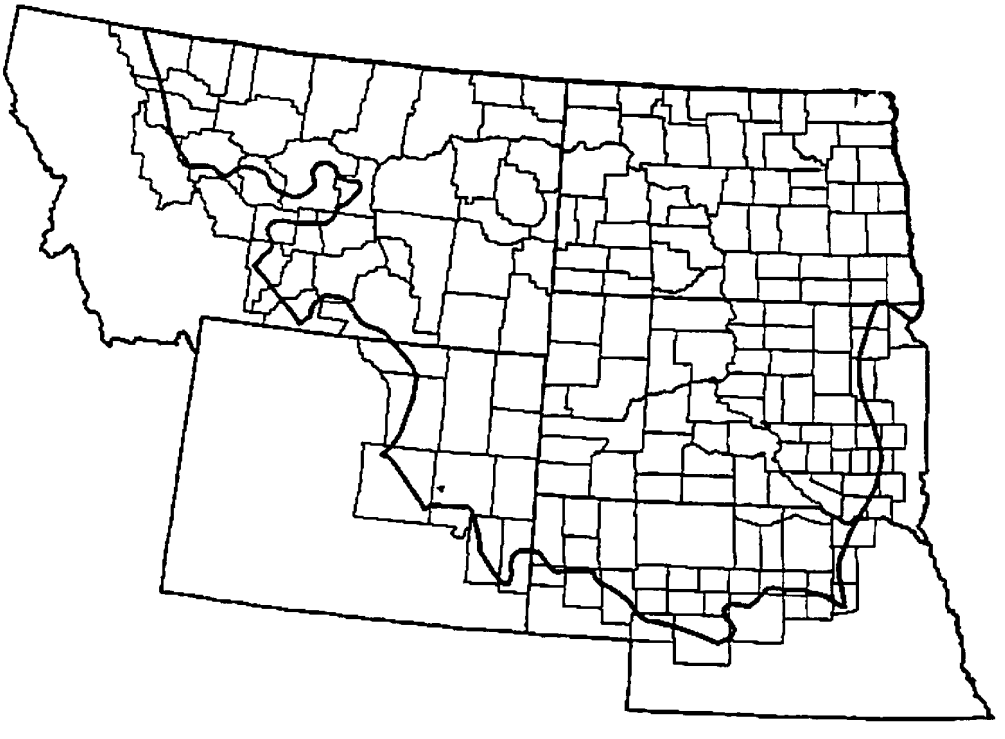
NORTHERN GREAT PLAINS AQUATIC ASSESSMENT
November 1998



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Executive Summary

This assessment of the aquatic resources of the Northern Great Plains covers the area from central Montana to the Red River Valley of North Dakota and from the Canadian border to Sandhills of Nebraska. Portions of five states are within the assessment area, Montana, Nebraska, North Dakota, South Dakota and Wyoming. The condition and extent of aquatic resources such as streams, rivers, lakes, groundwater and wetlands were examined.

Measures of the status and condition of these resources include information regarding quality and use of both surface and groundwater and the status of aquatic species, both in an overall biodiversity and community sense and in particular the status of species of special concern. In addition, the condition of riparian areas and the condition and extent of wetland areas are also examined. Linked with information on the status and condition of aquatic resources is a discussion of the impacts of human activities to these resources, such as hydrologic modifications and pollution.

Five general questions were proposed at the outset of the investigation which were designed to determine the status and impacts to the various resources. These questions are presented here with major findings under each. The text of the report contains many more.

***Question 1* (Chapter 2):** What is known about the current status and apparent trends in water quality, aquatic habitat and aquatic species in the Northern Great Plains Assessment Area?

•There are 180 eight-digit hydrologic unit codes (watersheds) in the Northern Great Plains Assessment Area.
•Precipitation is highest in the southeastern portions of the NGPAA (eastern South Dakota and eastern Nebraska) at more than 20 inches. It is lowest in northeastern Wyoming and eastern Montana with less than 15 inches.
•The major aquifer systems located in the NGPAA include unconsolidated alluvial and glacial deposit aquifers, the High Plains aquifer system, the Northern Great Plains aquifer system and Great Plains aquifer system.
•The hydrograph of the Missouri River has changed from having two prominent flood peaks each year to a long steady flow covering most of the year.
•Most of the watersheds in the NGPAA experience mean flows of less than 1000 cfs. A few watersheds in the Yellowstone and Missouri River mainstems have mean flows of greater than 10,000 cfs. Much of the NGPAA experience wide variabilities in flow from year to year.
•Reservoir area is greatest in watersheds connected with the Missouri River, reflecting the existence of larger reservoirs such as Oahe, Sakakawea and Fort Peck.
•The watersheds with the highest percentages of assessed miles of streams partially supporting and not supporting uses include large sections of the NGPAA, particularly in the Red River basin, the tributaries to the Missouri in South Dakota, the Milk and other Missouri tributaries in Montana and the Platte basin in Nebraska.
•The watersheds with the lowest percentages of assessed miles of streams partially supporting and not supporting uses are the James Headwaters, the Little Missouri and parts of the Missouri River in North Dakota.
•The High Plains Aquifer generally has very good water quality in terms of dissolved solids.
•The greatest number of pesticide detections in ground water have occurred in Holt and Wheeler counties in Nebraska; Potter County in South Dakota; Rolette County in North Dakota and Teton County in Montana.
•There are 18 TE&SC aquatic species within the Northern Great Plains Assessment Area. Of these, 7 are fish and 11 are mollusks.
•There are no aquatic species listed as threatened. There are 3 endangered species, 1 fish (pallid sturgeon) and 2 mollusks (winged mapleleaf and fat pocketbook). An additional

species is proposed to be listed as endangered (topeka shiner).
•There are 3 candidate species, all of which are fish (sturgeon chub, sicklefin chub, and topeka shiner).
•There are 12 species which are of special concern that are not listed as endangered, threatened or candidates (global rank of G3 or lower).
•There is 1 bird species listed as endangered (least tern) and 1 listed as threatened (piping plover). These are listed as a result of changes in the hydrology of the Missouri River.
•The watersheds with the greatest number of endangered and special concern fish species are the Lower James, the Upper James and the Lewis and Clark Lake stretch of the Missouri River.

***Question 2* (Chapter 3):** What is the extent and composition of riparian and wetland areas? What are the land coverages in the Assessment Area?

•Eastern Montana has the most riverine wetlands according to the NRCS. Central and eastern North Dakota, northeastern Wyoming and much of South Dakota have the least amounts of riverine wetlands.
•The greatest decreases in riverine wetlands during the period 1982 to 1992 have occurred in northeast Wyoming and central South Dakota. The greatest increases have occurred in the Black Hills and Sand Hills.
•The greatest concentration of wetlands in the NGPAA occur in the Prairie Pothole region of ND, SD and MT.
•73% of historical wetland acres remain in Montana; 55% in North Dakota; 65% in South Dakota; 65% in Nebraska; and about 60% in Wyoming.
•Most wetland losses have been the result of conversions for agriculture.
•The greatest losses since presettlement by percentage have occurred in North Dakota, with the most extensive drainage occurring in the Red River Valley.
•Wetland losses in the last ten years have been reduced to less than 3% per year in most parts of the NGPAA. However, in many parts of the NGPAA, increases in wetland acreage are being noted.
•Recent changes (since 1980s) have seen wetland losses the Little Missouri basin, western North and South Dakota, the Red River Valley, the lower Yellowstone, Niobrara and Cheyenne Rivers. Recent gains have been recorded in the Milk, Upper Yellowstone, Powder, Belle Fourche, Loup, Platte, James and Sheyenne River basins.
•The Sand Hills and northeastern North Dakota contain the largest amounts of palustrine wetlands and the least amounts occur in western and central South Dakota.
•Increases by percentage in palustrine wetlands from 1982 to 1992 occurred in the western and eastern portions of the NGPAA. Decreases have occurred in much of the central NGPAA, with the largest in western North Dakota.

***Question 3* (Chapter 4):** What laws, policies and programs for the protection of water quality, streams, wetlands and riparian areas are in place, and how do they affect aquatic resources, other resources and human uses within the Northern Great Plains Assessment Area?

•The Clean Water Act, the Safe Drinking Water Act and the Endangered Species Act are the three major pieces of federal legislation available to protect aquatic resources.
•Numerous grant and restoration programs are available from various federal and state agencies for the protection and restoration of aquatic systems.

***Question 4* (Chapter 5):** What are the current and potential effects on aquatic resources from various human activities?
•Human population in the NGPAA is mainly

centered around a number of cities (Billings, Fargo, Bismarck, Rapid City, Casper, etc). Much of the area has a low population density.

•Human population growth is occurring fastest in counties with the larger cities, the area surrounding the Black Hills, southern Montana, northeastern Wyoming and in a number of Indian Reservations.

•Watersheds with the greatest number of stream miles impacted from dams, diversions and wetland drainage are the Upper and Lower Tongue, the Lower Powder, the Sun River, the Upper Missouri-Dearborn, the Lower Bighorn, the Lower Souris, Upper Sheyenne, Pembina, Middle Sheyenne, Upper James, Lower Sheyenne, Maple River and the Western Wild Rice River.

•Watersheds with the greatest amount of irrigated acreage are the Milk, Teton, Yellowstone, Platte, North Platte, Lower Loup, Niobrara, Elkhorn, Belle Fourche, Upper Tongue and Lewis and Clark Lake. Relatively little irrigated cropland occurs throughout much of North Dakota, South Dakota, the Sand Hills and outside of major river valleys in eastern Montana and northeastern Wyoming.

•Watersheds with the greatest total number of NPDES dischargers (major and minor) are Lewis and Clark Lake, Upper Elkhorn, Middle Platte-Buffalo, Middle North Platte River-Scottsbluff, Lake Sakakawea, Little Powder River, Beaver Creek (Cheyenne River watershed), Lance Creek, Salt Creek (Powder River watershed) and the Middle North Platte River-Casper.

•Agricultural activities in general impact the ability of assessed streams to meet designated uses across large areas of the NGPAA.

•Watersheds with the greatest number of assessed stream miles impacted by nutrients are the Upper Powder, Lower Yellowstone-Sunday, Middle Milk, Cedar Creek (in North Dakota), Lower Souris, Upper James, Western Wild Rice River, Maple River and Lower Sheyenne.

•Watersheds with the greatest number of assessed stream miles impacted by siltation are the Western Wild Rice River, the Lower Sheyenne, Cedar Creek, Lower Heart, Upper Powder, Clarks Fork of the Yellowstone, Upper Missouri-Dearborn and the Smith River.

•Watersheds with the greatest number of assessed stream miles impacted by irrigated crop production are mainly in Montana and Wyoming.

•The Universal Soil Loss Equation predicts the greatest potential for erosion in the NGPAA to be in parts of western North Dakota and southeastern South Dakota.

•The greatest concentration of total animal units are in parts of Nebraska (due to cattle and hogs). The lowest concentrations are in a swath from northeastern Montana to northeastern North Dakota.

•The largest areas of harvested cropland are in eastern and central North Dakota, northeastern South Dakota, along the Platte River in Nebraska and northern Montana. The lowest amounts are in northeastern Wyoming, southeastern Montana and western South Dakota.

•Pesticide runoff potential is greatest in the Red River Valley, the lower James, lower Missouri, lower Loup and Middle Platte River basins. The lowest is in western South Dakota, northeastern Wyoming and most of Montana.

•The greatest amounts of nitrogen fertilizer used are in eastern and northern North Dakota, the Platte River Valley and north-central Montana. The lowest amounts used are in western South Dakota and northeastern Wyoming. Nitrogen runoff potential is greatest in the Platte Valley, eastern South Dakota and southeastern North Dakota. It is lowest in northeastern Wyoming and scattered areas of Montana.

•Sediment delivery potential is greatest in parts of the Red River Valley, Elm River (James basin), Lewis and Clark Lake watershed and the Two Medicine River and the Teton River in the Upper Missouri basin. It is lowest in northeastern Wyoming, the Sand Hills and

southeastern and eastern Montana.

***Question 5* (Chapter 6):** What are the status and apparent trends in water usage and supplies within the Northern Great Plains Assessment Area including water rights and uses on National Forest System Lands?

•The greatest total water use in the NGPAA is in the Platte Valley of Nebraska and the Missouri River near around Bismarck. Surface water use is greatest in the Missouri near Bismarck, in the Yellowstone, Platte and Milk River basins. Ground water use is greatest in the Platte, Niobrara, Loup and Elkhorn basins. Watersheds which use more than 25 million gallons per day of ground water are predominantly restricted to Nebraska.

•Overall, irrigation is the greatest single type of use for water in the NGPAA. The greatest total use (surface and ground) for irrigation is in the Yellowstone, Platte, Milk, Niobrara, Lower Loup and Elkhorn basins.

•The greatest uses for thermoelectric use are in the Missouri River near Bismarck and the Lower South Platte.

•Water use for agriculture (irrigation and livestock) declined during the period 1985 to 1995 in much of South Dakota, North Dakota, northern Nebraska and eastern Montana, with the greatest decreases seen in the Lower Belle Fourche and the Middle Niobrara watersheds. The greatest increases were seen in parts of the Platte, Loup, Powder, Tongue, Upper Yellowstone and Marias River basins.

•Total water use changes during the period 1985 to 1995 closely match the changes in agricultural water use.

Aquatic Assessment Introduction

1.1 INTRODUCTION

This assessment of the aquatic resources of the Northern Great Plains outlines the status of water quality and quantity for both surface water and ground water, aquatic habitats (streams, rivers, lakes, wetlands and riparian areas) and the aquatic species that use these habitats. It also describes the impacts of human activities on water quality, water quantity and aquatic habitats and organisms, as well as programs and projects being undertaken to protect and restore these resources. The report examined patterns, and where enough data were available, assesses future trends. Five questions were posed regarding the aquatic resources of the Northern Great Plains that this assessment addresses. The five questions are listed below, along with the corresponding chapter.

a. What is known about the current status and apparent trends in water quality, aquatic habitat and aquatic species within the Northern Great Plains planning area? (Chapter 2)

b What is the extent of riparian and wetland areas and composition? (Chapter 3)

c What laws, policies and programs for the protection of water quality, streams, wetlands and riparian areas are in place, and how do they affect aquatic resources, other resources and human uses within the Northern Great Plains Assessment Area? (Chapter 4)

d. What are the current and potential effects on aquatic resources from various human activities? (Chapter 5)

e. What are the status and apparent trends in water usage and supplies within the Northern Great Plains Assessment Area? (Chapter 6)

This assessment is a broadscale effort to establish current aquatic conditions in the Northern Great Plains. It will also be used in the preparation of finer-scale assessments to be performed at the landscape level. The landscape scale assessment focusses on the individual National Grassland Units that are contained within the larger Northern Great Plains Assessment Area.

1.2 DESCRIPTION OF THE ASSESSMENT AREA

The Great Plains cover 600 million acres spanning from Saskatchewan and Alberta to the southwestern United States and Mexico and from the foothills of the Rocky Mountains east to Illinois (Ostlie, et al. 1996). This assessment covers the northern portion of the Great Plains, approximately 250 million acres, of which only about four million acres are within the National Grassland system. The vast majority of land in this area is in private ownership. The area included in this assessment is shown in Figure 1.2.1. The Northern Great Plains Assessment Area (NGPAA) consists of portions of five states: eastern and northern Montana, all of North Dakota, the western five-sixths of South Dakota, northeastern Wyoming, and north central and northwestern Nebraska. Areas in Canada that may fall within the ecoregions used to define this assessment were not included. The area is drained by two major river systems. The Red and Souris Rivers flow to Hudson Bay, and the Missouri River drains to the Mississippi River and the Gulf of Mexico. There are numerous important subbasins including the Sheyenne, a tributary to the Red River, and the Yellowstone, Little Missouri, Cheyenne, James, Powder, Niobrara and Platte Rivers, tributaries to the Missouri River.

Topography

Elevations range from about 700 to 800 feet above sea level in the North Dakota prairie pothole country and along the Red River to 6000 feet in the Powder River Basin and Missouri Escarpment (U.S. Forest Service, 1994). The southern portion of the Northern Great Plains in the Nebraska Sand Hills ranges between two thousand and four thousand feet in elevation.

The northern and eastern parts of the region are typified by glaciated plains and hills with numerous kettle lakes and moraines. The Red River valley is flat with rolling terrain at the edges. Western and central areas of the Northern Great Plains are gently sloping to rolling plains with badlands and tablelands as one moves further west. The southern portion contains the Nebraska Sand Hills consisting of dunes stabilized by vegetation with gently sloping valleys between the dunes.

The boundary between the western Great Plains and the glaciated northeastern plains in central North Dakota is referred to as the Missouri Escarpment (Keefer, 1974). West of the escarpment, the country levels off onto the Missouri Plateau, which stretches to central Montana, northeastern Wyoming and northwestern South Dakota. The most eastern segment of the Missouri Plateau is a 12 to 25-mile wide strip of irregular terrain of hills and lakes called the Missouri Coteau (Keefer, 1974). The landscape of the Missouri Plateau is dominated by plains and low-lying hills interrupted by entrenched river valleys and isolated uplands, buttes and mesas. The Williston and Powder River Basins are downfolds separate from the adjacent geologic features (Keefer, 1974). The Williston Basin is located in western North Dakota, northwestern South Dakota and eastern Wyoming, while the Powder River Basin is located in southeastern Montana and northeastern Wyoming.

Hydrology

The hydrology of the Northern Great Plains varies considerably over the region. Well developed dendritic drainages exist in the central and western parts and fairly disorganized drainages characterize the northeastern section (U.S. Forest Service, 1994). Large portions of the northeastern Northern Great Plains have terminal drainages which flow to small lakes and wetlands, never entering the Missouri or Red Rivers. These drainages are most common in eastern North Dakota and northeastern South Dakota. The southern Northern Great Plains (Sand Hills) has many small lakes and ponds.

The dominant hydrologic feature of the Northern Great Plains is the Missouri River. Exiting the Rocky Mountains in western Montana, the Missouri River travels eastward to North Dakota, where it converges with the Yellowstone River. It then flows southeast and southward through central South Dakota before turning eastward again forming the boundary between South Dakota and Nebraska. Five dams have been constructed on the Missouri River in this section, the largest of which form Fort Peck Reservoir in Montana, Lake Sakakawea in North Dakota and Lake Oahe in North and South Dakota. Another larger reservoir, Canyon Ferry, is just upstream of the NGPAA on the Missouri.

Geology/Soils

The underlying geology of the assessment area is predominantly Cretaceous shale with Tertiary sandstone in the Sand Hills and Quaternary alluvium covering Archean granite under portions of the Red River Valley (U.S. Forest Service, 1994). In addition, the Red River Valley has lacustrine deposits from once being covered by the Glacial Lake Agassiz. Glacial till covers the northern and eastern parts of the assessment area. The central and

western portions of the assessment area have soils of fine to medium texture and in the Sand Hills, the sandstones are covered by loess and dune sand.

Climate

The Great Plains climate results from its orientation on the continent with respect to the Rocky Mountains and the Gulf of Mexico (Reichman, 1989). Pacific air flows in from the west and loses its moisture passing over the Rocky Mountains, resulting in scarce rainfall, which in turn yields the arid shortgrass prairies. Further east, the airflow is warmed and rehydrated by the northerly flow of moist air from the Gulf of Mexico. The increased rainfall yields the mixed and tallgrass prairies. Therefore, there is a general increase in rainfall on the Northern Plains from west to east, with 10 to 20 inches per year falling in the west and 17 to 24 inches falling in the Red River Valley, Sand Hills and eastern South Dakota (U.S. Forest Service, 1994).

Average temperatures increase from north to south, from 36° to 45°F in northern Montana and the Red River Valley to 48° to 52°F in the Sand Hills (U.S. Forest Service, 1994). Correspondingly, the growing season ranges from approximately 100 to 130 days in the north and northwest to 130 to 160 days in the south and southeast. Evapotranspiration in the Sand Hills is about eight to nine inches during the warmest months (Willhite and Hubbard, 1990).

Grasslands

Fire and grazing are the major factors in maintaining grasslands across regional scales, while local variation, however, is more influenced by topography, soils, and seed source availability (Harrington and Harmon, 1995). North to south gradients in temperature, day length, and precipitation, along with the west to east moisture gradient, affect the natural distribution of grass species. The temperature gradient also influences the distribution of agricultural crops: spring wheat, rye, oats, and barley are grown in the north; corn is grown in the central plains; and winter wheat and grain sorghum is grown in the south (Harrington and Harmon, 1995). The moisture gradient coincides with the subdivision of the grasslands into shortgrass steppe, mixed-grass prairie and tallgrass prairie. The following is a brief discussion of the vegetation types that appear on the Great Plains (from Harrington and Harmon, 1995).

Shortgrass Steppe consists of grasses that are 20 to 50 cm high. Blue grama and buffalo grass dominate this area, but western wheatgrass, needle-and-thread, and wiregrass are also important. These grasses are timed to grow with spring rains and most go dormant in the summer. They may have evolved in response to grazing pressure from native ungulates as indicated by their lowness and focus on root production. Shorter grasses can tolerate years of below normal rainfall

Mixed-Grass Prairie is a transition zone between shortgrass and tallgrass. Therefore, it contains species of both regions. Blue grama and buffalo grass occupy a lower layer, while little bluestem, needle-and-thread, side-oats grama and western wheatgrass penetrate above this level to heights of about 125 cm. This zone shifts eastward in dry years and westward in wet ones. These are not species migrations, but changes in species dominance within the region. A comparison of climate factors to vegetation types shows that the mixed-grass prairie coincides with a region receiving 50% or less of normal rainfall during July of major drought years.

Tallgrass Prairie contains grasses that grow to more than two meters in height. It has the greatest species diversity of the grassland

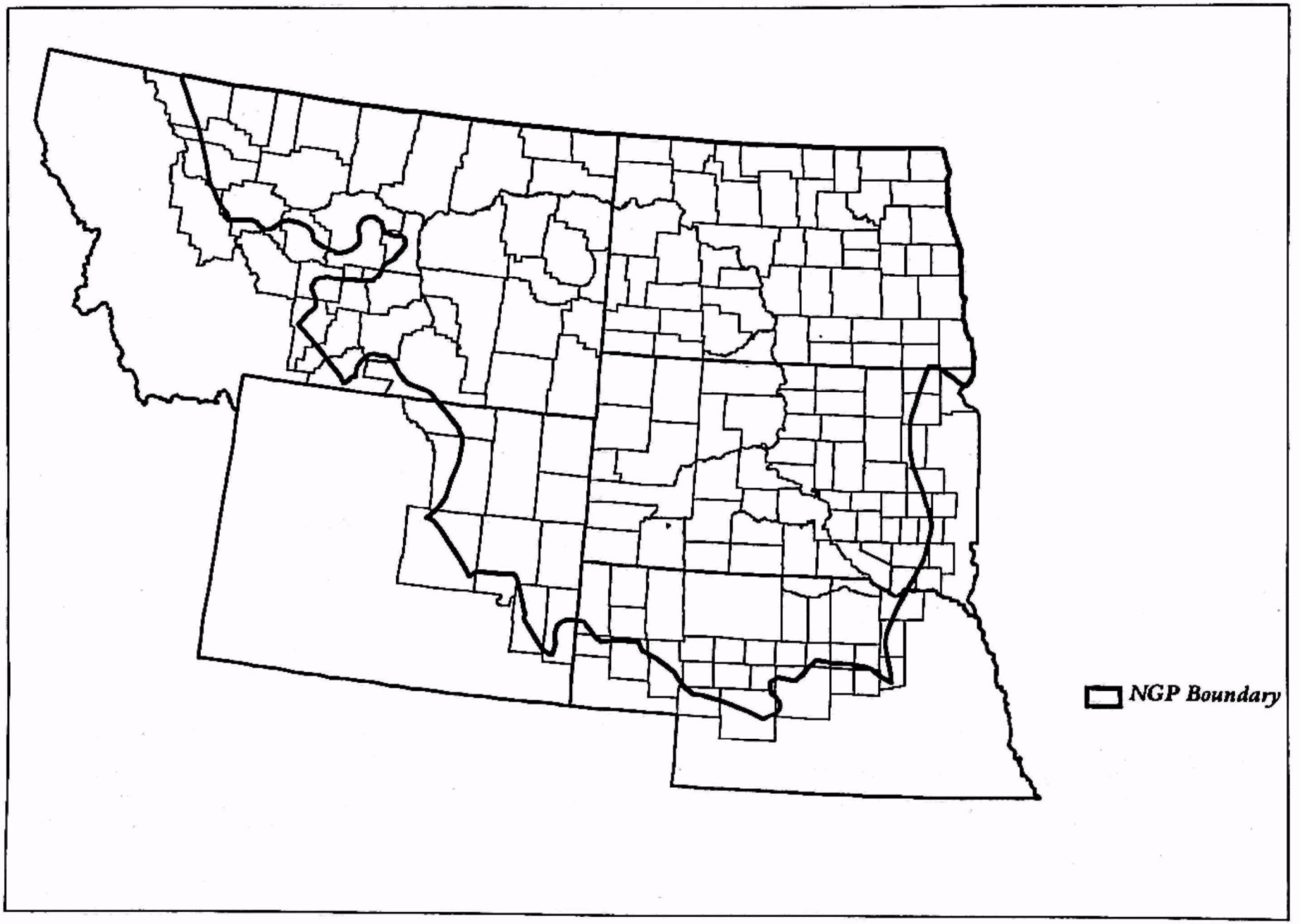

Figure 1.2.1 Northern Great Plains Assessment Area

types with the dominants being big bluestem, Indian grass, and switchgrass. On drier sites, little bluestem, side-oats grama, prairie dropseed, needlegrass and June grass are common. Climate and fire both play a role in maintaining tallgrass prairie.

Riparian Forests penetrate into the grassland region along major streams. They use the local ground water supply of the stream and, as a result, are somewhat resistant to major droughts. Cottonwoods, elms, willows and ashes are the dominant trees. Their seedlings germinate during spring flooding.

In the NGPAA, grasses dominate the landscape, with variations in species depending on the rainfall and temperature regime of the area. Bluestem and indian grass mixed with northern floodplain forest was the original vegetation of the Red River Valley (U.S. Forest Service, 1994). To the west and south, floodplain forest reaches into the grasslands along the streams, but grasses change to a wheatgrass-bluestem-needlegrass community. In the Nebraska Sand Hills, bluestem and sandreed mix with wheatgrass and needlegrass. Farther west, a grama-wheatgrass-needlegrass community begins to dominate. In some areas, especially in the southwest portion of the assessment area, ponderosa pine grows on some of the higher ridges and slopes leading to higher elevations (Black Hills, Bighorn Mountains, etc.).

Land Use

The Red River Valley is considered to be prime farmland and the landscape is dominated by agriculture. Wheat, sugar beets and potatoes are grown here. To the west and southwest from the Red River Valley, dryland crops take over as well as cattle grazing. Reaching the extreme southern and western parts of the NGPAA, such as the Nebraska Sand Hills and the Powder River Basin, grazing becomes the dominant land use.

Mineral extraction is important in some parts of the assessment area. Surface mining for coal and oil and gas extraction is common in parts of Wyoming, Montana and North Dakota. Metal mining (gold, silver, etc.) is important in the Black Hills. While not in the assessment area, this mining has impacted Great Plains streams beyond the Black Hills.

The human population of the counties within the NGPAA is 1,953,363 based on 1995 Census Data estimates. This estimate includes some areas outside the boundary used for the NGPAA because the population for entire counties is used, whether or not the entire county is within the boundary. The majority of this population lives in eastern and central North Dakota, eastern South Dakota, the eastern side of the Black Hills, the North Platte Valley in Wyoming and Nebraska, and along the Yellowstone, Milk and Upper Missouri Rivers in Montana. The areas with very low population densities are the Sand Hills of Nebraska, central and western South Dakota and much of eastern Montana and northeastern Wyoming outside of major river valleys. Noticable population increases occurred between 1985 and 1990 in the northeast part of the Black Hills and in parts of central North Dakota.

1.3 WATERSHEDS OF THE NORTHERN GREAT PLAINS

The NGPAA contains all or portions of 180 eight-digit hydrologic unit codes. This size unit represents the scale at which the information in this assessment will be analyzed and presented. Throughout the document, eight-digit hydrologic units will be synonymous with the term watershed. The average size of a eight-digit hydrologic unit code in the NGPAA is 1,191,087 acres (1861 square miles), with

ranges from 7735 to 4,321,835 acres (12 to 6753 square miles). The watersheds in the assessment area are depicted in Figure 1.3.1, along with four of the major drainage areas (Hudson Bay, Yellowstone River, Platte River and the rest of the Missouri River basin).

1.4 ECOLOGICAL REGIONS OF THE NORTHERN GREAT PLAINS

Two major ecological divisions divide the Northern Great Plains Assessment Area: the Prairie Division (along the Red River in North Dakota) and the Temperate Steppe Division (the remaining area) (U.S. Forest Service, 1994). Within the Prairie Division in the Northern Great Plains, is the Prairie Parkland Province and the Red River Section within that Province.

The Temperate Steppe Division has two ecological provinces, the Great Plains Steppe and the Great Plains Dry Steppe. The Great Plains Steppe Province has four sections: the Northeastern Glaciated Plains, the North-Central Great Plains, the Western Glaciated Plains and the Nebraska Sand Hills. The Great Plains Dry Steppe Province also has four sections: the Powder River Basin, the Northwestern Glaciated Plains, the Northwestern Great Plains and the Northern Glaciated Plains. The Black Hills are not included in the NGPAA, but are discussed as necessary when they influence the plains surrounding them or when particular data sets include them. The ecological sections are shown in Figure 1.4.1. The following is an overview of each ecological section within the NGPAA, with information primarily from *Ecological Subregions of the United States,* U.S. Forest Service (1994), unless otherwise noted.

Prairie Division

Prairie Parkland Province

This Division and Province contain only one ecosection within the NGPAA. The *Red River Valley Section* encompasses the eastern one-sixth of North Dakota and a portion of western Minnesota that is not included in the Assessment Area. It is 18,300 square miles in size (including the Minnesota side). The Red River of the North flows through this section before crossing the border into Canada, eventually entering Lake Winnipeg and Hudson Bay. The Red River is formed by the confluence of the Bois de Sioux River and other tributaries. This section was the southern extension of what originally was the Glacial Lake Agassiz. Therefore, it is often referred to as the Glacial Lake Agassiz Plain. Tributaries to the Red River enter from the uplands to the east and west. The major tributaries entering from the North Dakota side are the Sheyenne, Maple, Goose, Forest, Park, Tongue, and Pembina Rivers. The original vegetation of this area was bluestem-indiangrass with northern floodplain forest along the rivers and streams.

The topography is level, creating meandering streams. The Red River varies greatly in flow, with destructive floods occurring on occasion in April and May from snowmelt and rainfall (U.S. Environmental Protection Agency, 1992a). Because of the low gradient, floods that do occur tend to inundate large areas (North Dakota Department of Health, 1988). Originally there were numerous wetlands in this region, however, most have been drained for agriculture. Large numbers of both nesting and migrating waterfowl were once supported by these wetlands, but many have been reduced in numbers, especially pintail, mallard, teal, and canvasback. However, others such as Canada goose and sandhill crane are doing well because of grain residues from agriculture.

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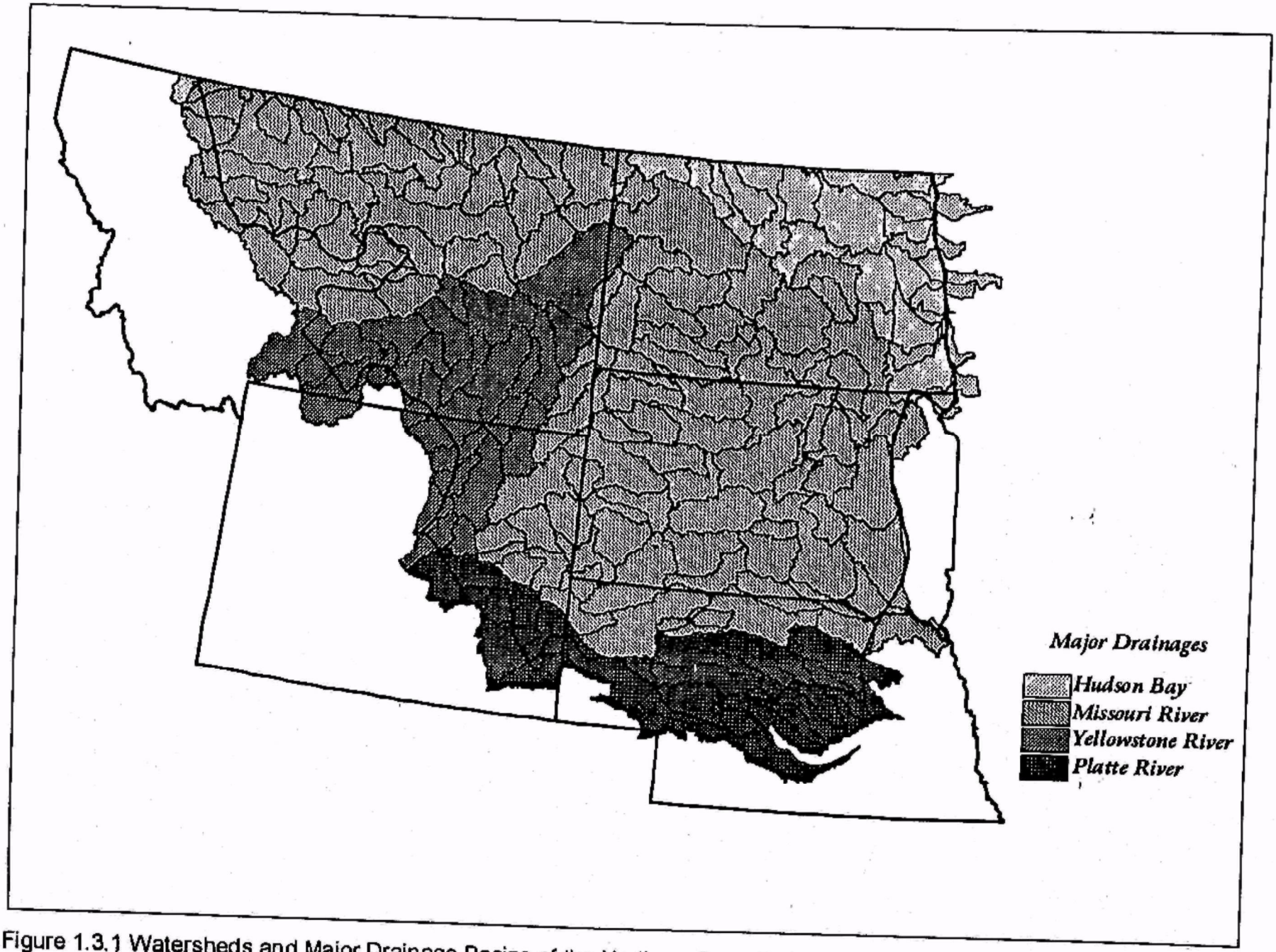

Figure 1.3.1 Watersheds and Major Drainage Basins of the Northern Great Plains

The land cover in the southern part of this section is predominately cropland mixed with riparian woodland and pasture. The central area grows more small grains and corn. The northern part is a mixture of the same coverages in the south and central with the addition of wheat, potatoes and sugar beets. This region is the most populated area in North Dakota, with major population centers along the Red River itself, including the cities of Fargo, Grand Forks and Wahpeton. Non-irrigated agriculture is the most important economic activity in this section. The eastern portion of the Sheyenne National Grassland is in this section.

Temperate Steppe Division

Great Plains Steppe Province

The *Northeastern Glaciated Plains Section* is located in east-central and northern North Dakota and covers an area of 27,900 square miles. The terrain is level to undulating glacial till and lake plains. Drainage in this area is disorganized with numerous pothole lakes and ponds, many of which serve as terminal drainages, the largest of which is Devils Lake. The Devils Lake basin became closed after the last glaciation receded and southerly drainage into the Sheyenne River ceased (Ryckman, 1995). The Souris River drains the northwestern part of this section. Its headwaters are in Canada, but the Souris flows into the United States and out again, joining the Assiniboine River and eventually the Red River, near Winnipeg, Manitoba. The headwaters of the James River and the Sheyenne River are in the Northeastern Glaciated Plains as are several of the smaller rivers that drain to the Red River, including the Turtle, Maple, Forest and Park. The Pembina River also enters from Canada, flowing through this section before entering the Red River Valley.

Many of the wetlands in this section have been drained. However, remaining wetlands provide important habitat for waterfowl. The depressions, ponds and potholes are used as resting and feeding grounds along north-south migration routes and as nesting and rearing areas for numerous species of ducks. This area is part of what is commonly referred to as the Prairie Pothole Region. Despite the wetland losses that have occurred, this region is the most productive waterfowl breeding area in the country. The native vegetation is wheatgrass-needlegrass-bluestem.

Small grains, corn, riparian woodland, pasture and mixed cropland occur in the southeastern part of this section. North of this, the small grains and corn begin to dominate. Farther north, wheat, barley and sunflowers are grown and dominate the land use to the north and west, mixed in with scattered grassland. The Turtle Mountains are in the northeastern portion of this section, near the Canadian border and have a land cover consisting of cropland, wetlands, pasture and some woodlands. Most of the northeastern portions of the Northeastern Glaciated Plains are cropland for wheat, potatoes and sugar beets.

The largest cities in this section are Jamestown, Devils Lake and Minot. The Fort Totten and Turtle Mountain Indian Reservations are located in this area. The economy is predominantly agriculturally based. The western parts of the Sheyenne National Grassland is in this section.

The *Western Glaciated Plains Section* forms a corridor 11,600 square miles in size running north to south through east-central South Dakota. This section is an important migration corridor for most species of waterfowl and potholes or associated wetlands provide breeding habitats for many species. The land is level to undulating glacial till plains with a native vegetation of wheatgrass-bluestem-needlegrass and floodplain forest.

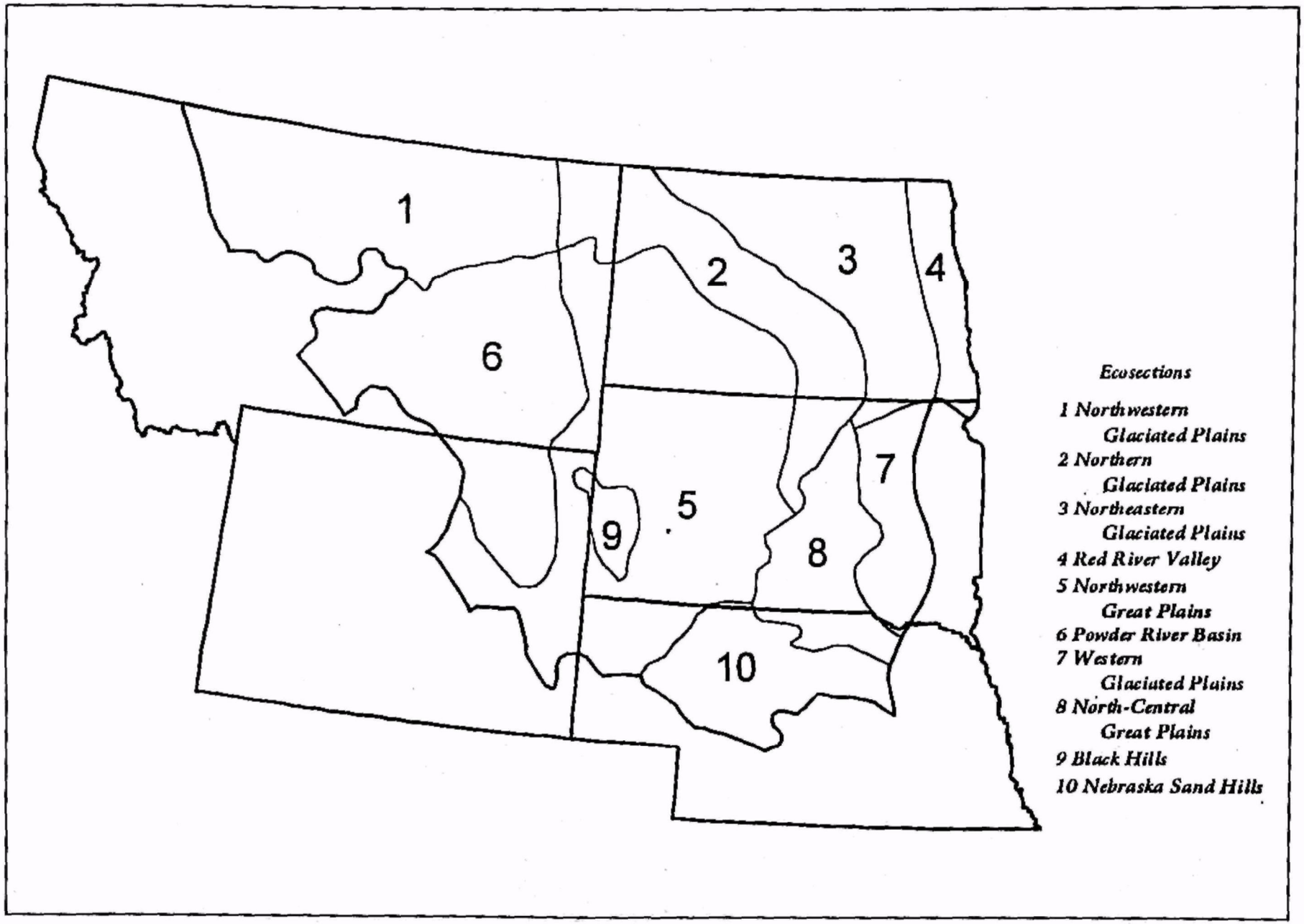

Figure 1.4.1 Ecological Sections of the Northern Great Plains (from Ecological Regions of the United States, U.S. Forest Service

Most of this section is drained by the James River. The southern portion is drained by the Missouri River and its immediate tributaries (Choteau Creek). Portions of this section drain into lakes and wetlands that do not reach either the James or the Missouri. The Missouri River is dammed just downstream of this section (Gavins Point), which forms Lewis and Clark Lake, whose waters reach up into the southern tip of the section.

In the northern and central portions of this section, a mosaic of cropland, riparian woodland, pasture and wetlands dominate. In the south, this changes to corn, soybeans and alfalfa. The largest cities in this section are Aberdeen, Huron and Mitchell, however, there are numerous small towns. The economy is based on agriculture with some manufacturing. The Yankton Indian Reservation and the northern portion of the Santee Indian Reservation in Nebraska are in this section. No national grassland units fall within the Western Glaciated Plains.

The *North-Central Great Plains Section* extends from northern Nebraska to southern and central South Dakota and is 16,700 square miles in size. The area is level to gently rolling till plains with potholes and well-defined drainage systems. Prairie potholes are important habitat for many species of migrating waterfowl. The native vegetation is wheatgrass-needlegrass-bluestem and northern floodplain forest.

The northeastern parts of this section drain to the James River, while the Missouri River flows through the central part. The White River enters from the Northwestern Great Plains Section and joins the Missouri River. The Missouri has two dams in this section, Big Bend and Fort Randall, which form Lake Sharpe and Lake Francis Case, respectively. The southern parts of this section are drained by the Niobrara and its tributaries such as the Keya Paha River and Ponca Creek.

The land cover in the northern reaches of this section is scattered crop and hayland mixed with bluestem-wheatgrass-needlegrass. This grass complex is the dominant vegetation in the western and southwestern region of the North-Central Great Plains. Croplands of corn, soybeans, and alfalfa mix with riparian woodland and pasture in the southeast portion.

This section is not heavily populated, the largest towns being Winner and Chamberlain. The Rosebud, Lower Brule and Crow Creek Indian Reservations are within this section. The southwestern half of the Fort Pierre National Grassland is in this section.

The *Nebraska Sand Hills Section* contains about 19,300 square miles located in north-central Nebraska. It is an area of loess and dune sand stabilized by vegetation. The native vegetation is wheatgrass-needlegrass-bluestem with bluestem-sandreed. Only a few minor scattered areas of cropland exist. The Niobrara River flows through the northern edge of the Sand Hills, entering from the southern portion of the Northwestern Great Plains. The headwaters of the Loup River, its tributaries (Cedar Creek, Calamus Creek, Dismal River, Middle, North and South Forks) and the Elkhorn River are in the Sand Hills. The Niobrara flows to the Missouri River, the Loup and the Elkhorn flow to the Platte River and eventually to the Missouri River. The High Plains Aquifer, which stretches from southern South Dakota to the Texas panhandle, reaches its greatest thickness under the Sand Hills (Bleed, 1990).

The human population in the Sand Hills is very small. Most towns in this area have only a few hundred inhabitants. The largest nearby towns, Valentine and Alliance are on the very edge outside of the Sand Hills. Most of the land is in large ranches and cattle production is

the main economic activity. The Bessey Unit of the Nebraska National Forest and the Samuel R. McKelvie National Forest are in the Sand Hills.

Great Plains Dry Steppe Province

The *Northwestern Glaciated Plains Section* section covers 40,700 square miles in northern Montana. The terrain is level to gently rolling glacial till plains and rolling hills on the Missouri Plateau. There are high density dendritic drainage patterns on areas of exposed marine shales. Low to medium density drainage patterns occur on the better drained glacial till. The native vegetation is grama-wheatgrass-needlegrass.

The Marias River and its tributaries flow into this section from the Rocky Mountains and then join the Missouri River. The Milk River enters from Canada (after starting in the United States) and meets the Missouri River just downstream from Fort Peck Dam. The Missouri River mainstem exits the Rocky Mountains, collects flow from the Marias and Milk, and enters the Northern Glaciated Plains. The Missouri River is dammed to produce Fort Peck Reservoir.

Around the Fort Peck Reservoir in the southeastern part of this section, the dominant land cover is grama-wheatgrass-needlegrass grassland. The central and western parts are a mixture of grassland and dry cropland. Irrigated cropland occurs east of the Rocky Mountains and in the Milk River Valley. Grassland mixed with conifers spreads out from the mountains in the west and southwest. A few small mountain ranges dominated by ponderosa pine, douglas-fir and other conifers dot the region. These include the Little Rocky Mountains, the Sweet Grass Hills, the Highwood Mountains and the Bear Paw Mountains. The Little Belt and Judith Mountains form the southwest limit of this section.

The major population centers in this section are Great Falls, Havre, Glasgow and Wolf Point. All or parts of four Indian Reservations are contained within this section, including Blackfeet, Rocky Boys, Fort Belknap and Fort Peck. It also includes all of the Charles M. Russell National Wildlife Refuge surrounding Fort Peck Lake. The economy is based primarily on ranching and irrigated agriculture. There are no national grassland units in the Northwestern Glaciated Plains.

The *Northern Glaciated Plains Section* forms a band from northwestern North Dakota to north-central South Dakota along the Missouri River covering 26,900 square miles. The land is gently undulating to rolling glacial till plains. The wildlife species here are typical of riparian areas and prairie potholes. The streams form low to medium dendritic drainage patterns, and change to high density dendritic patterns where the sedimentary rocks are exposed due to erosion of badlands.

The Missouri River dominates this region. It enters this section before the confluence with the Poplar River, joins the Yellowstone River and becomes impounded as Lake Sakakawea behind Garrison Dam. The Missouri then flows into the Northwestern Great Plains, but tributaries to it flow west from the Northern Glaciated Plains. This region is known as the Missouri Coteau and it contains numerous terminal lakes, ponds and wetlands.

Dry cropland, grassland, riparian woodland and pasture dominate the southern part of this area, which changes to grassland with scattered cropland and hayland to the north. In the northwestern portion, dry cropland with scattered grassland and wheat is the primary land cover. The far northwestern portion is covered by wheatgrass-needlegrass.

The largest city in the Northern Glaciated Plains is Williston, North Dakota. This section includes the Fort Berthold Indian Reservation and the northern portions of the Little Missouri National Grassland. The economy is based on agriculture, recreation, oil and gas extraction and coal mining.

The *Northwestern Great Plains Section* is located in southwestern North Dakota, western South Dakota, northwestern Nebraska, northeastern Wyoming and southeastern Montana. It is the largest of the ecological sections in the Northern Great Plains with an area of 76,100 square miles. The terrain is gently sloping to rolling shale plains. There are some steep flat-topped buttes and badlands. The drainages are long, structurally controlled second and third order streams with low gradients and are fed by high density dendritic first order streams.

The Missouri River is dammed in this section to produce Lake Oahe After exiting Oahe Dam it flows into the North-Central Great Plains. Much of the Little Missouri River's headwaters and mainstem flow through the northwestern part of this section. Both the Cheyenne and the Belle Fourche Rivers enter this section from the Powder River Basin, flow around the Black Hills (collecting their tributaries), and join the Missouri River, forming an arm of Lake Oahe. Two important streams with headwaters in this section are the Niobrara and the White. The Niobrara enters the Sand Hills from this section and the White enters the North-Central Great Plains. A number of tributaries to the Missouri have essentially their entire flow in the Northwestern Great Plains from headwaters to mouth. These include the Grand, Moreau, Knife, Cannonball, Heart and Bad Rivers. The Powder River leaves the Bighorn Mountains and briefly enters this section before entering the Powder River Basin. The southwestern edge of this region contains the North Platte River and its northern tributaries.

The northern part of this section is grassland composed of grama and buffalo grass. Toward the northeast and east this changes to a mix of grassland, scattered cropland, hayland and bluestem-indiangrass-wheat-grass. The southeast is bluestem-indiangrass-wheatgrass as it grades into the Sand Hills. Further to the south, a pine-grassland-brushland mosaic begins, with stands of pine found along the Pine Ridge area. A dry cropland/grassland mix intermingles with these other types up to the North Platte River, where irrigated crops are found. The southwest area, which reaches into and between the southern end of the Bighorn Mountains and the Laramie Mountains, is grama-wheatgrass-needlegrass and sagebrush steppe. The northwestern section contains grama-buffalo grass, dry cropland, some grassland/conifer mix and a small amount of irrigated crops along the Belle Fourche River, north of the Black Hills.

Major population centers in the Northwestern Great Plains are Bismarck, Dickinson, Chadron, Alliance, Pierre, Rapid City, Hot Springs, and Casper. All or portions of the following National Grasslands are located in this section: Thunder Basin, Little Missouri, Grand River, Cedar River, Oglala, Buffalo Gap and Fort Pierre. In addition, the Pine Ridge Unit of the Nebraska National Forest Pine Ridge and the Custer National Forest are located here. The Northwestern Great Plains include portions or all of the Rosebud, Pine Ridge, Cheyenne River and Standing Rock Indian Reservations as well as the Badlands and Theodore Roosevelt National Parks. The economy is based on irrigated and dryland agriculture, ranching, tourism, oil and gas extraction and coal mining.

The *Powder River Basin Section* covers 45,000 square miles in southeastern Montana

and northeastern Wyoming. The landscape is gently rolling to steep dissected plains on the Missouri Plateau with some flat-topped buttes. Low to medium density drainages occur on more permeable surfaces.

The Musselshell River rises in the Crazy, Little Belt and Big Belt Mountains and drains to the Missouri River at Fort Peck Reservoir. The Yellowstone River is a major feature of this section, leaving the mountains, and flowing through the northern part, exiting to the Northwestern Great Plains before entering the Missouri. The Powder River is a dominant feature of the eastern part, entering from the Northwestern Great Plains and flowing to its confluence with the Yellowstone River. As mentioned earlier, the Belle Fourche and Cheyenne Rivers have much of their headwaters in this section.

The western border of this section is formed by the Bighorn, Beartooth, Little Belt and Crazy Mountains. Grassland mixed with conifers covers much of the central portion of this region, especially along and to the south of the Yellowstone River. Grama and buffalo grass mixed with dry cropland is the dominant land cover in the east-central area, with grama-wheatgrass-needlegrass/dry cropland more common further north. In the south, west of the Black Hills and east of the Bighorns, grama-wheatgrass-needlegrass and sagebrush steppe are the most common.

The major population centers in this section are Gillette, Sheridan, Miles City and Billings. This area includes portions or all of the Crow and Northern Cheyenne Indian Reservations. The economy is based on agriculture, ranching, and coal mining. Portions of the Thunder Basin National Grassland and the Custer National Forest are located in the Powder River Basin.

1.5 HISTORICAL PERSPECTIVE

The history of the Great Plains has been driven by the extremes of weather that have occurred over time. While humans have lived in the Great Plains for at least 11,000 years (Flores, 1995), they have been at the mercy of great droughts and severe winters. The longest drought period known was the Altithermal, a two thousand year drought that caused the abandonment of the Great Plains (Flores, 1995). Indian peoples moved into the Great Plains about 1000 years ago, but they too were driven out by drought in 1299 (Flores, 1995).

White settlement of the Northern Great Plains began in the latter half of the 19th century. The Northern Great Plains were obtained by the United States from France as part of the Louisiana Purchase and the expedition of Lewis and Clark marked the opening of the area for settlement. Initially, the plains were an area to pass through on the way to California or Oregon, but starting in the 1850s, these areas began to be settled, helped by the passage of the Homestead Act in 1862.

By the late 1870s and 1880s the Plains Indian Tribes had been forcibly relocated to reservations and the free-roaming bison herds had been eliminated. With this change, expansion of cattle into the Northern Great Plains then began with the utilization of the open range system (Miller, 1990). Speculative ventures led to overstocking of the range and overgrazing (Miller, 1990). The large herds entered the winter of 1886 in poor condition and severe blizzards nearly destroyed the industry, with some ranches experiencing losses of 50 to 75% (Miller, 1990; Manning, 1995). As a result, a transition from open range to producing hay to winter-feed cattle began, which is the system used today (Miller, 1990; Manning, 1995).

