of darter species found there.

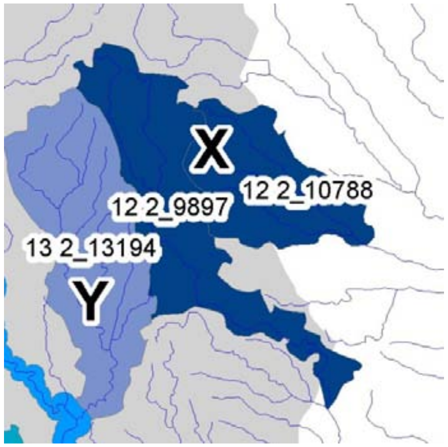
Detailed information about Minnesota River – Southern Drainages portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
W	4 3_700	Blue Earth River	4_3A 14	n/a	MNF37	6	6	n/a	1
W	4 3_630	Cottonwood River	4_3A 9	n/a	Mnf18	0	5	n/a	1

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
W	3 2_1539	Yellow Medicine River basin	3_2A 3	n/a	Mnf06	2	5	n/a	1
W	4 2_1606	Redwood River basin	4_2A 3	n/a	MNF08	1	5	n/a	1
W	3 2_1259	Yellow Bank River, North Fork	3_2A 3	n/a	SD03; MNf05	2	7	n/a	1
W	4 2_1875	Watonwan River	n/a	n/a	MNF36	n/a	n/a	n/a	1

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

X Iowa River/West Fork Cedar River Headwaters



The headwaters of both the Iowa River and West Fork of the Cedar River straddle the southeast boundary of the NTPE, where it meets the Central Tallgrass Priarie Ecoregion. These headwater systems comprise the northernmost extent of a portfolio area that extends down the mainstems of the Iowa and Cedar Rivers. Both of these large river systems intersect central Iowa before joining the Mississippi River in eastern Iowa. The headwater basins of these systems overlay fine ground and end moraines, however the main channels flow in alluvium, outwash, and sand. Three target mussel species are found in the NTPE portion of the portfolio area: *Alasmidonta marinata* (Elktoe), *Lampsilis cardium* (Plain pocketbook), *Quadrula nodulata* (Wartyback). The West Fork of the Cedar River is notable for its excellent biocriteria score, good fish assemblages and intact riparian corridors. This portfolio area crosses the Upper Cedar Conservation area in delineated in the Prairie Forest Border ecoregional plan (TNC-Prairie Forest Border Ecoregional Planning Team 2000). The upper Iowa River was noted by experts for its diverse mussel assemblage, including some state protected species. Hog confinements were considered a potential threat if lagoons were to spill. In addition, lowhead dams at Steamboat Rock and Iowa Falls are barriers to fish hosts in low water.

Detailed information about Iowa River/West Fork Cedar River Headwaters portfolio area AESs:

Port-folio Area ID	**Aquatic Ecological System (AES) ID**	**System Name**	**Aquatic Ecological System (AES) Type**	**Total Area (HA)**	**Expert Site ID**	**Total Number of Species and Assemblage Targets (post 1994)**	**Percent of Upland in Natural Cover**	**Portfolio Network Category**	**ABS Class (1=con-firmed ABS; 2= possible ABS)**
X	12 2_10788	West Fork Cedar River basin upstream of the confluence with Maynes Creek	12_2C 10	n/a	CA06	1	3	n/a	1
X	12 2_9897	Iowa River basin upstream of the confluence with the South Fork Iowa River	12_2C 8	n/a	IN05	3	5	n/a	1

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

Y Boone River

The Boone River Basin of central Iowa is composed of low to moderate gradient headwater and creek systems in fine ground and end moraines. In their lower reaches, these creeks grade into outwash, sand, alluvium and outwash, which is the primary substrate that underlies the mainstem of the Boone. Despite very low natural cover (0.7-2.4%) in the systems that comprise the Boone Basin, the mainstem supports quality riffle habitat, and good invertebrate and native fish diversity. Historically rich in mussels, the Boone today includes at least two target species: *Lampsilis cardium* (Plain pocketbook), and *Ligumia recta* (Black Sandshell). The basin has Iowa state protected designation.