After World War I, high wheat prices and the Enlarged Homestead Act led to an increase in farmers entering the Northern Great Plains (West, 1990, Obermiller, 1992). Between 70,000 and 80,000 people settled on Montana farms between 1909 and 1918, however, 60,000 would leave before 1922 (Manning, 1995). Wheat yields, however, did not peak until 1931 at more than 20 million acres in production (West, 1990). With so much land in production during favorable weather years, the stage was set for the drought that came in the 1930s. The "Dust Bowl" was triggered by a normal drought, but was made much worse by the great change that had occurred to the ecosystems of the Great Plains (Flores, 1995). As a result of the drought conditions of the 1930s, the United States government began purchasing submarginal lands from bankrupt farmers and planted cropland back into grasses and initiated grazing rotations on rangeland (West, 1990). These areas were referred to as Land Utilization (L-U) Projects (West, 1990). In 1937 the Bankhead-Jones Farm Tenant Act gave these lands to the Soil Conservation Service (now Natural Resources Conservation Service) to manage. These lands were later transferred in 1953 to the Forest Service to become the national grasslands. Some, however, were transferred to other federal agencies, such as the Fish and Wildlife Service for National Wildlife Refuges, prior to transfer to the Forest Service.

Agriculture in the Northern Great Plains underwent another major transformation following World War II with the introduction of irrigation from underground aquifers. In 1959, Nebraska irrigated less than a million acres of cropland; in 1977, it was seven million (Manning, 1995). Most of this change occurred from tapping into the Ogallala Aquifer, which by 1980 was watering 20% of the nation's cropland (Manning, 1995), only part of which is in the Northern Great Plains.

The draining of the vast wetland resources in the Northern Great Plains began with early settlement, but increased dramatically after the 1940s (Johnson and Higgins, 1997). High commodity prices and the introduction of mechanized farming, as well as federal assistance aided in creating pressures to drain wetlands (Johnson and Higgins, 1997). The issuance of Executive Order 11990, which required that effects of federal projects on wetlands be evaluated, and the requirements of Section 404 of the Clean Water Act have slowed the loss of wetlands.

Major changes in the Missouri River occurred in the years following World War II. Most prominent, was the construction of the six dams on the mainstem of the river. This brought about dramatic changes in the aquatic habitat of the river and has led to declines in a number of species dependent on the rivers natural flow regime. The creation of the reservoirs also flooded many prime areas on the Indian Reservations bordering the river.

During the 1970s, many changes occurred in how the aquatic resources of the Northern Great Plains (and all other areas) would be managed. The passage of the National Environmental Policy Act mandated that environmental effects of federal actions be analyzed. The numerous pollution control acts such as the Clean Water Act, the Clean Air Act, etc. brought changes in how wastes are disposed of into the environment. The Endangered Species Act requires the recovery of species that are endangered and threatened.

The Northern Great Plains are undergoing another time of change as population shifts, manifested as losses to most rural areas and growth in others. These changes will have differing impacts on the environment than previous events.

Status of Aquatic Resources

2.1 INTRODUCTION

Question 1 **What is known about the current status and apparent trends in water quality, aquatic habitat and aquatic species in the Northern Great Plains Assessment Area?**

This chapter examines the condition and extent of aquatic habitats in the Northern Great Plains from streams and rivers to lakes and ground water. These particular habitats are described in detail in Section 2.2. Wetlands and riparian areas are discussed separately in Chapter 3. Quality of surface waters is discussed in Section 2.3. On a watershed basis, the levels of selected parameters including fecal coliforms, dissolved solids and dissolved oxygen are compared to water quality standards. The overall water quality status for most watersheds as reported by state environmental agencies is also presented. In Section 2.4, the quality of ground water is examined for parameters such as dissolved solids, nitrates and pesticides.

The condition of aquatic habitat with respect to certain ecological measures is examined. In Section 2.5, the status of the aquatic species inhabiting these environments is presented and Section 2.6 specifically examines the status of aquatic species designated as endangered, threatened or of special concern. Section 2.7 describes an analysis of the risk to various aquatic species using a computer model.

At present, there is no regionwide water quality monitoring effort occurring in the Northern Great Plains Assessment Area (NGPAA). Available monitoring information is mainly the result individual state efforts. In addition, several U.S. Geological Survey NAWQA (National Water Quality Assessment) Program units fall within the NGPAA and more intensive monitoring is occurring there.

Each section in this report is generally organized with the following subheadings: introduction, key findings, data sources, data quality and gaps, spatial patterns and future trends.

2.2 STREAMS, RIVERS, LAKES AND AQUIFERS

Introduction

The Northern Great Plains Assessment Area contains a wide variety of aquatic habitats. These include perennial streams more common in the eastern portions, with fewer in the west; large rivers such as the Missouri; streams fed mainly by ground water in the Nebraska Sand Hills; large expanses of wetlands and lakes in the eastern and northern portions; large artificial lakes; numerous small ponds and stock ponds and extensive underground aquifers. This section discusses the characteristics of each waterbody type and its importance to the human and wildlife populations that depend on them.

Snowpacks are important in providing moisture to various aquatic systems. The Northern Great Plains snowpack ranges from 10 to 40 inches deep and, along with the snowpack in the Rocky Mountains, provides much of the moisture the region receives (Huntzinger, 1995). A larger amount of rainfall in the eastern parts, along with snowmelt, provides for more perennial streams. Further west, normally the only perennial streams are those that flow from mountains or are fed by ground water. In some places, infiltration of precipitation to shallow ground water is the only source of stream flow. Streams connected only to

ground water often have different temperature and water quality characteristics than stream flow originating from runoff (Huntzinger, 1995). Flooding can occur throughout the Great Plains, but occurs more frequently in the eastern part with its greater precipitation. Snowmelt from the mountains may cause flooding in the large rivers of the Great Plains, especially if coinciding with high spring rainfall.

Intermittent / Ephemeral Streams

Intermittent streams are those that are below the ground water table part of the year and flow only in response to precipitation events or ground water discharge (Montana Department of Environmental Quality, 1994). Therefore, much of the year they may be dry. Ephemeral streams are above the ground water table and flow only when there is precipitation (Montana Department of Environmental Quality, 1994). In the Northern Great Plains, intermittent and ephemeral streams are common over much of the area, especially in the western and central parts.

Great Plains streams are harsh environments for aquatic life. They generally have sandy bottoms, with the contours of the bottoms changing rapidly, smothering aquatic vegetation and burying eggs of fishes (Collins, 1985). In addition, there is very little cover and water temperatures can rise to lethal levels. Conditions in intermittent streams regularly approach the physiological tolerance limits of organisms and even slight perturbations from wastewater effluent, siltation or removal of shade may cause those tolerances to be exceeded (Zane, et al. 1989). As a result, plains rivers and streams are not particularly fertile. However, this underestimates their importance because these streams serve as focal points for numerous wildlife species and they have many unique species adapted to this environment.

Perennial Streams

Perennial streams are those that flow year round, because there is enough rainfall in the watershed and they have a continuous connection to ground water. In the NGPAA, perennial streams are represented by numerous streams in the east and the larger streams in the west, those that flow from the Black Hills and other mountain areas and Sand Hills streams fed by ground water. Since the flow in these streams is more stable and reliable, there is more biological diversity instream and in the riparian areas.

Sand Hills streams exist under a unique set of hydrologic conditions. Precipitation in the Sand Hills quickly recharges the ground water and later discharges into springs or seeps. In contrast, in areas outside of the Sand Hills with less sandy soils, precipitation runs off more easily, forming tributaries. Since Sand Hills streams derive their flow mostly from ground water rather than overland runoff, they are less likely to be affected by air temperature, are less likely to freeze during the winter and have little seasonal temperature variability (Bentall, 1990). Sand Hills streams also differ from most other streams in the Northern Great Plains in that they have few tributaries, flow at very steady rates, rarely flood and are low in dissolved solids (Bentall, 1990).

Large Rivers

The Missouri River is the dominant hydrologic feature of the Northern Great Plains. Originating in the snowmelt of the Northern Rocky Mountains it drains the vast majority of the region. The historical hydrologic pattern of the Missouri River consisted of a peak in March and April from snowmelt on the plains, a decline in May, a higher peak in June from snowmelt in the Rocky Mountains and rainfall throughout the

basin and a decline throughout the summer (Hesse, et al. 1989). This predam hydrograph defined the channel morphology and floodplain characteristics of the river (USFWS, 1994). The historical dominant discharge (flushing flows that occur about every 1.5 years on average) were estimated by Hesse and Mestl (1993) at about 100,000 cfs. This flooding of the Missouri River is critical to the aquatic life which has adapted to it. The high spring flows stimulated the native fish to spawn and maintained the high turbidity levels to which these species adapted (Pflieger and Grace, 1987). There are presently four species listed as threatened or endangered that are associated with the Missouri River: the bald eagle, the least tern, the pallid sturgeon and the piping plover. Several others are either proposed for listing, are candidates or are of special concern.

Between 1938 and 1963 six major dams were built on the mainstem of the Missouri River. These six dams can collectively store 92 billion cubic meters of water, which is more than the mean annual discharge at the mouth of 70 billion cubic meters (Schmulbach, et al. 1992). Johnson (1992) described the changes in flow after Lake Sakakawea began filling behind Garrison Dam in 1953. Between 1928 and 1953, about two-thirds of the annual peak flows were greater than 2500 cubic meters per second (Johnson, 1992). The largest peak on record was 14,150 cubic meters per second in 1952. After 1953 no peak has exceeded 2500 cubic meters per second, however, the total annual discharge has not changed.

This can be seen in the difference between the original natural hydrograph and the present one. The hydrograph now rises in March to a point much lower than the traditional flood peaks and stays at this level until November (Hesse and Mestl, 1993). River meandering has ceased and the flood pulse and floodplain connection have been nearly eliminated (U.S. Fish and Wildlife Service, 1994). The dams have become barriers to fish migration and sediment transport, have disrupted spawning cues and the temperature of the water released from the dams tends to be much colder than that to which the native fish are adapted (U.S. Fish and Wildlife Service, 1994). Overbank flooding is also one of the components of the original river that is missing from the postdam floodplain environment (Johnson, 1992).

Other large rivers in the Northern Great Plains include the Yellowstone, the Red River of the North and the Platte. The Yellowstone is one of the largest free-flowing rivers in the contiguous United States, however a significant amount of water is diverted from the river for irrigation. The Red also is undammed, but water quality problems from nonpoint and point source pollution affect it. The Platte River itself is largely outside of the NGPAA, although many of its tributaries originate within it. The discussion of the Platte is, therefore, much less extensive than the other major rivers, but since many activities affecting it derive from tributaries within the Northern Great Plains, it is examined when necessary.

Natural Lakes / Wetlands

The northeastern part of the Northern Great Plains (eastern and northern North Dakota and eastern South Dakota) contains numerous lakes and wetlands and is referred to as the Prairie Pothole region. Some of the lakes are large, such as Devils Lake and Long Lake. The lakes in the northeastern Northern Great Plains were formed by water filling depressions left by the retreating glaciers of the last ice age.

Numerous small, shallow natural lakes and ponds are also found in the Sand Hills. Much of the western third of the Sand Hills

region lacks streams and is referred to as the Closed Basin Area, containing many lakes and wetlands (Bleed and Ginsberg, 1990). Many of the interdunal valleys in the Sand Hills contain lakes, marshes and wet meadows that receive water from precipitation, surface runoff and ground water (Bleed and Ginsberg, 1990). In general, Sand Hills lakes tend to be alkaline. The lakes in the Closed Basin Area have the highest alkalinity and primary production within them is high due to the abundance of sunlight and shallow depths (Bleed and Ginsberg, 1990). Lakes in the central and eastern Sand Hills are lower in alkalinity. Species of algae, macrophytes, and zooplankton differ due to varying alkalinity levels (Bleed and Ginsberg, 1990).

Reservoirs

The largest reservoirs on the Northern Great Plains are those on the Missouri River: Fort Peck Lake, Lake Sakakawea, Lake Oahe, Lake Sharpe, Lake Francis Case and Lewis and Clark Lake. Fort Peck was the first to be completed in 1938. Fort Randall Dam (Lake Francis Case), Garrison Dam (Lake Sakakawea); Gavins Point (Lewis and Clark Lake), Oahe Dam (Lake Oahe) and Big Bend Dam (Lake Sharpe) were all completed in the period between 1952 and 1963. The largest three are Oahe, Sakakawea and Fort Peck. These dams are operated primarily for flood control, navigation and power production, depending on the need and the available flow (U.S. Fish and Wildlife Service, 1994).

Both the reservoirs themselves and the tailwaters from their releases support fisheries that were either not present or uncommon in the Northern Great Plains before the creation of the dams. For example, according to Owen and Power (1989) and Riis (1989) fishes in the Lake Sakakawea and Lake Oahe tailwaters changed from channel catfish and sauger to walleye, salmon and trout.

Aquifers

There are three major regional aquifer systems within the Northern Great Plains Assessment Area: the High Plains Aquifer System, the Northern Great Plains Aquifer System and the Great Plains Aquifer System. In addition, the unconsolidated and glacial deposit aquifers overlying these in many areas are extremely important.

Within the Northern Plains, the High Plains Aquifer covers southern South Dakota, southeastern Wyoming and most of Nebraska (U.S. Geological Survey, 1996). It consists mainly of aquifers in upper Tertiary and Quaternary rocks with water at less than 200 feet in depth and generally less than 400 feet in thickness. This is the aquifer saturating most of the Sand Hills area. The confining unit under this aquifer is the Chadron Formation. There are three aquifers (aside from the Quaternary dune sands and alluvium) within this aquifer. These are located in the Tertiary formations and are the Ogallala, Arikaree and Brule aquifers.

The Ogallala Formation is the principal geologic unit in the High Plains Aquifer and consists of unconsolidated gravel, sand, silt and clay (U.S. Geological Survey, In Press). It was deposited by eastward-flowing streams draining the Rocky Mountains during the late Tertiary Period. Within the NGPAA, the Ogallala is located throughout most of central and western Nebraska (U.S. Geological Survey, 1988). The Arikaree is in northwestern Nebraska and southeastern Wyoming and the Brule is in western Nebraska (near the North Platte) and southeastern Wyoming.

Water in the High Plains Aquifer is generally unconfined (at the water-table) (U.S. Geological Survey, In Press). Recharge to the High Plains Aquifer is from precipitation

and some infiltration by irrigation and natural discharge is to springs and streams. Most of the discharge from the High Plains Aquifer is by withdrawal by wells, and almost all is for irrigation (U.S. Geological Survey, In Press).

The Northern Great Plains Aquifer System underlies most of North Dakota, South Dakota, eastern Montana and northeastern Wyoming and it lies mostly within the Williston and Powder River basins and areas of structural uplift that flank these areas (U.S. Geological Survey, 1996a). The major aquifers of this system are sandstones of Tertiary and Cretaceous age and carbonate rocks of Paleozoic age. These aquifers form one of the largest confined aquifer systems in the United States. The individual aquifers within this system in the NGPAA include the Fort Union, the Hell Creek-Fox Hills, and the Inyan Kara Group (U.S. Geological Survey, 1988). A confining layer of Pierre Shale separates the Inyan Kara from the others above. The Fort Union formation underlies the Powder and Williston Basins in Wyoming, Montana and North Dakota. The Hell Creek/Fox Hills aquifer is most extensive in a band through central North Dakota and northwestern South Dakota. It rims the Powder and Williston Basins. The Inyan Kara Group is located in a band surrounding the Black Hills.

Regional movement of water in the Northern Great Plains Aquifer System is from recharge areas at high altitudes down the dip of the aquifers and then upward to discharge into shallower aquifers or to the land surface (U.S. Geological Survey, 1996a). The regional flow in the deep confined aquifers follows long flow paths from southwest to northeast. Most of the recharge to the aquifer system is from precipitation that falls on outcrop areas exposed by erosion or from streams that cross aquifer outcrops, seeping downward through the streambeds into the aquifers (U.S. Geological Survey, 1996a). Much of the discharge from the aquifer system is by upward leakage of water into shallower aquifers and some water discharges into lakes and streams near the North Dakota/Minnesota line (U.S. Geological Survey, 1996a).

In eastern North Dakota, highly mineralized water discharges from the lower aquifers by upward leakage into overlying unconsolidated deposits (U.S. Geological Survey, 1996a). Some of this saline water moves through permeable areas of the unconsolidated deposits into lakes, streams and wetlands, causing the surface water to be saline.

The Great Plains Aquifer System is composed of lower cretaceous water-bearing sandstone and underlies most of Nebraska (as well as western Kansas and eastern Colorado) (U.S. Geological Survey, In Press). This system is situated below the High Plains Aquifer System. Two major aquifers in the lower cretaceous make up this system, the Apishapa (lower) and the Maha (upper). The Maha underlies western South Dakota and northwestern Nebraska. The Apishapa underlies western Nebraska. In general, water in each aquifer flows from west-southwest to east-northeast (Jorgensen, et al. 1993). The major recharge area is in southeastern Colorado from precipitation falling on outcrop areas and flows east-northeast to central Kansas and eastern Nebraska (U.S. Geological Survey, In Press). Some recharge does occur from leakage from the overlying High Plains Aquifer System as well.

Overlying these aquifer systems in some areas are the unconsolidated and glacial deposit aquifers. The unconsolidated systems are along streams and valleys throughout the NGPAA and the glacial deposit aquifers are very extensive north and east of

the Missouri River in North Dakota, South Dakota and Montana. They are recharged by precipitation and serve as a source of water to shallow wells and for recharge to the lower bedrock aquifers. In North and South Dakota, most of the cities east of the Missouri River that use ground water obtain water from glacial drift aquifers (North Dakota Department of Health, 1994; South Dakota Department of Environment and Natural Resources, 1996). Water from glacial drift aquifers is generally less mineralized than water from the bedrock aquifers.

Key Findings

•There are 180 eight-digit hydrologic unit codes (watersheds) in the Northern Great Plains Assessment Area.
•Precipitation is highest in the southeastern portions of the NGPAA (eastern South Dakota and eastern Nebraska) at more than 20 inches. It is lowest in northeastern Wyoming and eastern Montana with less than 15 inches.
•Stream density is highest in western South Dakota and is lowest in eastern and central North Dakota.
•Three major aquifer systems are located in the NGPAA. They are the High Plains, the Northern Great Plains and Great Plains aquifer systems.
•The hydrograph of the Missouri River has changed from having two prominent flood peaks each year to a long steady flow covering most of the year.
•Most of the watersheds in the NGPAA experience mean flows of less than 1000 cfs. A few watersheds in the Yellowstone and Missouri River mainstems have mean flows of greater than 10,000 cfs. Much of the NGPAA experience wide variabilities in flow from year to year.
•Reservoir area is greatest in watersheds connected with the Missouri River, reflecting the existence of larger reservoirs such as Oahe, Sakakawea and Fort Peck.

Data Sources

The eight-digit watershed boundaries were digitized from 1:100,000-scale maps. The stream density in each watershed was determined from the U.S. Environmental Protection Agency's Reach File version 3.0 (RF3). RF3 is based on the 1:100,000-scale U.S. Geological Survey Digital Line Graph (DLG) data.

Information on the aquifer systems of the Northern Great Plains was provided by the U.S. Geological Survey. Precipitation information was obtained from the National Climate Data Center. Missouri River information was obtained from the U.S. Army Corps of Engineers Draft Environmental Impact Statement for the Missouri River Master Water Control Manual, the U.S. Fish and Wildlife Service's Biological Opinion to the Draft Master Manual and literature reviews. The streamflow information was obtained from STORET.

Spatial Patterns

Table 2.2.1 lists all of the eight-digit watersheds in the NGPAA. There are 180 eight-digit watersheds wholly or partly within the Northern Great Plains.

Figures 2.2.1 and 2.2.2 show the precipitation for the Northern Great Plains for 1990 and 1993, respectively. A near normal precipitation year occurred in 1990 and a wet year in 1993. There is a general trend of increasing precipitation from northwest to southeast. This precipitation pattern determines much of the aquatic features of the Northern Great Plains landscape, with higher stream flows in the east and streams in the west dependent on streamflow derived from the higher elevation regions. As can be seen from Table 2.2.1 and Figure 2.2.3, stream density in the Northern Great Plains is

highest in the Black Hills and adjacent areas of northeastern Wyoming, western South Dakota and southwestern North Dakota. It is lowest in the prairie pothole regions of North and South Dakota. Nebraska was not included in this analysis.

The discharge of the Missouri River has changed since the construction of the mainstem dams. Formerly two flood peaks occurred in March/April and June. However, due to the construction of the mainstem dams, these peaks have been replaced by a long steady flow from March through November. The effects of this change are discussed in more detail in Chapters 3 and 5.

Figure 2.2.4 shows the amount of reservoir area in each watershed. The Missouri River reservoirs stand out with their large individual areas, but other areas in the Upper James, North Platte, Belle Fourche, Marais, Souris and Sheyenne River watershed also have large impounded areas.

Streamflow in the NGPAA is shown for the period 1980 to 1995 in Figures 2.2.5, 2.2.6 and 2.2.7. From the minimum flow data recorded, for the most part at the lowest station in each watershed, much of the NGPAA experienced very low flows within this time frame. Only the Missouri and Yellowstone stand out with relatively high minimum flows. A comparison of the low flow data with high flows in Figure 2.2.7 shows the extreme variability present within these plains river system. Some watersheds that experienced flows of less than 500 cfs at the lowest flow have maximum flows of more than 20,000 cfs. One, the Lower Cheyenne River, ranged from a low of 5 cfs to a high of 48,400 cfs during this period.

2.3 SURFACE WATER QUALITY

Introduction

Surface water quality is affected by many different factors, both natural and human-caused. Natural factors include the nature of the geology and soils of the watershed, climate (temperature and precipitation) and ecological factors. Human-caused factors include pollution from point sources such as municipal and industrial wastewater plants, pollution from nonpoint source runoff from crops, rangeland and cities and modifications of streams by channelization, diversion, dam construction and removal of riparian vegetation. All of these activities, along with any natural limitations, may impact the quality of water and therefore, determine whether the stream or lake can support aquatic life or be used as a drinking water source.

Point sources can contribute any number of pollutants to surface water, ranging from biochemical oxygen demand, ammonia, suspended solids, pH and fecal coliforms in municipal wastewater to any of these plus metals, organics and temperature changes in industrial wastewater. Nonpoint source pollution can contribute fecal coliforms, nutrients and solids from livestock uses to sediment, pesticides and nutrients from cropland to any number of hydrologic modifications that may cause temperature and sediment changes in streams. In addition, irrigation of cropland can add salinity and in some instances pollutants such as selenium.

In this section, data is presented by watershed showing the condition of surface water quality. Highlighted are the percentage and number of miles (for streams) or acres (for lakes) that are not meeting the beneficial uses designated for by the state. Table 2.3.1 lists the classification system for waterbodies used in each State. The states assign these

uses, which include such designations as aquatic life, recreation, drinking water and agriculture along with the specific water quality criteria necessary to protect the beneficial uses. The criteria are the actual concentrations of specific pollutants that are allowed in the waterbody. A given waterbody can have from only one to many use designations. Waterbodies are defined as individual lakes or stream segments that are delineated by the state. A few Indian Tribes in the Northern Great Plains are working toward designation of beneficial uses for Tribal waters.

States are required by Section 305(b) of the Clean Water Act to assess the ability of the waterbodies of the state to meet the uses for which they are designated and report this to Congress every two years. The states report the number of miles of streams and acres of lakes that are fully supporting, are fully supporting but threatened, partially supporting or not supporting uses. However, the actual number of stream miles assessed within a given watershed varies greatly and caution must be used in interpreting this data. For example, a watershed covering an extensive area may have had only a small number of miles assessed and these assessed miles may not be representative of the entire watershed. Therefore, while quantitative values are shown in the figures derived from the 305b data, these should be recognized as essentially qualitative and show areas that are potentially in good or poor condition.

Each state has varying criteria as to how to determine full support versus partial or nonsupport, but generally it involves either the number of exceedances of a standard when there is monitoring data or other evaluation methods when there is no data. The State of Montana, for example, uses the following definitions for use support (Montana Department of Environmental Quality, 1994):

Full Support - uses are at natural condition or best practical condition and water quality standards are not being violated.
Threatened - fully supporting uses, but a new activity or an increase in existing activities may result in water quality standards violations.
Partial Support - uses are not being supported at natural or best practical levels and water quality standards are not being met (this category includes everything from slight impairment to nearly not supporting).
Non Support - has acute toxics or human health criteria violations, where biological or physical data indicate severe degradation or where other data indicate that water quality standards are violated and one or more uses cannot be attained.

The U.S. EPA recommends that for uses to be fully supporting, less than 10% of the monitored parameters should exceed criteria (U.S. Environmental Protection Agency, 1992). To be partially supporting, between 11 and 25% of values exceed criteria and not supporting means that more than 25% of values exceed criteria. South Dakota uses concentrations of total suspended solids, total dissolved solids, pH, temperature, dissolved oxygen, unionized ammonia, fecal coliform, metals and others to determine total use support (South Dakota Department of Environment and Natural Resources, 1996).

Data in this report is also presented for many of the specific pollutants that are of widespread importance in the Northern Great Plains. These pollutants include total solids, dissolved solids, nutrients, ammonia, dissolved oxygen (too little, rather than too much), fecal coliforms and biochemical oxygen demand.

Since eight-digit watersheds cover such a large area, numerous variations in water quality criteria and beneficial uses occur within

Table 2.2.1 Hydrologic Unit Watersheds (8-digit) that are fully or partly within the Northern Great Plains Assessment Area, grouped by major drainage basins.

Hydrologic Unit Code	River Basin Name
Souris River Watershed	
09010001	Upper Souris River
09010002	Des Lacs River
09010003	Lower Souris River
09010004	Willow Creek
09010005	Deep River
Red River of the North Watershed	
09020101	Bois de Sioux River
09020104	Upper Red River
09020105	Western Wild Rice River
09020107	Red River (Elm-Marsh)
09020109	Goose River
09020201	Devils Lake
09020202	Upper Sheyenne River
09020203	Middle Sheyenne River
09020204	Lower Sheyenne River
09020205	Maple River
09020301	Red River (Sandhill-Wilson)
09020306	Red River (Grand Marais-Red)
09020307	Turtle River
09020308	Forest River
09020310	Park River
09020311	Lower Red River
09020313	Pembina River
Saskatchewan River Watershed	
10010002	Saint Mary River
Upper Missouri/Marais River Watersheds	
10030102	Upper Missouri River-Dearborn
10030103	Smith River
10030104	Sun River
10030105	Belt Creek
10030201	Two Medicine River
10030202	Cut Bank Creek
10030203	Marais River
10030204	Willow Creek
10030205	Teton River
Fort Peck Lake/Musselshell River Watersheds	
10040101	Missouri River (Bullwacker-Dog)
10040102	Arrow Creek
10040103	Judith River
10040104	Missouri River (Fort Peck Reservoir)
10040105	Big Dry Creek

Table 2.2.1 continued Hydrologic Unit Watersheds (8-digit) that are fully or partly within the Northern Great Plains Assessment Area, grouped by major drainage basins.

Hydrologic Unit Code	River Basin Name
10040106	Little Dry Creek
10040201	Upper Musselshell River
10040203	Flat Willow Creek
10040202	Middle Musselshell River
10040204	Box Elder Creek
10040205	Lower Musselshell River
Milk River Watershed	
10050001	Milk River Headwaters
10050002	Upper Milk River
10050003	Wild Horse Lake
10050004	Middle Milk River
10050005	Big Sandy Creek
10050006	Sage Creek
10050007	Lodge Creek
10050008	Battle Creek
10050009	Peoples Creek
10050010	Cottonwood Creek
10050011	Whitewater Creek
10050012	Lower Milk River
10050013	Frenchman Creek
10050014	Beaver Creek
10050015	Rock Creek
10050016	Porcupine Creek
Missouri-Poplar River Watersheds	
10060001	Missouri River (Prairie Elk-Wolf)
10060002	Redwater River
10060003	Poplar River
10060004	West Fork Poplar River
10060005	Missouri River (Charlie-Little Muddy)
10060006	Big Muddy Creek
10060007	Brush Lake
Yellowstone Watershed	
10070002	Upper Yellowstone River
10070004	Upper Yellowstone River-Lake Basin
10070005	Stillwater River
10070006	Clarks Fork of the Yellowstone River
10070007	Upper Yellowstone River-Pompeys Pillar
10070008	Pryor Creek
10080015	Lower Bighorn River
10080016	Little Bighorn River
10090101	Upper Tongue River
10090102	Lower Tongue River

Table 2.2.1 continued Hydrologic Unit Watersheds (8-digit) that are fully or partly within the Northern Great Plains Assessment Area, grouped by major drainage basins.

Hydrologic Unit Code	River Basin Name
10090201	Middle Fork Powder River
10090202	Upper Powder River
10090203	South Fork Powder River
10090204	Salt Creek
10090205	Crazy Woman Creek
10090206	Clear Creek
10090207	Middle Powder River
10090208	Little Powder River
10090209	Lower Powder River
10090210	Mizpah Creek
10100001	Lower Yellowstone River-Sunday
10100002	Big Porcupine Creek
10100003	Rosebud Creek
10100004	Lower Yellowstone River
10100005	O'Fallon Creek
Lake Sakakawea Watershed	
10110101	Missouri River (Lake Sakakawea)
10110102	Little Muddy Creek
Little Missouri River Watershed	
10110201	Upper Little Missouri River
10110202	Boxelder Creek
10110203	Middle Little Missouri River
10110204	Beaver Creek
10110205	Lower Little Missouri River
Cheyenne River/Belle Fourche River Watershed	
10120101	Antelope Creek
10120102	Dry Fork of the Cheyenne River
10120103	Cheyenne River (Dry Fork to Lance Cr)
10120104	Lance Creek
10120105	Lightning Creek
10120106	Cheyenne River (Angostura Reservoir)
10120107	Beaver Creek
10120108	Hat Creek
10120109	Middle Cheyenne River-Spring
10120110	Rapid Creek
10120111	Middle Cheyenne River-Elk
10120112	Lower Cheyenne River
10120113	Cherry Creek
10120201	Upper Belle Fourche River
10120202	Lower Belle Fourche River
10120203	Redwater River

Table 2.2.1 continued Hydrologic Unit Watersheds (8-digit) that are fully or partly within the Northern Great Plains Assessment Area, grouped by major drainage basins.

Hydrologic Unit Code	River Basin Name
Lake Oahe Watershed	
10130101	Missouri River (Painted Wood-Square Butte)
10130102	Missouri River (Upper Lake Oahe)
10130103	Apple Creek
10130104	Beaver Creek
10130105	Missouri River (Lower Lake Oahe)
10130106	Western Missouri Coteau
10130201	Knife River
10130202	Upper Heart River
10130203	Lower Heart River
10130204	Upper Cannonball River
10130205	Cedar Creek
10130206	Lower Cannonball River
10130301	North Fork Grand River
10130302	South Fork Grand River
10130303	Grand River
10130304	South Fork Moreau River
10130305	Upper Moreau River
10130306	Lower Moreau River
10140101	Missouri River (Fort Randall Reservoir)
Fort Randall Reservoir/White River Watershed	
10140102	Bad River
10140103	Medicine Knoll Creek
10140104	Medicine Creek
10140105	Crow Creek
10140201	Upper White River
10140202	Middle White River
10140203	Little White River
10140204	Lower White River
Niobrara River Watershed	
10150001	Ponca Creek
10150002	Niobrara River Headwaters
10150003	Upper Niobrara River
10150004	Middle Niobrara River
10150005	Snake River
10150006	Keya Paha River
10150007	Lower Niobrara River
James River Watershed	
10160001	James River Headwaters
10160002	Pipestem Creek
10160003	Upper James River
10160004	Elm River

Table 2.2.1 continued Hydrologic Unit Watersheds (8-digit) that are fully or partly within the Northern Great Plains Assessment Area, grouped by major drainage basins.

Hydrologic Unit Code	River Basin Name
10160005	Mud Creek
10160006	Middle James River
10160007	Eastern Missouri Coteau
10160008	Snake Creek
10160009	Turtle Creek
10160010	Northern Big Sioux Coteau
10160011	Lower James River
Lewis and Clark Lake Watershed	
10170101	Missouri River (Lewis & Clark Lake)
10170102	Vermillion River
North Platte River Watershed	
10180007	Middle North Platte River-Casper
10180008	Middle North Platte River (Glendo Reservoir)
10180009	Middle North Platte River-Scotts Bluff
10180011	Lower Laramie River
10180012	Horse Creek
10180014	Lower North Platte River
South Platte River Watershed	
10190018	Lower South Platte River
Platte River Watershed	
10200101	Middle Platte River-Buffalo
Loup River Watershed	
10210001	Upper Middle Loup River
10210002	Dismal River
10210003	Lower Middle Loup River
10210004	South Loup River
10210005	Mud Creek
10210006	Upper North Loup River
10210007	Lower North Loup River
10210008	Calamus River
10210009	Loup River
10210010	Cedar River
Elkhorn River Watershed	
10220001	Upper Elkhorn River

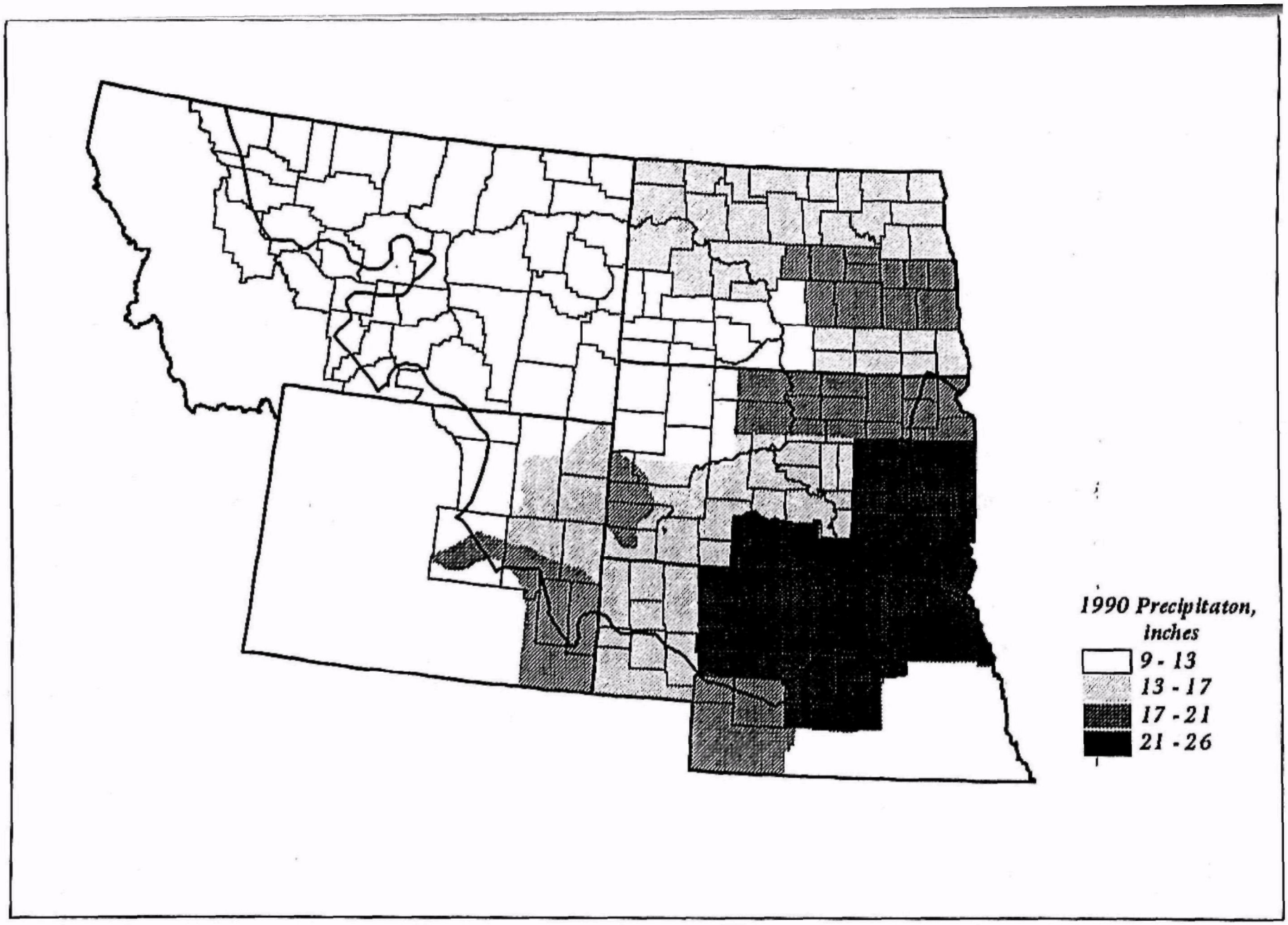

Figure 2.2.1 Precipitation for the Northern Great Plains in 1990

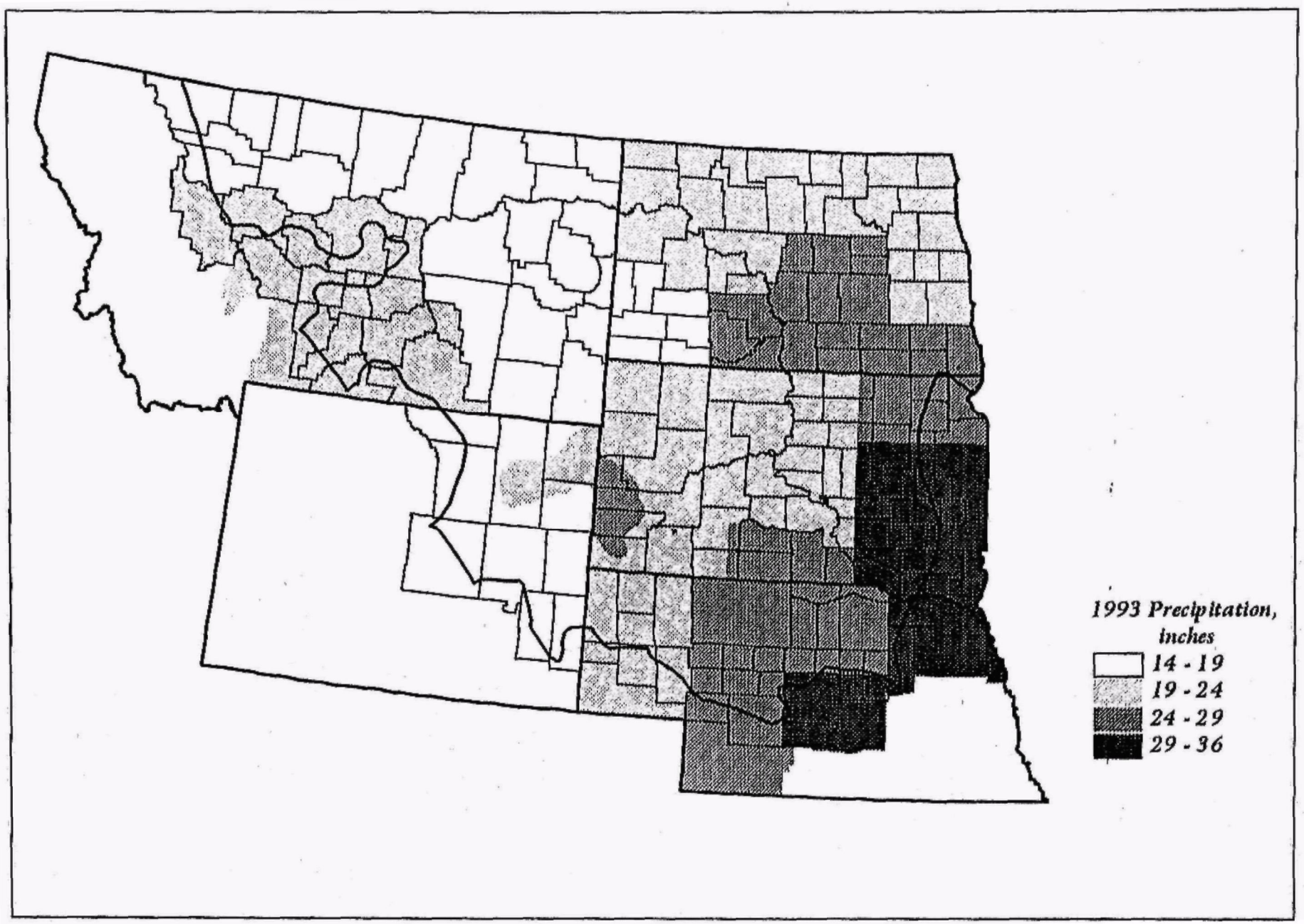

Figure 2.2.2 Precipitation for the Northern Great Plains in 1993

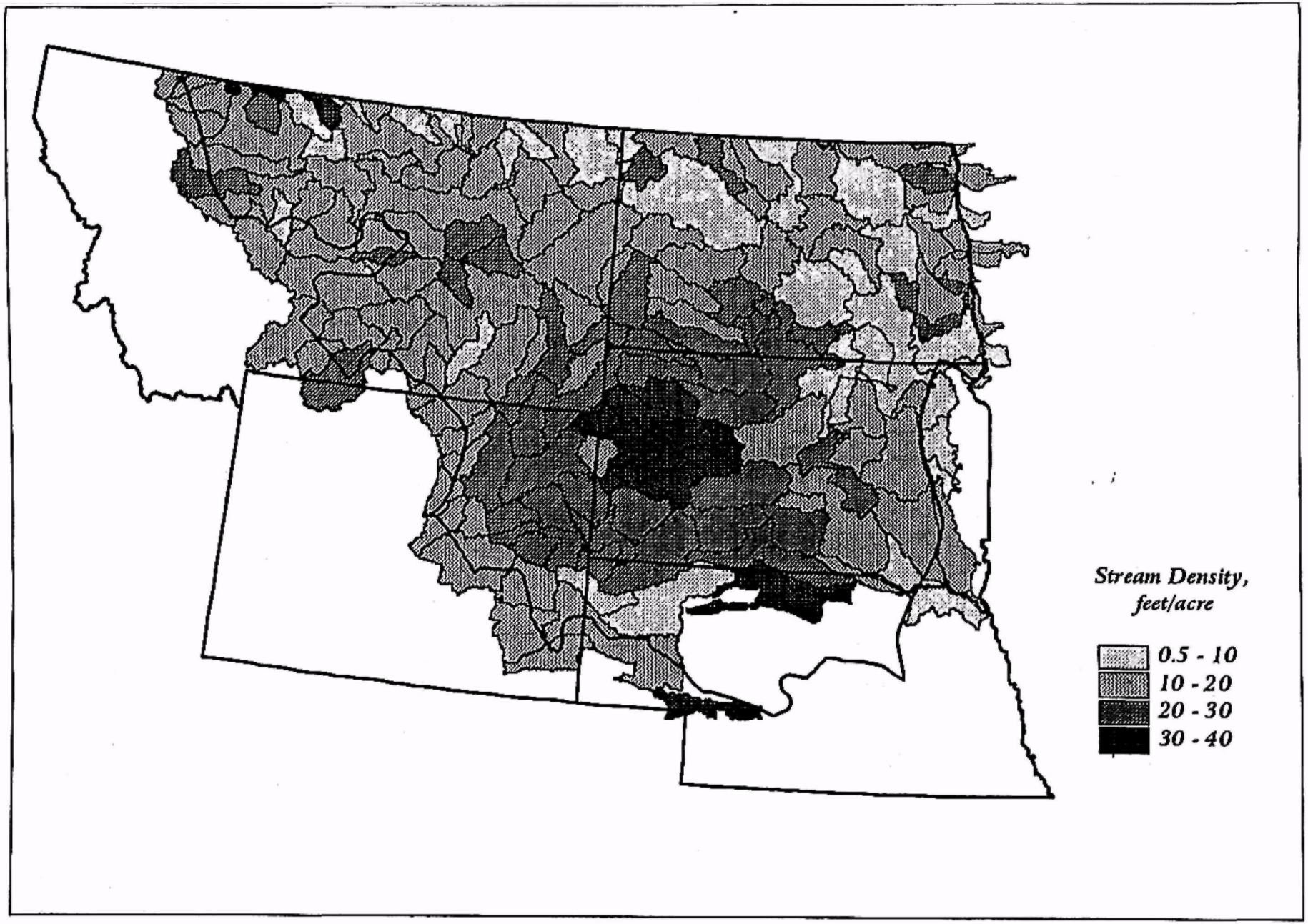

Figure 2.2.3 Stream Density by Watershed in the Northern Great Plains

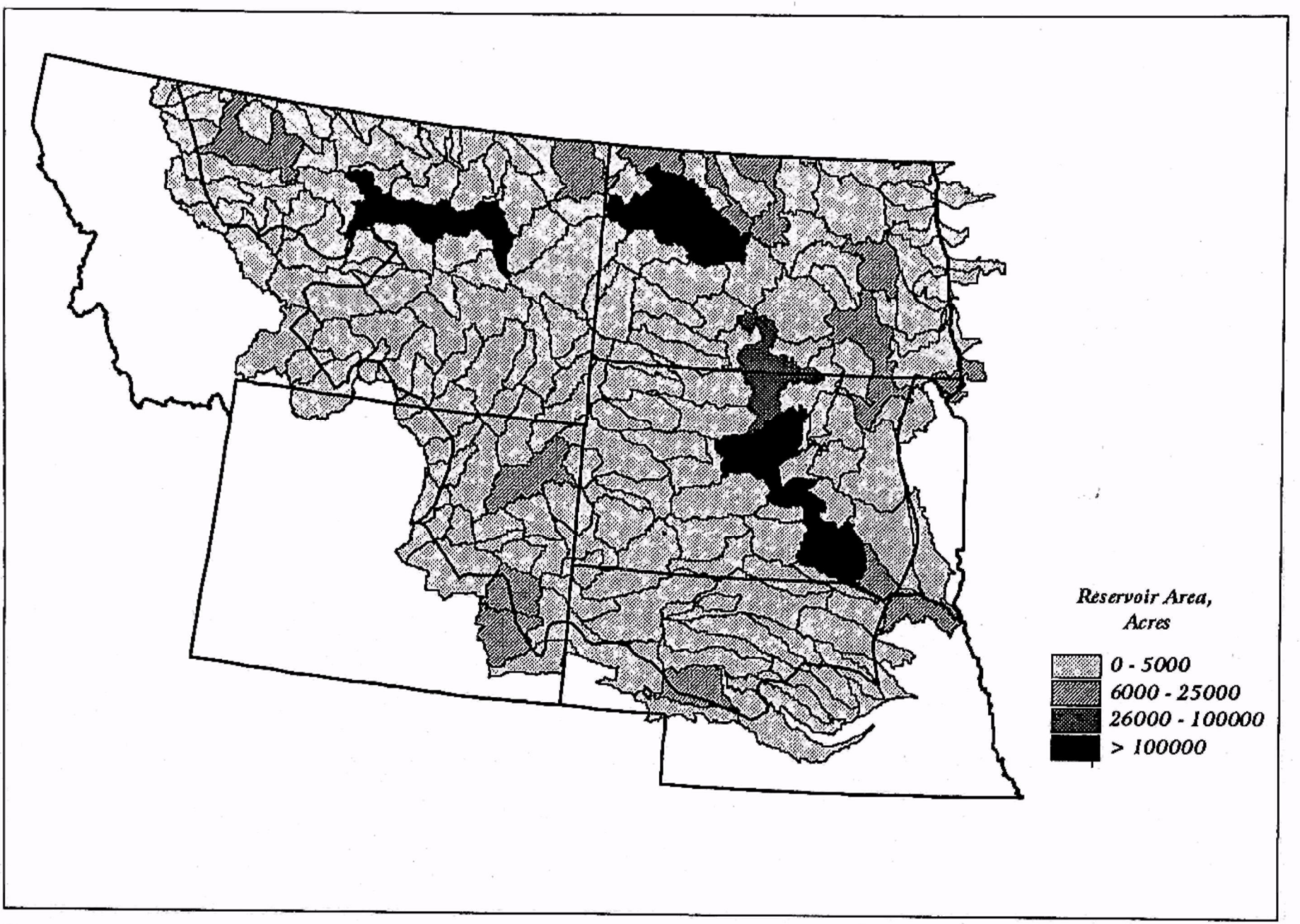

Figure 2.2.4 Reservoir Area in the Northern Great Plains

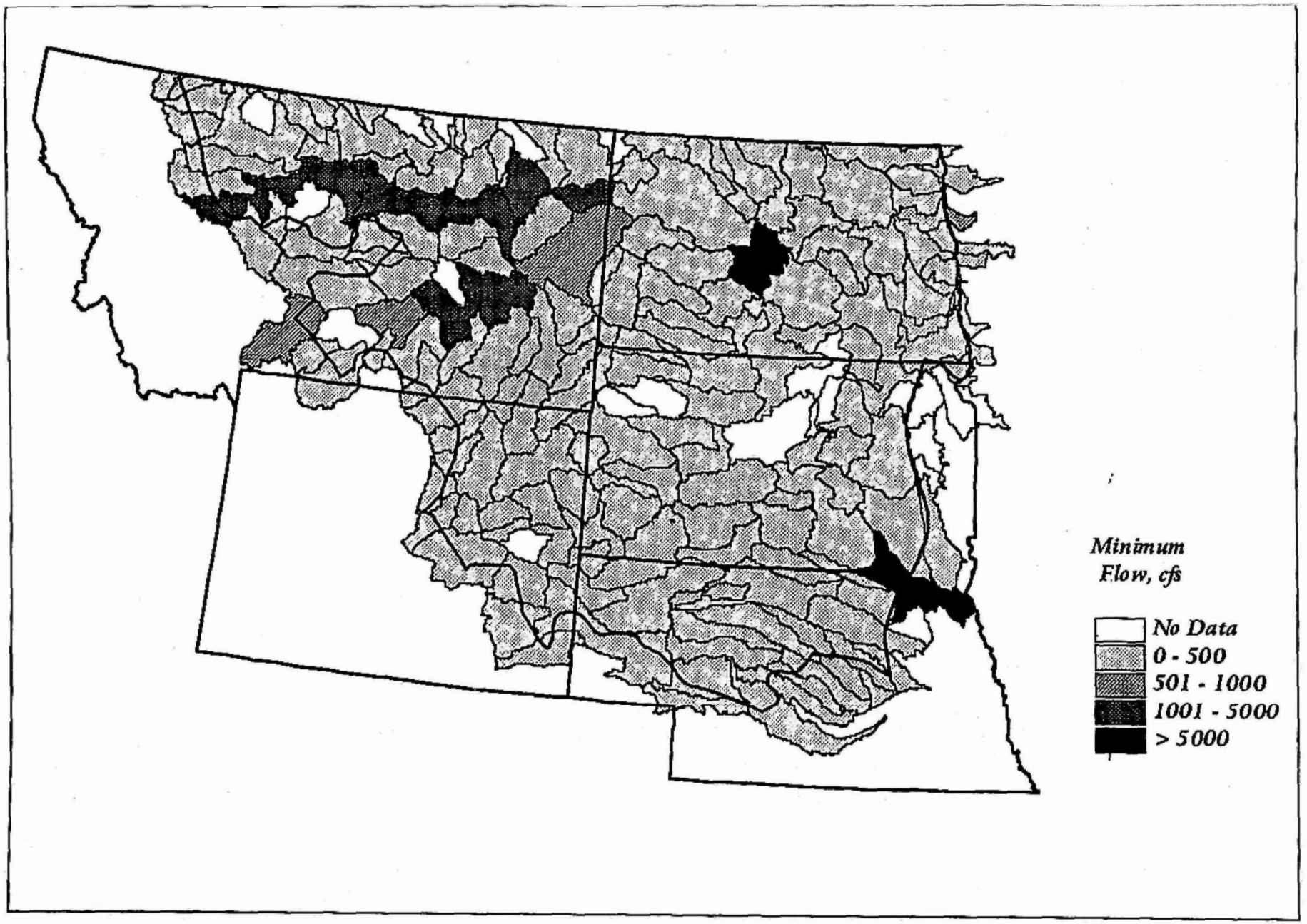

Figure 2.2.5 Minimum Flows During the Period 1980 to 1995

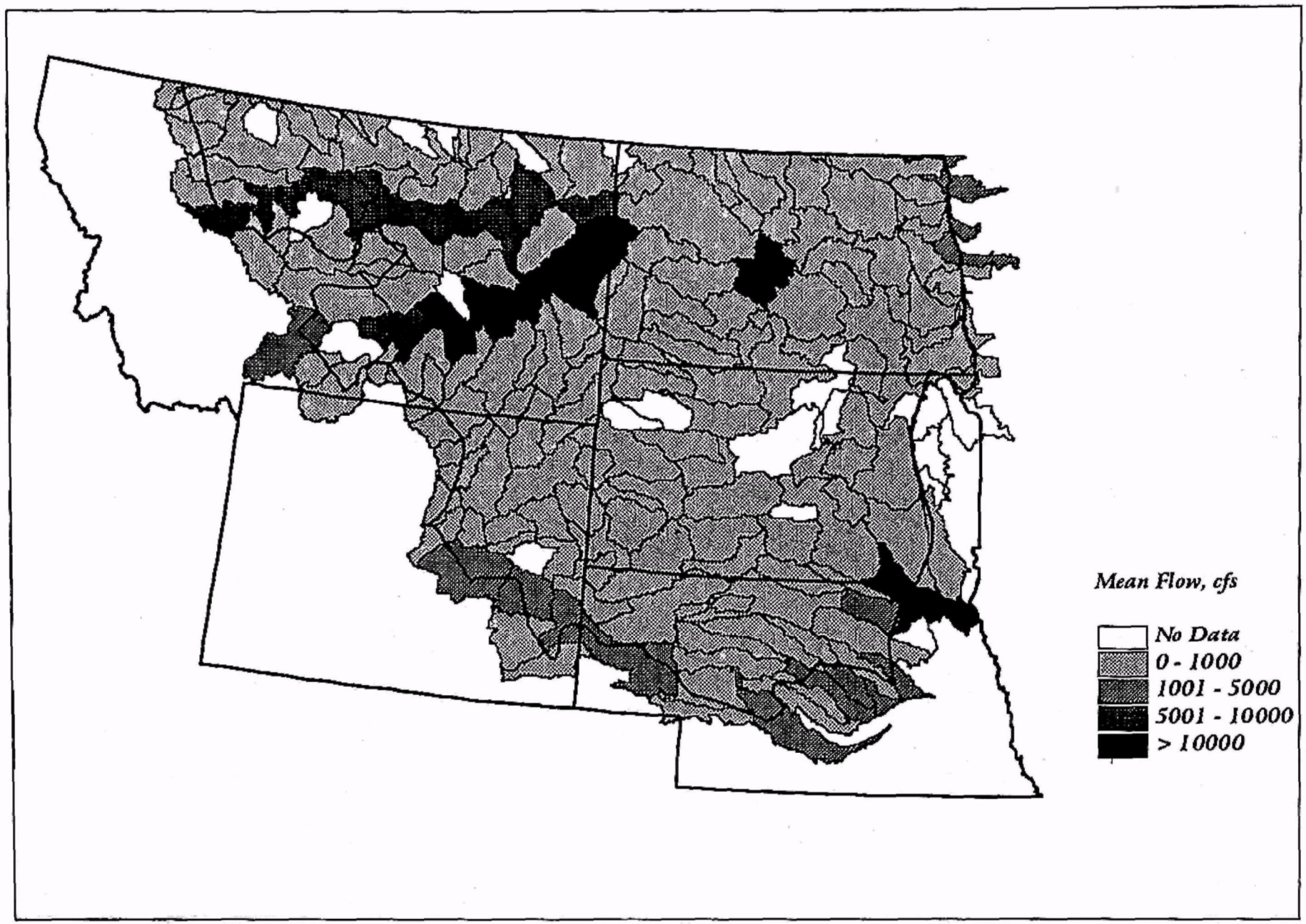

Figure 2.2.6 Mean Flows During the Period 1980 to 1995

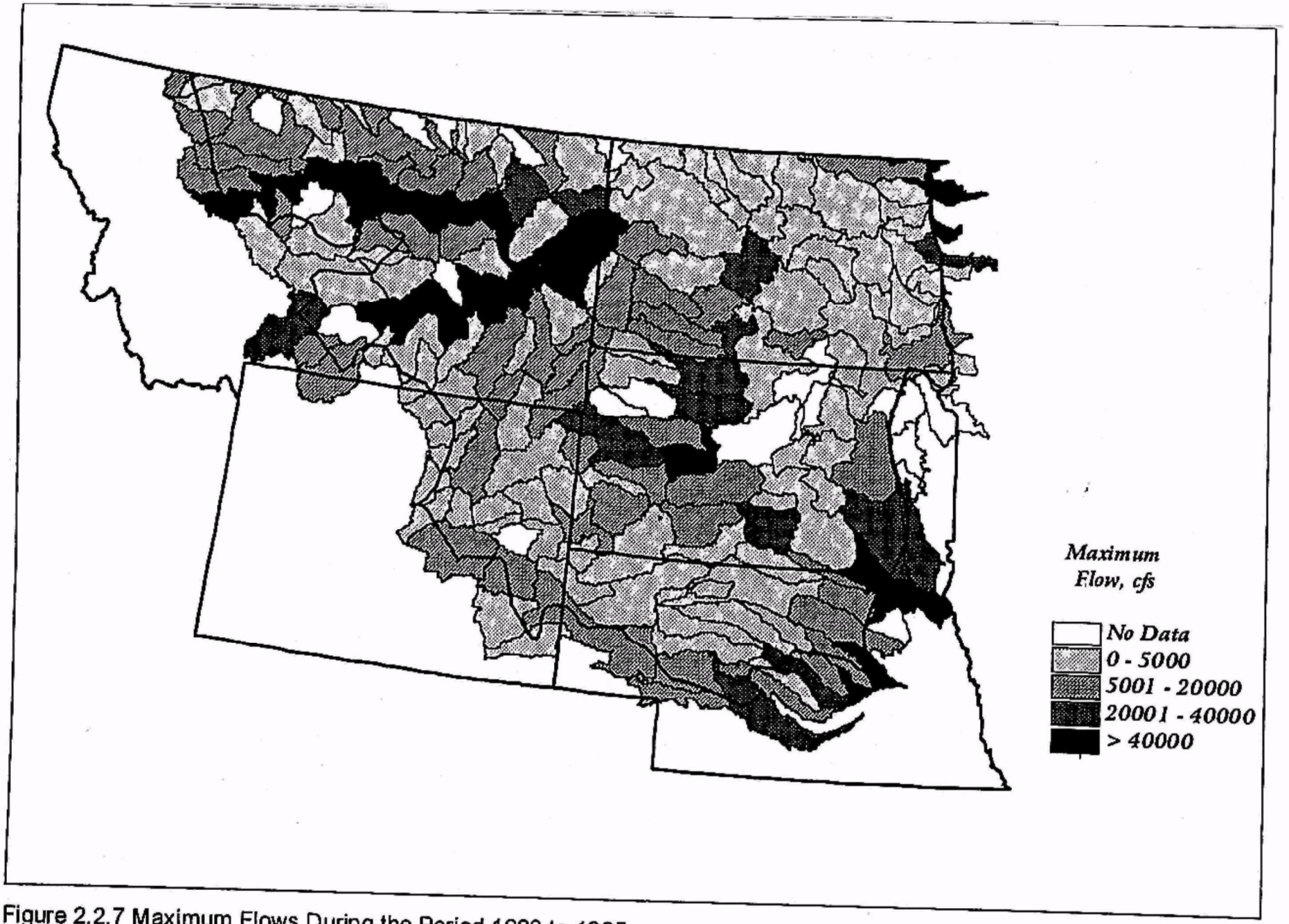

Figure 2.2.7 Maximum Flows During the Period 1980 to 1995

watersheds. A specific stream segment or lake within a watershed may have more or less stringent criteria. This report, therefore, compares levels of specific pollutants with common water quality criteria levels in the Northern Great Plains, not the actual water quality criteria at the specific station from which the data was obtained, since they vary from state to state and segment to segment. The station in each watershed used was chosen based on the amount of data available (ten years or more), whether it was on the mainstem and how far downstream in the basin it was (lowest was preferred). This information was not meant to show the status of all streams within a watershed, but was chosen as an integrator of effects from all over the watershed to varying degrees of applicability. Another given station in the same watershed could have better or worse water quality depending on the segment it is in. It was decided not to try to use all data from all stations since this would overwhelm the broadscale nature of this assessment, which is meant to show *potential* problem areas.

The use of the 305(b) report information, however, seeks to balance the use of data from only one station (in each watershed) by adding in the assessments states have done on numerous segments in each watershed.

Key Findings

•The watersheds with the highest percentages of assessed miles of streams partially supporting and not supporting uses include large sections of the NGPAA, particularly in the Red River basin, the tributaries to the Missouri in South Dakota, the Milk and other Missouri tributaries in Montana and the Platte basin in Nebraska.

•The watersheds with the highest percentages of assessed miles of streams not supporting uses include the Lower James, western South Dakota Missouri River tributaries, parts of the Platte basin and some upper Missouri tributaries in Montana.

•The watersheds with the lowest percentages of assessed miles of streams partially supporting and not supporting uses are the James Headwaters, the Little Missouri and parts of the Missouri River in North Dakota.

•The watersheds with the lowest percentages of assessed miles of streams not supporting uses are in much of North Dakota, eastern Montana, and the Sand Hills of Nebraska (Loup and Niobrara drainages).

•The watersheds with the highest percentages of assessed acres of lakes partially supporting and not supporting uses are Fort Peck Reservoir, Lake Sakakawea and Devils Lake.

•Fecal coliforms are highest the in White, Niobrara, Lower Loup and James River watersheds. They are generally less than 400 in most monitored watersheds as a median value.

•Dissolved solids are highest in the North Fork of the Grand River, the Redwater River in Montana, O'Fallon Creek, the South Fork of the Powder, the Little Powder, the Angostura Reservoir section of the Cheyenne River and the Eastern Missouri Coteau watersheds. They are lowest in the Niobrara and Loup watersheds and the Tongue, Lower Yellowstone, Upper James and parts of the Sheyenne, Milk and Upper Missouri River watersheds.

•Dissolved oxygen is lowest in the Upper Little Missouri and South Fork of the Moreau watersheds, however, the problem is widespread.

•Most lakes in the NGPAA have a trophic status listed as mesotrophic. Wyoming and Nebraska have the largest percentage of lakes listed as eutrophic or hypereutrophic.

•Fish consumption advisories have been issued for Box Butte Reservoir, Beaver Creek (Loup Watershed), Merritt Reservoir and Lake Ogallala in Nebraska; the Missouri River, Red River and twenty-two lakes in North Dakota

Table 2.3.1 Surface Water Beneficial Use Classifications Used by States in the Northern Great Plains

Montana	
A (A-closed and A-1)	Very high quality (mainly for protection of domestic use).
B (B-1, B-2, B-3)	For domestic use after treatment, growth and propagation of aquatic life (B-1 and B-2 are for coldwater aquatic life and B-3 is for warmwater aquatic life), agriculture and industry. Most streams are B in Montana.
C-1 and C-2	Same uses as B, but no domestic drinking water use.
C-3	Waters naturally high in total dissolved solids, but may support warmwater fishes.
I	Impacted. An activity does not allow the water to fully support drinking, recreation or fishery uses. The goal is to improve these waters to fully support the uses that it can.
Wyoming	
1	No further degradation by point sources is allowed; nonpoint sources must be controlled through best management practices
2	Waters other than Class 1 that are supporting game fish, have the potential to support game fish or include nursery areas or food sources for game fish.
3	Same as Class 2, but for non-game fish.
4	Waters that do not have the potential to support fish and includes all intermittent and ephemeral streams. Does have protection for agriculture and industry.
South Dakota	
1	Domestic Water Supply Waters
2	Coldwater Permanent Fishlife Propagation Waters
3	Coldwater Marginal Fishlife Propagation Waters
4	Warmwater Permanent Fishlife Propagation Waters
5	Warmwater Semipermanent Fishlife Propagation Waters
6	Warmwater Marginal Fishlife Propagation Waters
7	Immersion Recreation Waters
8	Limited Contact Recreation Waters
9	Wildlife Propagation and Stock Watering Waters
10	Irrigation Waters
11	Commerce and Industry Waters

Table 2.3.1 Surface Water Beneficial Use Classifications Used by States in the Northern Great Plains

Nebraska	
	Recreation
	Aquatic Life (Coldwater Class A and B; Warmwater Class A and B)
	Industrial
	Public Drinking Water Supply
	Agriculture (Class A and B)
	Aesthetics
North Dakota	
	Agriculture
	Industrial
	Domestic and Municipal Water Supply
	Recreation
	Fishing (Cold, Cool, Warm)
	Aquatic Life

and in the Marais, Milk, Missouri, Clarks Fork of the Yellowstone and Tongue Rivers in Montana.

•Watersheds with high total solids concentrations include the White and the Cheyenne.

•Atrazine is one of the pesticides most often detected in streams in the eastern NGPAA.

•Nitrates in the Red River have been found to be at concentrations less than 1 mg/l. In central Nebraska, the concentrations ranged from 0 to 1.8 mg/l, with some smaller agricultural watersheds having values as high as 3.7mg/l.

•Missouri River water quality is generally good with a few problems such as low dissolved oxygen in reservoirs, cold temperatures below dams and mercury in the Cheyenne River arm of Lake Oahe.

Data Sources

Much of the information used in this section was obtained from the 305(b) Water Quality reports prepared by the States of Montana, Nebraska, North Dakota, South Dakota and Wyoming. The 1996 reports were used from Nebraska, South Dakota and Wyoming, the 1994 report was used for Montana and the 1998 report was used for North Dakota. Information from the 1996 303(d) lists of impaired waterbodies was also used. These reports presented information on miles and acres of waters assessed and the condition with regard to meeting designated uses, the causes (e.g., ammonia, nutrients) of failing to meet the uses and the sources (e.g., agriculture, municipal wastewater). In several cases use support information was not presented by watershed and the data had to be converted into that form. The reports also provided information on where toxic impacts were noted and where fish consumption advisories had been issued. Additional information on fish consumption advisories was obtained from the U.S. Environmental Protection Agency's Index of Watershed Indicators (U.S. Environmental Protection Agency, 1997a).

Information on individual pollutants was retrieved by the U.S. Geological Survey-Water Resources Division from the Storet database. This covered the period from 1980 to 1995. The data is presented as the minimum, median and maximum values (whichever is most informative) for the station used in each watershed. The information on the effects of large dams on water quality and much of the water quality information on the Missouri River itself was obtained from the Draft Environmental Impact Statement for the Missouri River Master Water Control Manual by the U.S. Army Corps of Engineers.

Data Quality and Gaps

Large areas in the Northern Great Plains would likely benefit from more water quality data collection. Fecal coliform data is lacking in eastern Montana. Total solids data is missing for eastern Montana and most of North Dakota. There is only scattered data for BOD, with most of Montana, southwestern North Dakota, northwestern and central South Dakota and parts of Wyoming lacking information. Data on ammonia was not represented geographically because it was lacking within the Storet dataset and, therefore, no conclusions over this broad an area could be obtained. However, it should be noted again that this analysis is based on one station in the watershed and there could be more data from other stations. The station used though, is the one most likely to have the most data and is the one generally where data would be most likely to be regularly collected.

The quality of the information in Storet is variable for some parameters and needs to be verified. In addition, there are quality concerns with regard to the 305(b) reports; much of the

assessments are not based on monitoring, but on evaluations using some other data, and can also be subjective. Methods for using available data, preparing the 305(b) reports and defining use support varies from state to state, therefore, one should be careful making direct comparisons between states.

There is some question as to the relationship between the use of fecal coliforms as a measure and the causes of waterborne illnesses to swimmers. Presently, there is research in developing a better measure, but currently, only fecal coliform data is widespread enough to assess this aspect of water quality.

Spatial Patterns

The quality of waters in the Northern Great Plains has generally improved in the last 25 years. Much of this improvement has been due to controls placed on point sources. According to the U.S. Environmental Protection Agency (1990), based on the 305(b) reports submitted by the states, 60% of the assessed rivers and streams in the Northern Great Plains were fully supporting their designated uses (nationwide it was 70%). The three leading causes of the 40% not fully supporting are sediment, nutrients and pathogens. Agriculture was responsible for 77% of the impairment. For lakes and reservoirs in the NGPAA, 81% of them were fully supporting uses, with nutrients, sediment and organic enrichment being the top three causes. Agriculture was responsible for 60% of the impairment.

Figure 2.3.1 presents the assessed miles of streams in each watershed which are partially supporting or not supporting uses (i.e. not fully supporting). Watersheds with over 300 assessed miles not fully supporting uses include the Lower Yellowstone, Fort Peck Reservoir, Clarks Fork of the Yellowstone, Lake Sakakawea, Upper Cannonball, Upper and Middle James, Upper White, North Platte-Scottsbluff, and the Middle Platte-Buffalo. Watersheds with less than 50 miles not fully supporting uses include parts of the Missouri River in North and South Dakota, parts of the Niobrara and Loup Rivers in Nebraska, the James Headwaters, the Upper Cheyenne River in Wyoming and the Missouri River above Fort Peck in Montana.

The miles of streams in each watershed not supporting uses is presented in Figure 2.3.2. The Lower James River has over 200 miles not supporting. However, a number of watersheds have more than 100 miles listed as not supporting, including the White River basin, Lake Sakakawea, the Grand, Moreau and Lower Cheyenne in South Dakota, the Western Wild Rice River in North Dakota, the Upper Powder and North Platte-Casper in Wyoming and the Lower North Platte, Lower Loup and South Loup in Nebraska. Large areas of the NGPAA have watersheds with less than 50 miles of assessed streams not supporting uses.

The percentage of assessed miles of streams partially supporting or not supporting uses by watershed is presented in Figure 2.3.3. The majority of watersheds in the NGPAA have more than 50% of assessed miles which are not fully supporting designated uses and large areas that have watersheds with more than 90% not fully supporting. Notable areas not supporting include the Red River basin, the Platte basin, Missouri River tributaries in western South Dakota and a number of scattered watersheds in Montana. Only a few watersheds have less than 10% of assessed miles listed as not fully supporting. These include the James Headwaters, parts of the Souris River basin, the Missouri River above Fort Peck Reservoir, Big Porcupine Creek and Boxelder Creek in the Little Missouri basin.

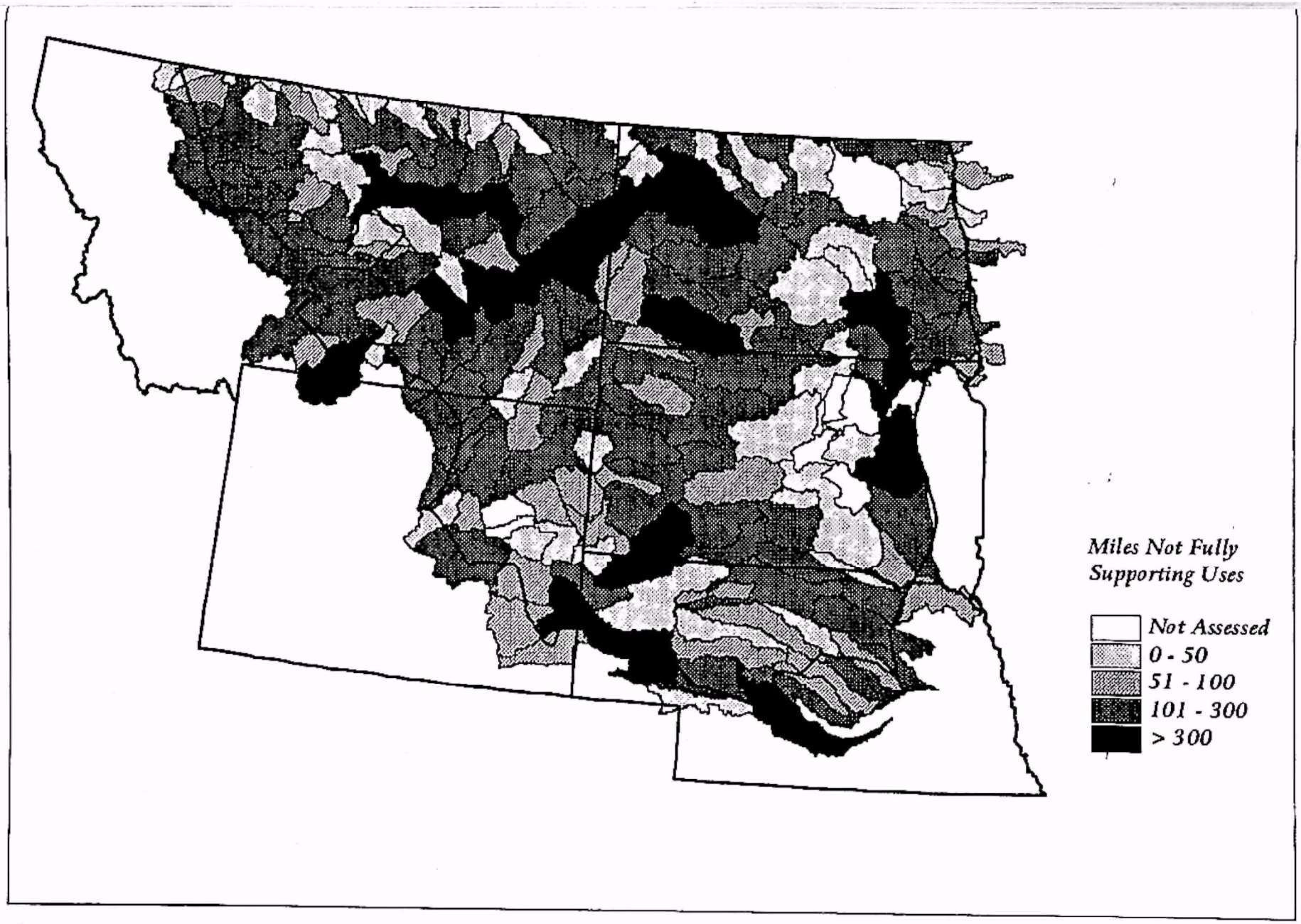

Figure 2.3.1 Miles of Streams in Each Watershed Not Fully Supporting Designated Uses

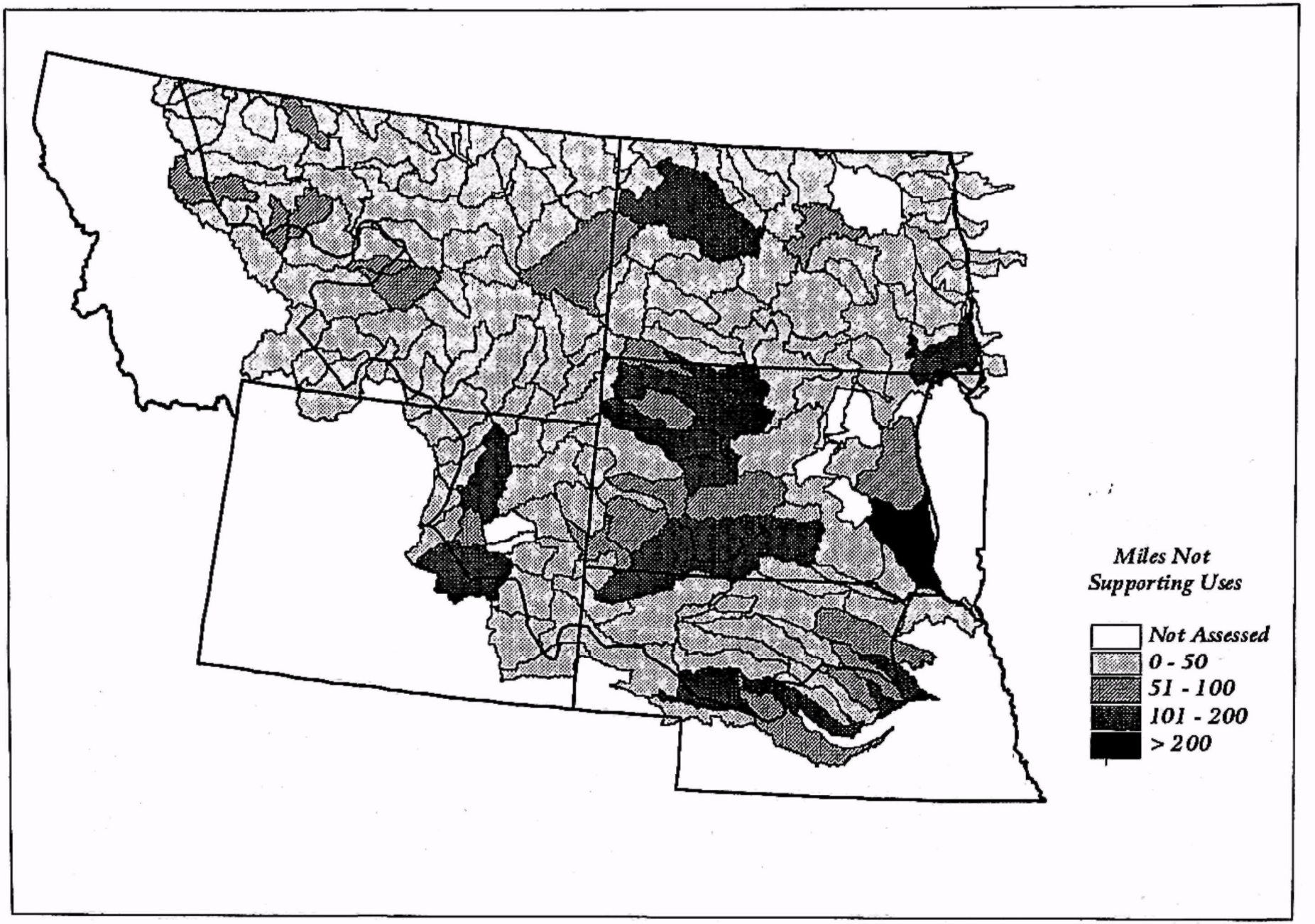

Figure 2.3.2 Miles of Streams in Each Watershed Not Supporting Uses

Figure 2.3.3 Percentage of Assessed Miles of Streams in Each Watershed Not Fully Supporting Uses

The percentage of miles of streams in each watershed not supporting uses is presented in Figure 2.3.4. The western South Dakota tributaries of the Missouri, the Lower James, Arrow Creek and Sage Creek stand out as watersheds with more than 90% of assessed miles listed as not supporting uses. In contrast, much of North Dakota, eastern Montana, central South Dakota and the Sand Hills of Nebraska have watersheds with less than 10% of assessed miles not supporting uses.

Figure 2.3.5 shows the acres of lakes partially supporting or not supporting uses by watershed. Fort Peck Reservoir, Lake Sakakawea and Devils Lake are watersheds with the largest amounts of assessed lake acreage not fully supporting uses.

Figure 2.3.6 shows the percentage of acres of lakes partially supporting or not supporting uses by watershed. The majority of watersheds in the NGPAA with assessed lake acres have percentages of more than 90% not fully supporting uses. This figure differs dramatically from 2.3.5 due to small amounts of assessed acres not fully supporting uses, but these small amounts have high percentages.

Table 2.3.2 lists the trophic status of lakes in the Northern Great Plains. This includes information from all lakes in each state, including those not within the Assessment Area since the information is presented in the state 305(b) reports by state. Data on trophic status by watershed were not available for each state. Trophic status is defined as the degree of nutrient enrichment of a lake and its ability to produce algae (Montana Department of Environmental Quality, 1994). Most assessments to determine the trophic status use Carlson's Index, which uses total phosphorus, chlorophyll *a* and secchi disc depth. From the least enriched to the most enriched, lakes are categorized as oligotrophic, mesotrophic, eutrophic and hypereutrophic. The Carlson index value of 35 is a transition between oligotrophic and mesotrophic and 50 is the transition between mesotrophic and eutrophic (Montana Department of Environmental Quality, 1994).

The majority of assessed lakes in the Northern Great Plains are classified by the states as mesotrophic. Individual states varied widely in the percentage of assessed lakes listed as eutrophic/hypereutrophic. Wyoming listed the most with 56% and Nebraska was second with 42%. South Dakota, North Dakota and Montana listed 17%, 19% and 10%, respectively, as eutrophic/hypereutrophic. Again, values do not represent only lakes within the NGPAA.

Sources of fecal coliform are sewage-treatment plant discharges and runoff from feedlots and grazing areas. Where they are found, it is likely that contamination from human or animal wastes has occurred. Fecal coliform criteria apply to streams that have a recreation beneficial use, with immersion recreation (swimming) generally having more stringent criteria than for boating only. The water quality criteria for fecal coliforms is generally around 200 MPN (most probable number) for waters with a recreation use classification. It can be higher for other classifications in some States.

Figure 2.3.7 presents the median levels of fecal coliforms in each watershed where data was available. The lower White, middle Niobrara, some lower Loup tributaries, the Upper Moreau, Keya Paha Creek and Elm Creek in the James watershed are the areas with the largest median fecal coliform values. The maximum levels of fecal coliforms are shown in Figure 2.3.8. Many of the same areas with high median fecal coliform levels also have high maximum levels, but a few

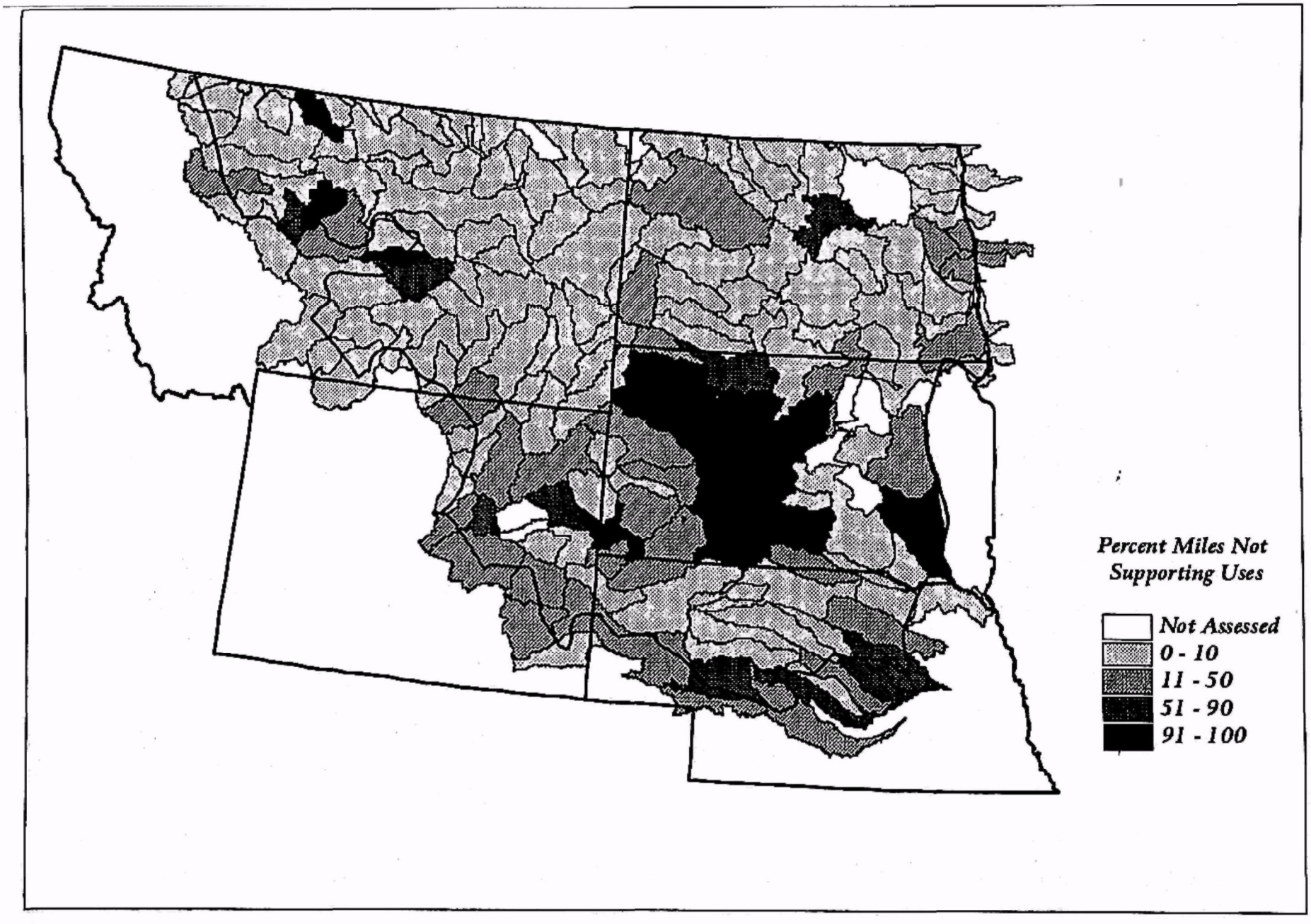

Figure 2.3.4 Percentage of Assessed Miles of Streams in Each Watershed Not Supporting Designated Uses

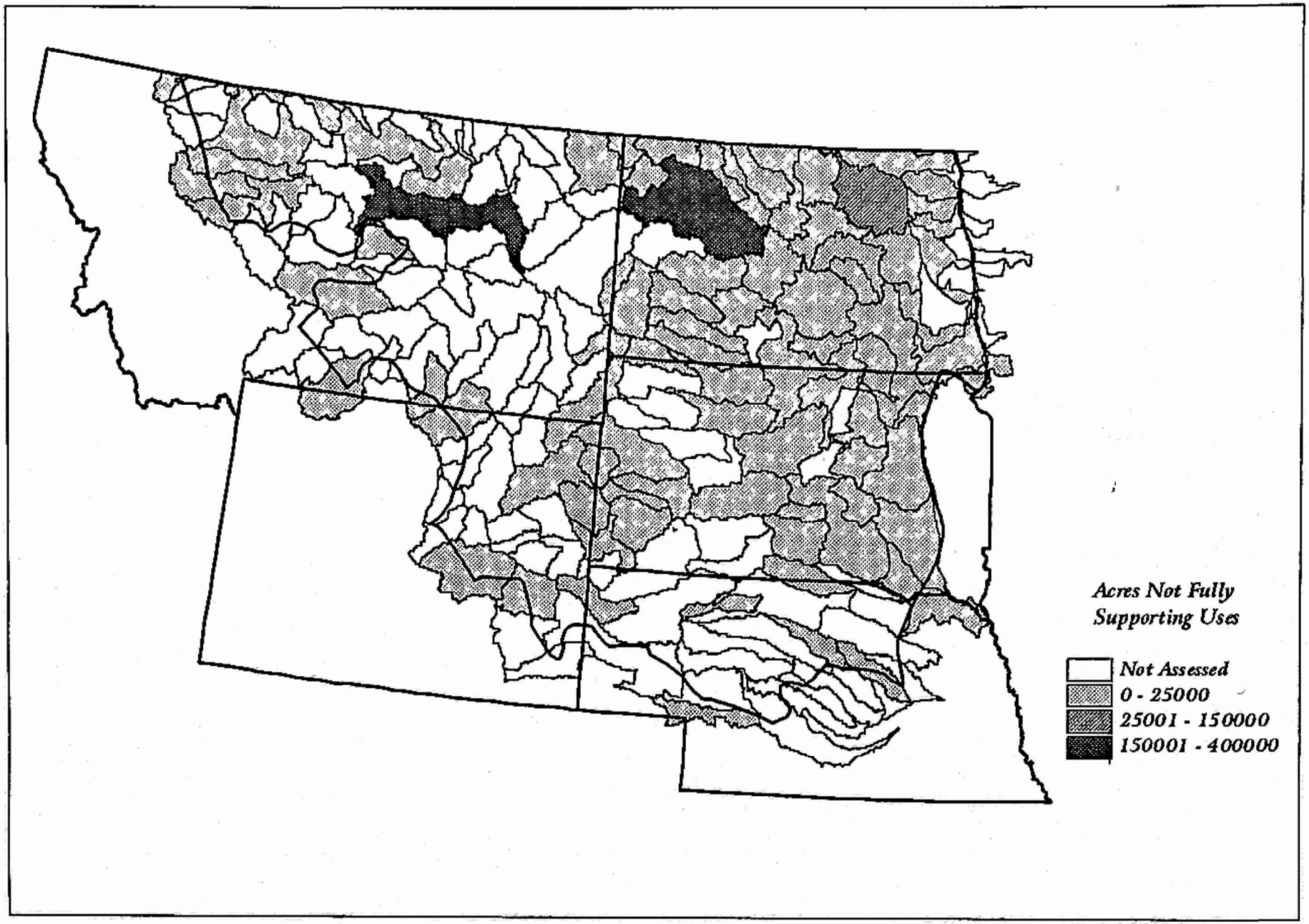

Figure 2.3.5 Acres of Lakes in Each Watershed Not Fully Supporting Designated Uses

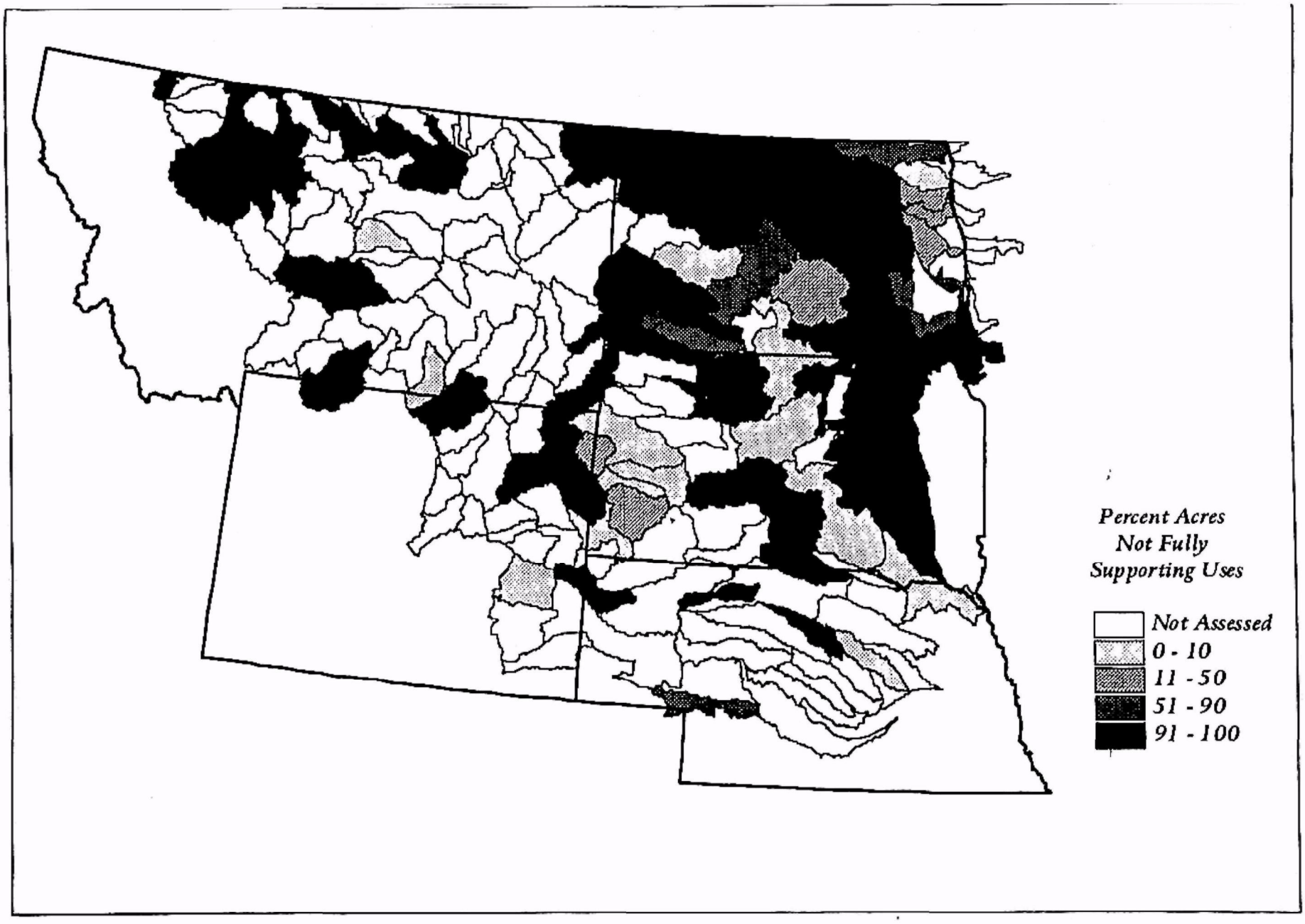

Figure 2.3.6 Percentage of Assessed Acres of Lakes in Each Watershed Not Fully Supporting Designated Uses

Table 2.3.2 Trophic Status of Lakes in the Northern Great Plains States (includes lakes within these states outside of the Northern Great Plains Assessment Area).

Trophic Status	Number*	Area (in acres)	Percent of Assessed
Oligotrophic	52	345,928	14
Mesotrophic	120	1,604,632	66
Eutrophic	202	332,188	14
Hypereutrophic	153	170,642	7
Total Assessed	537	2,423,441	
Total Not Assessed	7998	317,976	

*Wyoming not included because lakes were not enumerated (only acreage was reported).

areas are added such as the lower James, the Missouri and Rapid Creek. Some of these may be due to infrequent large discharges of fecals from a source such as a wastewater treatment plant, but which is not sustained over the long term. Much of the Northern Great Plains has low median levels of fecals, however, individual streams within these watersheds could have very high levels. Many areas within Montana and Wyoming, however, are lacking in Storet data.

Dissolved solids levels (median) are presented in Figure 2.3.9. While high dissolved solids concentrations can result from the natural geology and soils, agriculture and some industrial wastewater dischargers can contribute large amounts. U.S. EPA guidance recommends a level of 500 mg/l of dissolved solids for drinking water. Levels of more than 2000 mg/l are unsuitable for irrigation (National Research Council, 1973). While cattle can drink water that has up to 10,000 mg/l total dissolved solids, swine are limited to below 7000 and poultry to below 3000 (Olson and Fox, unknown date). As the figure shows, there are large areas within the Northern Great Plains where the median values are far above the 500 mg/l guidance, especially parts of the Upper Powder, Little Powder, Cheyenne, Grand, and Redwater Rivers, as well as O'Fallon Creek and streams in the Eastern Missouri Coteau. Maximum levels (Figure 2.3.10) are highest in the Devils Lake, Upper Missouri and Apple Creek watersheds. Some of the lowest dissolved solids levels are in the Nebraska Sand Hills and in parts of Montana.

Dissolved oxygen (Figures 2.3.11 and 2.3.12) is critical for aquatic life. Median and minimum dissolved oxygen levels are presented, since in this case, there is a problem when there is too little rather than too much. Most fish species need levels greater than 3 or 4 mg/l and juvenile fish need even higher levels of between 5 to 8 mg/l (U.S. Environmental Protection Agency, 1995). Dissolved oxygen can be depleted by the breakdown of organic compounds or by rapid growth of algae. Typically, dissolved oxygen water quality criteria range from 5.0 to 7.0 mg/l for waterbodies classified for aquatic life, with higher use classifications at the upper end. Problem areas for median dissolved oxygen show up in the Upper Little