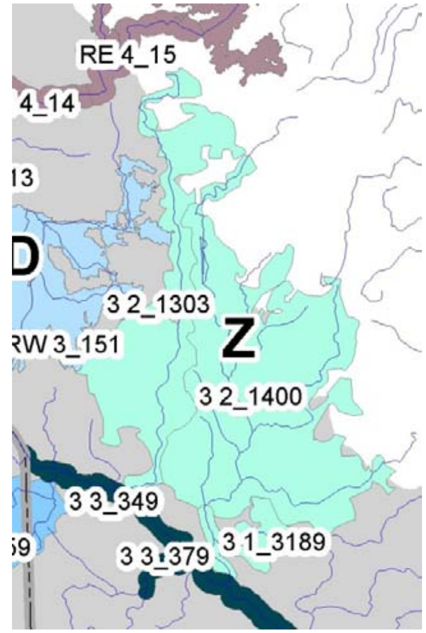
Detailed information about Boone River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
Y	13 2_13194	Boone River basin	13_2C 36	n/a	IN09	3	3	n/a	1

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*

Z Chippewa/Pomme de Terre Rivers

(from Weitzell et al. 2003)



This area is located in the northern headwaters of the Minnesota River basin and straddles the border between the Northern Tallgrass Prairie and the Prairie Forest Border Ecoregions. Headwater and creek systems are largely perennial, low to moderate gradient, with low drainage density. These systems are heavily lake dominated, draining areas of coarse glacial outwash and medium textured ground and end moraines. A small area of the Chippewa River mainstem, the only small river system within this area, is low gradient and flows through alluvium. Land use within the area is largely agriculture (74%), with about 17.6% of the area remaining in natural cover including wetlands.

The central portion of the Upper Chippewa River (MN) portfolio area was also identified in the Prairie-Forest Border ecoregional plan (TNC 2001) as significant for aquatic and terrestrial resources. Known as the Glacial Lakes Region, this landscape lies on the Alexandria Moraine, and supports numerous natural upland and lowland community types. In the current study, three additional sites within this portfolio area were identified as significant by regional experts, based on high water quality and the presence of state listed fish species, including the pugnose shiner (*Notropis anogenous*) and the least darter (*Etheostoma microperca*). The headwaters of the East Branch Chippewa River represent one of only a couple known localities for these two species within the Minnesota River Basin. Additional sites for pugnose shiners within the area include Lake Florida and Lake Andrew, Kandiyohi Co, MN. Four UMRB mussel targets also occur in the area.

Detailed information about Chippewa/Pomme de Terre River portfolio area AESs:

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
Z	3 3_379	Lower Chippewa River from theSwift/Chippewa county line to the confluence with the Minnesota River.	3_3A 9	n/a	MN25	0	10	n/a	1
Z	3 2_1303	Pomme de Terre River basin	3_2A 6	n/a	MNF25	2	12	n/a	1

Port-folio Area ID	Aquatic Ecological System (AES) ID	System Name	Aquatic Ecological System (AES) Type	Total Area (HA)	Expert Site ID	Total Number of Species and Assemblage Targets (post 1994)	Percent of Upland in Natural Cover	Portfolio Network Category	ABS Class (1=con-firmed ABS; 2= possible ABS)
Z	3 2_1400	Chippewa River basin north of the Swift/Chippewa county line	3_2A 6	n/a	MNF23	1	11	n/a	1
Z	3 1_3189	Dry Weather Creek	3_1A 4	n/a	MN20		2	n/a	2

***This table includes all non-nested headwater through large river systems captured in the portfolio network (i.e., size 1 and 2 headwater and creek systems totally encompassed by size 3 small river systems are not included). "N/A" indicates data that were not available. Portfolio network categories and ABS classes are defined in Chapter 2, Table 2.3.*