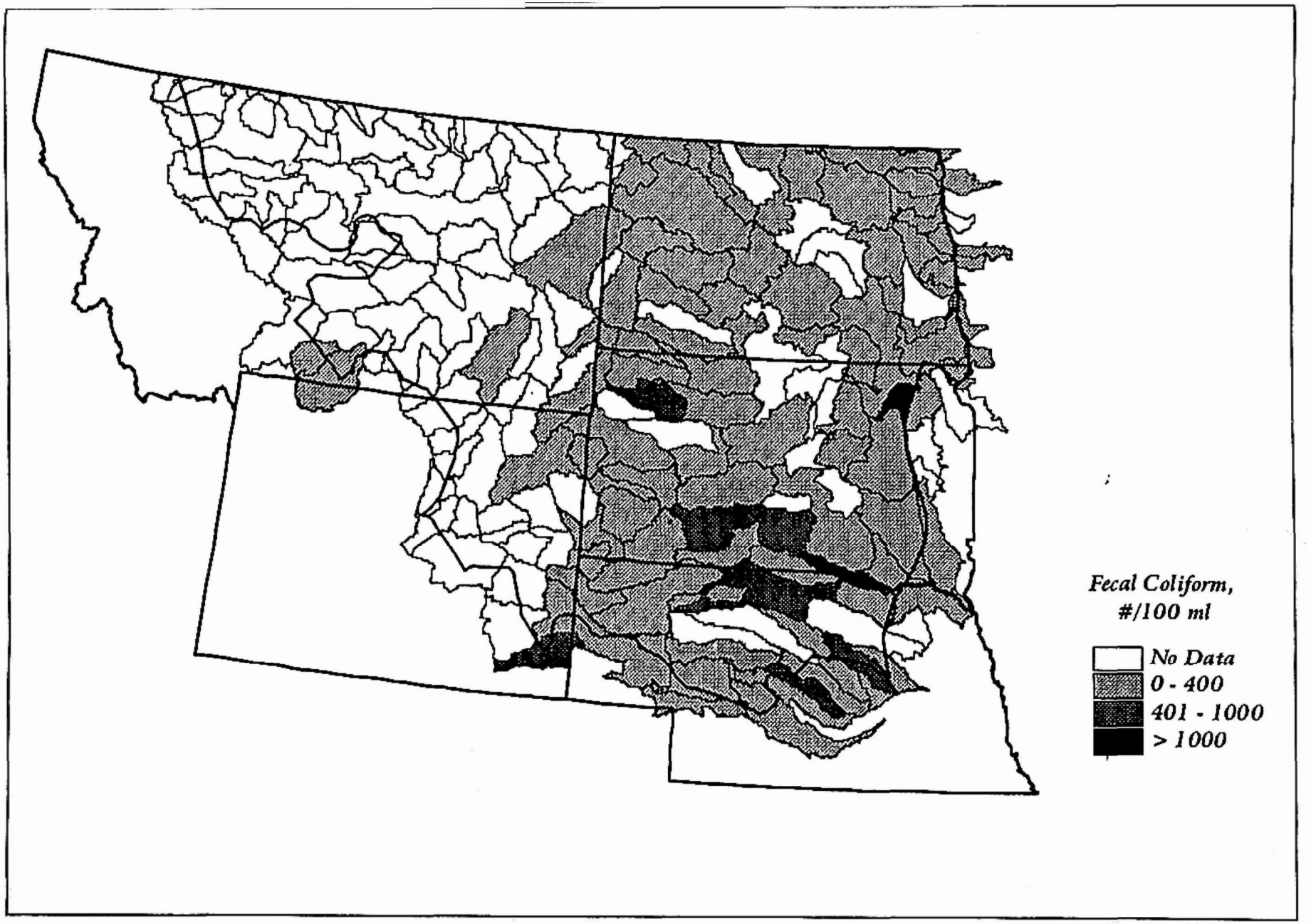

Figure 2.3.7 Median Fecal Coliform in the Northern Great Plains

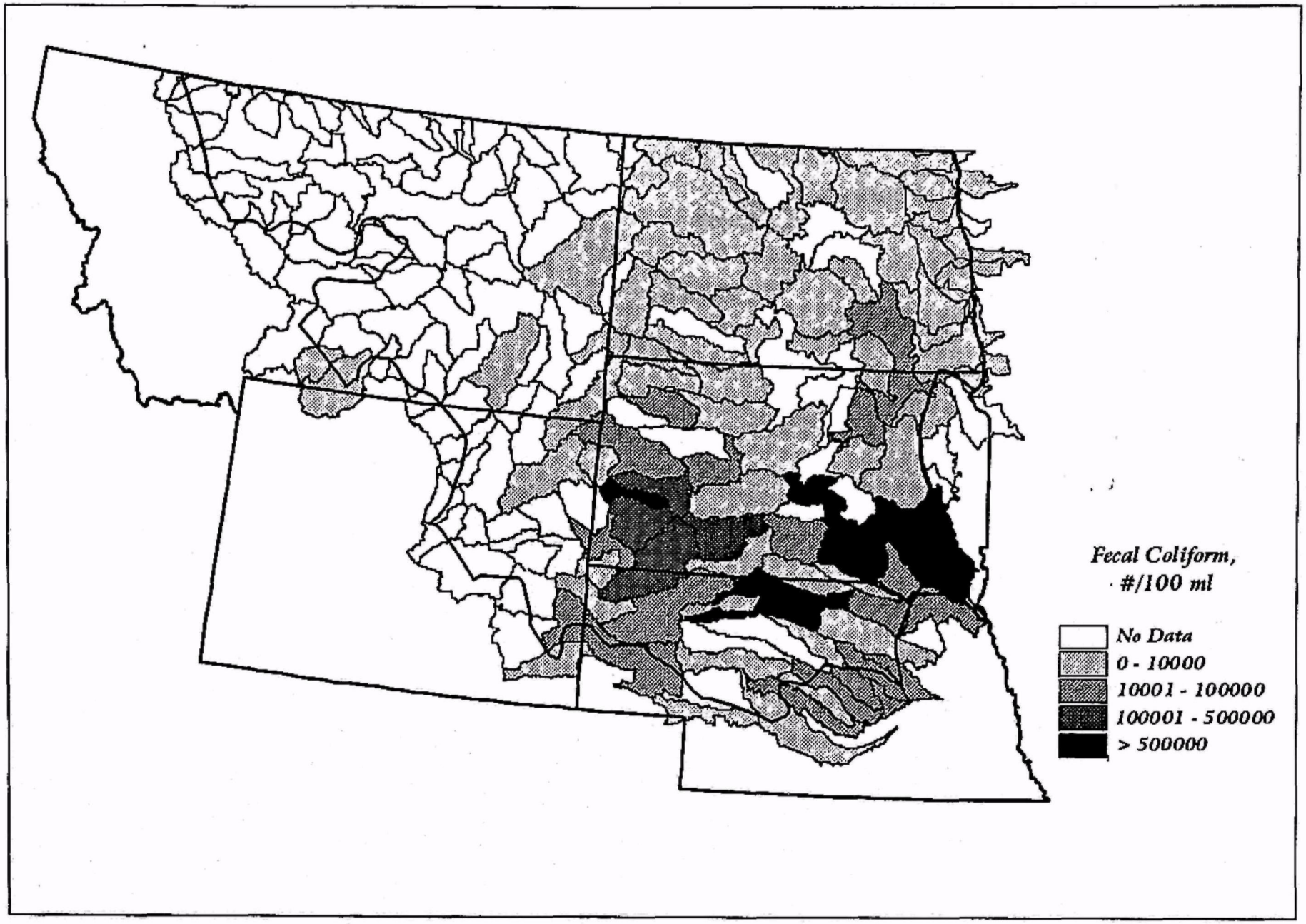

Figure 2.3.8 Maximum Fecal Coliform Levels in the Northern Great Plains

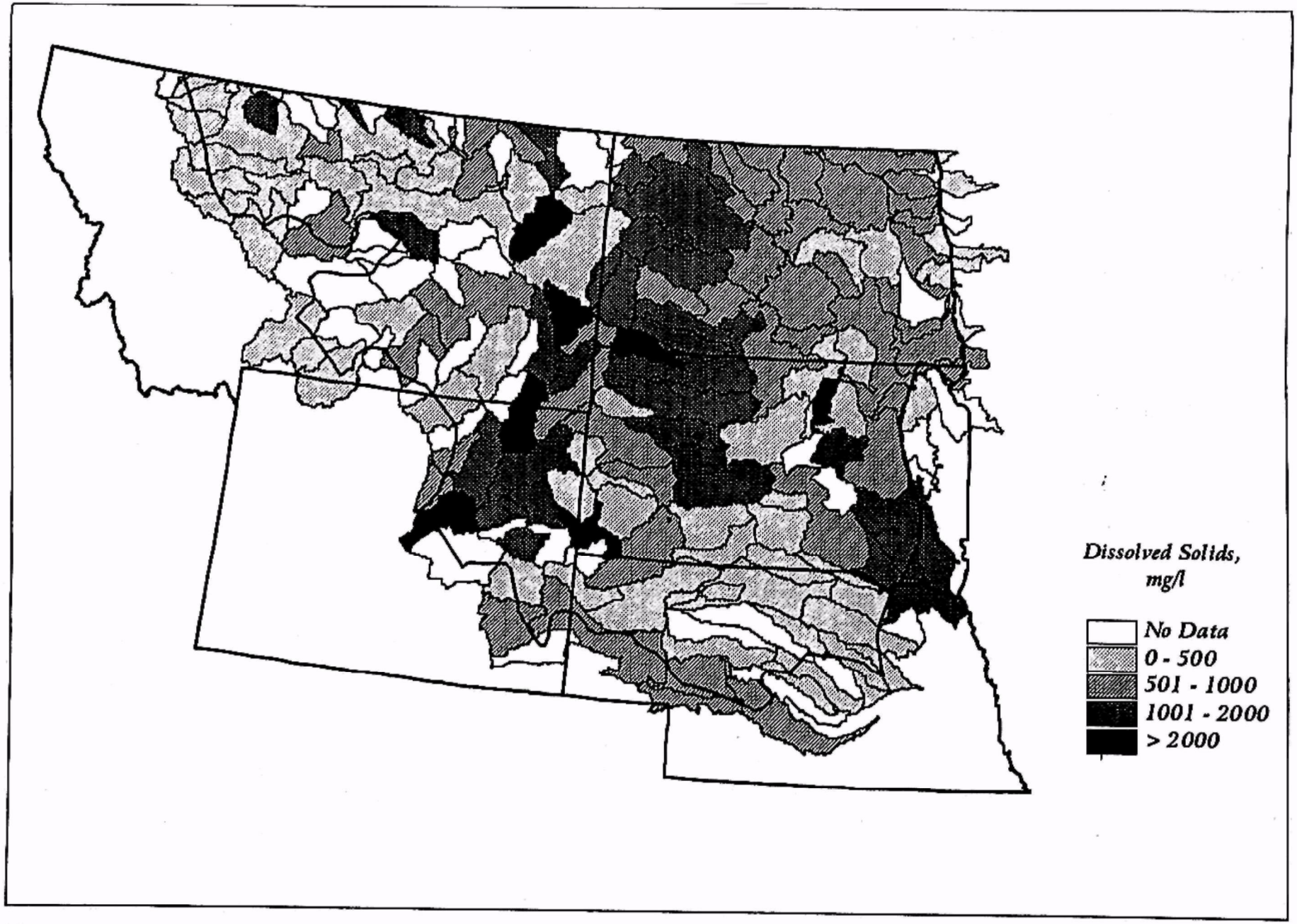

Figure 2.3.9 Median Dissolved Solids Levels in the Northern Great Plains

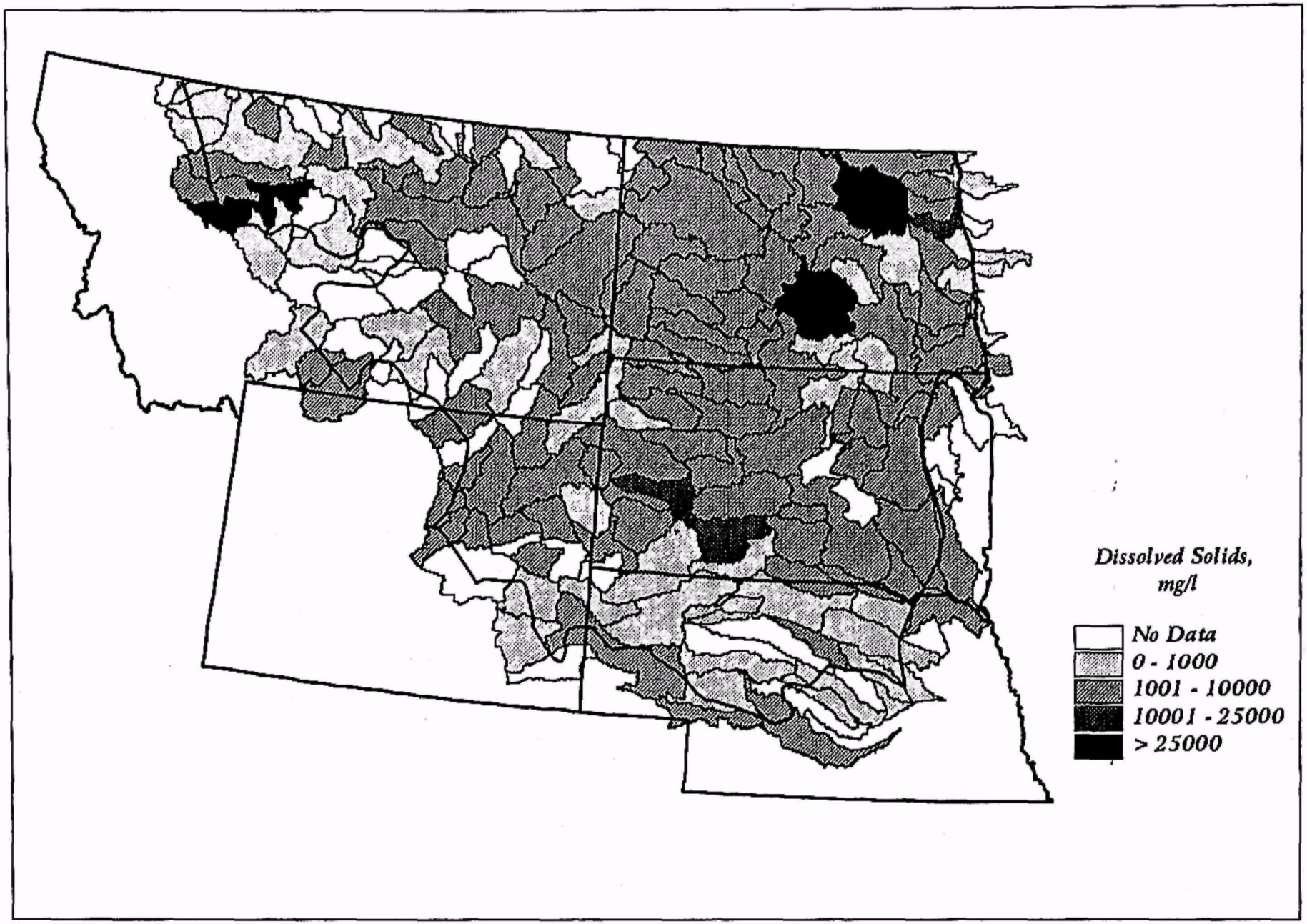

Figure 2.3.10 Maximum Dissolved Solids Levels in the Northern Great Plains

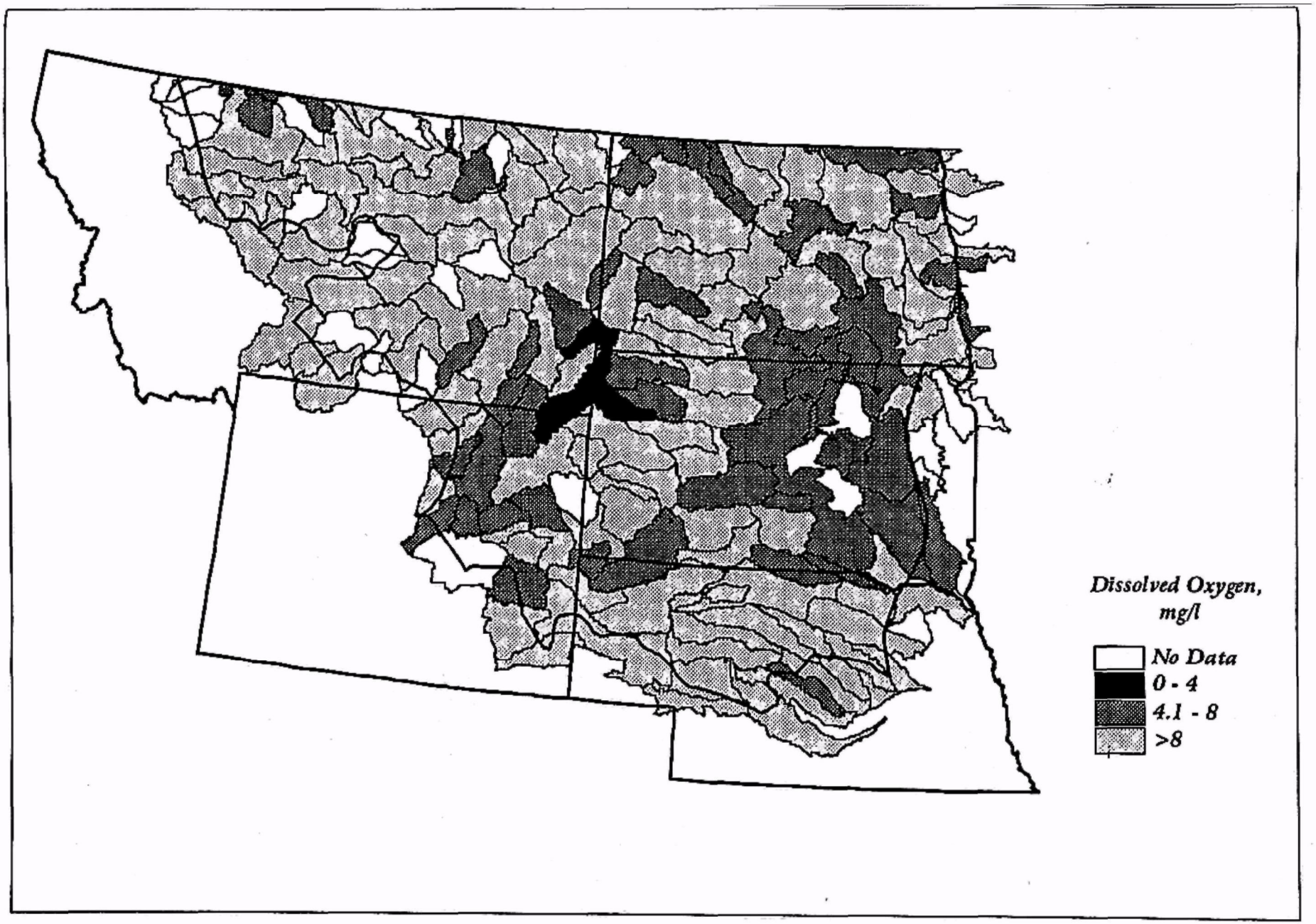

Figure 2.3.11 Median Dissolved Oxygen Levels in the Northern Great Plains

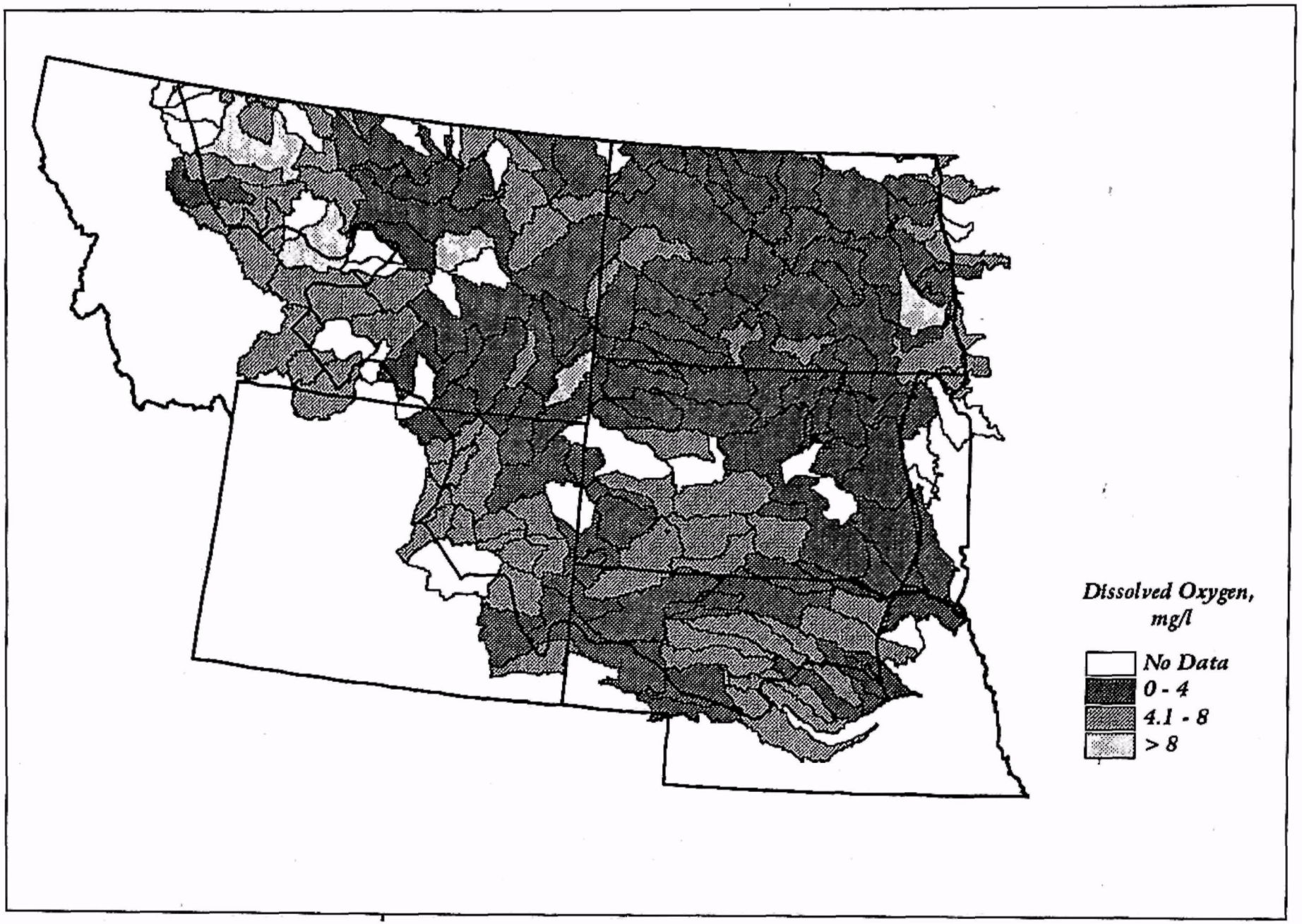

Figure 2.3.12 Minimum Dissolved Oxygen Levels in the Northern Great Plains

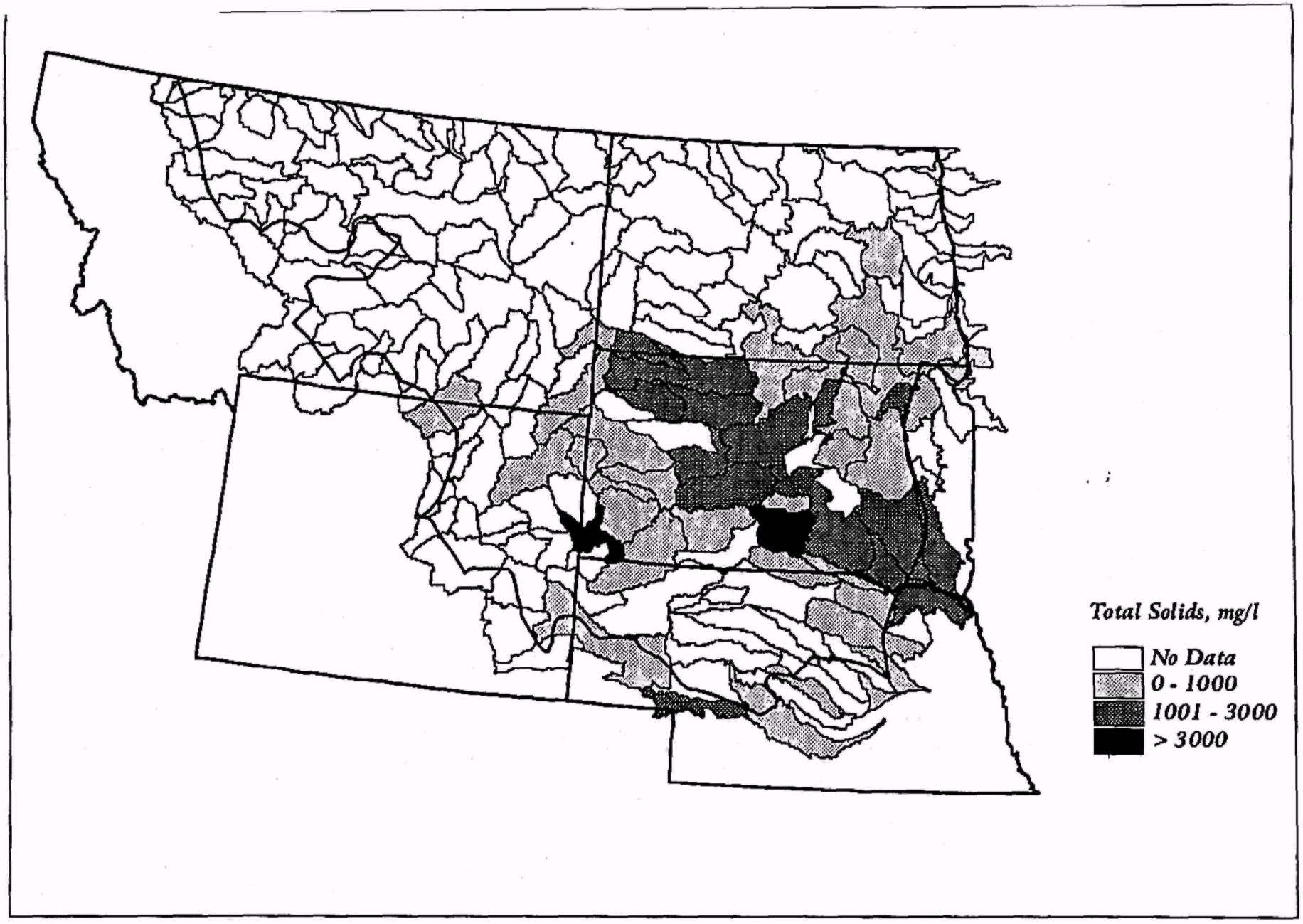

Figure 2.3.13 Median Total Solids Levels in the Northern Great Plains

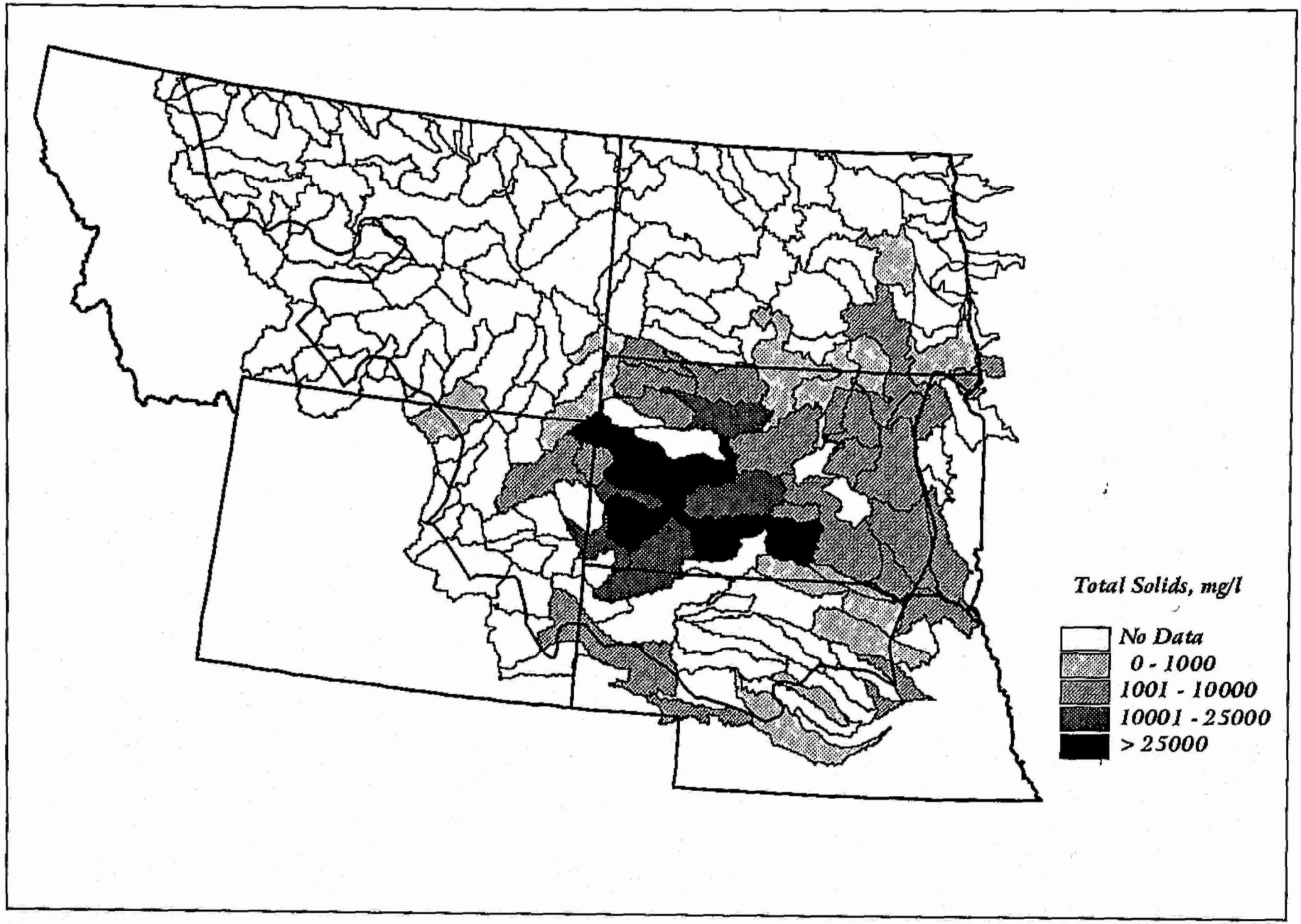

Figure 2.3.14 Maximum Total Solids Levels in the Northern Great Plains

Missouri River and the South Fork of the Moreau River. However, when the minimum levels that have been recorded are reviewed in Figure 2.3.12 it is obvious that most areas within the Northern Great Plains are susceptible to low dissolved oxygen at some time or another.

Figures 2.3.13 and 2.3.14 show the median and maximum levels of total solids, respectively, in each watershed where data was available. This data is limited mainly to South Dakota and parts of Nebraska, with Montana, Wyoming and North Dakota generally lacking data. The limited data does show, however, problem areas in the Cheyenne, White, Lower James and Lower Missouri River watersheds. High total solids or suspended sediment can result from land cover disturbances, including agriculture, mining or construction. This loading can affect aquatic organisms by covering them or their habitat and can fill reservoirs.

Biochemical Oxygen Demand (BOD) is a measure of the organic material in the water. This material can be used by algae and other organisms to create a low dissolved oxygen situation. Generally, the more BOD, the more the possibility that low dissolved oxygen may result. The numbers used in the figure correlate with technology-based discharge limits for National Pollutant Discharge Elimination System (NPDES) permits, which are 30 mg/l on a monthly basis. This is not a water quality standard and should only be referred to as a basis for comparison. Numerous factors could determine whether this level (or one higher or lower) is harmful to the aquatic system. These include background dissolved oxygen, streamflow volume and velocity, and mixing. Nevertheless, a higher BOD value instream is an indication that dissolved oxygen levels may be threatened. Figure 2.3.15 presents the median level of BOD in each watershed where data was available. Areas such as the Upper Missouri, Upper Yellowstone, and Cheyenne River stand out as places where a relatively high median BOD value in stream exists. The Missouri River in North Dakota has areas approaching this value.

Data for ammonia was not widespread enough in the Northern Great Plains to discern any spatial patterns across this broad an area. However, since it is an important pollutant it should not be ignored. One of the sources of ammonia is effluent from municipal sewage treatment plants, this being an area where additional point source controls could provide more water quality benefits. Nonpoint sources, however, are also significant. The water quality criteria for ammonia varies with pH and temperature, since the unionized form is the most dangerous to aquatic life. At high pH and temperatures, the unionized form is more prevalent and the total ammonia criteria under these conditions are very low.

Figure 2.3.16 shows the watersheds where ammonia has been implicated in state 305b reports as impacting uses. Watersheds with the greatest number of miles impacted by ammonia are the Upper Red, the Upper and Middle James, parts of the Yellowstone, the Middle Platte-Buffalo, the Upper Elkhorn, Mud Creek in Nebraska and Rapid Creek in South Dakota.

On occasion, when sampling of fish tissue shows a concern, states may issue fish consumption advisories. These may take the form of limits on the number of fish that should be eaten (by either the general population or for susceptible individuals only) or outright bans on fish consumption.

Within the NGPAA, in 1994 and 1995, Nebraska issued fish consumption advisories for Box Butte Reservoir, Beaver Creek (Loup River Watershed), Merritt Reservoir and Lake

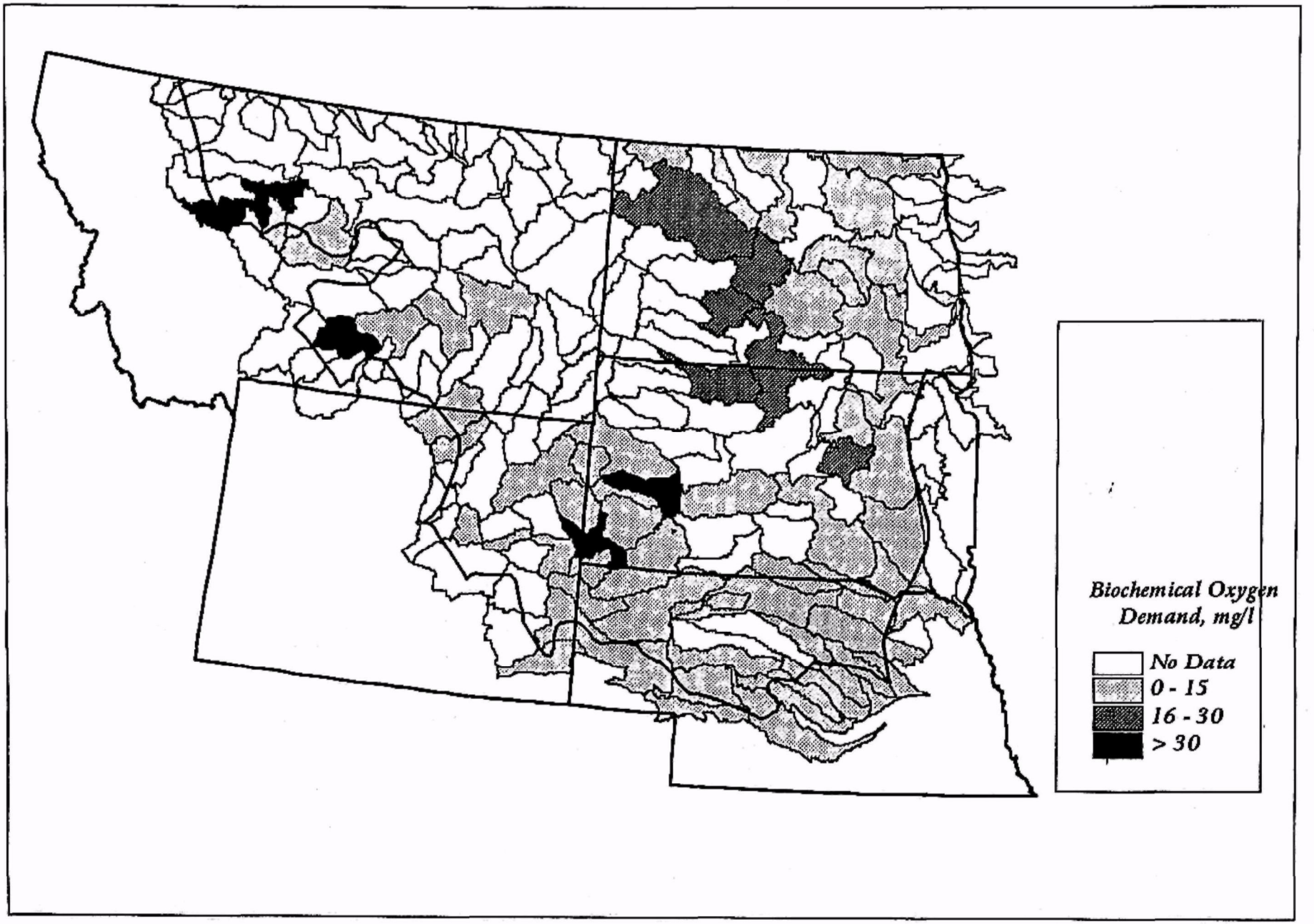

Figure 2.3.15 Median Biochemical Oxygen Demand in the Northern Great Plains

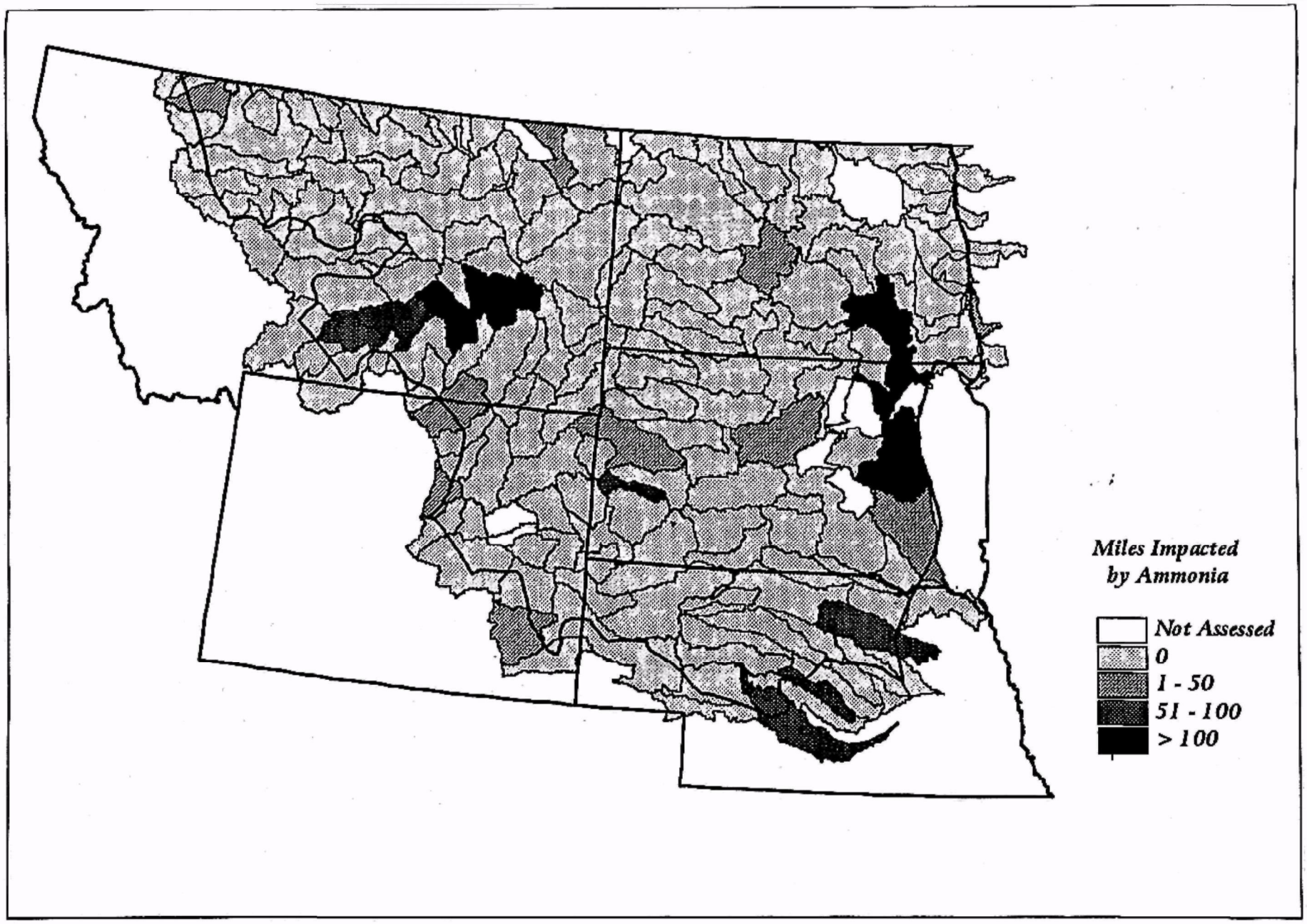

Figure 2.3.16 Miles of Assessed Streams in Each Watershed Impacted by Ammonia

Ogallala (Nebraska Department of Environmental Quality, 1996). These were issued for mercury in Box Butte and Merritt Reservoirs; dieldrin in Beaver Creek and Lake Ogallala and polychlorinated biphenyls (PCBs) also in Lake Ogallala. South Dakota monitored fish flesh in over 44,000 lake acres for mercury, PCBs, chlordane and toxaphene and found levels too low to warrant issuing fish consumption advisories (South Dakota Department of Environment and Natural Resources, 1996). Wyoming did not issue any fish consumption advisories during the 1994-5 period (Wyoming Department of Environmental Quality, 1996). North Dakota has issued fish consumption advisories for eighty-one miles of the Missouri River, 291 miles of the Red River and for twenty-two lakes for a total of 471,391 acres (North Dakota Department of Health, 1994). The largest lakes include Lake Sakakawea, Jamestown Reservoir, Devils Lake, Lake Audubon, Lake Ashtabula, Lake Darling and Lake Tschida. These advisories have been issued for mercury. In addition, North Dakota states that 306 miles of the Little Missouri have elevated levels of toxics (North Dakota Department of Health, 1994). The toxics include chromium, copper, lead and arsenic resulting from highly erosive soils compounded by overgrazing and oil exploration and extraction (North Dakota Department of Health, 1994). Montana has issued advisories in the Marais, Milk, Missouri, Clarks Fork of the Yellowstone and Tongue River watersheds (U.S. Environmental Protection Agency, 1997a).

Contamination in wildlife has been studied in a few areas within the assessment area, namely the Cheyenne River and the Red River. In the Cheyenne River, Hesse et al. (1975) found elevated mercury levels in fish-eating birds. This contamination derived from historical discharges of mercury used in gold mining in the Black Hills tributaries of the Cheyenne River.

A few studies investigating the water quality of irrigation projects have been performed in the Northern Great Plains. Greene, et al. (1990) sampled aquatic organisms in the vicinity of the Angostura Reservoir and irrigation project on the Cheyenne River. Levels of selenium in fish downstream of the project was two to five times more than in fish sampled above. Seven fish (out of nine) had levels above 10 ug/g which is above the level suggested to cause detrimental effects in fish (Greene, et al. 1990). Samples of fish and blackbird eggs had less than the recommended level of pesticides and fish had less than the recommended levels of PCBs.

Roddy, et al. (1991) performed a similar study for the Belle Fourche project. Downstream fish had higher arsenic and selenium. The highest selenium value was 5.7 ug/g, which is lower than the 10 ug/g toxic effects level for whole fish (Lillebo, et. al, 1988). Duck livers had selenium values ranging from 6.5 to 27.5 ug/g. Ten ug/g is considered the threshold of biological effects for aquatic bird liver samples (Lemly, 1993).

Goldstein, et al. (1996) sampled fish from various points in the Red River and found no differences in concentrations of mercury in the fish with respect to the sampling site. The authors point out that this is indicative of a diffuse atmospheric source of mercury rather than large point sources. Sampling of fish (fillets) in the Red River in 1990 for mercury by the Minnesota Department of Natural Resources found concentrations ranging from 0.32 ppm to 1.3 ppm (Goldstein, 1995). Fish consumption advisories were issued by both Minnesota and North Dakota based on this data (Goldstein, 1995). The levels of total PCBs have declined in Red River fish, but were still high enough as of 1993 for

Minnesota to maintain a fish consumption advisory based on the data (Goldstein, 1995).

Pesticides are a water quality concern in areas of high agricultural activity such as portions of the Northern Great Plains. Goolsby, et al. (1991) found pesticides in streams in Nebraska, North Dakota, South Dakota and other Midwestern States. Atrazine was detected the most often and in the largest concentrations. The values for a number of pesticides exceeded maximum contaminant levels (MCLs) as defined under the Safe Drinking Water Act in about half the samples. Pesticides have been detected in the Missouri River and include chlordane, atrazine, alachlor, diazinon, dieldrin, DDT, simazine and others (U.S. Army Corps of Engineers, 1994).

Instream samples for pesticides in the Red River, a large fraction has detectable quantities of 2,4-D, g-HCH and atrazine (Tornes and Brigham, 1994), however, all were well below the maximum contaminant levels. Brigham et al. (1994) estimated the total load of several pesticides at various sampling points in the Red River basin. The Red River itself at Emerson, Manitoba (where it crosses into Canada) had an estimated load of 610 kilograms of atrazine, 1400 kilograms of bentazon and 280 kilograms of cyanazine. These loading values indicated that less than 1% of these applied pesticides were transported out of the basin (Brigham, et al. 1994).

Nutrient loading to waters in the Northern Great Plains is of concern because of the large agricultural input. Nitrogen and phosphorus are the two most important nutrients entering waters. High levels of these pollutants stimulate plant growth which can then deplete dissolved oxygen. Impairment can occur when phosphorus concentrations exceed 0.05 mg/l in lakes and 0.1 mg/l in streams (Huntzinger, 1995).

Mueller, et al. (1992) reported on surface water nutrient sampling results from numerous U.S. Geological Survey National Water-Quality Assessment (NAWQA) Program studies, including a study of the Red River Basin and Central Nebraska Basins. In data from sites that had drainage areas of greater than 10,000 square miles, nitrates in the Red River were all less than 1 mg/l, while the Central Nebraska basins ranged from 0 to 1.8 mg/l. In smaller areas draining agricultural regions in Central Nebraska, nitrates reached as high as 3.7 mg/l. Total phosphorus samples for the large drainage area in the Red River ranged from 0.1 to 0.5 mg/l and Central Nebraska was similar. In Central Nebraska, total phosphorus values were as high as 1.8 mg/l in areas draining agricultural regions.

Water Quality of the Missouri River

According to the U.S. Army Corps of Engineers (1994) water quality is generally good in the mainstem of the Missouri River. However, there are some water quality problems. Low dissolved oxygen in reservoirs is a problem due to oxygen demanding sediments in the mainstem lakes. In addition, since most of the mainstem dams release water from lower depths, the low dissolved oxygen in the reservoirs can result in low dissolved oxygen releases downstream. There are temperature concerns below the reservoirs, as well, since the bottom water is much colder than natural conditions. This benefits introduced coldwater fish species, but is detrimental to the native Missouri River fishes because it is unsuitable for spawning and development of warm water fishes (U.S. Fish and Wildlife Service, 1994).

The water quality in some Missouri River tributaries is at times poor because of nutrients from runoff, sewage treatment plants, and pesticides. In Lake Oahe water entering the lake has slightly elevated levels of arsenic and

mercury. The mercury problem is limited to sediments in the Cheyenne River Arm. The source of the mercury is historical mining areas in the Black Hills. Contaminated fish were first noticed in 1973. In Lake Francis Case a huge sediment load is received from the White River. This sediment remains in the lake and adds total suspended solids to the tailwaters of Fort Randall Dam.

Future Trends

Agriculture is a large contributor to water quality problems in the NGP and will continue to be so in the near future. Most of the effects from agriculture are in the form of nonpoint sources, which are difficult to control and there are limited regulatory means for control of them. Debate is currently ongoing concerning any possible changes in the operation of the Missouri River dams to improve wildlife habitat and water quality and it remains to be seen if changes will occur.

Water quality improvements, however, have occurred from implementation of point source controls on municipal and industrial sources, all of which are required to have permits to discharge. For the most part these sources are as tightly regulated as they will likely be in the near future, with the possible exception of more ammonia stringent limits for municipal wastewater plants. With some exceptions (namely, some concentrated animal feeding operations), in the Northern Great Plains, point sources now have restricted and limited impacts to water quality. Most benefits to be gained in the future will result from improvements in nonpoint source control and minimizing the impacts of hydrologic modifications.

In areas where population growth is occurring, residential and commercial development may have water quality effects. These changes can increase the number of point sources, loadings to present point sources and more stormwater runoff from construction and from the added roads, streets and parking lots. Quicker runoff of precipitation can also affect the hydrology of streams within the developed area. In the Northern Great Plains, these effects will be limited in area compared to the more widespread effects of agriculture, but in a local area they can be very important.

2.4 GROUND WATER QUALITY

Introduction

The quality of ground water is affected by dissolved minerals from surrounding rocks and by other pollutants added by human activities. Total dissolved solids is an important indicator for assessing the quality of ground water. Total dissolved solids content can vary widely based on hydrogeologic condition. Ground water may also naturally contain other constituents such as sulfates and chlorides that may make it unusable.

There are no federal rules mandating beneficial use classifications for ground water, although many states have ground water classification systems and standards based on use. Ground water may have use classifications applied to it, much like surface water, and the classifications generally reflect categories of human uses, such as drinking, stock watering and irrigation. Table 2.4.1 presents as an example the ground water classification system used by the State of Montana. The classification is based on the total dissolved solids content. There are federal standards under the Safe Drinking Water Act which are referred to as maximum contaminant levels (MCLs). These are enforceable standards set to protect human health. MCLs apply at the tap after treatment.

Human activities that can pollute ground

water include use of agricultural fertilizers and pesticides, feedlots, landfills and other wastesites, unmaintained septic tanks, leaking underground fuel storage tanks and spills of toxic substances (Brouchard, et al. 1992). In the NGPAA the most important pollutants that may be found in ground water are nitrates, pesticides and dissolved solids. Locally, ground water is contaminated by toxics from fuel leakage, toxic spills and hazardous waste sites.

The maximum contaminant level for nitrate is 10 mg/l. This is the level necessary to protect infants from methemaglobinemia (also known as blue-baby syndrome). This is a problem for infants up to about four months of age since they lack the necessary enzyme to reduce the methemoglobin produced by nitrite converted from high concentrations of nitrate (Mueller, et al. 1995). A nationwide analysis found that 16% of the nitrate samples from agricultural areas exceeded the drinking water standard and that concentrations were highest within 100 feet of the land surface (Mueller, 1995).

Pesticides (herbicides, insecticides and fungicides) are another pollutant of concern to ground water in the Northern Great Plains. There are a number of pesticides with MCLs, including alachlor (0.002 mg/l), atrazine (0.003 mg/l), 2,4-D (0.07 mg/l) and 2,4,5-T (0.05 mg/l). Most of the MCLs for pesticides are set for cancer risk, nervous system damage or liver or kidney damage (U.S. Environmental Protection Agency, 1993). There are MCLs for other pollutants such as metals and organics, but most of these are limited to specific localities in the Northern Great Plains.

Key Findings

•The major aquifer systems located in the NGPAA include unconsolidated alluvial and glacial deposit aquifers, the High Plains aquifer system, the Northern Great Plains aquifer system and Great Plains aquifer system.

•The High Plains Aquifer generally has very good water quality in terms of dissolved solids.

•The Great Plains Aquifer has high dissolved solids in central and southwestern Nebraska.

• Portions of the Northern Great Plains Aquifer reach extremely high levels of dissolved solids in North Dakota.

•The greatest number of pesticide detections in ground water have occurred in Holt and Wheeler counties in Nebraska; Potter County in South Dakota; Rolette County in North Dakota and Teton County in Montana.

•Aquifer vulnerability is greatest in parts of northeastern Montana, scattered areas in the Missouri Escarpment in North Dakota as well as larger areas in Bottineau, McHenry, Richland and Ransom counties in North Dakota, much of eastern South Dakota and areas south of the White River, southeastern Wyoming, and throughout most of Nebraska.

•Nitrates are above 3 mg/l in greater than 25% of sampled wells in central South Dakota, western and north-central Nebraska, eastern Wyoming and eastern North Dakota.

Data Sources and Methods

The information in this section was obtained from large-scale ground water reports by the U.S. Geological Survey, the report by the U.S. Environmental Protection Agency entitled, *Pesticides in Ground Water Database*, which compiled monitoring information from 1971 to 1991 (U.S. Environmental Protection Agency, 1992b), state 305(b) reports and other reports.

Data Quality and Gaps

Large areas in the Northern Great Plains are missing pesticide monitoring data for wells. This is not necessarily surprising since where problems are suspected is where monitoring

Table 2.4.1 Montana's Groundwater Classification System

I	Suitable for public and private water supplies. Irrigation use with little or no treatment. Specific conductivity of less than 1000 uSiemans/cm at 25°C.
II	Can be used for water supply when better supplies are not available. The primary purpose is for irrigation, stock watering and industry. Specific conductivity is between 1000 and 2500 uSiemans/cm at 25°C.
III	Use is for stock watering and industry. Specific conductivity is between 2500 and 15,000 uSiemans/cm at 25°C.
IV	Use is for industry only. Specific conductivity is greater than 15,000 uSiemans/cm at 25°C.

tends to be done (i.e. where there is heavy pesticide or fertilizer use). Much less ground water monitoring for pesticides appears to have been done in the Montana and South Dakota portions of the NGPAA.

Spatial Patterns

Wyoming reports that most of its ground water is of good quality (Wyoming Department of Environmental Quality, 1994), but some of Wyoming's aquifers within the NGPAA have naturally high levels of fluoride and selenium. Specifically, the area with high fluoride encompasses eastern Campbell County, southeastern Johnson County and northeastern Natrona County. High selenium was noted in eastern Natrona County. Of 63 wells sampled in the North Platte Alluvial Aquifer in Goshen County, 35 were above 10 mg/l for nitrate (Wyoming Department of Environmental Quality, 1996). Twenty-four were sampled for pesticides with none found above the MCLs (although pesticides were detected in 18 of the wells) (Wyoming Department of Environmental Quality, 1996).

South Dakota states that the pollutant most frequently found in ground water is nitrate (South Dakota Department of Environment and Natural Resources, 1996). Two aquifers in South Dakota within the NGPAA were sampled for nitrates and highlighted in the 1996 305(b) report (South Dakota Department of Environment and Natural Resources, 1996). Six wells were sampled in the Bowdle Aquifer in Potter, Walworth and Edmunds Counties in 1994 and two were found to have samples above 10 mg/l for nitrate. Similarly, of four wells sampled in the Delmont Aquifer of Charles Mix and Douglas Counties (also in 1994), two had nitrates above 10 mg/l.

Ground water quality in North Dakota is reported to be generally good with the exception of naturally occurring problems in a few aquifers (North Dakota Department of Health, 1994). Monitoring has been done in the Oakes, Icelandic and Warwick aquifers in North Dakota (North Dakota Department of Health, 1994). Of the total wells sampled (137), pesticides were detected in two wells (1.5%), nitrate was detected in thirty-six wells (26.3%) and both pesticides and nitrate were detected in one well (0.7%). Eight (5.8%) wells had nitrate at a level greater than 10 mg/l.

A study of water quality in the High Plains Aquifer in Nebraska was performed in which wells were sampled for nitrate and atrazine, a common pesticide (Druliner, et al. 1996). Only two areas out of six were in the NGPAA. These included Box Butte County in western Nebraska and an area encompassing Holt, Garfield and Wheeler Counties in the northeast. For nitrates in Box Butte County, 11 wells were sampled that ranged from 2.4 to 13 mg/l, only one exceeded the 10 mg/l maximum contaminant level (MCL) set by the U.S. Environmental Protection Agency. In the Holt, Garfield, Wheeler area, nitrates ranged from 0.1 to 51 mg/l, with 30 out of 75 sampled wells exceeding 10 mg/l.

An analysis of nitrate data from the states in the NGPAA determined the percentages of sampled wells in each state with more than 10 mg/l nitrate (Madison and Brunett, 1985). Not all of the wells were necessarily within the NGPAA boundary. In Montana, 3.8% (2821) wells were above 10 mg/l. In Nebraska the figure was 9.3% (2326 wells). In North Dakota, South Dakota and Wyoming the figures were 4.6% (7387 wells), 6.7% (1996 wells) and 3.8% (1477 wells), respectively.

The distribution of nitrate concentrations in ground water in the Northern Great Plains was complied by Madison and Brunett (1985), as well. For most of the region where there were more than five wells per county in the database, fewer than 25% of the sampled wells had nitrate concentrations greater than 3 mg/l (considered to be above background levels). A few areas, such as central South Dakota, western and north-central Nebraska, parts of eastern Wyoming, parts of eastern North Dakota and north-central and south-central Montana show more than 25% of the sampled wells with greater than 3 mg/l nitrate. The rest of the NGPAA had less than 25% of sampled wells with greater than 3 mg/l nitrate. This data, however, does not represent random samples because known problem areas are sampled more often (Madison and Brunett, 1985).

The naturally occurring total dissolved solids concentrations in the Northern Great Plains Aquifer System was reported by the U.S. Geological Survey (1996). In the lower Paleozoic portions of this aquifer system, water with less than 3000 mg/l dissolved solids only occurs in the Big Horn Mountains area and from the Black Hills eastward to central South Dakota (U.S. Geological Survey, 1996a). Throughout much of North Dakota, the lower Paleozoic aquifers contain total dissolved solids in excess of 100,000 mg/l. In the lower Cretaceous (Inyan Kara aquifer) part of this system, water with less than 3000 mg/l dissolved solids occurs only near the recharge zones (U.S. Geological Survey, 1996a). In North Dakota this aquifer has dissolved solids mostly between 3000 and 10,000 mg/l. The upper Cretaceous aquifers (Hell Creek/Fox Hills), by contrast, are less than 3000 mg/l in most of its range, with the exception of a small area in Bottineau and McHenry Counties in North Dakota (U.S. Geological Survey, 1996a). The median total dissolved solids ranges from 910 mg/l in Montana to 1060 mg/l in North Dakota (U.S. Geological Survey, 1988). Seventy-five percent of nitrate samples were less than 1.5 mg/l and selenium concentrations in 18% of samples exceeded 2.4 mg/l (U.S. Geological Survey, 1988). The Fort Union aquifer (Lower Tertiary) has a median total dissolved solids concentration of 1600 mg/l in Montana and about 1100 mg/l in Wyoming. Naturally occurring selenium is 50 to 600 ug/l in some areas (U.S. Geological Survey, 1988).

In the Great Plains Aquifer System,

specifically the Maha Aquifer, total dissolved solids are less than 5000 mg/l over much of Nebraska, but reach very high levels in central and southwestern Nebraska (U.S. Geological Survey, In Press). Thomas County has levels of between 20,000 and 50,000 mg/l, while an area including portions of Garden and Morrill Counties reaches levels greater than 120,000 mg/l (U.S. Geological Survey, In Press).

The High Plains Aquifer System (which includes the Ogallala Aquifer) generally has very good water quality. Under the Sand Hills this system has total dissolved solids concentrations of less than 250 mg/l and is generally below 1000 mg/l where it exists in Nebraska. In South Dakota and Wyoming the quality of the water from the High Plains Aquifer is suitable for most uses nearly everywhere it occurs, although there are some local total dissolved solids readings of more than 500 mg/l (U.S. Geological Survey, 1996a). Selenium is a problem in some areas where the aquifer overlies Pierre Shale (U.S. Geological Survey, 1996a). The median selenium in Wyoming was 8 ug/l (U.S. Geological Survey, 1988).

In the unconsolidated aquifers in North Dakota, sampling showed that they are generally less than the MCL for total dissolved solids and nitrates, with some local exceedances for nitrates (U.S. Geological Survey, 1988). Arsenic exceeds 50 ug/l in an area greater than 170 square miles in southeastern North Dakota. Alluvial and glacial aquifers in Montana had a median total dissolved solids of concentration of 2000 mg/l (U.S. Geological Survey, 1988). In the glacial drift/alluvial aquifers in South Dakota, 75% of samples exceeded the MCL for total dissolved solids, with a median of 670 mg/l and in the alluvial valley fill aquifers in Wyoming, 75% of samples had a total dissolved solids concentration of less than 760 mg/l (U.S. Geological Survey, 1988).

Figure 2.4.1 presents the results of over 20 years of sampling compiled by the U.S. Environmental Protection Agency (1992b) for pesticides. Pesticides were detected most commonly in Holt and Wheeler counties in Nebraska; Potter County in South Dakota; Rolette County in North Dakota and Teton County in Montana. Low numbers of detections were recorded in eastern, southern and western North Dakota, the Sand Hills of Nebraska and parts of northeastern Wyoming. Pesticides detected in the NGPAA counties included 2,4-D, 1,2-D, aldicarb sulfone, aldicarb sulfoxide, atrazine, dicamba, MCPA, picloram, simazine, alachlor, ethyl parathion, methyl parathion, cyanizine, fonofos, dieldrin, propachlor and metolachlor. None of the pesticides detected in Northern Great Plains counties were above the MCLs, with the exception of one sample each from Wheeler and Holt Counties in Nebraska. Wheeler County had one aldicarb sample at 3 ug/l and Holt County had one atrazine sample at 22.7 ug/l.

In more recent data, atrazine was sampled in ten wells in Box Butte County (Druliner, et al. 1996) and was detected in two, with a high value of 0.7 ug/l. In Holt, Garfield and Wheeler counties, forty-two wells were sampled and atrazine was detected in twenty-five of them, with a high of 1.8 ug/l. The MCL for atrazine is 3.0 ug/l.

Tornes and Brigham (1994) reported that the majority of pesticide analyses for ground water in the Red River basin were not above laboratory reporting limits and were usually below MCLs. The wells with reportable levels were mainly in the southern and southeastern part of the basin and atrazine was the most commonly found pesticide.

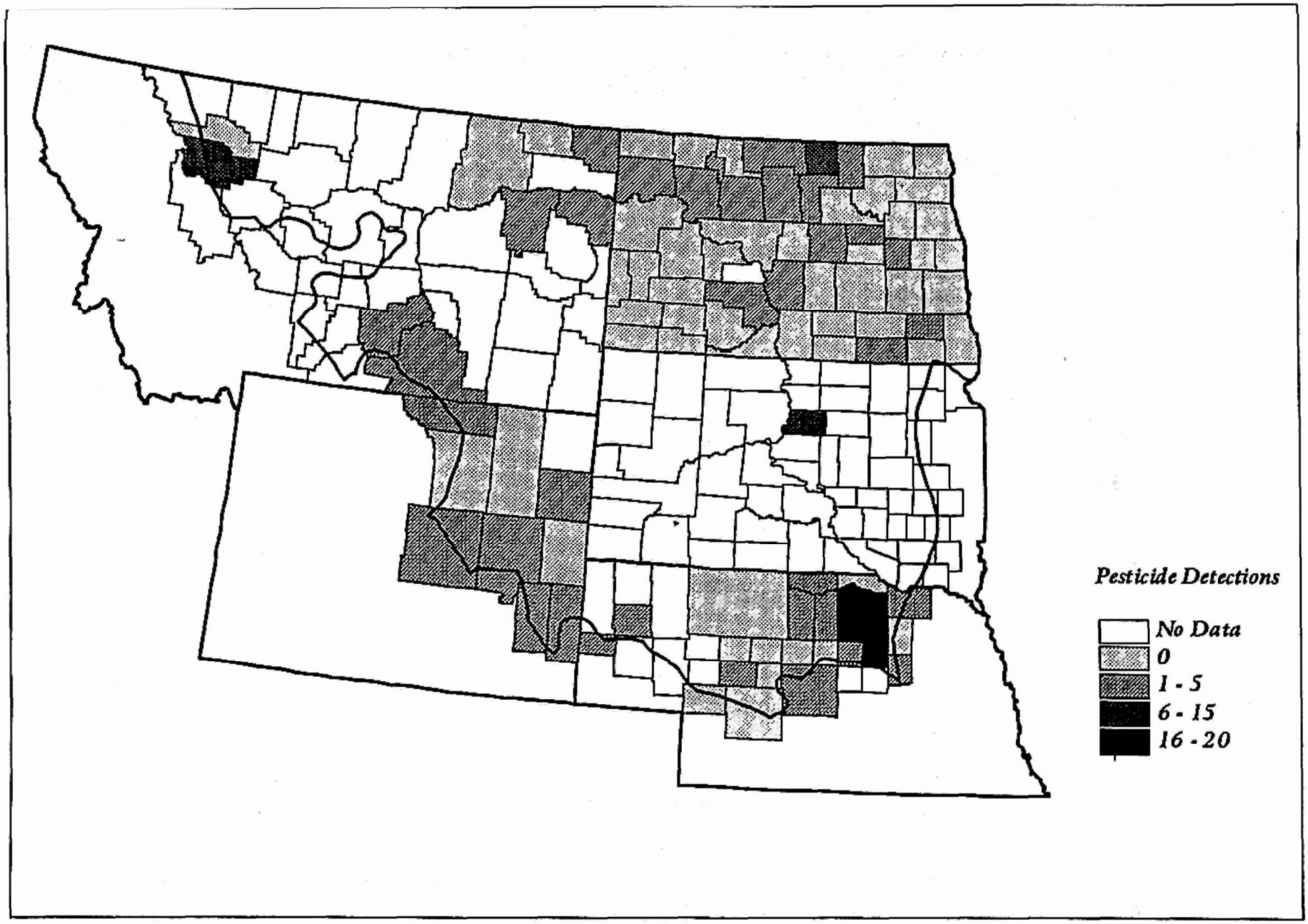

Figure 2.4.1 Pesticide Detections in Ground Water Wells in the Northern Great Plains

The U.S. Environmental Protection Agency (1991) published a report assessing the vulnerability of aquifers to contamination throughout the United States on a state-by-state basis. For Nebraska, essentially all of the area within the NGPAA is rated as vulnerable due to the predominance of unconsolidated and semiconsolidated deposits. However, the likelihood of contamination was rated low due to the low population density. Population density alone is not a good predictor of vulnerability, however, since agricultural areas with low populations may contaminate aquifers. For the part of Montana within the NGPAA, most was rated as moderate to low vulnerability, except for areas along rivers and portions of northeastern Montana in Daniels, Valley, Roosevelt, Blaine and Dawson Counties. Most of North Dakota is rated as moderate to low vulnerability. The areas with high vulnerability include river areas, scattered areas along the Missouri Escarpment and larger areas within Bottineau, McHenry, Richland and Ransom Counties. The Sheyenne National Grassland is within a high vulnerability area. Most of western South Dakota has moderate to low vulnerability, except for river areas and much of the area south of the White River. Much of eastern South Dakota east of the Missouri is rated as high vulnerability, although it is a mosaic of high and low. As for the Wyoming portion of the NGPAA, northeast Wyoming is rated moderate to low in vulnerability, while southeastern Wyoming is rated high (southeastern Converse, southern Niobrara and almost all of Platte and Goshen Counties).

Future Trends

The natural causes of poor quality ground water will, of course, always be a problem. In the Northern Great Plains, aside from localized ground water impacts from sites such as landfills and underground storage tanks, most impacts to ground water will come from agricultural uses. Confined animal feeding operations and the use of pesticides and nitrogen fertilizer on cropland are the primary sources of ground water contamination in this region.

The use of nitrogen fertilizers has grown considerably since the end of World War II, but has leveled off. Table 2.4.2 shows the changes in amounts of nitrogen fertilizer used through four decades in the top ten counties within the NGPAA in terms of use in 1985. In addition to the increased amounts of nitrogen fertilizer used, the percentage of nitrogen in fertilizer has increased from 6.1 to 20.4% during the period 1950 to 1970 (Madison and Brunett, 1985).

The future impacts to the ground water resources in the most vulnerable areas will depend upon any changes in land use in those areas. For example the vulnerable areas under the Sand Hills are not considered to be threatened because great changes in land use are not expected. This may not be true for all vulnerable aquifers in the NGPAA.

2.5 AQUATIC SPECIES

Introduction

Biodiversity is the variety of life and its processes and it includes the variety of organisms, the genetic differences among them and the communities and ecosystems in which they occur (The Keystone Center, 1991). An actual assessment of biodiversity includes examining the links between species, not just enumerating the species. However, since other portions of this report will look at the functioning of the aquatic systems of the Northern Great Plains, this section will deal only with the aquatic species

Table 2.4.2 Trends in Nitrogen Fertilizer Use for the Top Ten Counties in the NGPAA, in pounds

County	1945	1955	1965	1975	1985
Cass, ND	5390	281600	1654264	8614776	16126220
Custer, NE	4961	843937	3484064	7441282	14302790
Lincoln, NE	4939	840058	3468052	7407083	14078070
Richland, ND	3873	202337	1188632	6189944	13109990
Antelope, NE	5916	1006409	4154808	8873860	12930340
Knox, NE	4196	713649	2946191	6292489	12586210
Grand Forks, ND	4184	218620	1284285	6688065	12568250
Cavalier, ND	3069	160341	941925	4905186	11650150
Boone, NE	4306	732385	3023538	6457688	11478190

richness of the plains.

The information presented in this and the following section is weighted heavily toward fishes, since the best information available is for this group.

Key Findings

•There are fewer endemic fish species in the NGPAA than in many other areas due to low topographic relief and the recent origin of the plains.
•The Missouri River has 138 native fish species and 35 introduced fish species.
•With a few exceptions, the fish species diversity increases from west to east.
•There are 75 fish species in the Red River basin, only 51 of which exist on the North Dakota side.
•Three typical fish habitats are found in the NGPAA. These are large streams with variable flow, a sandy substrate and high levels of turbidity and dissolved solids; prairie ponds, marshes and small streams that are clear and relatively stable; and residual pools of highly intermittent streams.
•The NGPAA has low aquatic mollusk diversity. Most of the mollusk species found here overlap from nearby regions. Diversity is highest in the eastern portions.

Spatial Patterns

There are fewer endemic species in the Great Plains than in other areas due to its recent origin and general lack of physical barriers (Ostlie, et al. 1997). The only areas within the Great Plains with a relatively high degree of endemism are found outside the NGPAA in areas such as the Hill Country of Texas and the Black Hills of South Dakota (Ostlie, et al. 1997). Of approximately 250 fish species found in the Great Plains area assessed in The Nature Conservancy Report, *A Status of Biodiversity in the Great Plains*, only 34 (14%) are endemic (a smaller set of these actually occur in the Northern Great Plains).

The increase in rainfall on the Northern Great Plains from west to east influences the physical characteristics of the waterbodies and therefore, the fauna that can be supported. Aquatic vertebrate and invertebrate diversity generally increases from west to east, however, a few minnow and killifish species become increasingly dominant westward (Cross and Moss, 1987) and most of the fish species in the Great Plains are native to eastern North America (Ostlie, et al. 1997). The Missouri River stands out with a large number of species even in the west because of its larger flow.

The NGPAA is drained by two major river systems. These are the Missouri, flowing to the Mississippi and the Red River of the North flowing to Hudson Bay. These two systems are in the Mississippi and Hudson Bay zoogeographic provinces, respectively.

The Mississippi Province (of which only the western part is in the Northern Great Plains) contains all of the Mississippi-Missouri drainage and is the richest province in North America in obligatory freshwater fishes with 280 to 300 species (Moyle and Cech, 1982). The majority of these (88%) are freshwater dispersants, incapable of traveling long distances in salt water. This high percentage indicates that this is an ancient drainage (Moyle and Cech, 1982). The Mississippi province is important in North America as a center of fish evolution (indicated by the abundance of families such as Centrarchidae, Percidae and Cyprinidae), as a refuge during times of glaciation from which species have been able to reoccupy waters they were forced to vacate (most of the species found in the Hudson Bay Province are also characteristic of the northern parts of the Mississippi Province) and as a refuge for representatives of past fish faunas (evidenced by presence of relicts such as sturgeons and paddlefish) (Moyle and Cech, 1982).

The western Mississippi drainage has 27 resident native families and 235 resident native species (Moyle and Cech, 1982). In order, among native fishes, the Cyprinidae, Percidae, Catostomidae and Ictaluridae are the most diverse (collectively they make up about 70% of the fauna) and the Cyprinidae and Percidae alone contribute more than 50% of the species. The Missouri River itself has 138 native fish species. However, when introduced species are included, the total is 173. Nineteen percent of the Missouri River fish species are introduced.

The Hudson Bay Province includes most of central Canada and the portion of the United States drained by the Red and Souris Rivers. The fish fauna shows a strong affinity with the Mississippi River basin, particularly in freshwater dispersants (Moyle and Cech, 1982). Most of these freshwater dispersants occur in the southern edges of the drainage (which is the Red and Souris Rivers). There is some divergence between the Red and Souris Rivers, however. There are 29 fish species in the Red that do not occur in the Souris (Moyle and Cech, 1982). Underhill (1989) presents evidence that the major source of fish species to the Red River basin was through a connection to the Mississippi drainage. Of the 75 native species in the Red River, 73 of them are in common with the Mississippi drainage. These 75 species are not evenly distributed in the Red River basin, however, since 51 occur in the North Dakota drainages and 71 on the Minnesota side (Goldstein, 1995).

According to Cross and Moss (1987) there are three fish habitats typical of the Great Plains: large streams with variable flow, a sandy substrate and high levels of turbidity and dissolved solids; prairie ponds, marshes and small streams that are clear and relatively stable; and residual pools of highly intermittent streams. The larger, turbid Great Plains rivers contain the only unique fish species in the region (Ostlie, et al. 1997, Cross and Moss, 1987). Examples include the pallid sturgeon, sturgeon chub, sicklefin chub, western silvery minnow, plains minnow, goldeye, flathead chub and plains killifish. Examples of Great Plains fishes whose habitat includes clear, small streams, ponds and marshes fed by springs are the topeka shiner and plains topminnow (Ostlie, et al. 1997).

Within the entire prairie region 90 species of reptiles and 34 species of amphibians occur and the numbers of these decrease from east to west and south to north as well (Corn and

Peterson, 1996). Salamanders are especially under represented with only 5 species. Only ten species of herptiles (8 reptile and 2 amphibian) are considered endemic to the prairie (Corn and Peterson, 1996).

With respect to aquatic invertebrates, the mollusks of the Great Plains are essentially species that originated in the eastern, boreal and Rocky Mountain regions (Ostlie, et al. 1997). Freshwater mussels are most diverse in the southeastern United States and the diversity decreases significantly in the Great Plains. The Missouri River and many of its tributaries are not good habitat for mollusks due to the sediment load. In the NGPAA, most of the mollusk species are found in the eastern portions of North Dakota, South Dakota and Nebraska.

Table 2.5.1 lists all of the fish species known or expected to occur in the NGPAA. Table 2.5.2 lists the aquatic-dependent reptiles and amphibians of the NGPAA.

2.6 THREATENED, ENDANGERED AND SPECIAL CONCERN AQUATIC SPECIES

Introduction

Threatened and endangered species are those that have been listed by the U.S. Fish and Wildlife Service under the Endangered Species Act. Endangered means that the species is in danger of extinction throughout all or a significant portion of its range. Threatened means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. The term "species" includes any subspecies of fish, wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature.

In addition to listed species, the U.S. Fish and Wildlife Service keeps a list of species with the potential to be added to the list, known as candidates. Formerly there were three lists, however, this has been recently modified such that there is now only one candidate list - those where sufficient information exists to list, but the process to do so has not yet been completed or other species have a higher priority.

In addition to the federally designated endangered, threatened and candidate species, this Assessment also examines special concern species. This term includes candidates for listing, those proposed for listing and those ranked as G1, G2, or G3 by state natural heritage programs and The Nature Conservancy. The rankings in this system (Ostlie, et al. 1997) are as follows:

G1 - critically imperiled; extremely rare, occurring in five places or less or is highly vulnerable to extinction,

G2 - imperiled; occurs in 6-20 places or is vulnerable to extinction,

G3 - rare; locally abundant, but occurs in only 21-100 locations or is vulnerable to range-wide extinction,

G4 - apparently secure, and

G5 - demonstrably secure; no apparent risk.

Most of the focus in this report has been on those aquatic species that are federally-listed or are ranked G1-G3 (TE&SC), however, there are additional aquatic species that are listed by individual States as endangered, threatened or of special concern. These are considered separately in this assessment.

Table 2.5.1 Fish Species Reported to Occur in the Northern Great Plains Assessment Area.

Scientific Name	Common Name	Occurrence
Alosa chrysochloris	Skipjack Herring	NE, ND, SD
Ambloplites rupestris	Rock Bass	ND, SD
Amia calva	Bowfin	ND
Anguilla rostrata	American Eel	NE, SD
Aplodinotus grunniens	Freshwater Drum	MT, NE, ND, SD
Campostoma anomalum	Central Stoneroller	NE, ND, SD, WY
Carassius auratus	Goldfish	MT, NE, ND, SD, WY
Carpiodes carpio	River Carpsucker	MT, NE, ND, SD, WY
Carpiodes cyprinus	Quillback	NE, SD, WY
Carpiodes velifer	Highfin Carpsucker	NE, SD
Catostomus catastomus	Longnose Sucker	MT, NE, ND, SD, WY
Catostomus commersoni	White Sucker	MT, NE, ND, SD, WY
Catostomus platyrhynchus	Mountain Sucker	MT, NE, ND, SD, WY
Coregonus clupeaformis	Lake Whitefish	ND
Cottus bairdii	Mottled Sculpin	MT
Couesius plumbeus	Lake Chub	MT, NE, ND, SD, WY
Ctenopharyngodon idella	Grass Carp	MT, NE, ND, SD, WY
Culea inconstans	Brook Stickleback	MT, NE, ND, SD
Cyprinella spiloptera	Spotfin Shiner	NE, ND, SD
Cyprinus carpio	Common Carp	MT, NE, ND, SD, WY
Dorosoma cepedianum	Gizzard Shad	NE, ND, SD
Esox americanus vermiculatus	Grass Pickerel	NE, SD
Esox lucius	Northern Pike	MT, NE, ND, SD, WY
Esox masquinongy	Muskellunge	ND, SD
Etheostoma exile	Iowa Darter	MT, NE, ND, SD, WY
Etheostoma nigrum	Johnny Darter	MT, NE, ND, SD, WY
Etheostoma spectibile	Plains Orangethroat Darter	NE, WY
Fundulus diaphanus	Banded Killifish	NE, ND, SD
Fundulus sciadicus	Plains Topminnow	NE, SD, WY
Fundulus zebrinus	Plains Killifish	MT, NE, SD, WY
Hiodon alosoides	Goldeye	MT, NE, ND, SD, WY
Hiodon tergisus	Mooneye	NE, ND, SD
Hybognathus hankinsoni	Brassy Minnow	MT, NE, ND, SD, WY
Hybognathus placitus	Plains Minnow	MT, NE, ND, SD, WY
Hybopsis aestivalis	Speckled Chub	NE
Hybopsis argyritis	Western Silvery Minnow	MT, NE, ND, SD, WY
Hypentelium nigricans	Northern Hog Sucker	SD
Ichthyomyzon castaneus	Chestnut Lamprey	NE, ND
Ichthyomyzon unicuspis	Silver Lamprey	NE, SD
Ictalurus furcatus	Blue catfish	NE, SD
Ictalurus melas	Black Bullhead	MT, NE, ND, SD, WY
Ictalurus natalis	Yellow Bullhead	NE, ND, SD

Table 2.5.1 continued Fish Species Reported to Occur in the Northern Great Plains Assessment Area.

Scientific Name	Common Name	Occurrence
Ictalurus nebulosus	Brown Bullhead	ND, SD
Ictalurus punctatus	Channel Catfish	MT, NE, ND, SD, WY
Ictiobus cyprinellus	Bigmouth Buffalo	MT, NE, ND, SD
Ictiobus niger	Black Buffalo	NE, SD
Lepisosteus osseus	Longnose Gar	NE, ND, SD
Lepisosteus platostomus	Shortnose Gar	MT, NE, ND, SD
Lepomis cyanellus	Green Sunfish	NE, SD, WY
Lepomis gibbosus	Pumpkinseed	ND, SD
Lepomis humilis	Orangespotted Sunfish	NE, ND, SD
Lepomis macrochirus	Bluegill	NE, ND, SD
Lepomis megalotis	Longear Sunfish	ND
Lota lota	Burbot	MT, NE, ND, SD, WY
Luxilus cornutus	Common Shiner	NE, ND, SD, WY
Macrhybopsis gracilis	Flathead Chub	MT, NE, ND, SD, WY
Macrhybopsis storeiana	Silver Chub	NE, ND, SD
Micropterus dolomieui	Smallmouth Bass	ND, SD
Micropterus salmoides	Largemouth Bass	MT, NE, ND, SD, WY
Morone chrysops	White Bass	NE, ND, SD
Morone saxatilis	Striped Bass	NE
Moxostoma anisurum	Silver Redhorse	ND
Moxostoma erythurum	Golden Redhorse	ND, SD
Moxostoma macrolepidotum	Shorthead Redhorse	MT, NE, ND, SD, WY
Moxostoma valenciennesi	Greater Redhorse	ND
Nocomis biguttatus	Hornyhead Chub	NE, ND, SD, WY
Notemigonus crysoleucas	Golden Shiner	MT, NE, ND, SD, WY
Noturus flavus	Stonecat	MT, NE, ND, SD, WY
Noturus gyrinus	Tadpole Madtom	NE, ND, SD
Notropis atherinoides	Emerald Shiner	MT, NE, ND, SD
Notropis blennius	River Shiner	NE, ND, SD
Notropis dorsalis	Bigmouth Shiner	NE, ND, SD, WY
Notropis heterolepis	Blacknose Shiner	NE, ND, SD
Notropis hudsonius	Spottail Shiner	MT, NE, ND, SD
Notropis lutrensis	Red Shiner	NE, SD, WY
Notropis rubellus	Rosyface Shiner	ND, SD
Notropis shumardi	Silverband Shiner	NE, SD
Notropis volucellus	Mimic Shiner	ND
Notropsis stramineus	Sand Shiner	MT, NE, ND, SD, WY
Oncorhynchus clarki	Cutthroat Trout	MT, WY
Oncorhynchus mykiss	Rainbow Trout	MT, NE, ND, SD, WY
Oncorhynchus nerka	Kokanee Salmon	MT

Table 2.5.1 continued Fish Species Reported to Occur in the Northern Great Plains Assessment Area.

Scientific Name	Common Name	Occurrence
Perca flavescens	Yellow Perch	MT, NE, ND, SD, WY
Percina caprodes	Logperch	ND, SD
Percina maculata	Blackside Darter	NE, ND, SD
Percina phoxocephala	Slenderhead Darter	SD
Percina shumardi	River Darter	ND
Percopsis omiscomaycus	Trout-perch	MT, NE, ND, SD
Phenacobius mirabilis	Suckermouth Minnow	NE, SD, WY
Phoxinus eos	Northern Redbelly Dace	MT, NE, ND, SD
Phoxinus neogaeus	Finescale Dace	MT, NE, ND, SD, WY
Pimephales notatus	Bluntnose Minnow	NE, ND, SD
Pimephales promelas	Fathead Minnow	MT, NE, ND, SD, WY
Pimephales vigilax	Bullhead Minnow	NE, SD
Polydon spathula	Paddlefish	MT, NE, ND, SD
Pomoxis annularis	White Crappie	MT, NE, ND, SD, WY
Pomoxis nigromaculatus	Black Crappie	NE, ND, SD
Prosopium williamsoni	Mountain Whitefish	MT
Pungitius pungitius	Ninespine Stickleback	ND
Pylodictis olivaris	Flathead Catfish	NE, ND, SD
Rhinichthys atratulus	Blacknose Dace	NE, ND, SD
Rhinichthys cataractae	Longnose Dace	MT, NE, ND, SD, WY
Salmo trutta	Brown Trout	MT, NE, ND, SD, WY
Salvelinus fontinalis	Brook Trout	MT, NE, ND, SD, WY
Salvelinus namaycush	Lake Trout	MT, NE, ND, SD, WY
Scaphirhynchus platorynchus	Shovelnose Sturgeon	MT, NE, ND, SD, WY
Semotilus atromaculatus	Creek Chub	MT, NE, ND, SD, WY
Semotilus margarita	Pearl Dace	MT, NE, ND, SD, WY
Stizostedion canadense	Sauger	MT, NE, ND, SD, WY
Stizostedion lucioperca	Zander	ND, more?
Stizostedion vitreum	Walleye	MT, NE, ND, SD, WY
Umbra limi	Central Mudminnow	NE, SD

Sources: Lee, et. al., 1980; Page and Burr, 1991; North Dakota Game and Fish Department, 1994

Table 2.5.2 Amphibian and Reptile Aquatic Species Reported to Occur in the Northern Great Plains Assessment Area.

Scientific Name	Common Name	Occurrence
Acris crepitanus	Northern Cricket Frog	NE, SD
Ambystoma tigrinum	Tiger Salamander	MT, NE, ND, SD, WY
Chelydra serpentina	Snapping Turtle	MT, NE, ND, SD, WY
Chrysemys picta belli	Western Painted Turtle	MT, NE, ND, SD, WY
Emydoidea blandingii	Blanding's Turtle	NE, SD
Graptemys pseudogeographica	False Map Turtle	NE, ND, SD
Hyla chrysoscelis	Cope's Gray Treefrog	ND, SD
Hyla versicolor	Common Gray Treefrog	ND, SD
Kinostemon flavescens	Yellow Mud Turtle	NE
Necturus maculosus	Mudpuppy	ND
Pseudacris triseriata	Boreal Chorus Frog	MT, NE, ND, SD, WY
Rana blairi	Plains Leopard Frog	NE, SD
Rana catasbeiana	Bullfrog	MT, NE, ND, SD, WY
Rana pipiens	Northern Leopard Frog	MT, NE, ND, SD, WY
Rana sylvatica	Wood Frog	ND, SD
Trionyx muticus	Smooth Softshell	NE, ND, SD
Trionyx spiniferus	Spiny Softshell	MT, NE, SD

Sources: Freeman, 1990; Holberg and Gause, 1992; Behler and King, 1979

Key Findings

•There are 18 TE&SC aquatic species within the Northern Great Plains Assessment Area. Of these, 7 are fish and 11 are mollusks.
•There are no aquatic species listed as federally threatened. There are 3 federally endangered species, 1 fish (pallid sturgeon) and 2 mollusks (winged mapleleaf and fat pocketbook). An additional species is proposed to be federally listed as endangered (topeka shiner).
•There are 3 federal candidate species, all of which are fish (sturgeon chub, sicklefin chub, and topeka shiner).
•There are 12 species which are of special concern that are not listed as endangered, threatened or candidates (global rank of G3 or lower).
•There is 1 bird species listed as endangered (least tern) and 1 listed as threatened (piping plover). These are listed as a result of changes in the hydrology of the Missouri River.
•In addition to the endangered and special concern species listed here, there are 11 fish and three herptile species listed by the various states in the NGPAA as threatened, endangered or of special concern.
•The watersheds with the greatest number of endangered and special concern fish species are the Lower James, the Upper James and the Lewis and Clark Lake stretch of the Missouri River.
•The Lower Yellowstone, the Lower Tongue, Lake Sakakawea and the Fort Peck Reservoir reach of the Missouri River are also important areas for special concern fish species.
•The Western Glaciated Plains contain the largest number of endangered and special concern fish species.

•The distribution of the pallid sturgeon, the only presently federally-listed fish species in the NGPAA is the Missouri River, lower Yellowstone, lower Powder and lower James Rivers.
•The overall diversity of special concern species by ecological province 0.004 - 0.007 per 10,000 hectares. By comparison, the Black Hills ecological province has 0.063 per 10,000 hectares.
•The Platte, Niobrara, Missouri, Yellowstone, and Lower Cheyenne Rivers and the Sand Hills stand out as areas of high amounts of occurrences of federally-listed species (includes all species, not only fish and aquatics).

Data Sources

The information on endangered, threatened and special concern aquatic species was provided by state natural heritage programs, the Northern Prairie Wildlife Research Center and the Biological Resources Division (BRD) of the U.S. Geological Survey. The BRD obtained information on species locations through a research of literature. Lists of species from the U.S. Fish and Wildlife Service were also used.

Data Quality and Gaps

While some of the records on fish occurrences were old, most are recent. More than two-thirds of the fish data is from 1980 or later, and more than 40% of the data is from 1990 or later. The age of the data for mollusks and herptiles was as least as recent. However, there was a significant lack of good locational data on rare mollusks in the Northern Great Plains. The list used in this assessment includes all species that may be within the NGPAA, even though locations have not been verified.

Spatial Patterns

Table 2.6.1 lists the threatened, endangered and special concern aquatic species of the NGPAA. As stated above these are aquatic species that are listed federally or are categorized as G1, G2 or G3.

Figure 2.6.1 presents the distribution of endangered and special concern fish species by watershed. Obvious patterns stand out. It can be seen that most of the special concern fish species are connected at least to some extent to the Missouri and James Rivers. By far the watersheds with the most special concern fish species are the Lower James, the Lower Missouri and the Upper James. These watersheds have as many as five special concern fish species. The Upper Missouri, Lake Sakakawea, Lower Powder and Lower Yellowstone fall in the next category as having either two or three special concern species. A similar pattern is revealed when the number of special concern species is matched with ecoregions of the Northern Great Plains.

As seen in Figure 2.6.2, the Western Glaciated Plains have the most fish species at risk with six. The Northeastern Glaciated Plains, the North-Central Great Plains and the Northern Glaciated Plains are close behind. The least number of special concern species are in the watersheds and ecoregions of the Red River Valley, northern Montana and Nebraska Sand Hills. It needs to be investigated as to whether these patterns are due to variations in the numbers of endemic species or variations in impacts.

Figures 2.6.3 through 2.6.9 present individual distributions for the seven special concern fish species. Again, the strong ties to the Missouri and James Rivers are evident.

Table 2.6.1 Threatened, endangered, and special concern (TE&SC) aquatic species occurring within the Northern Great Plains Assessment Area. These species are either federally listed as endangered (E), candidate (C), or globally ranked as G1, G2 or G3 by The Nature Conservancy.

Scientific Name	Common Name	Global Rank	Federal Rank
Fish			
Acipenser fulvescens	Lake Sturgeon	G3	
Macrhybopsis gelida	Sturgeon Chub	G2	C
Macrhybopsis meeki	Sicklefin Chub	G3	C
Moxostoma valenciennesi	Greater Redhorse	G3	
Notropis anogenus	Pugnose Shiner	G3	
Notropis topeka	Topeka Shiner	G3	C (PE)
Scaphirhynchus albus	Pallid Sturgeon	G1G2	E
Mollusks			
Alasmidonta marginata	Elktoe	G3G4	
Arcidens confragosus	Rock-pocketbook	G3	
Cyprogenia aberti	Western Fan-shell	G2	
Lampsilis higginsii	Higgins Eye	G1	
Leptodea leptodon	Scaleshell	G1G2	
Plethobasus cyphyus	Bullhead (Sheepnose)	G3	
Pleurobema sintoxia	Round Pigtoe	G3G4	
Potamilus capax	Fat Pocketbook	G1	E
Quadrula fragosa	Winged Mapleleaf	G1	E
Quadrula metanevra	Monkeyface	G3	
Venustaconcha ellipsiformis	Ellipse	G3	

The pallid sturgeon is presently the most imperiled fish species (if not of all aquatic species) in the Northern Great Plains. It is a bottom dweller and is found in areas with a strong current and firm sand bottom in the main channel of large turbid rivers (Ashton and Dowd, 1991). In the Northern Great Plains this mainly means the Missouri River with some occurrences in the lower James, Lower Yellowstone and Lower Powder Rivers. The pallid sturgeon is slow-growing and late maturing and feeds on small fish and immature aquatic insects (Ashton and Dowd, 1991). There has been no successful reproduction documented in recent years (Ashton and Dowd, 1991). Reasons for the fish's decline include blockage of migration patterns by dams, alteration of temperature regimes below dams and reduced spawning habitat due to changes in flow regimes (U.S. Fish and Wildlife Service, 1995; Ashton and Dowd, 1991).

The topeka shiner is presently proposed to be listed as an endangered species. It occurs in the James River (from mouth up into North Dakota), the Vermillion, the Lewis and Clark Lake region of the Missouri River and in the Upper North Loup River in Nebraska. It prefers habitats of small, headwater prairie streams with good water quality and cool temperatures. The topeka shiner's decline is most likely attributable to nutrient and sediment loading to streams

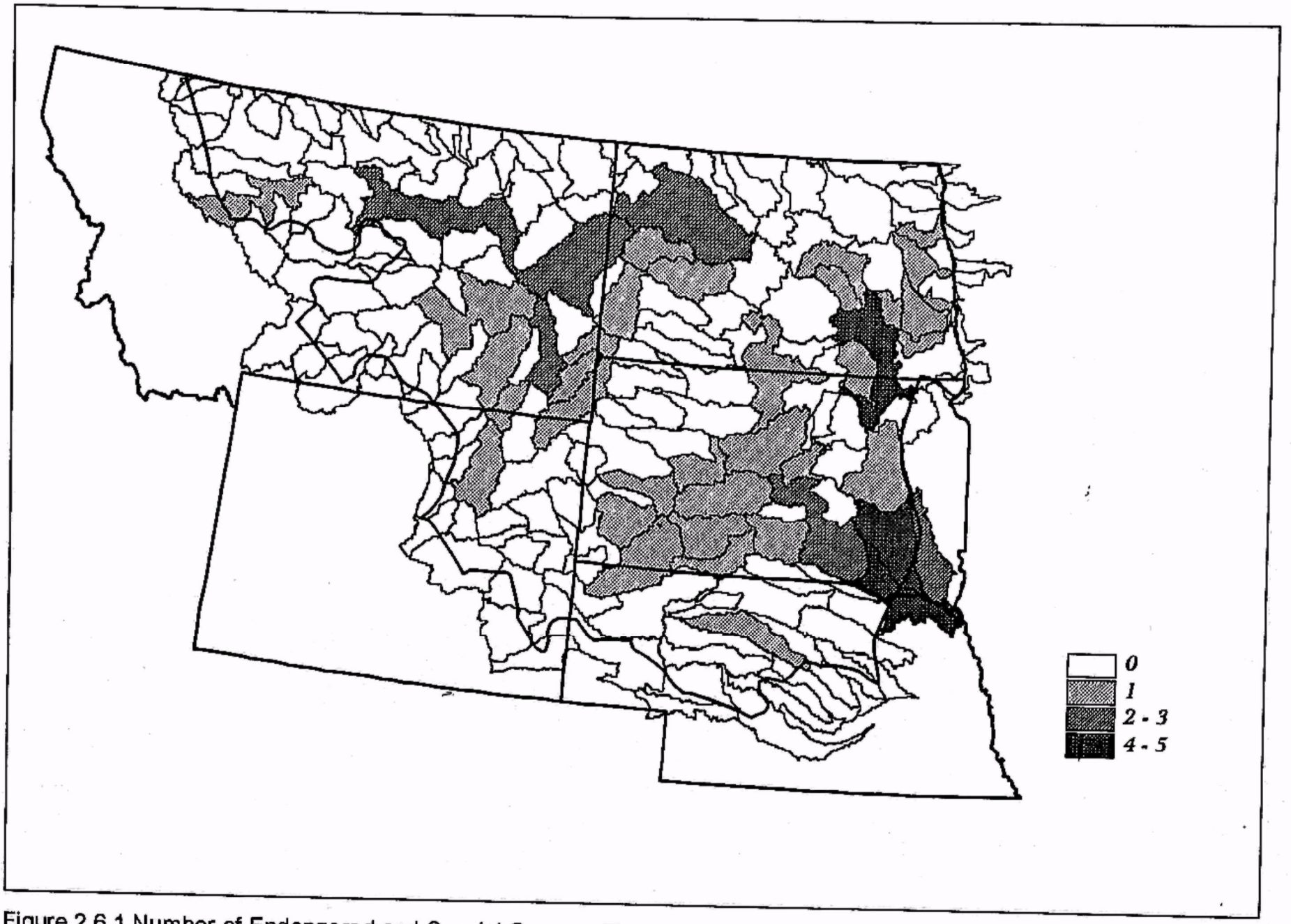

Figure 2.6.1 Number of Endangered and Special Concern Fish Species Per Watershed

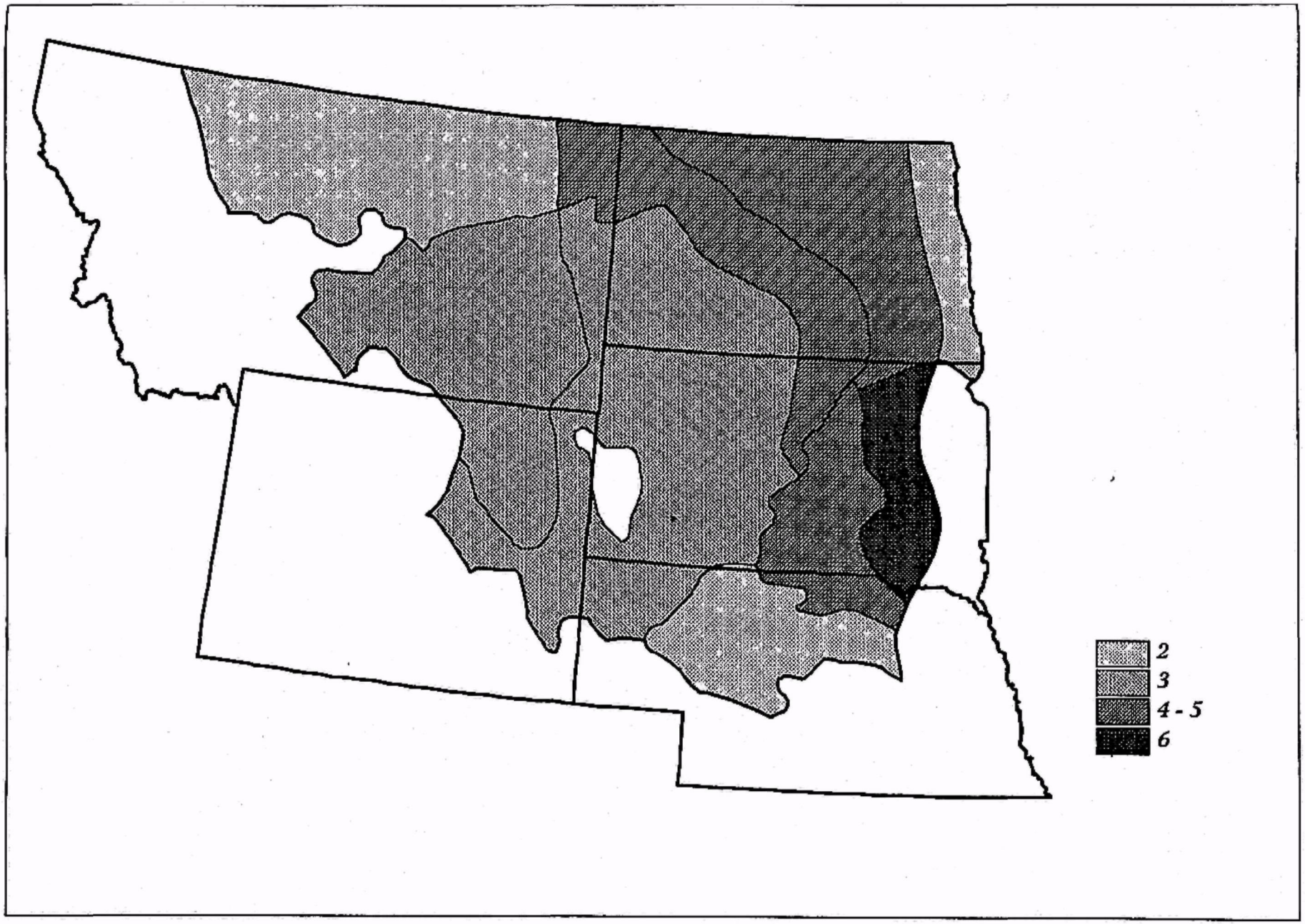

Figure 2.6.2 Number of Endangered and Special Concern Species Per Ecoregion

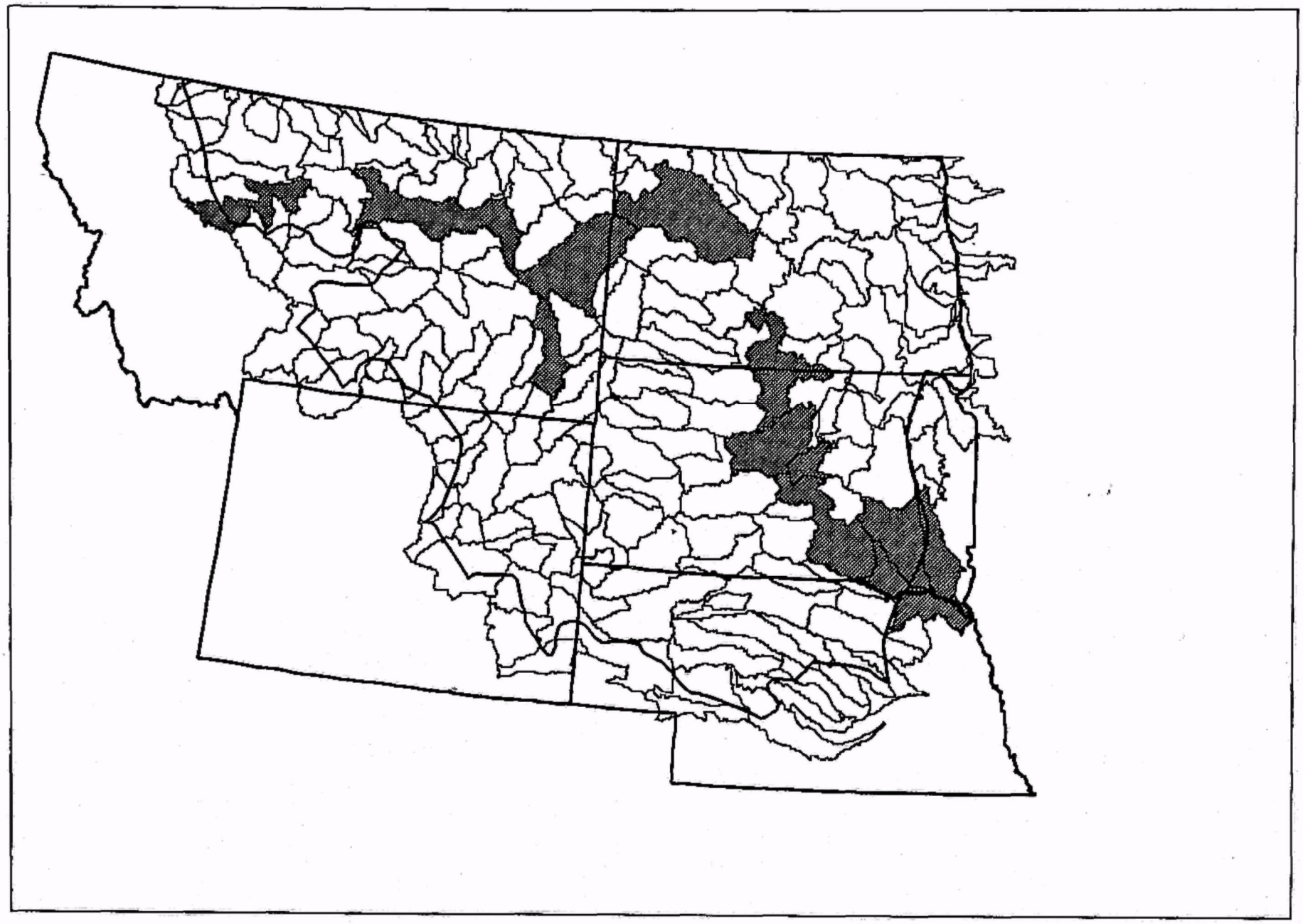

Figure 2.6.3 Pallid Sturgeon Occurrence in the Northern Great Plains

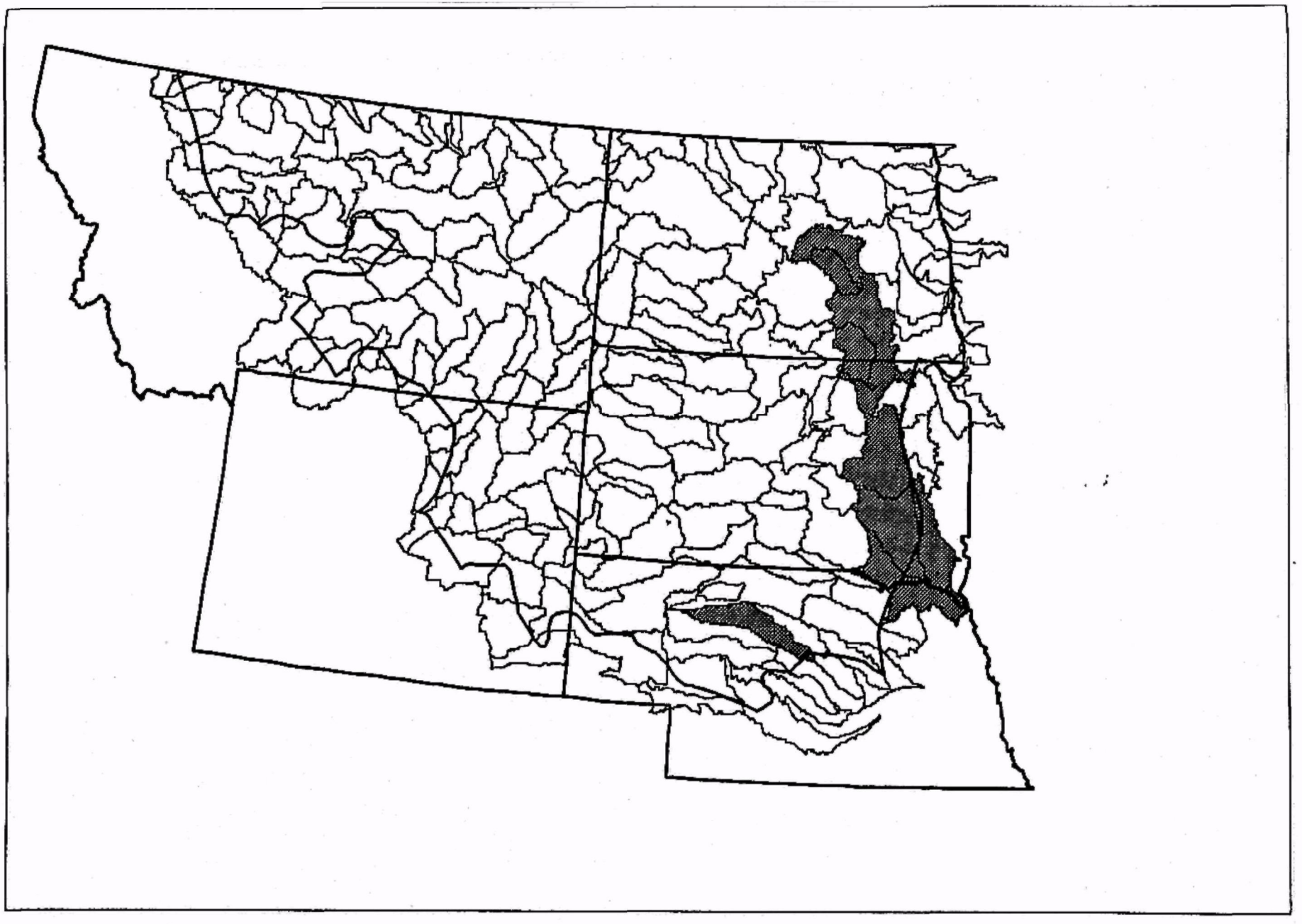

Figure 2.6.4 Topeka Shiner Occurrence in the Northern Great Plains

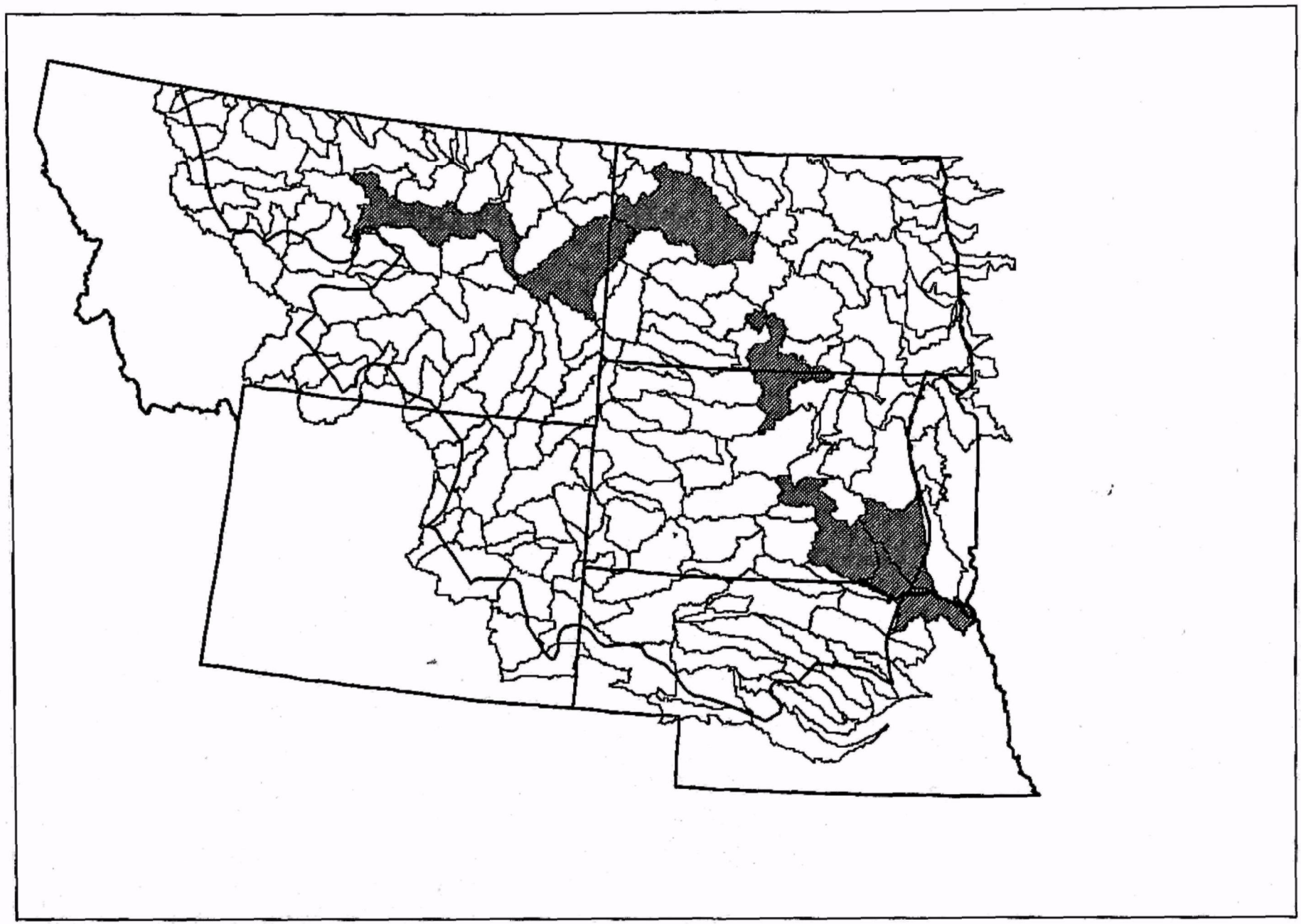

Figure 2.6.5 Sicklefin Chub Occurrence in the Northern Great Plains

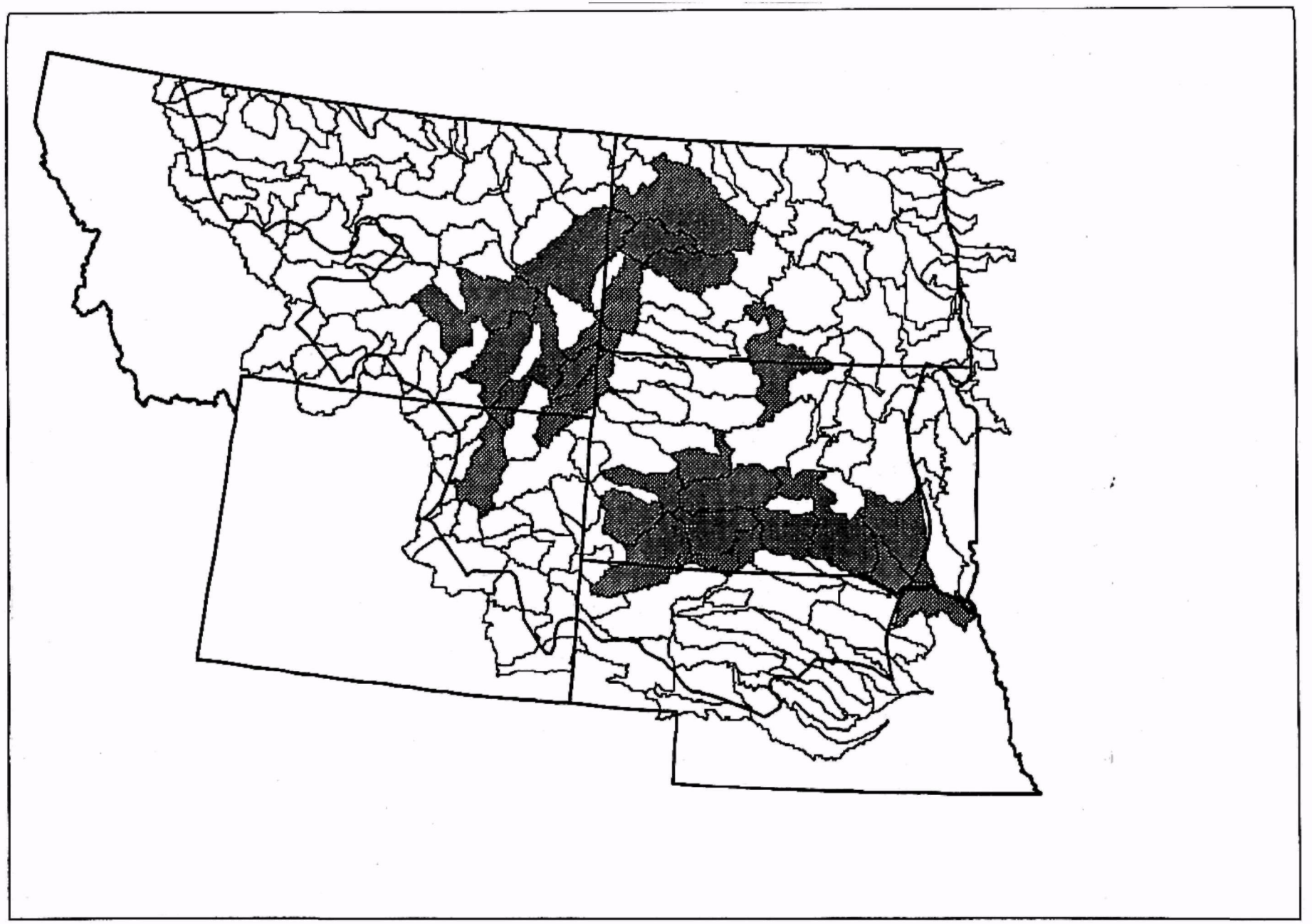

Figure 2.6.6 Sturgeon Chub Occurrence in the Northern Great Plains

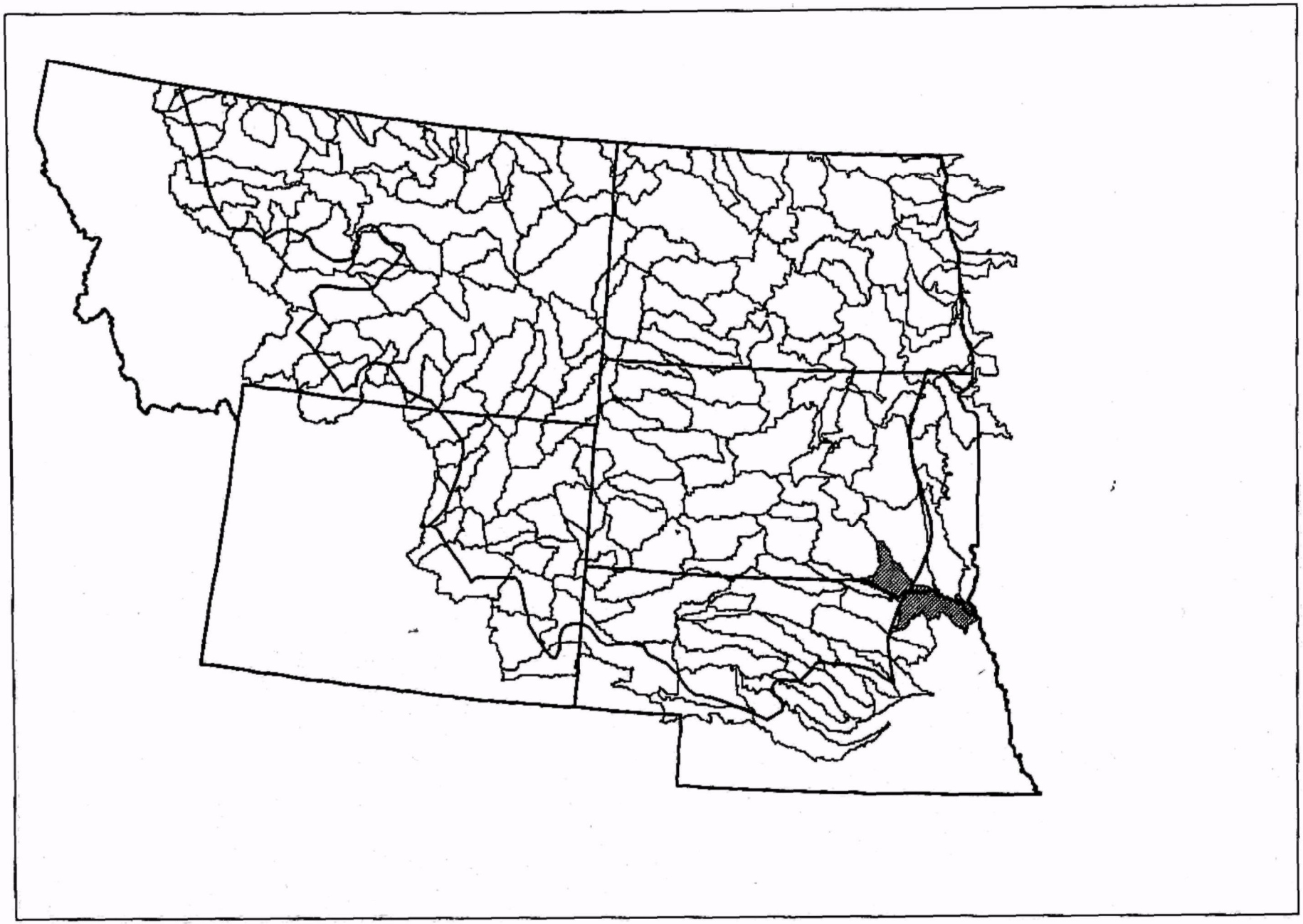

Figure 2.6.7 Lake Sturgeon Occurrence in the Northern Great Plains

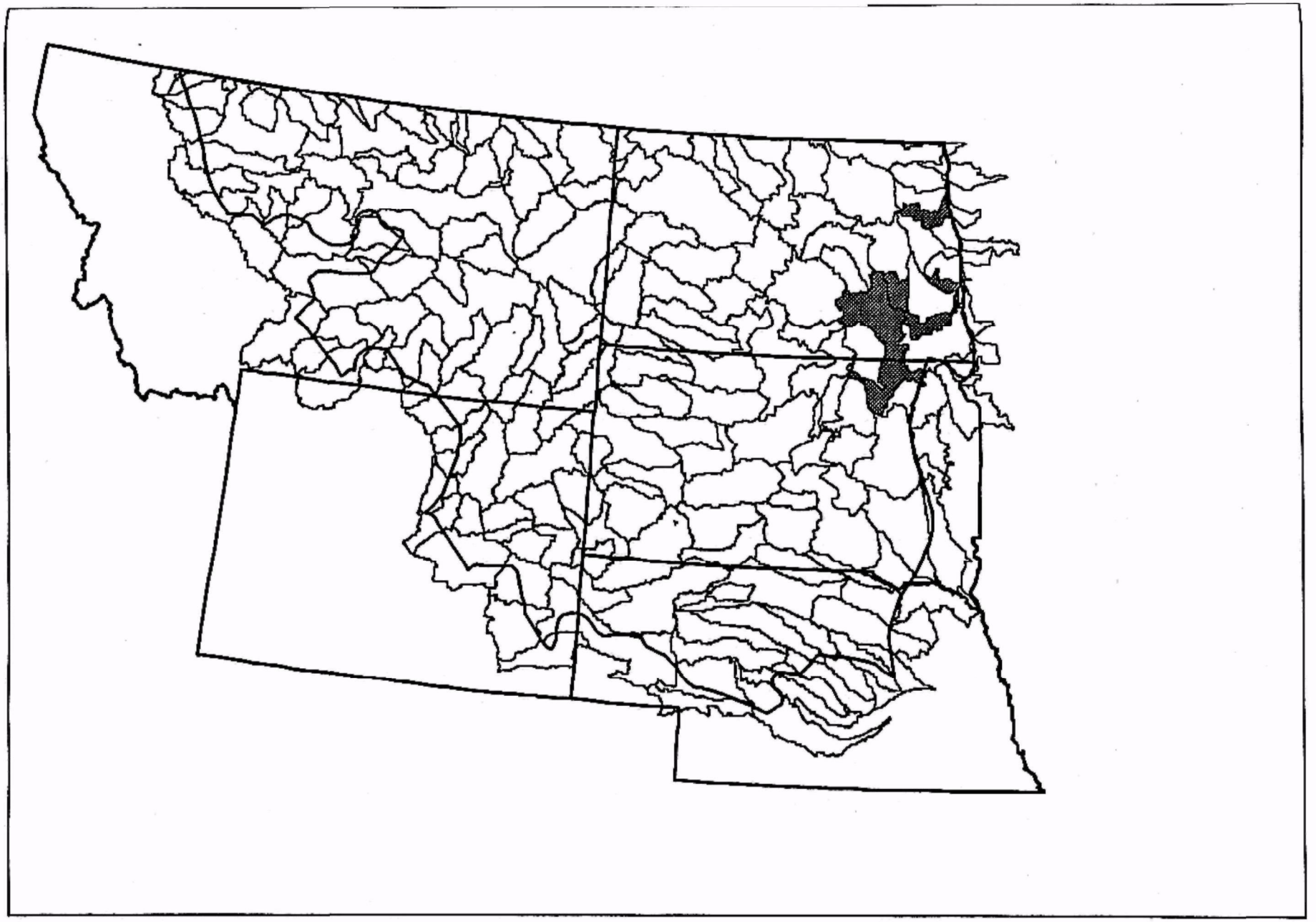

Figure 2.6.8 Pugnose Shiner Occurrence in the Northern Great Plains

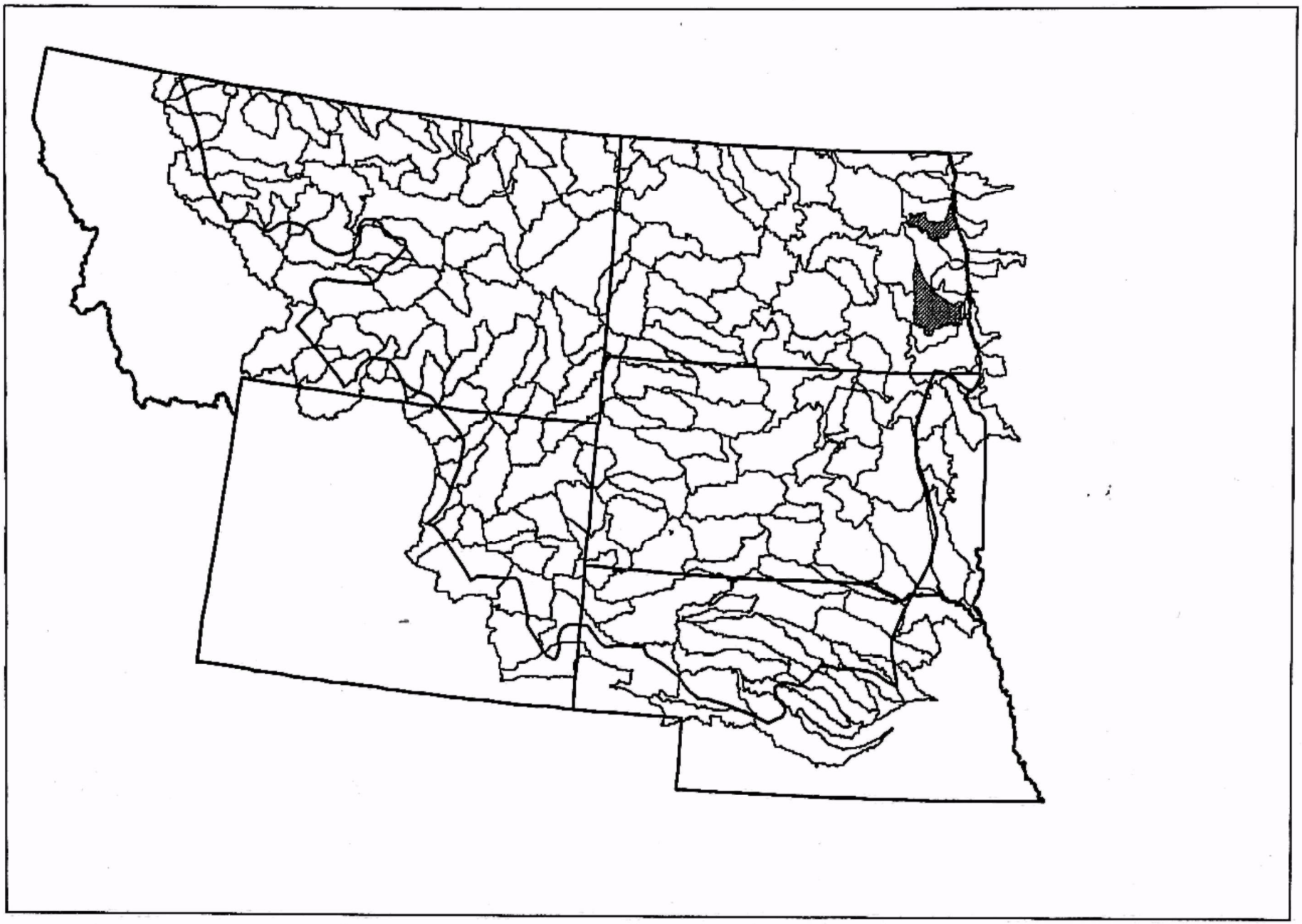

Figure 2.6.9 Greater Redhorse Occurrence in the Northern Great Plains

from agriculture (Federal Register, 1997).

The sicklefin chub is a candidate for federal threatened or endangered listing. It occurs in a range very similar to that of the pallid sturgeon, although no occurrences are recorded for the Powder River. Sicklefin chubs prefer the main channels of large turbid rivers in areas of strong current over sand or fine gravel (Ashton and Dowd, 1991). They are in decline due to habitat loss from altered flow regimes and loss of turbidity (Ashton and Dowd, 1991; U.S. Fish and Wildlife Service, 1995).

Sturgeon chubs are also a candidate for listing, but are more widespread than either the pallid sturgeon or sicklefin chub. It occurs in the Missouri, Little Missouri, Yellowstone, Tongue, Powder, White, Bad and Cheyenne Rivers. The habitat requirements are swift current areas of large silty rivers, usually over a gravel bottom (Ashton and Dowd, 1991). They are also declining due to habitat loss from altered flows, possibly from decreased turbidity (Ashton and Dowd, 1991).

Lake sturgeon is a G3 species found in the Northern Great Plains only in the Lewis and Clark reach of the Missouri River. It prefers the bottom of lakes and large rivers over mud, sand or gravel (Page and Burr, 1991).

The pugnose shiner, also a G3 species, occurs in the Upper James in North and South Dakota and the Lower Sheyenne and Turtle Rivers in North Dakota. Its habitat includes clear vegetated lakes and vegetated pools and runs of creeks and rivers, usually over sand and mud (Page and Burr, 1991).

The other G3 species, the greater redhorse is found in the Turtle and Maple Rivers in the Red River drainage of North Dakota. It prefers large streams with clear waters and bottoms of clean sand, gravel or boulders (U.S. Fish and Wildlife Service, 1995). It is imperiled by lowhead dams, channelization, nonpoint source pollution and degradation of riparian areas (U.S. Fish and Wildlife Service, 1995). It reaches the western edge of its range in eastern North Dakota.

Two bird species that warrant mention are the threatened piping plover and the endangered least tern. While not specifically aquatic species, their imperilment is a direct result of changes in the Missouri River. Habitat required for nesting has been lost from channelization and from changes in the river's flow. Both species nest on barren beaches of sand or gravel, areas which were previously created by the natural spring flooding regime and were dry in late summer, but now can be flooded.

There are 11 species of mollusks that potentially occur in the NGPAA and are listed as G3 or less by The Nature Conservancy. Survey data for these species within the Northern Great Plains is generally poor, however. They are listed in this report because of their possible occurrence, although it is likely that at least some of them do not occur within the NGPAA. Four species (higgins eye, bullhead, fat pocketbook and winged mapleleaf) are not considered to exist north of Nebraska within the Missouri basin, and it is not known if they reach up into the tributaries that are in the NGPAA. Since the fat pocketbook and winged mapleleaf are listed as endangered it is important to determine more about these species' ranges. Five other species (monkeyface, western fan-shell, rock-pocket book, elktoe and round pigtoe) are thought to exist within South Dakota and Nebraska, as well as many other states to the east. Again, however, it is not certain that they occur within the NGPAA. One species, the round pigtoe, is known from the Vermillion watershed, adjacent to the NGPAA from a 1993 observation. Two

species, the ellipse and the scaleshell, almost certainly do exist within the NGPAA, but the range is poorly known. The scaleshell was observed in the Lewis and Clark Lake watershed in 1982 and the ellipse is considered a resident of North Dakota. The scaleshell is listed as a G1G2 species, underscoring the importance of determining where it exists.

Table 2.6.2 is a listing of all the aquatic species either listed or are special concern species by the individual states. These overlap in some instances with the federal list, but some unique species are rare in a state due to a regional decline or the state is at the edge of a species range.

Overall, the density of special concern species in the Great Plains is low (Ostlie, et al. 1997). The density of species of concern by ecoregion province is 0.004 per 10,000 ectares in the Great Plains Steppe Province, 0.005 per 10,000 hectares in the Great Plains Dry Steppe Province and 0.007 in the Prairie Parkland (Temperate) Province. As a way of comparison, the Black Hills Province has 0.063 per 10,000 hectares, the highest in the Great Plains (Ostlie, et al. 1997). Mapping by Ostlie, et al. (1997) of patterns of documented occurrences of federally listed species clearly show areas tied to aquatic systems. In the Northern Great Plains, the Platte River, the Niobrara River, the Missouri River, the Yellowstone River, the Lower Cheyenne River and the Sand Hills stand out. This particular analysis includes all species that use these aquatic systems, including birds and mammals.

Future Trends

As of this writing, the topeka shiner is proposed for listing as an endangered species. Two other fish, the sicklefin chub and the sturgeon chub are candidates for listing and it is presumed they will be proposed for formal listing some time in the future. This region is fortunate in that it does not have a great number of imperiled species compared to other regions of the country. The Great Plains with 28% of continental United States land mass, contain only 6.6% of G1-G3 species (Ostlie, et al. 1997). As mentioned before, however, this most likely reflects the lower number of endemic species, not necessarily lower impacts. This could also reflect a lack of adequate surveys in the region.

The Missouri and James Rivers stand out in the region as areas of significant importance to imperiled aquatic species. The problems caused by dams and altered flow on the Missouri and altered flow and nonpoint source pollution in the James are likely to continue in the near future, but pressures to change are building. The slowing in the loss of wetlands (see Chapter 3) should also slow the decline of many species.

2.7 FUNCTIONAL ANALYSIS FOR AQUATIC SPECIES

Introduction

Each aquatic species has a set of conditions under which it can best survive. Specific ranges of temperature, pH, dissolved oxygen or current velocity and many others represent these conditions and if forced outside of these ranges for a certain length of time, the species is put at risk. This section compares the ranges of certain critical parameters for several aquatic fish species representing six guilds with the conditions that exist in the watersheds within their ranges.

Key Findings

•The analysis shows that for fish species representing four of the six guilds, most

watersheds where the species exists are in fair to good condition based on the parameters used.

•For two species, pallid sturgeon and longnose dace, the opposite is true - most watersheds where these species exist have parameters outside the optimum range at least half of the time.

Data Sources and Methods

This analysis was done using the program Netweaver provided for this project by Pennsylvania State University and Knowledge Garden, Inc. Netweaver is a knowledge-based system in which a dependency network is created to answer specific questions based on the data provided. The Netweaver program is linked to the GIS program, ArcView, using the Forest Service's Ecosystem Management Decision Support (EMDS) System.

In this project a network was created for six fish species representing six important guilds in which the water flow and water quality parameters necessary for their survival were available. Therefore, in each species' dependency network, a number of different parameters (representing values for each species) such as dissolved oxygen, flow, pH or temperature were connected to each other to ask the question "Where do the parameters exist within the necessary range to allow this species to survive?". The parameters were provided by the U.S. Geological Survey-Biological Resources Division. These networks were then linked within the ArcView/EMDS program to water quantity and water quality data provided by the U.S. Geological Survey-Water Resources Division. The water quality data is from Storet and the flow data is from WATSTORE. The system provided information as to whether in each watershed where data was sufficient, if the conditions necessary for the species existed. It is important to note that the data was for one station in the watershed, as mentioned before, usually the lowest in the watershed. Therefore, for certain guilds this may not represent the best habitat and the program will reflect this. It also must be noted that only a few parameters were available for each species (temperature, velocity, etc.) and that many other factors influence their survival.

Spatial Patterns

The six species (and the guilds they represent) used in the analysis were emerald shiner (planktivore in large rivers and reservoirs); fathead minnow (planktivore in ponds, lakes, slow rivers and river backwaters); longnose dace (benthic invertivore in small clean streams); yellow perch (benthic invertivore in lakes, ponds, slow streams and larger rivers); pallid sturgeon (benthic feeder on larger particles in larger turbid rivers and reservoirs); and walleye (piscivore). The parameters used for all species were temperature and velocity. In addition, for yellow perch, pallid sturgeon and walleye, minimum dissolved oxygen needs were also used and for fathead minnow and yellow perch, pH requirements were used.

For the analysis, the requirements for each species was matched with median or mean water quality or flow data for the one station in each watershed. Figures 2.7.1 through 2.7.6 present the results of each analysis for each species.

In Figure 2.7.1, using median/mean data for temperature and velocity, emerald shiner could be stressed in 13 watersheds, many in the upper Missouri River basin. The analysis, however, rated all other watersheds in its range as fair. Fathead minnow (Figure 2.7.2) has 24 watersheds rated as poor, but the range of this species is wide, therefore, this a small portion. This is based on temperature, velocity and pH. As with emerald shiner,

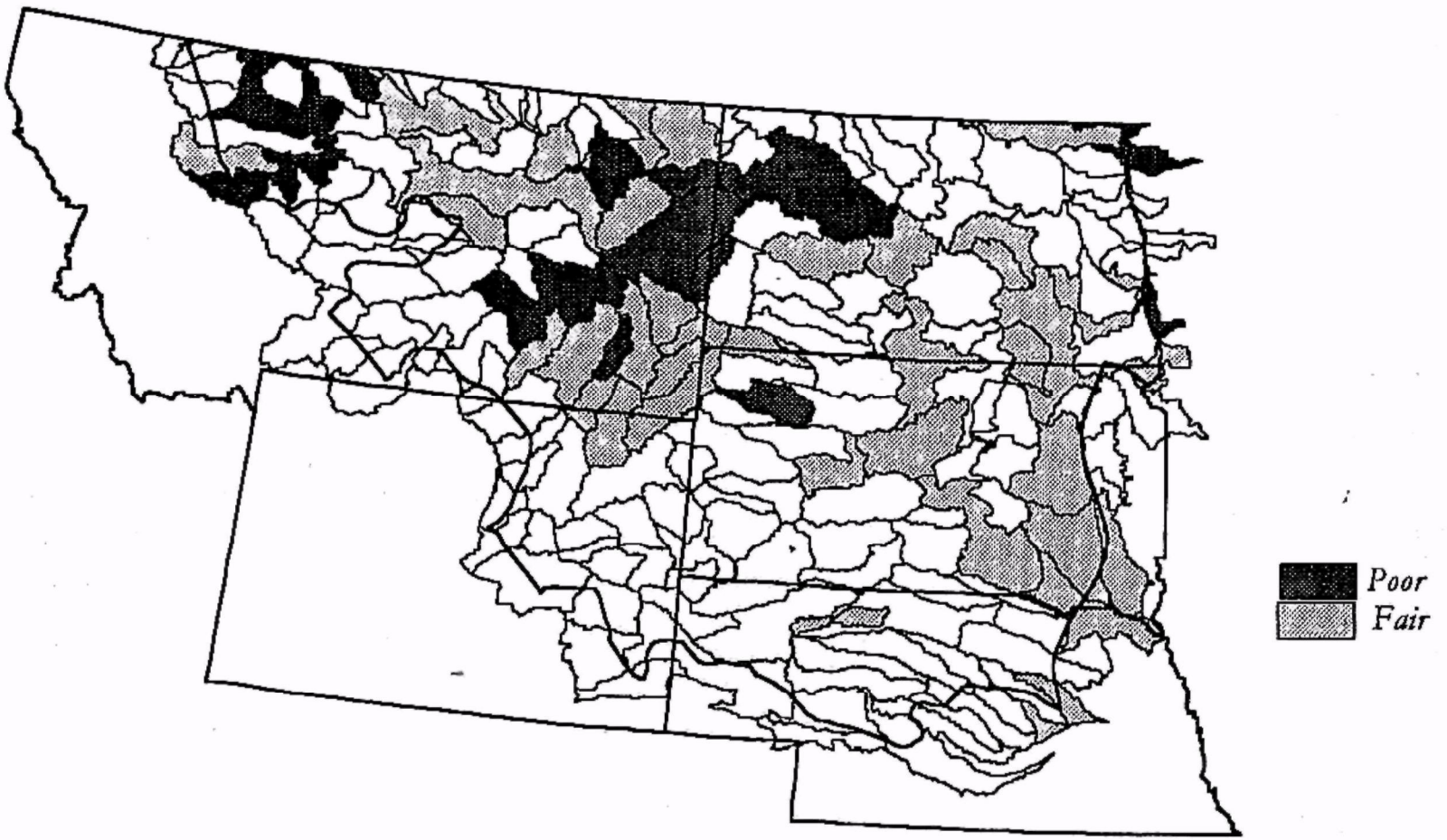

Figure 2.7.1 Functional Analysis for Emerald Shiner

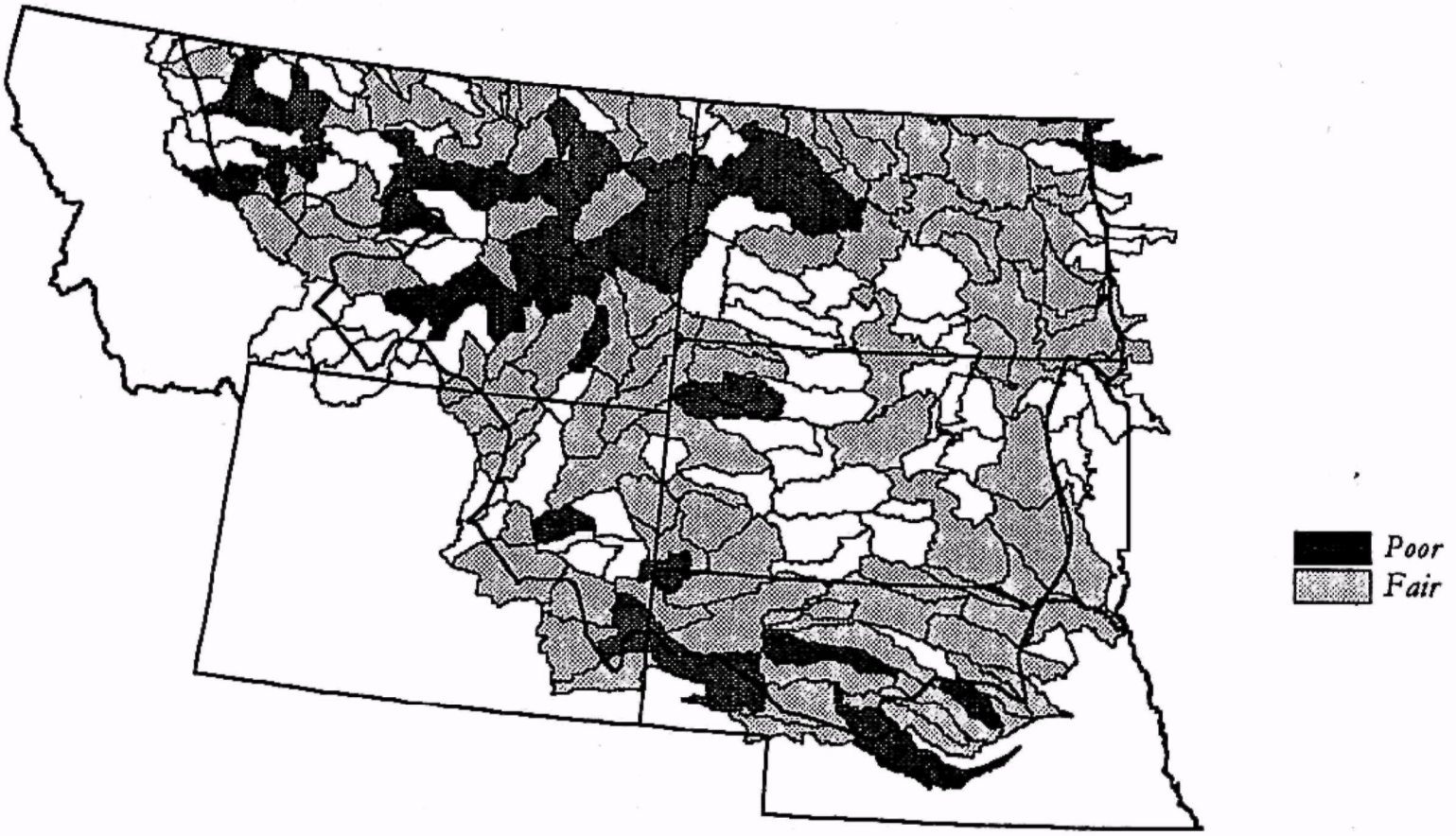

Figure 2.7.2 Functional Analysis for Fathead Minnow

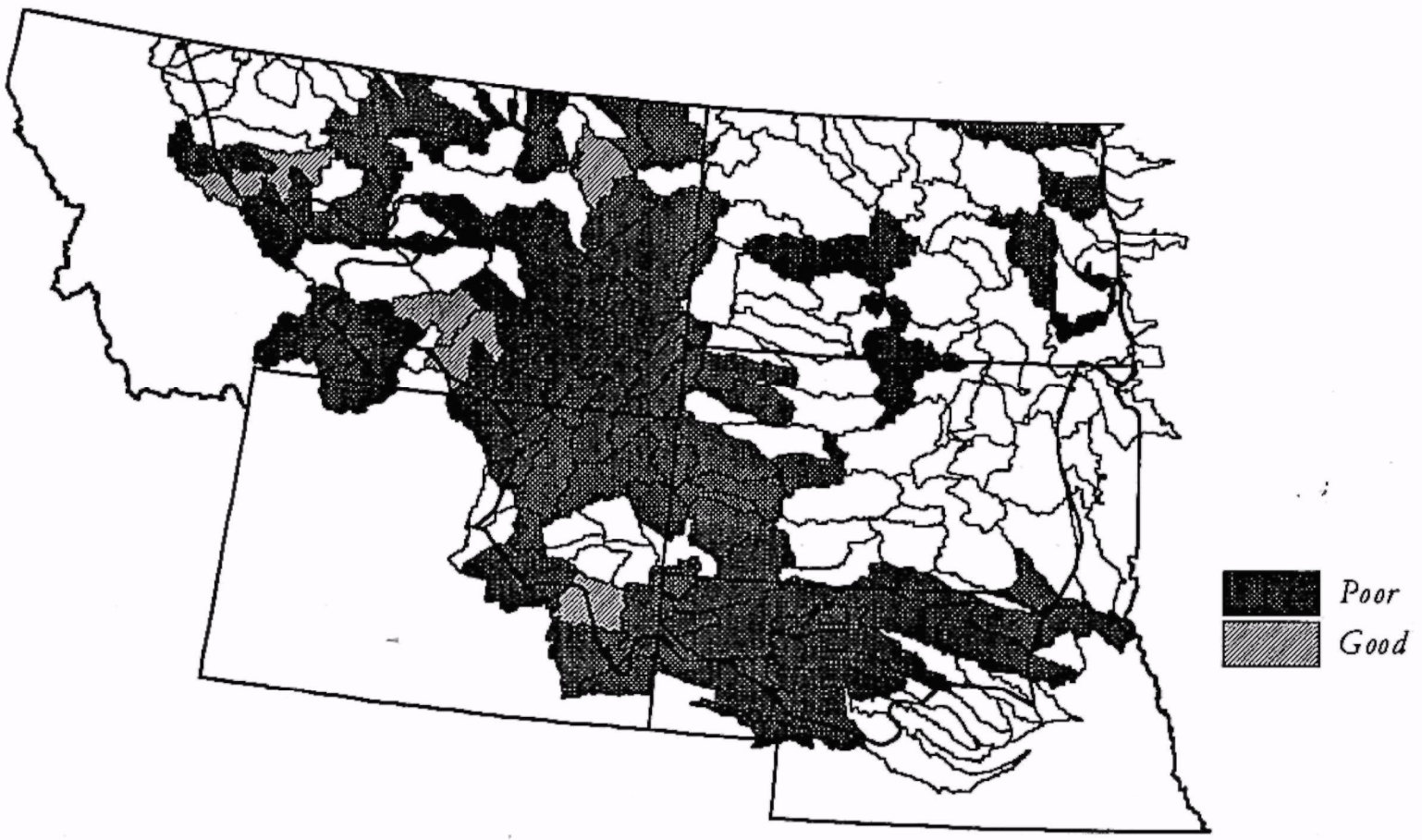

Figure 2.7.3 Functional Analysis for Longnose Dace

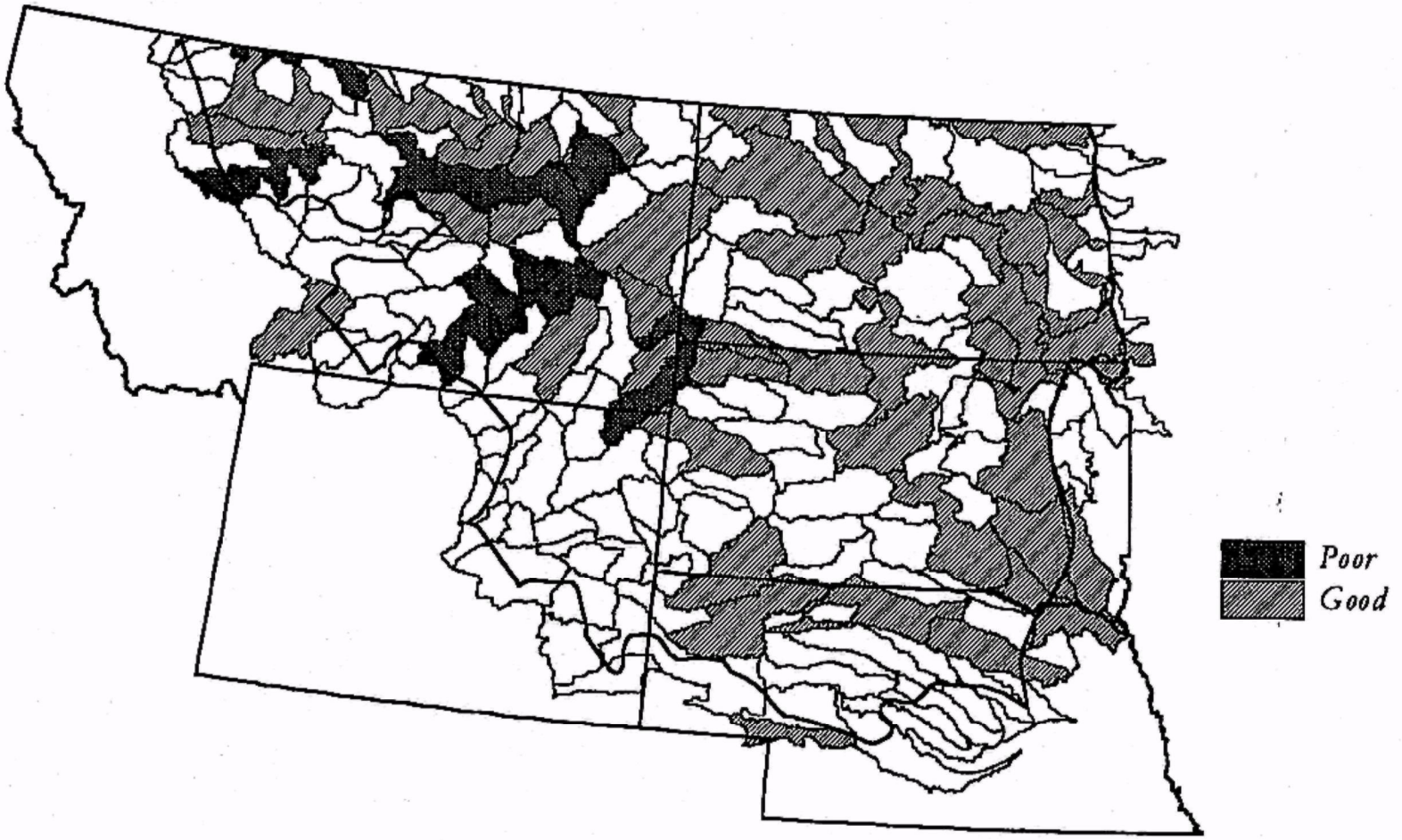

Figure 2.7.4 Functional Analysis for Yellow Perch

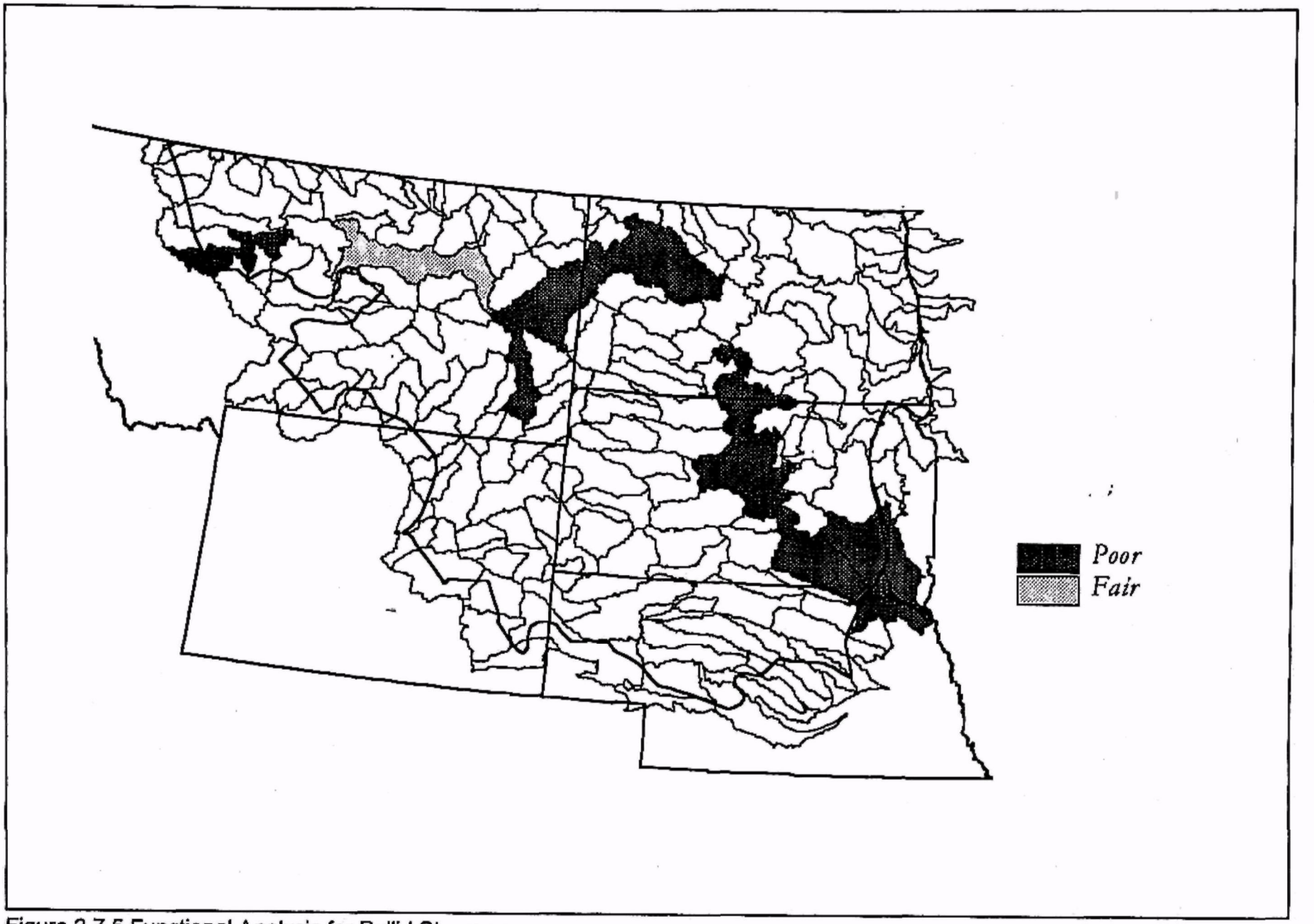

Figure 2.7.5 Functional Analysis for Pallid Sturgeon

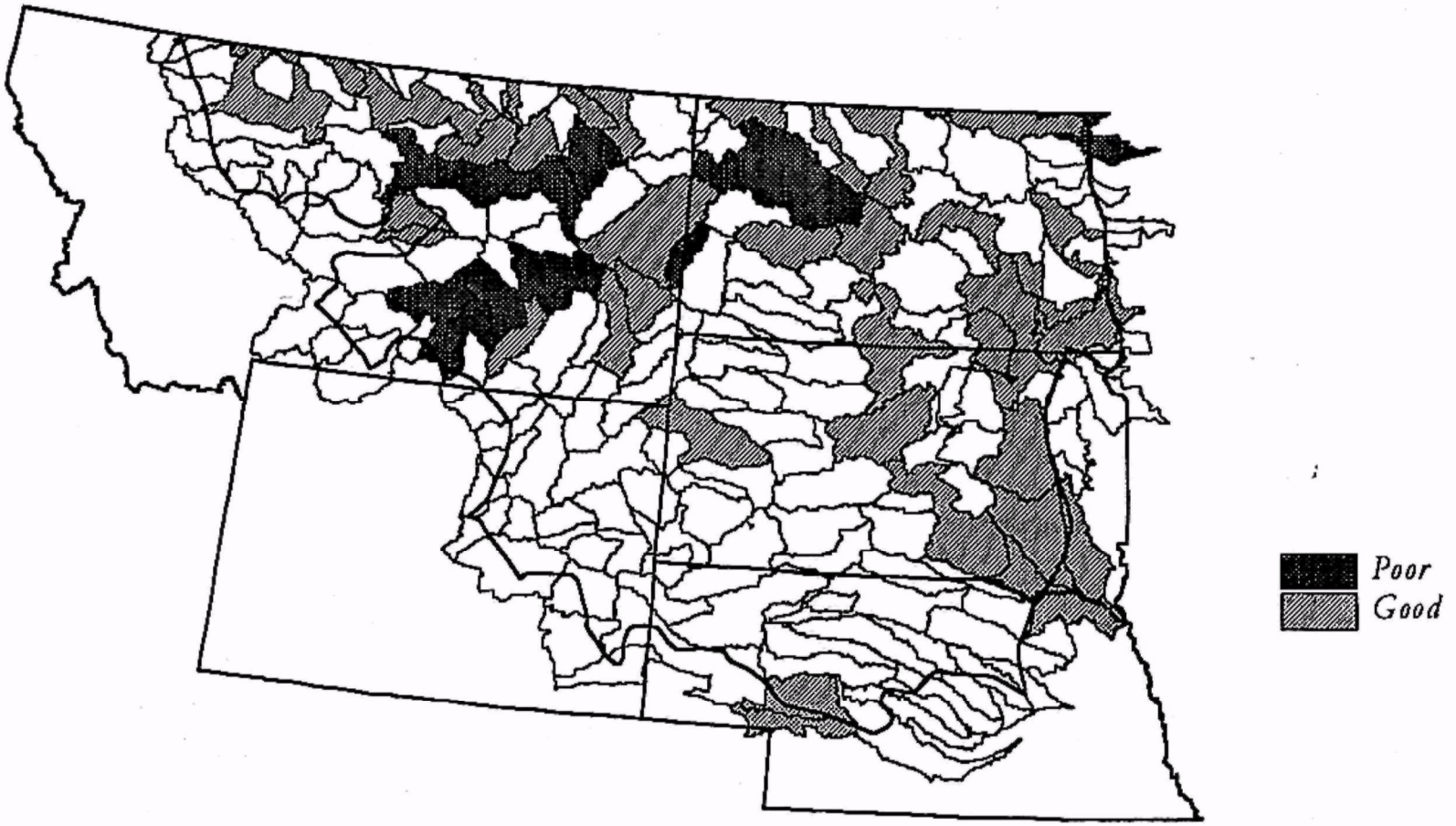

Figure 2.7.6 Functional Analysis for Walleye

though, the analysis rated all others as fair. Figure 2.7.3, longnose dace, shows only five watersheds rated as good, with the rest of the range as poor (using median/mean temperature and velocity). For this species, this is most likely an artifact of the way the stations for each watershed were chosen. The lowest station will most likely have larger flow and greater turbidity. This is not the preferred habitat of longnose dace or of the other species in this guild. Stations chosed at locations more appropriate for this guild would most likely have shown a different result.

The analysis for yellow perch used the most data for any species (median/mean temperature, dissolved oxygen, velocity and pH) and is presented in Figure 2.7.4. Seven watershed are rated as poor and all others as good. The watersheds with the most problems are located in the Upper Missouri basin. Figure 2.7.5 presents the analysis for pallid sturgeon and it shows only one watershed in this species range listed as fair. All others rated as poor based on median/mean data for temperature, velocity and dissolved oxygen. The one rated as fair is Fort Peck Lake reach of the Missouri River (10040104). Figure 2.7.6 shows the results for walleye in which median/mean temperature, dissolved oxygen and velocity were used. Eight stations rated as poor with all others good.

2.8 COMMUNITY INTEGRITY/AQUATIC HABITAT STUDIES

Introduction

This section looks at some of the fish and macroinvertebrate community studies that have been done on streams and rivers in the Northern Great Plains and examines some general community characteristics of intermittent streams. In addition, this section includes more detailed reviews of the aquatic communities, habitat and water quality characteristics of the James, Powder, Yellowstone, Missouri, Moreau, Cheyenne and Red Rivers, since these were rivers for which this information was available. The recent work of The Nature Conservancy with respect to significant aquatic landscapes in the Great Plains is also included.

There are several biological measures available to compare fish or other biological assemblages in a given stream to a reference or minimally impacted stream (Frenzel, 1996). These range from a simple measure of diversity or richness to multiple measures such as the Index of Biological Integrity (Karr, 1981) or the Rapid Bioassessment Protocol (RBP) (Pflakin, et al. 1989).

The Index of Biological Integrity uses several measures of the fish community to determine the status of the biotic integrity of a stream (Karr, 1981). Some of the measures used include number of species, presence of species intolerant of pollution, number of individuals, proportion of omnivores, insectivores and carnivores, as well as others. These measures are then used together in an index that ranks the quality of the site. Since this index was developed there have been several variations and other indices developed. The Rapid Bioassessment Protocol uses the IBI or benthic macroinvertebrate measures to assess biotic integrity and there are several different levels of complexity depending on the assessment needs (Pflakin, et al. 1989).

Most of the states in the NGPAA are just beginning to look at biological/community measures to determine aquatic condition. The exception is Nebraska, which is incorporating a biotic index now into its analysis of use support. Nebraska combines the IBI and ICI (Invertebrate Community Index) into the Combined Biotic Index (CBI) which has a value between 0.0 and 1.0 (Nebraska Department of

Environmental Quality, 1996). A stream with a value nearer to 0 is of good quality and those with CBIs less than 0.6 were found to be fully supporting uses, while those above 0.75 were not supporting (Nebraska Department of Environmental Quality, 1996).

Key Findings

•The NGPAA contains a large number of unique aquatic communities including the Missouri River, Devils Lake, the Lostwood area and the Nebraska Sand Hills.
•A study applying the IBI to the Platte River basin found the Dismal River and the Platte mainstem to have the highest IBI scores and richest fish assemblages. Sites with greater hydrologic variability tended to have fewer species.
•A study of Long Pine Creek found 125 macroinvertebrate taxa, and those found were indicative of good water quality. A similar study in Bone Creek (tributary of Long Pine Creek) found less taxa and indicators of an organically enriched system.
•The James River has 57 fish species inhabiting it.
•The Powder River has 32 fish species (25 native) and this system is unique in that it represents what was originally found in free-flowing plains rivers.
•The Yellowstone River is one of the longest free-flowing rivers in the contiguous United States and has 56 fish species.
•Within the Red River basin on the North Dakota side (the NGPAA) fish species richness is greatest in the Sheyenne River and the Red mainstem with greater than 40 species. It is lowest in the Wild Rice and Elm Rivers with less than 20 species.
•A survey of the Cheyenne River in South Dakota found 12 fish species and 14 total taxa of macroinvertebrates. A similar study on the Moreau River found 18 fish species and 22 macroinvertebrate taxa.

Data Sources

The information presented in this section was mainly obtained from literature reviews and from The Nature Conservancy Report, *A Status of Biodiversity in the Great Plains* (Ostlie, et al. 1997).

Data Quality and Gaps

There is a general paucity of ecological and community-level aquatic studies for streams within the Northern Great Plains. This seems to be especially true of many of the western Missouri River tributaries, although few streams within the entire NGPAA appear to have been exhaustively studied.

Analysis

While the Great Plains may contain less endemic species than many other parts of the country, it does contain a large number of unique natural communities. Ostlie, et al. 1997, reported that of the 619 natural communities occurring in the Great Plains, 304 (49%) are found exclusively or primarily within the Plains. This figure includes both aquatic and terrestrial communities and, is of course, not limited to the Northern Great Plains. It does show, however, that there are a number of unique assemblages of species in this region. Table 2.8.1 lists those aquatic landscapes of biological significance in the Northern Great Plains as identified by The Nature Conservancy (Ostlie, et al. 1997).

The following is a review of community studies done on several streams in the Northern Great Plains as well as a general overview of the community structure of intermittent streams, an important component of Northern Great Plains aquatic systems. In a number of the studies, fish or macroinvertebrates were used to determine the integrity of the community (diversity, Table

Table 2.6.2 Threatened, endangered, and special concern aquatic species occurring within the Northern Great Plains Assessment Area listed by individual states.

Scientific Name	Common Name	Listing by State	Global Rank
Fish			
Acipenser fulvescens	Lake Sturgeon	NE-T	G3
Catostomus catostomus	Longnose Sucker	SD-T	G5
Cycleptus elongatus	Blue Sucker	MT-sc	G4
Fundulus diaphanus	Banded Killifish	SD-E	G5
Macrhybopsis gelida	Sturgeon Chub	MT-sc; SD-T	G2
Macrhybopsis meeki	Sicklefin Chub	MT-sc; SD-T	G3
Notropis heterolepis	Blacknose Shiner	SD-E; NE-T	G5
Percopsis omiscomaycus	Trout-perch	SD-T	G5
Phoxinus eos	Northern Redbelly Dace	SD-T; NE-T	G5
Phoxinus neogaeus	Finescale Dace	SD-E; NE-T	G5
Polydon spathula	Paddlefish	MT-sc	G4
Scaphirhynchus albus	Pallid Sturgeon	MT-E; SD-E; NE-E	G1G2
Semotilus margarita	Pearl Dace	MT-sc; SD-T; NE-T	G5
Umbra limi	Central Mudminnow	SD-E	G5
Herptiles			
Emydoidea blandingii	Blanding's Turtle	SD-E	G4
Graptemys psuedogeographica	False Map Turtle	SD-T	G5
Rana pipiens	Northern Leopard Frog	MT-sc	G5

E - Endangered
T - Threatened
sc - Special Concern

Table 2.8.1 Aquatic Landscapes of Biological Significance in the Northern Great Plains as identified by The Nature Conservancy (Ostlie, et al. 1997)

Area	Features
Cannonball/Cedar Rivers (ND)	Flows through the second-highest proportion of good-to-excellent condition native rangeland in North Dakota. Three state-rare fish species are found here, along with blue sucker and pallid sturgeon.
Comertown Prairie (MT)	Rolling hills interspersed with lakes and ponds. Believed to be the largest remaining, relatively undisturbed pothole prairie complex in Montana. Important nesting and migration habitat for shorebird and waterfowl species, including piping plovers.
Devils Lake Basin (ND)	The largest natural lake in North Dakota. The basin and surrounding wetlands provide significant migratory and breeding habitat for shorebirds, sandhill cranes and waterfowl.
Dismal River (NE)	The river flows through a shallow braided canyon and primarily consists of spring-fed, near constant flow.
Keya Paha River (NE, SD)	The river is primarily spring-fed and forms the northeast boundary of the sandhills. Riparian woodlands and floodplain prairie are the principal natural communities.
Little Missouri River (MT, ND, SD, WY)	Highly turbid river that experiences periods of no flow during portions of the year, providing conditions for a unique ecosystem essential for various forms of aquatic life. Several rare plant and animal species find habitat in and along the river, including the sturgeon chub.
Lostwood (ND)	High quality example of the prairie pothole landscape mosaic situated on the kettlehole moraine and outwash of the Missouri Coteau. Numerous lakes and cattail marshes occur within a matrix of mixed grass prairie. Centers on Lostwood National Wildlife Refuge, a 10,000 acre site that is highly important for waterfowl and shorebirds. The piping plover is found here.
Medicine Lake Sandhills (MT)	The largest sandhill complex in Montana on the southeast side of Medicine Lake. Medicine Lake National Wildlife Refuge is located within the landscape encompassing the largest natural lake in northwestern Montana. The piping plover is found here.

Table 2.8.1 continued Aquatic Landscapes of Biological Significance in the Northern Great Plains as identified by The Nature Conservancy (Ostlie, et al. 1997)

Area	Features
Middle Loup River (NE)	Located in the heart of the sandhills, it is spring-fed and has a constant flow. It is primarily bordered by sandhill prairies and marshes that occur in the lower floodplain. The whooping crane can be found here.
Middle Missouri River (ND, SD, NE)	Includes reaches of the Missouri River that have remained unchannelized or not flooded beneath reservoirs in central North Dakota and southeast South Dakota and adjacent Nebraska. The river still maintains some semblance of its former self - wide and meandering with islands, sandbars, riverine wetlands and riparian forests. Special concern species present in these stretches include lake sturgeon, piping plover, blue sucker, whooping crane, bald eagle, scaleshell, sturgeon chub, sicklefin chub, pallid sturgeon and interior least tern.
Milk River (MT)	The Milk River flows through tracts of native mixedgrass prairie, moist meadows and shrublands. Several lakes provide staging and nesting areas for the American white pelican.
Nebraska Sandhills (NE, SD)	Numerous wetlands within the landscape make it an important waterfowl and shorebird stopover. Along the north edge of the landscape, the Niobrara River has cut a steep narrow valley. Minnechaduza Creek has several high-quality sandhill fens. The wetlands provide nesting habitat for numerous waterbird species. Special concern species found here include piping plover, blue sucker, whooping crane, bald eagle, topeka shiner and interior least tern.
Niobrara (NE)	This is the largest spring-fed, constant flowing river that drains the Nebraska Sand Hills. Piping plover, whooping crane, bald eagle and interior least tern are found here.
North Loup River (NE)	This spring-fed river drains the sandhills. Whooping crane and topeka shiner are found here.
Park River (ND)	This landscape encompasses all three branches of the river.

Table 2.8.1 continued Aquatic Landscapes of Biological Significance in the Northern Great Plains as identified by The Nature Conservancy (Ostlie, et al. 1997)

Area	Features
Pembina/Tongue Rivers (MB, ND)	Lowland woodlands and wet thickets are found along the banks of both rivers. The Pembina has eroded to a depth of 400 feet. A significant diversity of plant and animals exist.
Rocky Mountain Front (MT, AB)	This area is located in far western edge of the Northern Great Plains. Numerous small marshes and wetlands occur along several creeks and lakes. Riparian cottonwood communities and pine butte wetlands and fens occur here.
Sheyenne Delta (ND)	This area contains one of the most extensive woodlands in North Dakota. Fine examples of sedge meadow, wetland thickets and fens occur here. The Sheyenne National Grassland dominates the majority of this site. This area was listed as terrestrial by The Nature Conservancy, but it has been included here because of the extensive riparian areas.
Snake River (NE)	An intact river system with a natural hydrograph. It supports populations of the Great Plains endemic plains topminnow.
Souris River (ND, MB, SK)	The river valley contains extensive oxbows, fens, mixedgrass prairie, riparian forests, aspen woodlands and sand prairies. The landscape is an important breeding area for wood ducks and is home to numerous species that require riverine habitats. It provides habitat for numerous state and provincially-rare species.
Southern Missouri Coteau (ND, SD)	Located on a terminal moraine, this area is characterized by numerous pothole wetlands within a complex of mixedgrass prairie. Piping plover and whooping crane are found here.
Turtle Mountains (ND, MB)	This is a wooded kettlehole moraine. Numerous lakes and wetlands dot the forested landscape. Wetlands are used as breeding habitat for ring-necked ducks, red-necked grebes and several species of colonial waterbirds.

Table 2.8.1 continued Aquatic Landscapes of Biological Significance in the Northern Great Plains as identified by The Nature Conservancy (Ostlie, et al. 1997)

Area	Features
Missouri/Yellowstone Rivers (MT, ND)	This area encompasses much of the length of the Yellowstone River and portions of the Upper Missouri River in Montana. The Yellowstone is the largest unregulated river in the United States, displaying seasonally high flows of turbid water. It is these natural flow regimes that maintain the turbid aquatic habitat necessary for many of the large-river aquatic species in decline throughout the watershed. Together, the Yellowstone and the Upper Missouri provide the best remaining large-river fish populations within the entire Missouri River watershed. Species such as sicklefin chub, sturgeon chub, blue sucker, paddlefish and the pallid sturgeon still occur in relatively large numbers in this area. Sandbars and unvegetated stretches along these rivers provide important nesting areas for least tern and piping plover.

abundance, etc.) and make inferences about water quality. In addition, there is included a discussion of a number of general studies on several important river systems in the Northern Great Plains.

Intermittent Streams

Many streams in the Northern Great Plains are intermittent. Therefore, a general discussion of aquatic community characteristics of intermittent streams is included here. Zane, et al. (1989) reviewed the literature on the biology of intermittent streams, which is included here.

Intermittent streams have reduced aquatic plant and macroscopic algae diversity. However, emergent aquatic vegetation is common along the banks of permanent pools and intermittent streams are inhabited by a diverse array of diatoms and periphytic algae. These are the most important primary producers in these systems and along with plant litter they compose the food base (Zane, et al. 1989). Invertebrates dominate intermittent streams both numerically and functionally and virtually all biological processes of intermittent streams are mediated by macroinvertebrates (such as aquatic insects). While a few species of invertebrates are restricted to intermittent streams, generally there are fewer species in intermittent streams than in perennial streams. Plecopterans are reported to be rarely observed in plains streams (Merritt and Cummins, 1996). Invertebrate species assemblages reestablish rapidly in intermittent streams following drought, provided they have opportunities and adaptations to survive dry periods (Zane, et al. 1989). In a study in eastern South Dakota, of the 60 benthic taxa collected from riffles, 42 occurred in intermittent streams and 58 in perennial streams (McCoy and Hale, 1974). Two species, a stonefly and a caddisfly, were found exclusively in intermittent streams. In pools, of the 21 taxa collected, seven were in intermittent streams, one of which (a dragonfly) was absent from perennial streams.

Intermittent streams are dominated by a relatively small assemblage of fishes that are highly tolerant of variable and extreme physical conditions (Zane, et al. 1989). Even though they consist of relatively few species, the abundances are often high. Resident species are primarily small and feed on algae, detritus and invertebrates. There is some evidence that intermittent streams may be important nursery areas before cessation of flow because they are warm, support abundant invertebrate forage and lack large predatory fish (Zane, et al. 1989). In South Dakota a collection from two intermittent and five perennial streams found twnty-two species in the perennial streams, twelve of which also occurred in intermittent streams (McCoy and Hale, 1974). These were brassy minnow, central stoneroller, common shiner, bluntnose minnow, fathead minnow, blacknose dace, creek chub, white sucker, black bullhead, brood stickleback, green sunfish and johnny darter.

Platte, Loup and Elkhorn Rivers, Nebraska

Frenzel and Swanson (1996) sampled the fish communities at nine sites in the Platte River basin to determine an index of biological integrity. Although most of the sampling sites were just to the south of the NGPAA (one was in the NGPAA), this study is instructive of Great Plains streams. The Index of Biological Integrity (IBI) used in this study consisted of a combination of six measures. These were the number of native fish species, the number of native cyprinid species, the number of intolerant (to pollution) species, the percentage of tolerant species, the percentage of individuals as omnivores and the percentage of individuals as carnivores. Numbers of

species ranged from two (Shell Creek, a tributary to the Platte just east of the Loup River) to 21 (Platte River near Brady) and total fish abundance ranged from 41 (Shell Creek) to 7611 (Platte River near Brady). The IBI scores ranged from six at Shell Creek to twenty-four at several locations. The lowest IBI scores resulted from a few tolerant species comprising a sample. Higher scores generally came from samples collected at the Dismal River and at mainstem Platte River sites which have a greater degree of habitat complexity than do the smaller streams. IBI scores related to species tolerance suggested that sites with greater percentages of cropland in the basin had fish communities indicative of poor water quality (fish were tolerant of physical or chemical water quality degradation).

The Dismal River and Platte River sites were more hydrologically stable in this study and supported the richest fish assemblages. In contrast, the other sampled sites showed greater hydrologic variability, and the fish communities tended to have fewer species and larger percentages of trophic generalists. This corroborates the work of Poff and Allan (1995) who found that hydrologically variable sites typically were characterized by assemblages of trophic generalists, while stable sites included more specialists.

Long Pine Creek, Nebraska

The Long Pine Creek watershed (Brown County, Nebraska) was almost exclusively rangeland and hay meadows in 1965, but by the mid 1980s was 30% irrigated cropland (Maret, 1988). Historically, the streams in this watershed were of high quality, but water quality impairments as a result of the land use changes has occurred (Maret, 1985). Despite these changes, Long Pine Creek is the longest self-sustaining trout stream in Nebraska (Maret, 1988). This study used macroinvertebrates, which are considered to be excellent indicators of both long-term environmental changes such as siltation (Lenat, et al., 1979) and slug loadings of short duration (Prophet and Edwards, 1973).

The macroinvertebrate fauna from Long Pine Creek was found to include at least 125 taxa with the faunal assemblage dominated by mayflies, caddisflies and midges (Maret, 1988). This type of community structure is common for Midwestern streams (Maret and Christiansen, 1981). The taxa found all through Long Pine Creek were indicative of good water quality and the diversity of organisms was relatively balanced. The biotic index values found were in the good water quality range.

At least 90 taxa were collected from Bone Creek (a tributary of Long Pine Creek) and the predominant organisms were midges, tubificids and mayflies. Bone Creek fauna was made up of tubificid worms, which are indicative of an organic-enriched aquatic environment. It also had a silt-tolerant group of mayfly species and chironomids indicative of waters with organic enrichment and a high silt load. Stoneflies (indicators of good water quality) were collected from Long Pine Creek, but not in the headwaters of Bone Creek. They were collected in the lower portions of Bone Creek in the winter and spring, but disappeared in the summer. Bone Creek generally had a fair to poor biotic index and the invertebrate community was composed of pollution tolerant organisms (especially in the lower reaches).

Sand Hills Streams, Nebraska

Species richness and dominance were summarized for several physiographic areas in central Nebraska, including the Sand Hills (Zelt and Jordan, 1993). The streams sampled in the Sand Hills had median fish community richness of nine species in first to third order

streams. The single most dominant species took up 43% of the sample as a median of streams sampled. For macroinvertebrates, the Sand Hills streams had 24 species as a median and the most dominant one took up 30%.

James River, North and South Dakota

The James River has one of the lowest gradients of any river of similar length in North America (Berry, et al. 1993) and is dominated by catfish-carp-carpsucker community (Funk, 1970). The James is a typical warmwater stream with wide flow and temperature variation, shallow channels with uniform sandy beds and turbid waters (Winger, 1980; Cross and Moss, 1987). Berry, et al. (1993) recognized four river reaches. The first is the headwater reach in North Dakota, which is intermittent, incised into glacial drift and slopes 46 cm/km. The second reach is the lake plain where the glacial Lake Dakota covered the area. The gradient here is as low as 2.4 cm/km. This reach is dominated by hardwood timber, oxbows and wetlands. The third reach near Huron is relatively straight, has greater channel capacity and a narrower floodplain than other reaches. The fourth reach is from Huron to the Missouri River, in which meanders increase again and the river drops about 12 cm/km. Fifty to 65 percent of the watershed is cropland (corn and wheat) and pasture with about 2% forest, existing as narrow strips along the river.

There are 40 to 48 genera of phytoplankton in the James River (Hansen and Repsys, 1986). Macroinvertebrate diversity and abundance was found to be greater in oxbows than in the mainstem and was dominated by hemipterans, ephemeropterans and odonates (Larson, 1990). Chironomids dominated the benthic fauna in the mainstem (Hansen and Repsys, 1986), but mayflies, beetles, odonates and dipterans were also present. The clam community once comprised 17 species, but in 1985 only four were found (Perkins, 1986). Since 1975, 57 different species of fish have been found in the river (Berry, et al. 1993). More species were found in the river than in tributaries, but the tributaries contained some species that prefer high velocities, gravel substrates and clear water (central stoneroller, topeka shiner, blackside darter). Species richness has been reduced in the headwaters more than the lower parts (Berry, et al. 1993) Five of twenty species found in 1896 in North Dakota had not be collected recently, while only one of 20 from the lower river was missing.

The Jamestown Dam in North Dakota has almost eliminated flooding to the South Dakota state line but now silt is not deposited overland and floods do not flush the river substrate (Berry, et al. 1993). Small dams along the river have created pools that are fish refuges during low flow, but also trap organic material and inhibit fish movement. A drop in the water table from irrigation pumping and wetland drainage has resulted in loss of water from springs and some tributaries have become intermittent reducing nursery areas for juvenile fish.

Powder River, Wyoming and Montana

The Powder River in Wyoming and Montana has been relatively unaffected by water development, channelization and exotic species (Hubert, 1993). It is a low gradient stream with poorly developed riparian areas, highly fluctuating flows, extremely high turbidity and an unstable sand bottom. The river channel is shallow, highly braided and meanders substantially within the floodplain. Four tributaries provide most of the flow to the River. These are Crazy Woman Creek, Clear Creek, the Little Powder River and Mizpah Creek. The tributaries tend to have more well-developed riparian areas, less turbid water and

more stable bottom substrates than the Powder River (Hubert, 1993).

Of the sites studied by Rehwinkle (1978), Mizpah Creek had the greatest diversity of fish, indicating that it has the highest habitat diversity. The amount of riparian vegetation along the Powder River has been estimated at 6,010 hectares (Rehwinkle, 1978). The floodplain of the river and its tributaries are irrigated primarily for hay production. The biotic productivity of the Powder is low due to high turbidity and variation in flow and unstable bottom substrate (Hubert, 1993). The productivity is higher in the tributaries. The densities of macroinvertebrates are low, but they are unique among Montana streams (Hubert, 1993).

The Powder River and its tributaries support 32 species of fish, 25 of which are native (Hubert, 1993). The common species in the river are flathead chub, brassy minnow, plains minnow, western silvery minnow, sturgeon chub, goldeye, river carpsucker, shorthead redhorse, stonecat, common carp, longnose dace and channel catfish. Fifteen species each of fish have been reported from Mizpah and Crazy Woman Creeks. Large riverine fish may be migrating upstream during runoff in spring to spawn in tributaries or upstream areas of the Powder and this seasonal movement may be necessary for some species (Hubert, 1993).

The nearby Tongue River probably had a fish community similar to the Powder before water development and several species now exist only below the farthest downstream diversion dam (Hubert, 1993). The Powder River fish community is unique and probably represents the kind of community that was formerly found in free-flowing great plains rivers (Hubert, 1993).

Yellowstone River, Montana

The Yellowstone River is the longest free-flowing river in the contiguous United States, however, 31% of the drainage basin is upstream of storage reservoirs (most of which are in the Bighorn basin) (Koch, et al. 1977). The mean annual discharge near the mouth is 362 cms and the Bighorn River is the largest tributary to the Yellowstone with a mean annual discharge of 110 cms (White and Bramblett, 1993). The damming of the Bighorn caused an 80% reduction in sediment yield to the Yellowstone (five million metric tons). Since there has not been any reduction in sediment transport at the mouth of the Yellowstone (Koch, 1977), this indicates that the Yellowstone may be degrading its bed and banks to produce the extra sediment (White and Bramblett, 1993). The water quality is generally good from source to mouth, although a general deterioration is noted along that length (White and Bramblett, 1993). The river has a rich invertebrate fauna dominated by mayflies (37 species), caddisflies (36 species), stoneflies (37 species) and true flies (Newell, 1977).

There are 56 species of fish in the Yellowstone River (White and Bramblett, 1993) which exist in three zones: upper coldwater or salmonid zone; transition zone of both coldwater and warmwater species; and a lower warmwater zone (Haddix and Estes, 1976; Peterman, 1979). Only the last two are in the Northern Great Plains Assessment Area. The transition zone extends from the confluence with the Boulder River to the confluence with the Bighorn River and contains 30 species (White and Bramblett, 1993). The lower zone runs from the Bighorn confluence to the Missouri River and has 49 species (White and Bramblett, 1993).

Human activities have modified the channel morphology of the river much less

than other Northern Great Plains rivers (Silverman and Tomlinsen, 1984). Effects have occurred from water withdrawal for agricultural purposes since the vast majority of all water use in the Yellowstone basin is for irrigation (Montana Department of Natural Resources and Conservation, 1981). Water diversion structures in the lower Yellowstone are known to influence upstream movement of paddlefish, shovelnose sturgeon, sauger and walleye (White and Bramblett, 1993).

Cheyenne and Moreau Rivers, South Dakota

In a survey of the aquatic communities of the Cheyenne River within the Cheyenne River Indian Reservation, 14 total taxa of macroinvertebrates, ranging from 5 to 10 at various stations were found (Cheyenne River Sioux Tribe, 1997). Densities ranged from 33 to 382 organisms per square meter. The diversity index ranged from 1.18 to 2.11, which is considered to be below the recommendations for healthy environments (Wilhm, 1970). The upper and lower stations were dominated by ephemeroptera and trichoptera, while the middle station was dominated by chironomids.

Twelve species of fish in four families were found (Cheyenne River Sioux Tribe, 1997). Stations ranged from four to eight species with cyprinids dominating. Since similar plains streams support more diversity, it was believed that the system was being limited, possibly by poor water quality and a restricted macroinvertebrate community. The poor water quality could have been the result of heavy metals from historic Black Hills mining.

The Moreau River within the Cheyenne River Indian Reservation was also sampled for aquatic species (Cheyenne River Sioux Tribe, 1997). Twenty-two macroinvertebrate taxa were found, ranging from 10 to 18 at various stations. Density ranged from 247 to 3107 organisms per square meter. The diversity index ranged from 1.7 upstream to 3.18 downstream. The three upper stations were dominated by ephemenoptera and trichoptera and the lowest station by chironomids.

Eighteen fish species were collected from five families (11 at the highest and lowest stations and 14 at the two middle) (Cheyenne River Sioux Tribe, 1997). All were dominated by cyprinids.

Red River of the North, North Dakota

The low topographic relief of the Red River has led to the installation of dams to reduce flooding and drainage ditches to carry away excess water (Goldstein, 1995). Most of the dams are small, but there are 450 of them in the U.S. side of the basin and most discharge water over the top, therefore the impacts are usually not great (Goldstein, 1995). The ditching to drain water away is much more extensive on the Minnesota side (Goldstein, 1995).

Neel (1985) studied benthic macroinvertebrates in the Turtle River. One hundred and thirty-three taxa in 16 orders and 58 families were found, with a total mean density of 6686 individuals/m^2. They were dominated by the caddisfly genera *Cheumatopsyche* and *Hydropsyche* which represented 51%, corixid water bugs and elmid water beetles with 8 and 7% respectively, and small clams (*Pisidium* and *Sphaerium*), mayflies (*Stenonema*) and midges (*Chironomidae*) at 4% each. Stoaks (1975) found a similar community structure in the Forest River, another tributary to the Red on the North Dakota side. The macroinvertebrate community of the Red River are composed of mainly filtering and gathering collectors (Cummins and Merritt, 1984).

Cvancara (1983) listed 12 species of pelecypod mussels and eight species of

sphaeriid (pill) clams for the North Dakota part of the Red River. The most common mussels were *Anodonta grandis*, *Lasmigona complanata* and *Lampsilis radiata*. The most common pill clams were *Sphaerium lacustre*, *S. striatinum*, *S. transversum* and *Pisidium compressum*.

Goldstein (1995) compared the species similarities by streams within the Red River basin and found they could be categorized into five regions. These five were: 1) the Wild Rice and Elm Rivers on the North Dakota side; 2) the Sheyenne River in North Dakota, the Red River mainstem and the Otter Tail, Wild Rice, Red Lake and Buffalo Rivers in Minnesota; 3) the Maple, Goose, Forest, Park, Pembina and Turtle Rivers in North Dakota and Two Rivers in Minnesota; 4) the Clearwater and Roseau Rivers in Minnesota; and 5) the Thief and Middle Rivers in Minnesota. Groups two, three and four had the most commonality, while groups one and five had the least (Goldstein, 1995). The lowest species richness was in groups one and five with less than twenty species. Group two had rivers with the greatest species richness (<40), while groups three and four had between 20 and 30 species in their rivers (Goldstein, 1995).

Missouri River below Garrison Dam

Wolf, et al. (1996) studied the larval fish community below Garrison Dam in the summers of 1993 and 1994. The abundance and diversity was lower than expected given the number of adult fishes found in the tailwaters and the number of larval fishes collected in other studies of the Missouri and Mississippi Rivers. They felt that the low abundance and diversity were due to the hypolimnetic discharge (forty meters below the dam) of cold water from Lake Sakakawea. The larval fish species found also appeared later in the season than they would be expected. There had been no prior evaluation of the larval fish community below Garrison Dam.

Wetland and Riparian Habitats and Land Cover

3.1 INTRODUCTION

Question 2 **What is the extent and composition of riparian and wetland areas? What are the land coverages in the Assessment Area?**

Wetlands and riparian areas are of vital importance to wildlife and the functioning of aquatic systems. These areas are also of great importance hydrologically to the systems in which they belong. The Northern Great Plains contain about 10% of the nation's wetlands (U.S. Natural Resources Conservation Service, 1996) and they are of great significance to the nation and the North American continent as a whole.

The present extent, historical and future trends of these areas are examined, as well as conditions affecting the functioning of these systems. Section 3.1 introduces the characteristics and features of wetlands and riparian areas in general and the specific nature of those in the Northern Great Plains. Section 3.2 looks at the extent and condition of wetlands in the NGPAA. Section 3.3 examines the condition of riparian areas. Both of these sections present information on the changes that have occurred to these areas as a result of changing hydrology. Section 3.4 discusses the effects of large scale land use changes and the extent of human influence on the Northern Great Plains landscape.

Wetlands

Wetlands are areas that are inundated or saturated by surface or ground water often enough and for a long enough period of time to support (and under normal conditions do support) a prevalence of vegetation typically adapted for life in saturated soil conditions (Snyder, 1995). Cattails, willows, sedges, rushes, some smartweeds or other water-loving plants may be present. Cowardin (1979) defined wetlands as transitional lands between terrestrial and aquatic systems where the water table is at or near the surface or the land is covered with shallow water. It also must have one or more of the following: support, at least periodically, hydrophytes; be predominantly undrained hydric soil or have a nonsoil substrate saturated with water or covered by shallow water at some time during the growing season each year.

A way of classifying wetlands is by the hydrologic systems themselves. There are three types of wetland systems that occur in the Northern Great Plains. They are riverine, lacustrine and palustrine. Riverine are those associated with rivers and streams. Lacustrine are associated with lakes and ponds, while palustrine are marshes, wet meadows, fens, potholes, bogs and small shallow ponds (Tiner, 1996). In addition, there are classes within these systems such as emergent, scrub-shrub and forested (Cowardin, 1979). Emergent wetlands are dominated by erect, rooted, herbaceous hydrophytes. Scrub-shrub wetlands are dominated by vegetation less than 20 feet tall and forested wetlands are dominated by vegetation taller than 20 feet.

Another method of classifying wetlands is by the length of time water is standing. The State of North Dakota utilizes the following classification system for wetlands to describe the various types that occur within the State (North Dakota Department of Health, 1994). Much of this would probably apply to most palustrine wetlands in the Northern Great Plains. *Temporary wetlands* are shallow depressions which hold water or are waterlogged from spring runoff until early June. They frequently reflood during heavy summer or fall rains. *Seasonal wetlands* are depressions which normally hold water from spring runoff until mid-July. *Semipermanent or*

Intermittent wetlands are located in well-defined depressions or basins and in normal years hold water all summer. Freshwater semipermanent wetlands (commonly called cattail sloughs) are characterized by a predominance of cattail and bulrush vegetation and scattered open water areas. Saline semipermanent wetlands have a preponderance of alkali bulrush and scattered areas of open water. *Permanent wetlands* are located in well-defined basins which characteristically hold water throughout the year. They become dry only after successive years of below normal runoff and precipitation. Freshwater permanent wetlands typically have a border of aquatic vegetation and open water areas in the interior. Saline permanent wetlands are typically devoid of emergent vegetation and exhibit a white, salt-encrusted shoreline.

In the Northern Great Plains the most widespread area of wetlands is known as the prairie pothole region, an area that includes eastern South Dakota and eastern and northern North Dakota. A significant number of potholes also exist in northern Montana. The prairie pothole region encompasses about 14% of a larger region of glacial debris, scars, and depressions created by the last ice age and covers about 300,000 square miles from central Alberta to northwestern Iowa (North Dakota Department of Health, 1994). This area was formed when glaciers deposited a dense, clayey glacial till, and as the overlying ice melted, potholes (kettle lakes) remained where ice blocks had previously been imbedded (Winter, 1989). The glacial till inhibits infiltration of snowmelt, causing meltwater to flow overland into potholes. About 25% of the annual precipitation in North Dakota is snow and it accumulates in these depressions. When the snow melts in the spring the ground is still frozen, so snowmelt and spring rains do not readily infiltrate into the soil (Shjeflo, 1968). Snowmelt and spring rains are the major source of water to the prairie potholes. Potholes range from less than an acre in size to several square miles. About 79% of prairie potholes are one acre or smaller in size, and more than 66% are less than a half acre according to National Wetland Inventory estimates (Dahl, 1991).

The hydrology and water quality of wetlands vary over time (Winter, 1989). Prairie potholes can recharge ground water in the spring until evaporation and water uptake by plants causes the water level to drop below the water table. At that time, ground water begins to flow back into the wetland. Salinity of water in the wetland increases as evaporation concentrates minerals in the water through the summer and freezing concentrates them in the winter (LaBaugh, 1989). In spring, snowmelt dilutes the salinity. Some prairie wetlands are sustained by ground water inflow, which provides a constant, but commonly saline source of water. Other wetlands are sustained only by runoff and in wet years generally have freshwater, but during most years go dry. Some prairie potholes have brackish water resulting from a combination of ground and surface water.

The prairie potholes are primarily emergent wetlands (Stewart and Kantrud, 1973). Water must be present for significant periods to create the conditions that support hydrophytic vegetation which can survive in prolonged water-logged conditions; but water does not need to be ponded on the land's surface to provide wetlands many of their functions, including making them highly productive biologically (Dahl, 1991).

In eastern South Dakota, palustrine wetlands primarily include emergent wetlands such as marshes and sloughs, in which coarse, herbaceous vegetation like cattails and bulrushes are predominant; wet meadows, in which low, herbaceous vegetation like grasses

and sedges are predominant; and vegetated and shallow-water zones of stock ponds (Stewart and Kantrud, 1971). Prairie potholes are the most common type of palustrine wetland in South Dakota. Lacustrine wetland areas occur in the numerous glacial lakes in the eastern part of the State and in artificial impoundments throughout the State. Submersed vegetation like widgeongrass and pondweed are common in lacustrine wetlands. About 90% of the wetlands in the glaciated eastern South Dakota are associated with prairie ponds and lakes (primarily palustrine emergent wetlands) and the remaining 10% are riverine and those associated with stock ponds (Ruwaldt, 1979).

Steeper topography, a better developed drainage system and a generally more arid climate are factors that result in fewer wetlands in the western part of the NGPAA than in the eastern and northern parts (U.S. Geological Survey, 1996b). About 60% of the wetlands in the unglaciated portion of South Dakota are associated with stock ponds (U.S. Geological Survey, 1996b).

Further south in the Sand Hills of Nebraska, wetlands include wet meadows (where the water table is at or near the land surface) and marshes that are associated with lakes (U.S. Geological Survey, 1996b). Most of the lakes are 10 acres or less in area, average about 5 feet in depth (McCarraher, 1977) and are considered to be palustrine wetlands. In the central and eastern parts of the Sand Hills, lakes and marshes are typically slightly saline, are in hydrologic connection with ground water and commonly have surface outlets (Ginsberg, 1985). Many wetlands in the western Sand Hills are strongly alkaline and have little or no outflow. Lakes that have high alkalinity are found in areas where the ground water becomes mineralized as it moves through the rock formations.

The glaciated areas of the Northern Great Plains are susceptible to flooding due to the small topographic gradient. The storage capacity of prairie potholes is very important in controlling seasonal flooding (U.S. Geological Survey, 1996b). Shaw (1993) for example calculated that the flood crest of 1993 could have been lowered by two feet at St. Louis if 2.2 million acre-feet of storage had been provided, which could have been obtained by returning less than ½ of 1% of the drained wetlands in the basin to wetlands. Depressions in the Devils Lake basin can store up to 72% of the total runoff in a 2-year frequency event and 41% from a 100-year runoff event (Ludden, 1983). In the southern Red River Valley, Brun, et al. 1981, correlated increased streamflows with increase in wetland area artificially drained.

Wetlands are also important in controlling polluted runoff containing nitrates and pesticides as well as filtering sediment (Robinson, 1995). Restoring just one percent of a watershed's area to appropriately located wetlands has the potential to reduce polluted runoff of nitrates and herbicides by up to 50% (Crumpton and van der Valk, 1991). However, it should be noted that under the Clean Water Act, wetlands are considered to be waters of the United States, and as such, are not to be used to treat pollution, except for those specifically constructed for that purpose.

Stewart and Kantrud (1973) estimated that 67% of the wetlands (by area) in the Prairie Pothole region are seasonally flooded or temporarily flooded wetlands. The amount of snowpack accumulated during winter determines to what extent a wetland is filled. Small and temporary wetlands are valuable for maintaining biodiversity and wildlife habitat (Robinson, 1995). Many amphibian species spend at least a part of their life in small temporary wetland types and some fish species (such as northern pike) depend on

wetlands for part of their life cycle, most often for spawning.

The wetland habitat provided to migratory waterfowl contributes greatly to the overall biodiversity of North America (Knopf and Samson, 1995). Temporary wetlands that are inundated primarily in the winter or early spring are considered to be the backbone of productivity in the prairie wetland ecosystem and temporary and seasonal wetlands tend to be the first to provide open water for migrating waterfowl (Robinson, 1995). These wetlands are large producers of food supplies such as insects, worms, crustaceans and amphibians and certain plants. These food resources are necessary to complete migration and the historic wetlands in the Great Plains have influenced the evolution of shorebird migration (this complex of wetlands are required now for these birds when migrating from the Gulf of Mexico to Alaska) (Skagen and Knopf, 1993).

These wetlands are also important as breeding areas themselves. The prairie pothole region produces at least half of North America's waterfowl and a large number of marsh and aquatic birds (Kantrud, et al. 1989). It has been estimated that as many as 5.3 million dabbling ducks depend on small, temporary wetlands in the prairie pothole region (Robinson, 1995). Seven bird species and subspecies federally listed as threatened or endangered are known to use wetlands frequently or peripherally in the Rocky Mountain/Great Plains Region (Finch and Ruggerio, 1993). The Prairie Pothole region comprises only 10% of the waterfowl breeding area in the North American continent, but produces 50% of the ducks in an average year (Smith, et al, 1964) and 23 species of ducks have nested at least once in North Dakota (Faanes and Stewart, 1982). Researchers have found an average of 140 ducks per pothole per year in eastern South Dakota (U.S. Geological Survey, 1996b).

The composition of invertebrate species in the Prairie Potholes is determined by the hydrology of the wetland (Kantrud, et al, 1989). Seasonally flooded wetlands are dominated by invertebrates that can complete their life cycle before they dry out, meaning that species that can fly, survive drying or produce eggs that can survive drying are more common (Swanson, 1984). Salt concentrations also influence invertebrate fauna - as basins dry, many become more saline and salt-resistant species such as brine shrimp may dominate (Swanson, 1984).

Riparian Areas

The riparian zone is the area of vegetation paralleling streams and rivers that is influenced by the presence of water. The running water of these ecosystems provides a source of oxygen, water and minerals to this zone and these communities are usually flooded annually and are subject to erosion and deposition of materials (Mitsch and Grosselink, 1986). This provides for a highly productive system due to this convergence of energy and materials. The riparian corridor encompasses the stream channel and the terrestrial landscape from the highwater mark towards the uplands where vegetation may be influenced by elevated water tables or flooding, and by the ability of the soil to hold water (Naiman, et al. 1993). The riparian corridor is often small in headwater streams and in mid-sized streams, the corridor is larger, being represented by a distinct band of vegetation whose width is determined by long-term (>50 year) channel dynamics and the annual discharge regime (Naiman, et al. 1993). Riparian corridors on large streams are characterized by well-developed complex floodplains with long periods of seasonal flooding, lateral channel migration, oxbow lakes in old river channels, a diverse

vegetative community and moist soils (Naiman, et al. 1992). The diversity of riparian corridors is maintained by the natural disturbance regime, the nature of the disturbance (floods, fire, landslides, debris torrents, channel migration) and the ability of the biotic system to adjust to constantly changing conditions (Kalliola et al. 1992).

In the Northern Great Plains, especially in the west, riparian zones are extremely important for wildlife and basically function as oases (Mitsch and Grosselink, 1986). Riparian areas are an example of the edge effect; there is usually more wildlife here than in the uplands. The reasons for the greater wildlife diversity include the predominance of woody communities (nesting and roosting sites, shading of stream, production of leaf litter adds to organic input to stream), presence of surface water and soil moisture, diversity and interspersion of habitat features and corridors for dispersal and migration of animals (Mitsch and Grosselink, 1986).

Riparian zones support disproportionately large numbers of species compared to the relatively tiny area they occupy (Naiman, et al. 1993). These areas may contain the majority of a region's amphibians and reptiles (Brode and Bury, 1984). Many species of small mammals, bats, songbirds, amphibians and reptiles reside solely in riparian habitats (Seabloom, et al. 1978; Johnsgaard, 1979; Brode and Bury, 1984). In the Great Plains, 73% of 325 breeding bird species are reported to use riparian woodlands and 45% (117 species) of 260 regular breeders nest in riparian areas (Johnsgaard, 1979). Riparian habitats are valuable in the spring and fall as migratory corridors for songbirds (Stevens, et al. 1977) and as staging areas for whooping crane and sandhill cranes (Frith, 1974). In the Northern high plains, cavity nesters were found to be more abundant in cottonwood-dominated vegetation types than in three other vegetation types (Hopkins, et al. 1986). However, expansion of riparian areas onto the Great Plains, as a result of fire suppression has created continuous corridors, facilitating dispersal and permitting faunal mixing of previously isolated species between eastern and western United States (Knopf and Scott, 1991).

Riparian zones are highly valued as areas of wildlife habitat, recreation, timber, livestock forage and water, travel passageways for animals and humans, buffer zones between managed and natural areas; natural filters of surface runoff and waste, stabilizers of shorelines and stream channels, interceptors for precipitation and insulation for streams (Melton, et al. 1984).

Before the construction of dams and reservoirs, rivers of the Great Plains were dynamic systems with widely fluctuating flows, large bed loads of sand and silt, numerous unvegetated islands and multiple channels (Cross and Moss, 1987; Graf, 1988). The locations of point bars, islands and channels shifted frequently because of the high spring flows and large bed loads of sand and silt (Cross and Moss, 1987). Reservoirs have altered these characteristics. Water releases from these reservoirs follow a seasonal pattern: spring runoff is held and released as needed by irrigators and municipalities through the remainder of the year. The result is a reduction in spring flows (floods) and an augmentation of low flows during the summer and fall. This change in the hydrology is leading, in many places on the plains to a loss of the native cottonwood riparian communities and potentially to the local loss of species dependent upon them, especially cavity nesting birds (Knopf and Scott, 1990). Reservoirs also trap sediment because the reduced velocity causes sediment to settle out, consequently, water released from reservoirs is relatively sediment free. According to

Schmulbach, et al. (1992) the sediment load at the mouth of the Missouri River is now 50% of what it was before closing of the mainstem dams (125 millions tons now as opposed to 250 million tons before the construction of the dams).

In alluvial rivers, the moderated flows and removal of sediment degrade riverbeds downstream from reservoirs (Hammad, 1972; Petts, 1979; Williams and Wolman, 1984; Graf, 1988). In braided river channels, channels are cut off and multiple channels are reduced to a single channel (Williams, 1978; Graf, 1988). The degradation associated with the removal of sediment in the Missouri River is the most severe after the lowest dam (Gavins Point) since this is where the river attempts to recapture its sediment load (Schmulbach, et al. 1992). Associated with the incision of the single remaining channel, side channels and backwaters are reduced in abundance or eliminated due to lowering of water levels. Side channels are departures from the main channel in which there is a current during normal river stages and are important to fishes (Schmulbach, et al. 1975; Ellis, et al. 1979). Backwaters have a low current velocity and are partially separated from the main channel by bars that were formerly islands. The degradation of backwaters is significant, because they tend to have more diverse fish assemblages and are important habitats in the life cycle of many native fishes (Carter, et al. 1985).

Other impacts to riparian areas include ground water pumping from alluvial aquifers, livestock grazing, land clearing for agriculture or to increase water yield, mining, road development, recreational demand, fire, elimination of native organisms such as beaver and introduction of exotic organisms (Stromberg, 1993; Busch and Scott, 1995). Livestock are an important factor in the degradation of riparian areas in the west, including the Northern Great Plains. Livestock tend to congregate in riparian areas, eating vegetation and trampling streambanks (Manci, 1989). This leads to erosion and sedimentation and increases in stream temperatures.

3.2 WETLAND HABITAT CONDITION

Introduction

This section looks at the extent and condition of wetlands in the Northern Great Plains. The areal extent of historical wetlands are compared with the present extent and the causes for the loss are discussed. The water quality of wetlands is discussed, including both natural and human influences.

Key Findings

- The greatest concentration of wetlands in the NGPAA occur in the Prairie Pothole region of ND, SD and MT.
- 73% of historical wetland acres remain in Montana; 55% in North Dakota; 65% in South Dakota; 65% in Nebraska; and about 60% in Wyoming.
- Most wetland losses have been the result of conversions for agriculture.
- The greatest losses since presettlement by percentage have occurred in North Dakota, with the most extensive drainage occurring in the Red River Valley.
- Recent wetland losses have been reduced to less than 3% (over a ten year period) in most parts of the NGPAA. However, in many parts of the NGPAA, increases in wetland acreage are being noted.
- Recent changes (since 1980s) have seen wetland losses the Little Missouri basin, western North and South Dakota, the Red River Valley, the lower Yellowstone, Niobrara and Cheyenne Rivers. Recent gains have been recorded in the Milk, Upper Yellowstone, Powder, Belle Fourche, Loup, Platte, James and Sheyenne River basins.

•The Sand Hills and northeastern North Dakota contain the largest amounts of palustrine wetlands and the least amounts occur in western and central South Dakota.
•Increases by percentage in palustrine wetlands from 1982 to 1992 occurred in the western and eastern portions of the NGPAA. Decreases have occurred in much of the central NGPAA, with the largest in western North Dakota.
•Wetland water quality is impacted mainly from siltation from soil erosion from cropland. Pesticides can also impact wetland water quality in cropland areas.
•The Upper Missouri River (above Sioux Falls) has 74% of the mapped wetlands of the entire river, 53% of which occur in the four major deltas of Fort Peck, Lake Sakakawea, Lake Oahe and Lewis and Clark Lake. The Missouri River from Gavins Point Dam to Ponca has 90 acres of wetlands per mile and is the most natural of the reaches below Fort Peck Reservoir.

Data Sources

The information in this section was obtained from the U.S. Fish and Wildlife Service's National Wetlands Inventory, the U.S. Geological Survey - Biological Resources Division, the Natural Resources Conservation Service's National Resources Inventory, the U.S. Environmental Protection Agency's Index of Watershed Indicators and from the literature. Much information was obtained from the publication Prairie Basin Wetlands of the Dakotas (Kantrud, et al. 1989).

Data Quality

The information on historical and recent wetlands losses (Figures 3.2.2 and 3.2.3) were derived from EPA's Index of Watershed Indicators, which in turn obtained its information by compiling data from the National Wetlands Inventory and the National Resources Inventory. These two systems use different hydrologic accounting units (8-digit versus 6-digit) and have different sampling methods. The IWI interpolated the 6-digit information into 8-digits, therefore there is error associated with it. In addition, the NRI does not collect data on federal lands. Furthermore, the NWI data is reported by state, so that there is less reliability compared to historical data for watersheds that cross state lines. The NWI database has not been completed for the entire NGPAA. Maps are not completed for most of Montana and maps that have been completed for southwestern North Dakota, western South Dakota and eastern Wyoming have not been digitized. The only areas in the NGPAA with completed electronic versions of NWI maps are central and eastern South Dakota, most of North Dakota, most of Wyoming and National Grassland areas in western South Dakota and eastern Wyoming.

Spatial Patterns and Trends

Figure 3.2.1 presents an estimation of the concentration of palustrine wetlands by 1:250,000 quadrangle. This estimation was derived by determining the area of palustrine wetlands in a sample of 1:24,000 quadrangles in each larger 1:250,000 quadrangle. These wetlands were originally mapped under the National Wetlands Inventory. The map is meant to show the relative amount on a regional scale, not actual numbers. Not surprisingly, the prairie pothole areas of South Dakota, North Dakota and Montana have the greatest palustrine wetland area. The large blank area in eastern Montana is due to a lack of completed wetland information.

Figure 3.2.2 depicts the rate of wetland loss based on long-term (historical) losses (i.e., from the 1780s to the 1980s). This information is derived from EPA's Index of Watershed Indicators, but the presentation has

been changed from a relative ranking of wetland loss to percentages (however, see cautions under Data Quality and Gaps). The greatest historical losses have been in North Dakota with losses between 40 and 50%. The larger number of wetlands there, however, means that even with losses that high, there is still a significant amount of wetlands remaining. The least historical losses have been in large parts of Montana, South Dakota and Nebraska. As can be seen in Figure 3.2.3, recent (since 1980s) large gains in wetlands have occurred in Montana (Milk and Upper Yellowstone basins), with smaller gains in Wyoming (North Platte, Powder, Tongue and Belle Fourche basins), Nebraska (Loup and Platte basins) and the James and Sheyenne basins in North and South Dakota. Wetland losses have occurred recently in much of central and western South Dakota, central and western North Dakota plus the Red River Valley, the lower Yellowstone basin in Montana, the Niobrara in Nebraska and the upper Cheyenne in Wyoming. The greatest losses have occurred in the Little Missouri River basin. According to the information available from the National Wetlands Inventory, the EPA's Index of Watershed Indicators and the National Resource Inventory of the NRCS, it appears as though the trend of wetland loss is slowing and is reversing in some areas.

The amounts in acres of palustrine wetlands according to NRCS are presented in Figure 3.2.4. The Sand Hills and northeastern North Dakota are areas with large amounts of palustrine wetlands (MLRAs 65, 55A, 55B and 53B). The least amounts occur in western and central South Dakota. The darkest areas on the map in the northeastern portion of the NGPAA reflect the location of the prairie pothole region. The Red River Valley has notably less than adjacent areas due to extensive drainage.

The percentage change in palustrine wetlands from 1982 to 1992 according to the NRCS is presented in Figure 3.2.5. Slight decreases have occurred in much of the central NGPAA, with the largest in western North Dakota in MLRA 58C (Northern Rolling High Plains - Northeastern Part). Increases occurred in the western and eastern portions of the NGPAA, with the greatest increases in the Black Hills.

Montana

In Montana there are 840,000 acres of wetlands, which is 0.9% of the State (Dahl, 1990). Most of these are palustrine. In eastern Montana wetlands are fresh and saline marshes and greasewood scrubland adjacent to rivers and in unglaciated parts of eastern Montana (U.S. Geological Survey, 1996b). Wetlands occur in floodplains of streams in the Missouri and Yellowstone basins and are commonly associated with constructed livestock ponds. In glaciated areas of northern Montana wetlands are predominantly prairie potholes (U.S. Geological Survey, 1996b). About 73% of Montana's predevelopment (historical) wetlands remain (Dahl, 1990). Most wetland losses have been due to conversion of wetlands to croplands, particularly in the prairie pothole region of northern Montana. As of the mid-1980s about 20,000 acres of prairie in eastern Montana had been artificially drained for agriculture (Dahl, 1990).

North Dakota

Most of North Dakota's remaining wetlands are located in the Prairie Pothole region, which extends from the Missouri Coteau in central North Dakota eastward to the Red River Valley (North Dakota Department of Health, 1994). Wetland losses (by acreage) have not been as severe in North Dakota as in other parts of the region (North Dakota Department of Health,

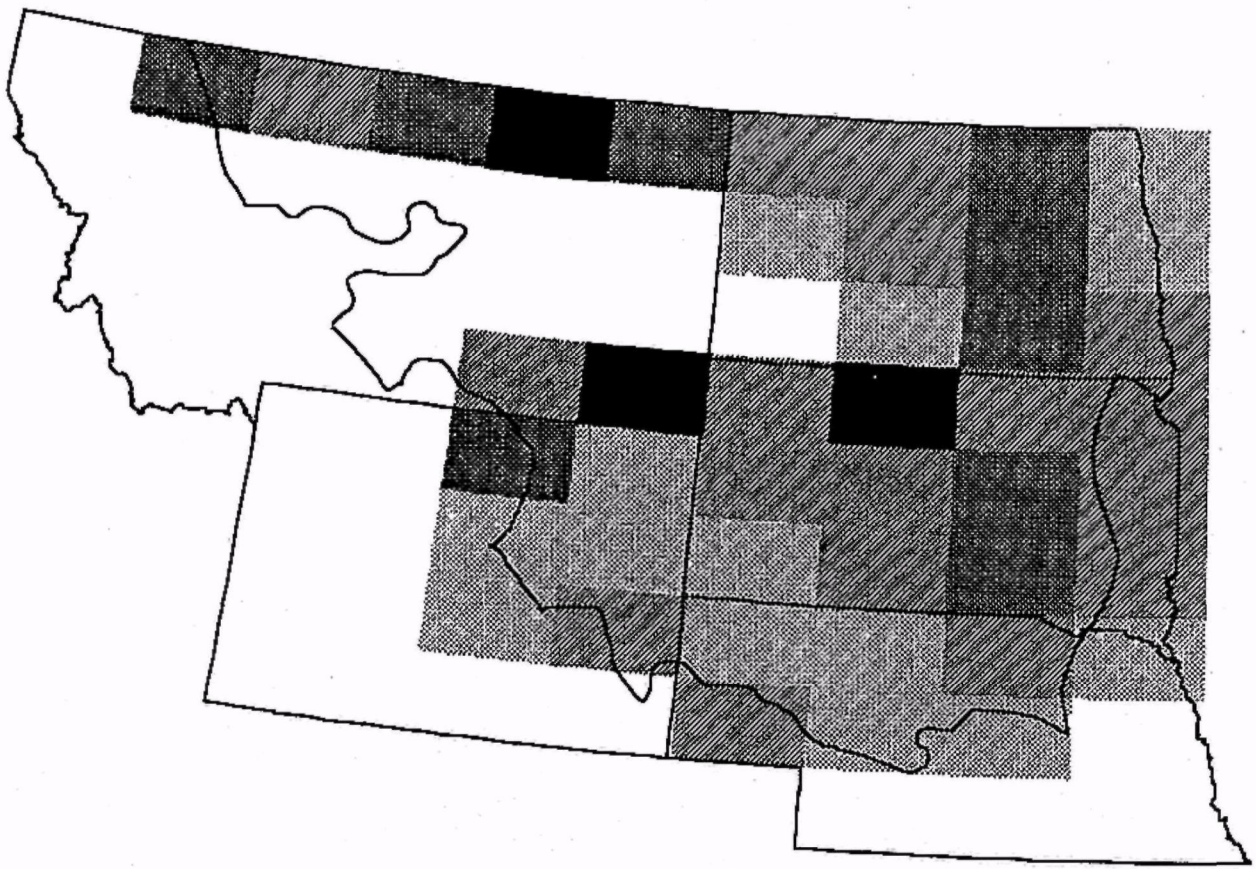

Figure 3.2.1 Concentration of Palustrine Wetlands in the Northern Great Plains

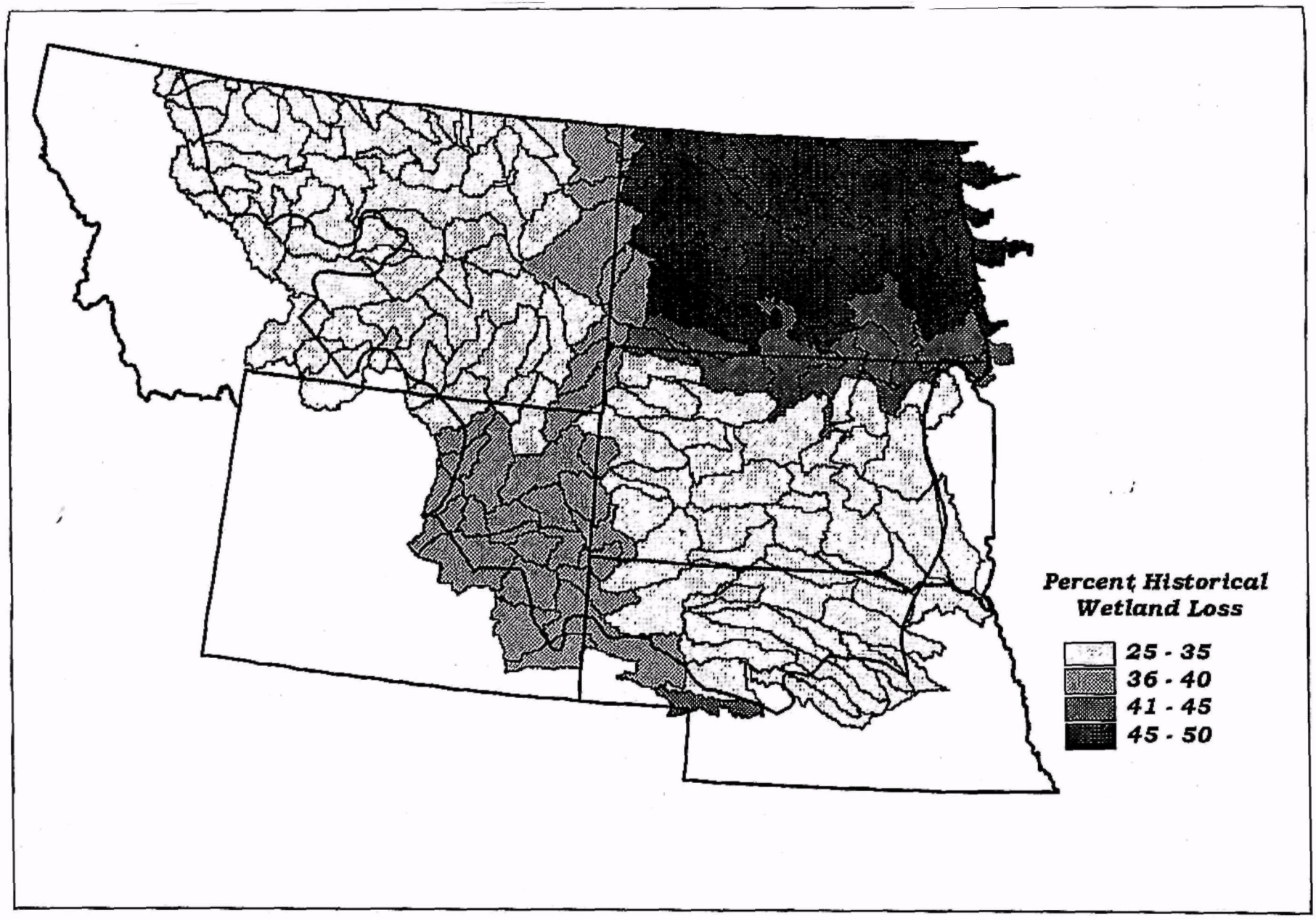

Figure 3.2.2 Historical Wetland Loss in the Northern Great Plains (1780s to 1980s) from the National Wetlands Inventory

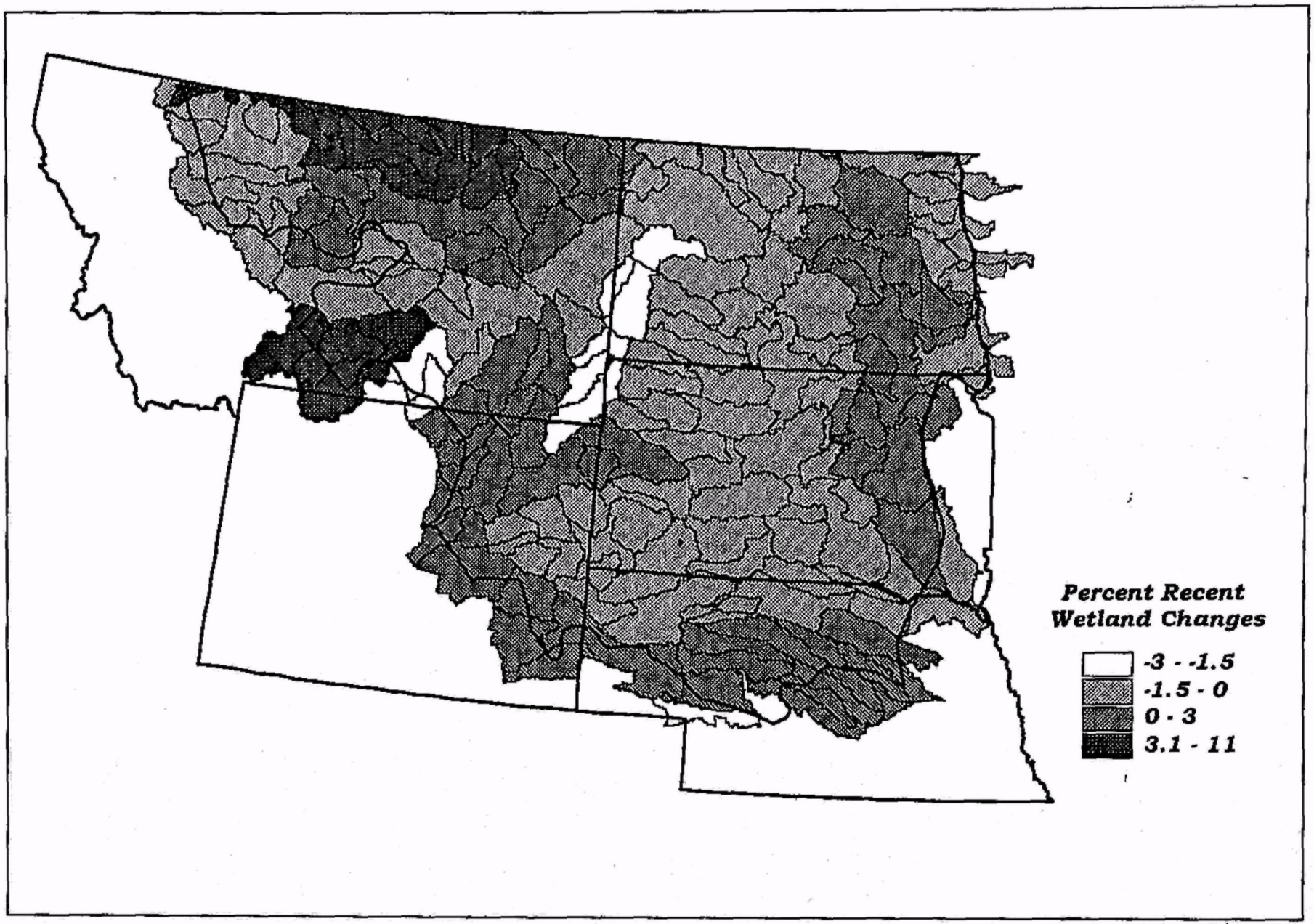

Figure 3.2.3 Recent Wetland Changes (between 1982 and 1992) as Measured by the National Resources Inventory

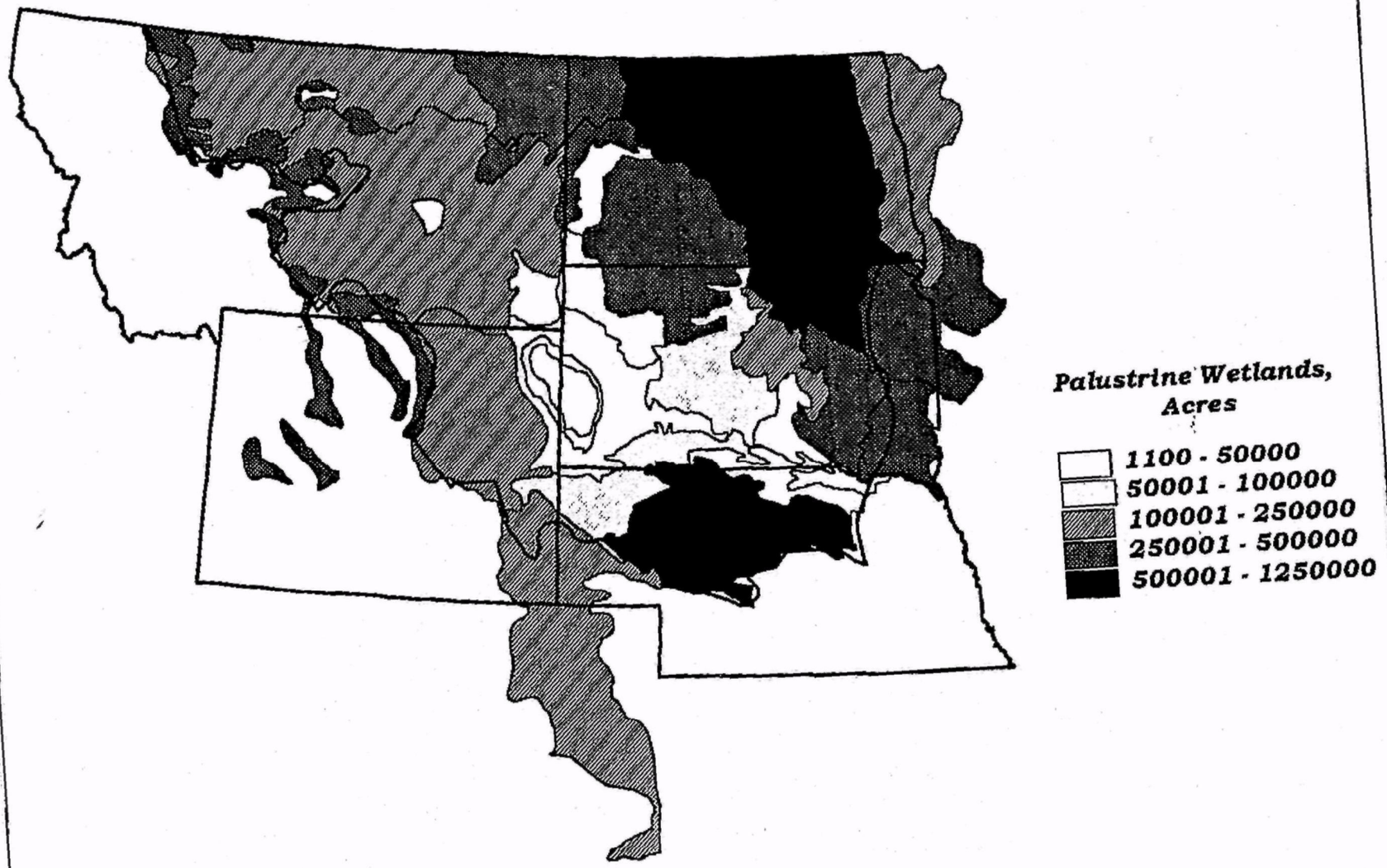

Figure 3.2.4 Amount of Palustrine Wetlands in the Northern Great Plains by Major Land and Resource Area

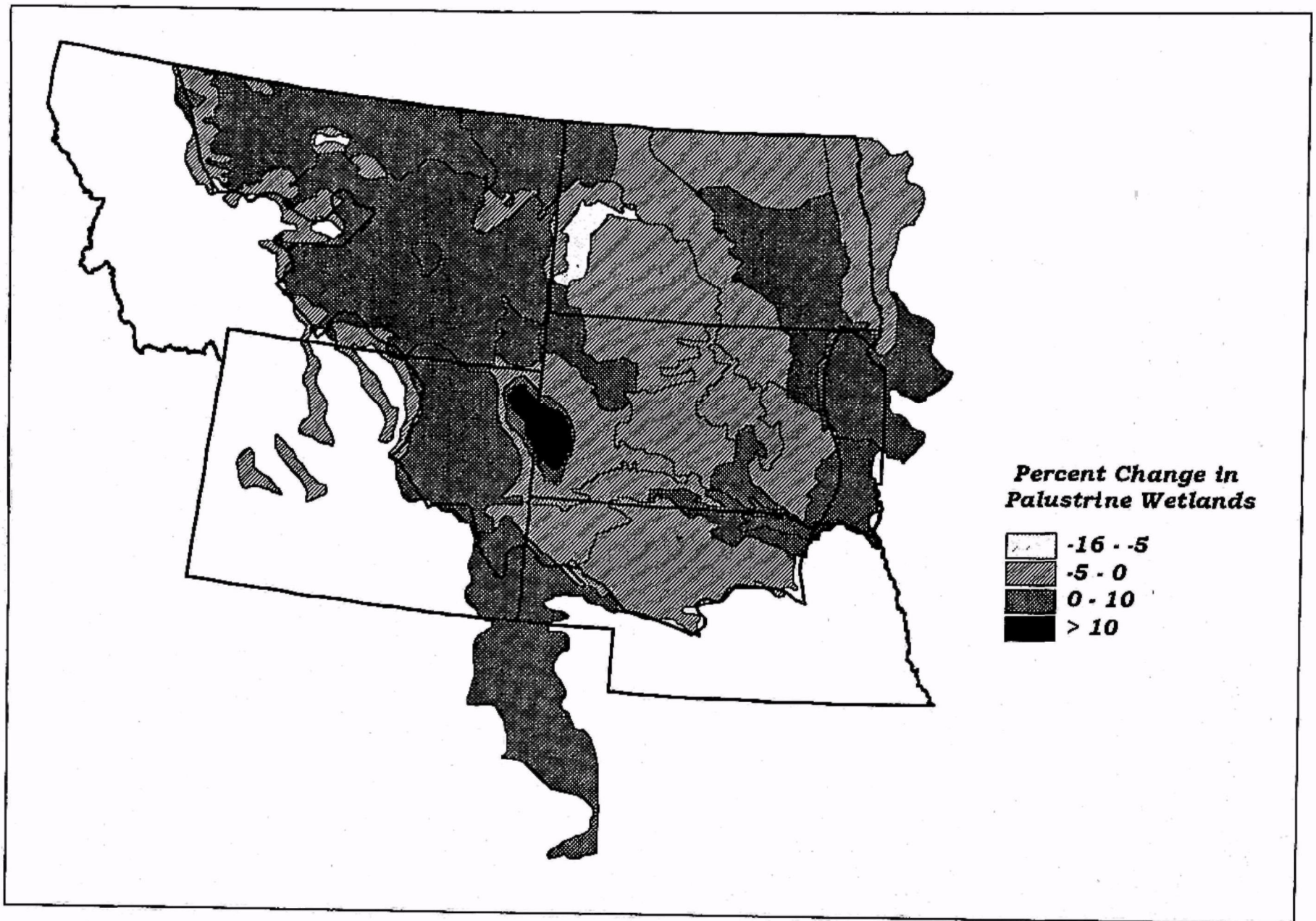

Figure 3.2.5 Percent Change in Palustrine Wetlands between 1982 and 1992 in the Northern Great Plains

1994). However, drainage, sedimentation, nutrient enrichment and pesticide contamination threaten wetland integrity (North Dakota Department of Health, 1994). Originally, there were about 5 million acres of wetlands in the State (11% of the State), but by the 1980s wetlands there were only 2.7 million acres (6% of the State), a 45% reduction (Dahl, 1990). Recent statewide estimates of losses continue at 1000 to 2000 acres per year (North Dakota Department of Health, 1994). According to Stewart and Kantrud (1973) there are 2.2 million acres of wetlands (81% of the State's wetlands) within the prairie pothole region of North Dakota. Approximate wetland numbers and areas by water regime were estimated at 698,000 temporary (113,000 hectares), 1,474,000 seasonal (583,000 hectares), and 127,000 semipermanent (345,000 hectares).

The most extensive drainage of wetlands in North Dakota has occurred in the Red River Valley where 1.2 million acres of wet meadows have been drained (U.S. Geological Survey, 1996b). A survey for North Dakota stated that 10.6% of the area of all privately owned natural basin wetlands in the Prairie Pothole Region of the State were drained from 1966 to 1980 (Kantrud, et al. 1989). The survey did not include temporary basins, so the loss rate is a conservative estimate (Kantrud, et al. 1989).

South Dakota

The most prevalent wetland type in South Dakota is the palustrine emergent wetland (the prairie pothole). South Dakota once had 2,735,100 acres of wetlands, today 1,780,000 remain, which represents about 3.6% of the State, a loss of 35% (Dahl, 1990). However, according to the 1992 National Resources Inventory conducted by the U.S. Natural Resources Conservation Service, 3,004,400 acres of wetland were found (South Dakota Department of Environment and Natural Resources, 1996). Ruwaldt (1979) estimated from a wetland inventory in 1973-4 that 71% of South Dakota's wetlands were palustrine, 19% were mixed palustrine and lacustrine associated with prairie ponds and lakes and stock ponds and 10% were riverine.

Agricultural conversions have accounted for most wetland losses in South Dakota (U.S. Geological Survey, 1996b). Northeastern portions of South Dakota have had relatively low drainage rates (1.5% of area of wetlands destroyed), whereas rates were as high as 7.5% in southeastern South Dakota (Kantrud, et al. 1989). Wittmier (1982) estimated that 34,505 hectares of temporary, seasonal, and semipermanent basins have been drained in South Dakota since 1964.

Nebraska

The estimated wetland acreage in the Sand Hills in 1980 was 1,322,451 acres (U.S. Geological Survey, 1996b). This included 112,478 acres of open water wetlands, 64,521 acres of marshes, 1,130,954 acres of subirrigated meadows and 14,498 acres of riparian wetlands. Nebraska as a whole has lost about lost about 1 million acres (35%) of the State's original wetlands (Dahl, 1990), with agriculture conversions being the principal cause of these losses. Agricultural conversions account for the loss of 28,000 acres (15%) of the original wetlands in the Sand Hills (U.S. Geological Survey, 1996b).

Wyoming

Wetlands in Wyoming cover about 1.25 million acres, or 2% of the State (Dahl, 1990). Twenty-six percent of these are palustrine, 35% are mixed lacustrine and palustrine, 9% lacustrine and 30% are riverine (U.S. Fish and Wildlife Service, 1955). This estimate, however, did not include much of the plains. Between the 1780s and 1980s Wyoming lost

38% (by area) of its wetlands (Dahl, 1990).

Wetland Water Quality

The primary cause of wetland degradation in the Prairie Pothole Region (and probably for most wetlands in the Northern Great Plains) is agriculture (Finer 1984). The most common form of degradation is from siltation caused by soil erosion from adjacent cropland (Kantrud, et al. 1989). Row crops generally result in more soil erosion than small grains, because of the additional cultivation required during the growing season (Kantrud, et al. 1989).

Agricultural chemicals contribute to degradation of wetland water quality. Most of the cropland in the Dakotas is treated with herbicides, but insecticide use is restricted primarily to sunflowers, which are now more widely grown (Kantrud, et al. 1989). Kantrud, et al. (1989) thought that the potential for agricultural chemicals to enter prairie wetlands and impact wildlife was high, particularly for the most toxic and widely used insecticides (Grue et al. 1986). The impact of herbicides on prairie wildlife is indirect and comes primarily from elimination of food and cover (Hudson et al. 1984; Hill and Camardese 1986).

Some natural characteristics of wetlands affect their water quality. When anaerobic conditions occur in either summer or winter they are referred to as summerkill or winterkill (Kling, 1975; Nickum, 1970). Summerkill lakes produce high midsummer populations of planktonic algae that later die, causing oxygen depletion and a summer fish kill (Kling, 1975). Winterkills occur when snow cover on the ice reduces photosynthesis, resulting in oxygen depletion within the water (Kantrud, et al. 1989) and increases in total dissolved solids, carbon dioxide, ammonia and hydrogen sulfide can also occur.

The location of wetlands with respect to soils and geology can affect water quality (Kantrud, et al. 1989). Wetlands located in outwash (highly permeable sand and gravel) had higher specific conductance and higher concentrations of sodium, potassium, sulfate and alkalinity (Kantrud, et al. 1989). Those located on till (low permeable silt and clay) had higher concentrations of calcium (Swanson et al. 1988). Wetlands that are saline in North Dakota tend to be located in outwash and are topographically low, serving as ground water discharge areas that concentrate salts (Kantrud, et al. 1989).

Missouri River Wetlands

In the entire Upper Missouri River (from the inlet to Fort Peck Reservoir to Sioux City) there are 306,000 acres of floodplain (U.S. Army Corps of Engineers, 1994). The upper river has 55% of the total floodplain acreage of the Missouri River, but 74% of the mapped wetlands, 53% of which occurs in the four major deltas (inlets to Fort Peck, Lake Sakakawea, Lake Oahe and Lewis and Clark Lake). These four deltas supported more than 59,000 acres of wetlands in 1991 (72% of all wetlands along the upper river). Delta wetlands expand during droughts because plants take over receding shoreline. However, delta wetlands are less diverse wetland complexes than riverine reaches because fluctuating water levels preclude trees and other species intolerant of long periods of inundation. In the major deltas, wetland types vary, ranging from 39% scrub-shrub/56% emergent in Lake Oahe to 55% scrub-shrub/37% emergent at Fort Peck. Forested wetlands range from 8 to 15% in the deltas. The wetlands of the delta in Lewis and Clark Lake are 83% emergent.

In the Missouri River from Fort Peck Dam to Lake Sakakawea abandoned channels and several oxbow lakes remain in the floodplain (U.S. Army Corps of Engineers, 1994). Fifty-

six percent of the wetlands in this reach are emergent characterized by large stands of reed canarygrass and common reed and 39% are scrub-shrub characterized by cottonwood and willow. Scrub-shrub wetlands consist primarily of thin bands of sandbar willow along the shorelines.

The Missouri River from Garrison Dam to Lake Oahe is restricted to one main channel with very few side channels (U.S. Army Corps of Engineers, 1994). Emergent wetlands comprise 68% of the wetlands and consist of quackgrass, bluegrass and mints with reed canarygrass and slough sedge in some areas. Most of the rest of the wetland acreage is scrub-shrub at 22% consisting of cottonwood, indigo bush and peachleaf willow. This reach supports only 38 acres/mile of wetland. Large diurnal and seasonal variations in river flow due to peaking operations of the dam impede wetland establishment and survival and islands are periodically scoured.

From Fort Randall Dam to Lewis and Clark Lake has few side channels and 30% of the wetland acreage is forested, consisting of peachleaf willow and cottonwood with some sandbar willow. Fifty-six percent of the wetland acreage is emergent with reed canarygrass and common reed and extensive stands of cattail and softstem bulrush have developed in old channels and backwaters.

The Gavins Point Dam to Ponca reach has 90 acres of wetlands per mile and is the most natural of all the reaches below Fort Peck Reservoir. Emergent wetlands cover 48% and scrub-shrub cover 49% of the area. Emergent wetlands have reed canarygrass with cattails in old channels, backwaters and near islands and scrub-shrub wetlands have dense stands of sandbar willow with peachleaf willow and cottonwood in less frequently flooded areas.

Future Trends

The rate of wetland loss has slowed to less than 3% per year and is increasing in many areas as a result of wetland protection laws and incentives. As long as these protections remain in place, this condition is expected to improve or at least hold stable. The water quality problems in wetlands are largely the result of nonpoint source pollution from agriculture. Efforts to impact nonpoint source pollution will affect the quality of the water in wetlands.

3.3 RIPARIAN HABITAT CONDITION

Introduction

This section discusses the condition and extent of riparian areas and riverine wetlands in the NGPAA. Several studies are highlighted that examined the condition of riparian areas along some of the major streams in the area and the effects that dams and diversions (hydromodification) have had on them. The extent and changes in riverine wetland area are also presented.

Key Findings

- Eastern Montana has the most riverine wetlands according to the NRCS. Central and eastern North Dakota, northeastern Wyoming and much of South Dakota have the least amounts of riverine wetlands.
- The greatest decreases in riverine wetlands during the period 1982 to 1992 have occurred in northeast Wyoming and central South Dakota. The greatest increases have occurred in the Black Hills and Sand Hills.
- Several studies on riverine habitat in the Missouri, Marais and North Platte Rivers indicate that establishment of young cottonwoods has declined in many areas downstream from dams.

•This loss of cottonwood regeneration is due to alterations of the magnitude of peak river flows. These reductions in peak flows cause a loss of new alluvium deposits, which are necessary for establishment of cottonwood seedlings.
•The loss of high flows has also cut off access to seasonally flooded backwaters, which are spawning, nursery and feeding areas for fish and feeding and breeding areas for migratory waterfowl.

Data Sources

Much of the information in this section came from literature surveys of research done on the riparian areas in the Northern Plains. Many of the studies focused on the effects of dams and diversions. The Biological Resources Division of the U.S. Geological Survey supplied information from the National Wetlands Inventory. The Natural Resources Conservation Service's National Resources Inventory data was also used.

Spatial Patterns and Trends

Figure 3.3.1 presents the amounts of riverine wetlands by NRCS' major land and resource areas (MLRA). The most exists in eastern Montana (MLRA 58A - Northern Rolling High Plains - Northern Part). The least is in central and eastern North Dakota, northeastern Wyoming and much of South Dakota (outside of the southeastern and northwestern parts). The amount of riverine wetlands is not synonomous with amounts of riparian area. However, in the absence of good riparian area information is can serve as one measure of the condition of the floodplain habitat. It is also important to compare the scale on this figure versus the amounts of palustrine wetlands in Figure 3.2.4. Palustrine wetlands are considerably more common overall.

The change in riverine wetland acreage from the period 1982 to 1992 by NRCS MLRAs is presented in Figure 3.3.2. The greatest decrease was in northeastern Wyoming and central South Dakota (MLRAs 58B and 63A) with losses between 5 and 11 percent. The greatest increase was in the Black Hills and the Sand Hills (MLRAs 62 and 65) with gains of more than 10 percent. Moderate increases occurred in large areas throughout the NGPAA in northern Montana, northern and eastern North Dakota and western South Dakota and Nebraska.

Figure 3.3.3 depicts the miles of streams within each watershed impacted by vegetation removal or streambank alteration as reported by in the state 305b reports. Montana reports this impact more than the other states, with the Yellowstone, Missouri, Milk and the Powder Rivers having watersheds with more than 100 miles of assessed streams impacted. However, the North Platte-Scottsbluff, the Red River and parts of Wyoming also are impacted significantly. Much of North Dakota, South Dakota and Nebraska are not reported to be impacted by streambank alteration or vegetation removal. This could be an artifact of how closely this impact is montored in these states.

The following is a summary of a number of studies regarding the effects of hydromodification on several aquatic systems within the Northern Great Plains Assessment Area. Hydromodification includes the loss of spring flood flows due to dams and diversions, the addition of flow in late summer from irrigation return, channelization and the removal of riparian vegetation.

Laramie River/Greyrocks Dam, Wyoming

Patton and Hubert (1993) studied the changes in the Laramie River downstream from Greyrocks Reservoir. The Laramie River

once had numerous shallow side channels but few remain. The side channels that currently exist provide shallow riffles that are important to small-stream fishes but such riffles and side channels are becoming rare. Fish assemblages were sampled from the main channel, remnant side channels and backwaters. Species richness and diversity were greatest in backwaters and greater in the main channel than the side channels. The side channels contained fishes common in small streams, the main channel contained fishes usually associated with larger streams. The findings suggest that the side channels in the Laramie River, while not having the greatest diversity compared with other stream habitats, are particularly important to some species, including white sucker, johnny darter and Iowa darter. In addition, two species that are rare in the Laramie River, longnose dace and plains topminnow, were collected only in side channels. The loss of side channels due to the dam could affect the future of these fishes in the river.

Missouri River, All States

The condition of the riparian zone of the Missouri River and the impacts of the mainstem dams upon it is reviewed in the U.S. Army Corps of Engineers Draft Environmental Impact Statement for the Missouri River Master Water Control Manual (U.S. Army Corps of Engineers, 1994) and the U.S. Fish and Wildlife Service Biological Opinion on that Draft EIS (U.S. Fish and Wildlife Service, 1994).

Cottonwood and willow have historically dominated the Missouri River floodplain forests because of the highly dynamic nature of the river channel (Johnson, et al. 1976). In the past, as the river meandered, it deposited alluvium on the inside of river curves (point bars), but on the opposite side it eroded banks often covered with forest vegetation (Johnson, et al. 1976). These point bars were optimal habitat for the establishment of cottonwood and willow seedlings, which need moist mineral soil located just above the river stage (Noble, 1979). In addition, seed dispersal of cottonwood and willow occurred primarily in June, coinciding with receding spring water levels and the exposure of recent alluvial deposits (Fenner, et al. 1985). Only cottonwood and willow germinate and persist under these conditions. If such sites with young seedlings remained uneroded, cottonwood-willow forests developed. If meandering by the river were to miss a particular forested area for a century or so, the cottonwood-willow forest would be replaced by green ash, box elder, american elm and bur oak (which can reproduce in the cottonwood understory) (Johnson, et al. 1976). Eventually, as the river channel shifted back across the floodplain, established forest was lost to erosion on the outside of the bend and new cottonwood forests became established inside (Johnson, et al. 1976). Since cottonwood and willow cannot reproduce under forest conditions, river meandering is necessary to maintain these communities on the floodplain.

The mainstem dams have dramatically reduced the rate of river meandering by altering the magnitude of peak flows (Johnson, et al. 1976). Flow alteration and a decline in the meandering rate would cause a reduction in the amount of new alluvium produced for cottonwood and willow regeneration and an increase in the successional ages of established forests due to an extension in their lifespans (Johnson, et al. 1976). The net effect would be to reduce the area of cottonwood forests in favor of species of the later successional types. This change would have major consequences because forests with cottonwood as a dominant have the maximum diversity of vascular plants (Keammerer, et al. 1975) and birds (Hibbard, 1972). Peaks in species number and

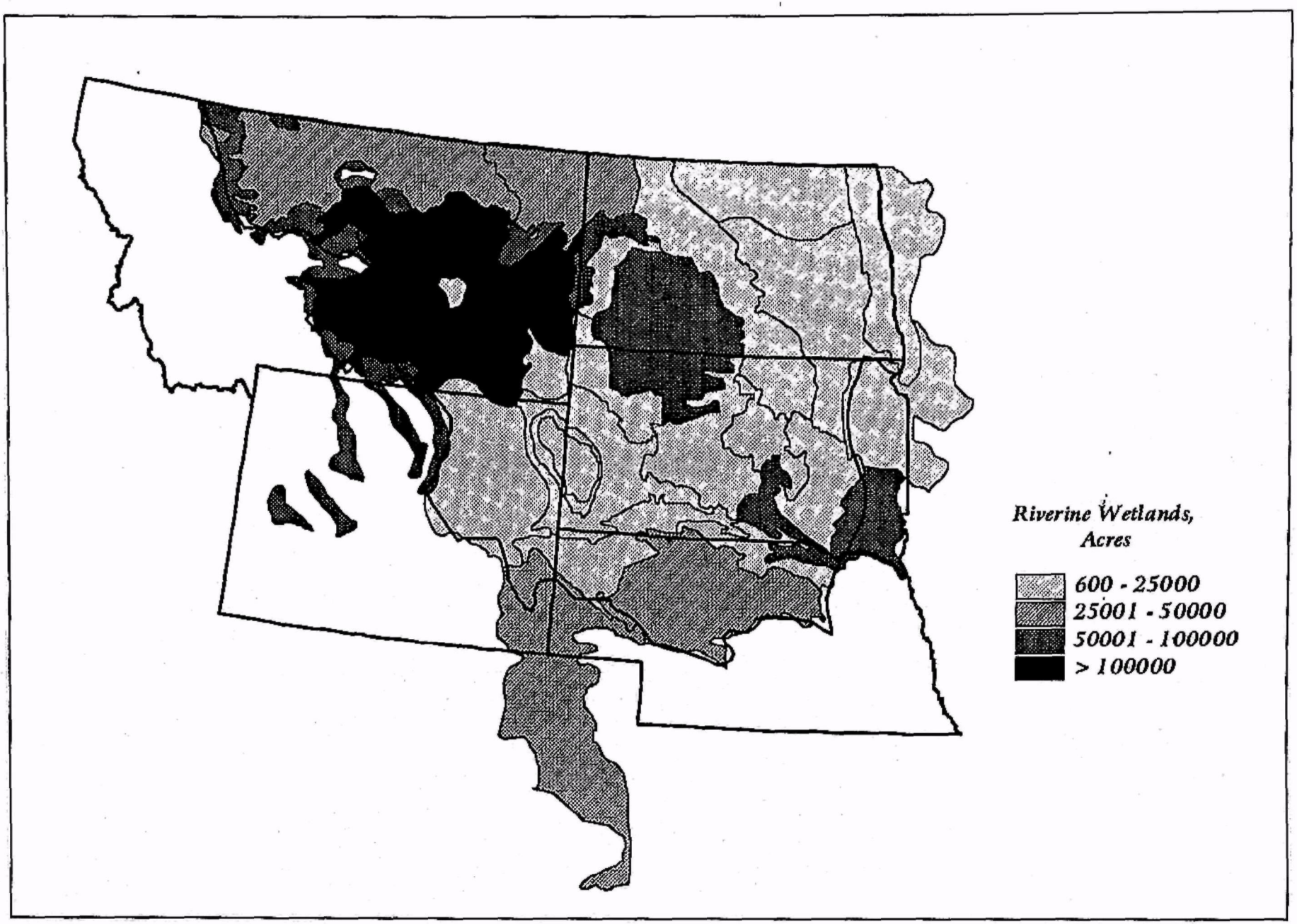

Figure 3.3.1 Amount of Riverine Wetlands in the Northern Great Plains by Major Land and Resource Areas

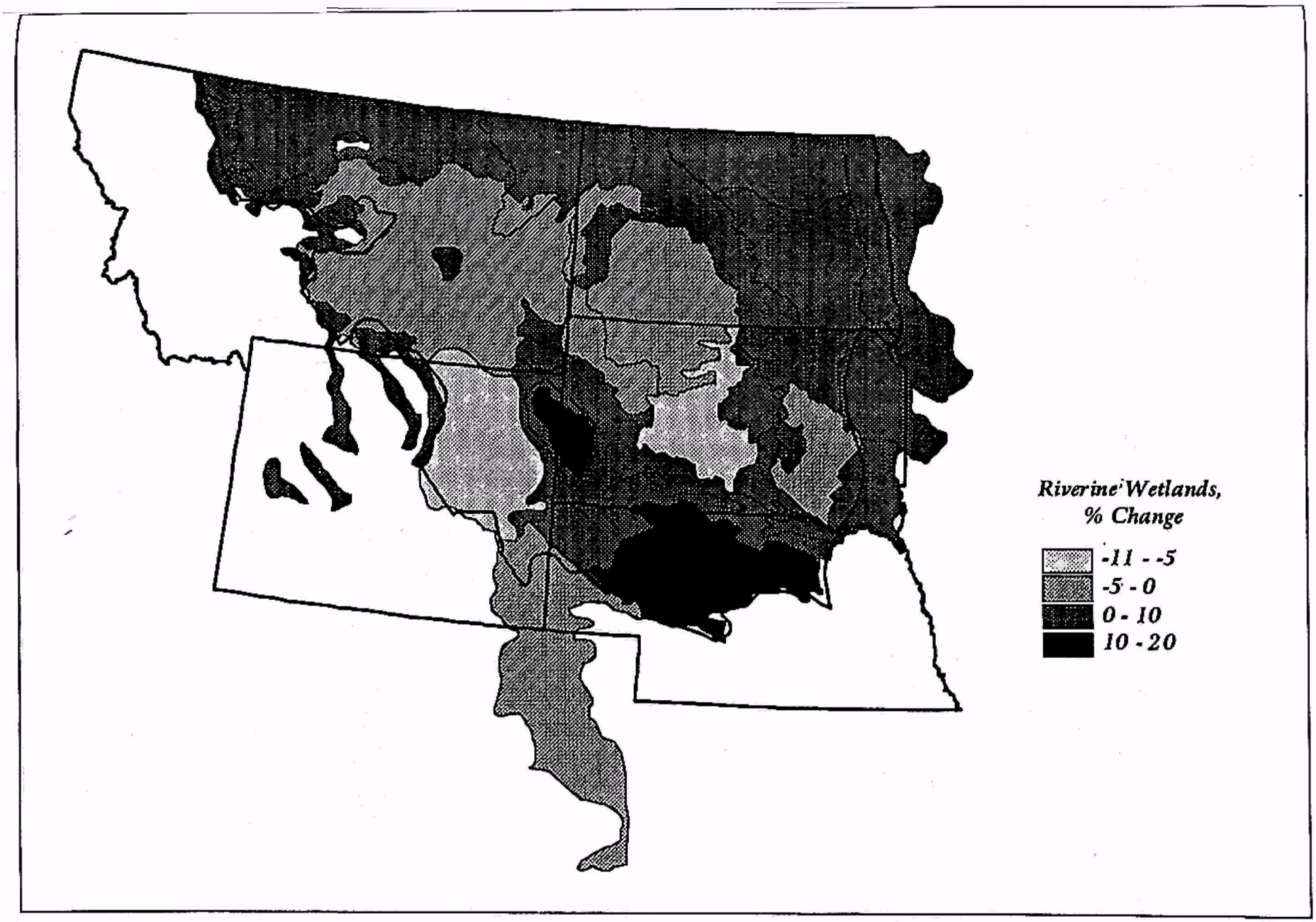

Figure 3.3.2 Percent Change in Riverine Wetlands between 1982 and 1992 by Major Land and Resource Areas

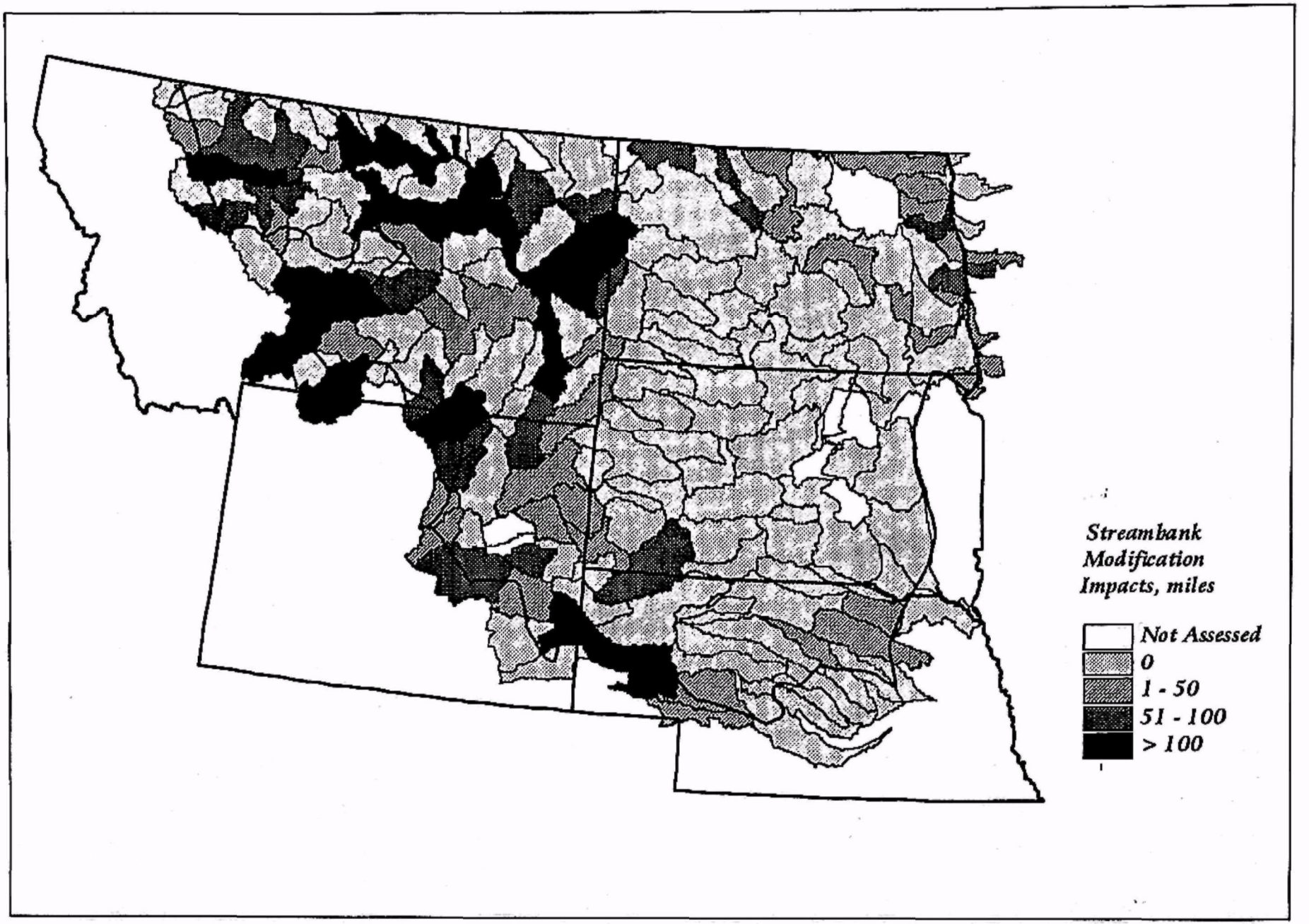

Figure 3.3.3 Miles of Assessed Streams in Each Watershed Impacted by Riparian Vegetation Removal and/or Streambank Alteration

population sizes of birds are reached in older successional forests because of their high vertical stratification (Hibbard, 1972), and additionally, the large size and hollow trunks and branches of older cottonwoods provide habitat for cavity nesting birds such as woodpeckers and wrens (Hibbard, 1972). The smaller size and sounder limbs of tree species in the newly dominating forests will not provide as many nesting cavities (Johnson, 1992).

In the upper Missouri river there is reduced cottonwood vigor, branch loss and high mortality in mature riparian cottonwood forests caused by reduced frequency of spring flooding and lowered water table (U.S. Army Corps of Engineers, 1994). Portions of the Missouri River in central Montana are generally devoid of cottonwood seedlings and most of the trees present are mature or overmature (Behan, 1981). Despite this, however, Busch and Scott (1995) referred to the stretch of the Missouri River between Fort Benton and Fort Peck Reservoir as one of the last semi-naturally functioning reaches along the entire Missouri River. It is also a National Wild and Scenic River. While some of the water in this part of the river is regulated by dams, this section is above all of the larger dams. The riverine reaches in the Upper Missouri River (as opposed to the reservoirs) contain 23,300 acres of wetland and 49,650 acres of riparian vegetation and the riverine reaches support 72% of the riparian vegetation in the upper river (U.S. Army Corps of Engineers, 1994).

In the reach from Fort Peck Dam to Lake Sakakawea there are many sandbars, islands and side channels (U.S. Army Corps of Engineers, 1994). The riparian vegetation consists of cottonwood and green ash and has a density of 67 acres/mile. This is lower than for any other part of the upper reach, due to clearing. In the Garrison Dam to Lake Oahe reach, the riparian forest comprises just over half of the riparian vegetation and consists of cottonwood, slippery elm, green ash and box elder. Sandbar willow, peachleaf willow and cottonwood occur along river sandbars. The acreage of riparian forest in this reach has been drastically reduced since settlement and by construction of Garrison Dam (U.S. Army Corps of Engineers, 1994).

Johnson, et al. (1976) detected numerous changes after the construction of Garrison and Oahe Dams. These included a decline in the growth of most tree species, low seedling recruitment of cottonwood and willow and low survivorship of box elder and american elm seedlings. Cottonwood and willow are predicted to decline in the future to be dominated by american elm, box elder and green ash (Johnson, 1992), with green ash eventually totally dominating the system, growing in dense stands, with a resulting decline in habitat diversity. Faunal diversity may then also decrease.

The reach of the Missouri River from Fort Randall Dam to Lewis and Clark Lake is a national recreation river. Nearly all of the riparian vegetation is forest, dominated by cottonwood mixed with green ash, russian olive, slippery elm and box elder. The Missouri River from Gavins Point Dam to Ponca is also a national recreation river and is the only segment downstream of Gavins Point Dam that has not been channelized. It has a wide braided channel with numerous islands and backwaters. However, as mentioned in Chapter 2, this is the area where significant erosion is occurring for the river to regain its lost sediment load. Riparian vegetation in this reach has been severely reduced by clearing for agriculture. Over one-half of the remaining area is forested, dominated by cottonwood, with lower densities of green ash, slippery elm, red cedar, russian olive, mulberry and box elder.

According to the Fish and Wildlife Service

(1994) habitat of the Upper Missouri River has been affected by the suppression of high flows. This loss of high flows has cut off access to seasonally flooded backwaters which provide spawning, nursery and feeding areas for fish and feeding and breeding areas for migratory birds. This same loss of connection to off-channel areas has reduced nutrient inputs to the upper river and resulting in a loss of productivity (U.S. Fish and Wildlife Service, 1994).

Seventeen species of ducks, three species of geese and one swan species occur along the Missouri River and it supports sixty-one species of shorebirds, wading birds and waterbirds (U.S. Army Corps of Engineers, 1994). All are dependent on Missouri River hydrology for supplying sandbars, shorelines and shallow water zones. The River provides breeding habitat for endangered interior least tern, bald eagle, and threatened piping plover. It provides migration and wintering habitat for endangered peregrine falcon and whooping crane and potentially provides habitat for endangered eskimo curlew, gray bat and Indiana bat (U.S. Army Corps of Engineers, 1994).

North Platte River, Wyoming

Miller, et al. (1995) looked at changes in the Rawhide Wildlife Management Area along the North Platte River in southeastern Wyoming that had occurred between 1937 and 1990 after shifts in flooding and intensity of flooding of the river. They found that the river declined in wetted area by 75% during that time frame. They also found that the areal proportion occupied by older cottonwoods increased, while that of younger cottonwoods decreased, although some traditional measures appeared insensitive to these changes. The proportion of the landscape that changed land types declined with increasing distance from the river. Further modification of the landscape structure and continued decline in cottonwood recruitment and increases in cottonwood mortality are expected. The reasons for these changes are alterations in the flow regimes toward reduced peak annual flows (a result of dams) and enhanced low flows (irrigation return flow and transmountain diversions).

Friedman, et al. (1997) state that a decrease in the peak flows in the Platte River temporarily increases cottonwood regeneration because of channel narrowing, however, cottonwoods decline over the long-term because of decreases in the necessary physical disturbances.

Marais River/Tiber Reservoir, Montana

Rood and Mahoney (1995) found that there is a deficiency of cottonwood seedlings downstream from the Tiber Dam that probably results from stabilized river flows (the dam traps spring flood flows and augments flows at other times). The reasons for the loss of cottonwoods were competition with grasses and shrubs encroaching due to lack of flooding, poor seedling establishment due to a lack of spring flooding, reduced formation of sandbars for seedling recruitment site due to reduction of erosion and deposition process, loss of sediment for bar expansion because silt now settles out in the reservoir, and an entrenched channel, which may have resulted from the combination of a lack of flooding and loss of sediment. They predict that there will be a progressive decline of the riparian cottonwood forests downstream from the dam unless a more dynamic river flow pattern is reestablished.

Future Trends

Pressures on riparian areas in the Northern Great Plains can be expected to continue. People are attracted to riparian areas much as

wildlife are. Development and recreation will continue to threaten riparian areas, especially in areas with increases in population. Changes in the operations of the dams may occur in the future, but without changes resulting in a more natural hydrograph, the riparian systems will continue to decline, as will the populations of the species dependent on them. Pressures from irrigated agriculture (diversions) will likely continue in certain areas of the western Northern Great Plains.

3.4 LAND COVER AND AQUATIC SYSTEMS

Introduction

Land use directly impacts the condition of aquatic systems. Areas with considerable acreage of row crops can have increased loadings of silt, nutrient and in some cases, pesticide to streams and lakes. Urbanized areas can contribute runoff from streets and siltation from road and building construction. In this section, the land cover of watersheds within the NGPAA are compared for the amounts of cropland versus grassland or forest that they contain. Cropland and pasture coverages are separated from each other and categorized as areas of intensive human use. These areas are where humans have most radically changed the landscape from the original condition and these are areas where one would expect aquatic systems to be impacted. This is not to say that aquatic systems in areas that are not cropland are not under stress and that these areas are pristine; they certainly are not. However, impacts are generally greater from changing the land cover as opposed to stressing the cover that is some semblance of the original.

Key Findings

•Intensive human influence is greatest in the eastern and northeastern portions of the NGPAA, reflecting the greater concentrations of cropland. It is least in west, southwest and central portions of the NGPAA.
•Grassland cover is greatest in central South Dakota, northeastern Wyoming, the Sand Hills and northern and southeastern Montana.
•Forest coverage is greatest in the western and southwestern margins of the NGPAA, as well as the Black Hills.

Data Sources

Land coverages were provided by Information in this section was provided by CALMIT at the University of Nebraska-Lincoln from AVHRR data at a resolution of about 1 square kilometer. The data was provided as numerous coverages, including, sagebrush, grassland (wheatgrass, grama, etc.), cropland (wheat, corn, etc.), dry cropland, ponderosa pine forest and others. These were further grouped into 10 categories by EPA Region VIII and the cropland coverages were grouped together for the intensive human influence analysis.

Spatial Patterns

Both natural and human-caused changes to the landscape can affect water quality and aquatic systems. Natural events such as fires or storms can add materials to aquatic systems, and the type and amounts of materials added depend on the nature of the land cover. Changes humans make to the landscape can be dramatic as well. Utilization of grasslands by grazing can change the runoff regimes and add materials to streams. However, the most dramatic changes involve large-scale replacement of the native ecosystems with agricultural systems, especially row crops. This section examines the extent of some of these coverages to highlight areas where intensive human influence on the landscape has occurred. This

will give an idea of where in the NGPAA the aquatic systems may be most impacted as a result of human activities. This assessment does not mean to imply that areas not highlighted are unimpacted. All of the NGPAA has been affected by human use at one time or another, this section looks at the relative amounts of human influence throughout the Northern Great Plains.

Intensive human influence on the landscape is presented in Figure 3.4.1. Areas of cropland, dry cropland and cropland/pasture mixtures were added together to get a percentage of human influence in each watershed. Eastern North Dakota, eastern South Dakota, northeastern Nebraska and northeastern Montana are areas with greater than 90% cropland in each watershed. Areas of extensive cropland also exist throughout much of North Dakota, central Nebraska and western South Dakota. The North-central Great Plains, Western Glaciated Plains, Red River Valley, Northeastern Glaciated Plains and Northern Glaciated Plains are the ecosections with the greatest intensive human influence in the NGPAA. In contrast, northeastern Wyoming, central South Dakota, the Sand Hills and northern and southeastern Montana show less cropland and less intensive human use. These areas match closely the non-cropped grassland areas depicted in Figure 3.4.2. Figure 3.4.3 presents the watersheds with the greatest amount of coniferous forest areas, with the western and southwestern margins of the NGPAA, as well as the Black Hills containing the greatest amounts.

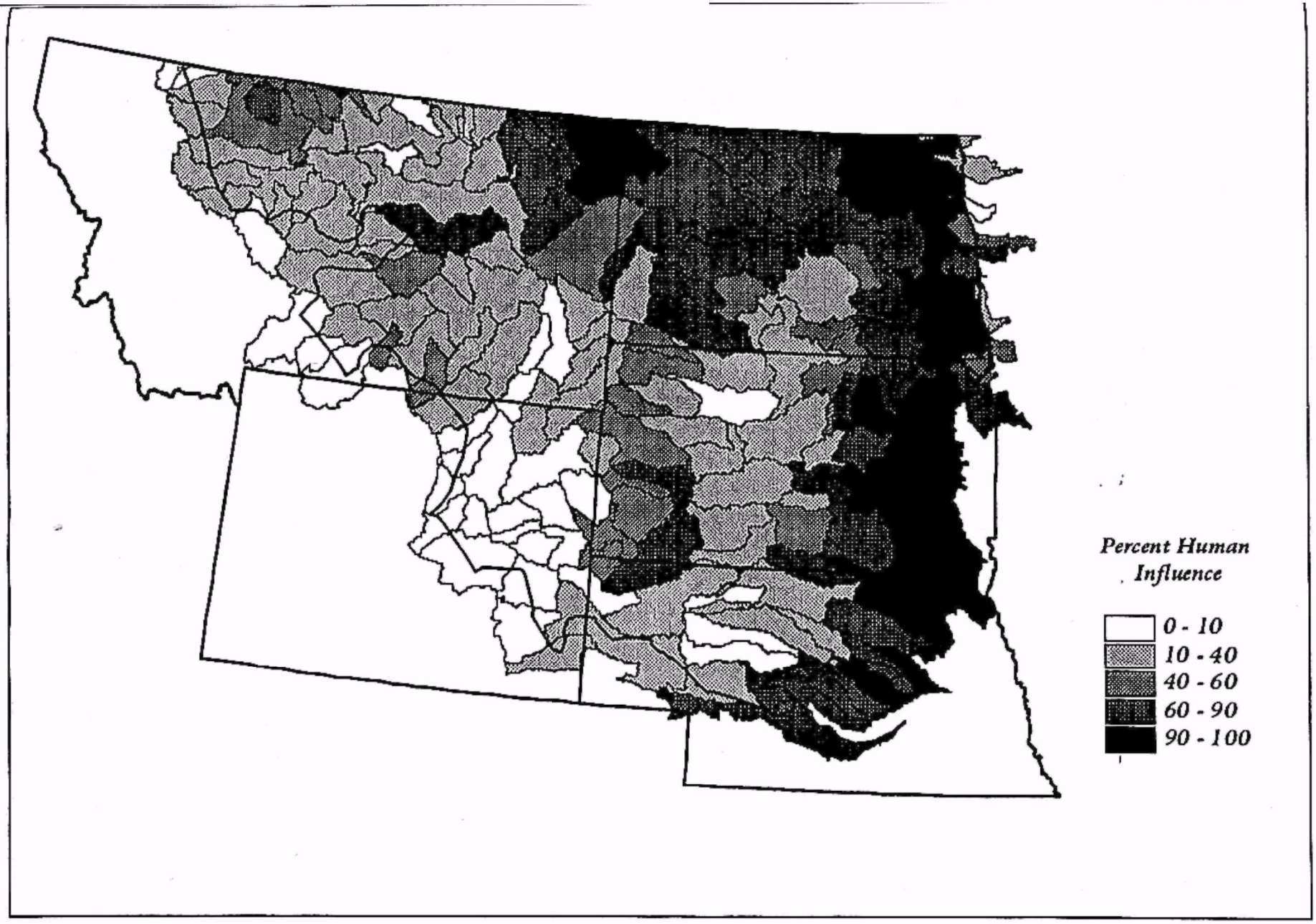

Figure 3.4.1 Intensive Human Influence in the NGPAA: Percentage of Cropland and Pastureland Coverages by Watershed

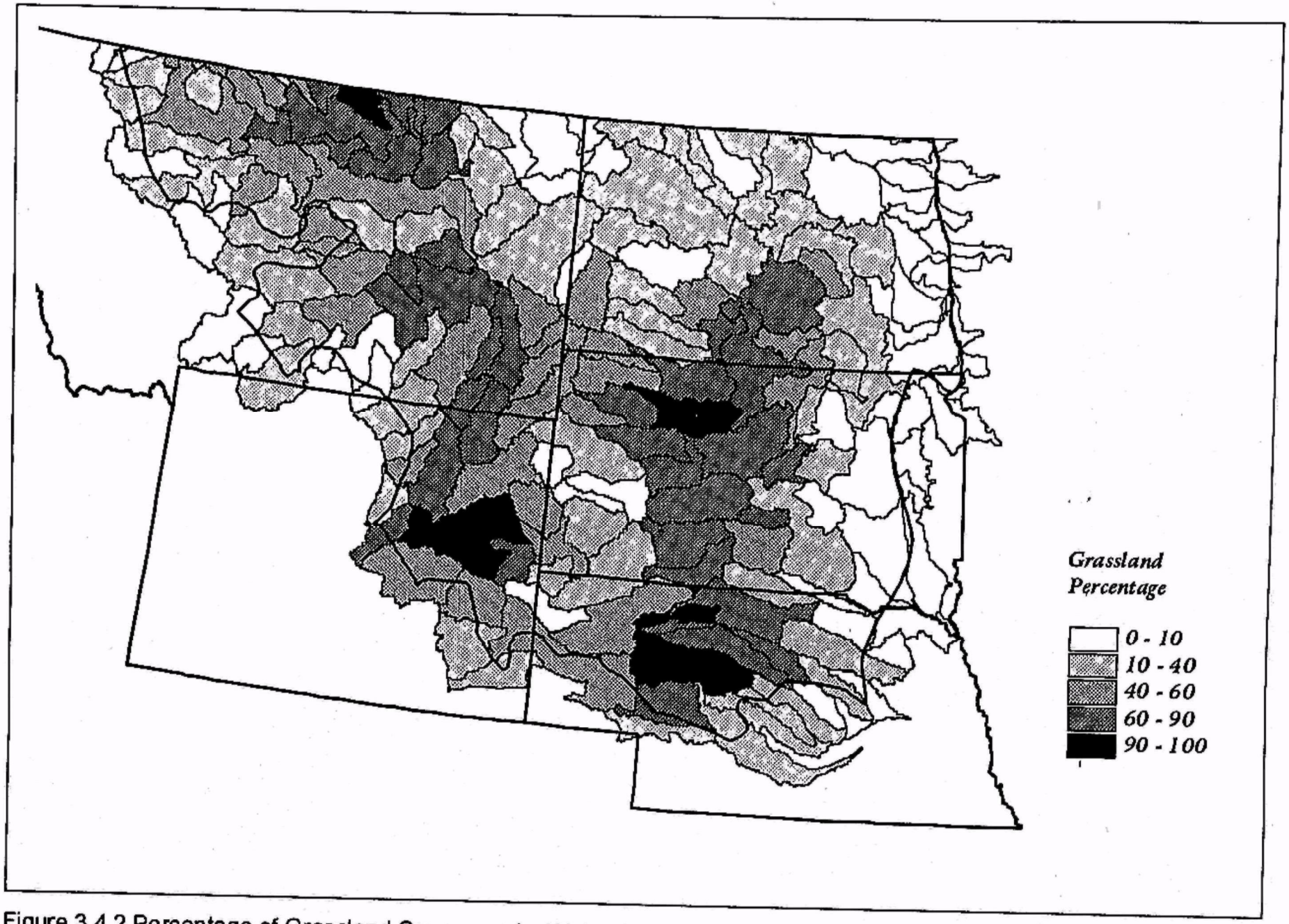

Figure 3.4.2 Percentage of Grassland Coverages by Watershed

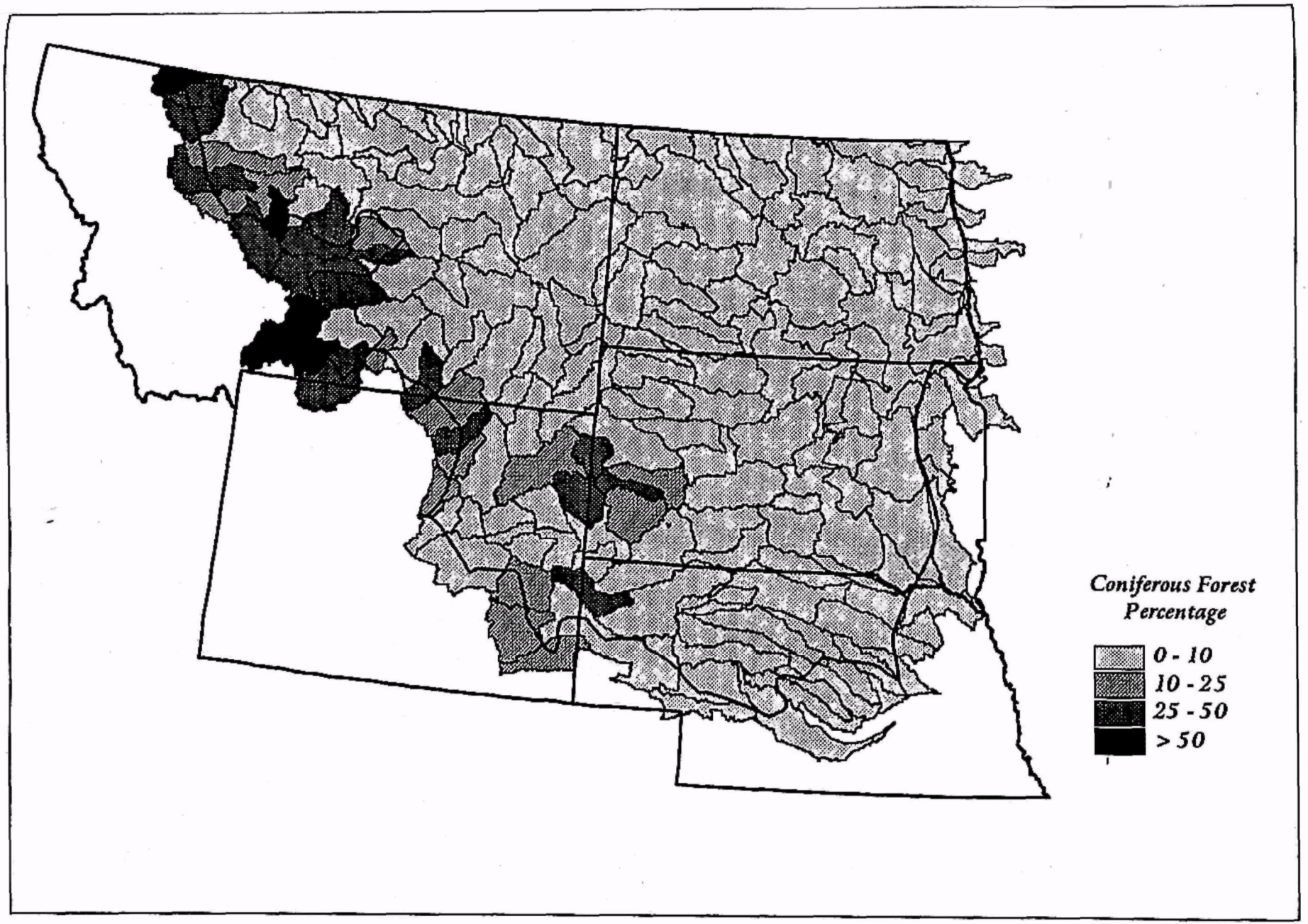

Figure 3.4.3 Percentage of Coniferous Forest Coverages by Watershed

Water Laws and Restoration Programs

4.1 INTRODUCTION

Question 3 **What laws, policies and programs for the protection of water quality, streams, wetlands and riparian area are in place, and how do they affect aquatic resources, other resources and human uses within the Northern Great Plains Assessment Area?**

This chapter describes the various laws, regulations and restoration programs in place to protect water quality and aquatic species. Section 4.2 focusses on laws. Highlighted are the Clean Water Act, the Safe Drinking Water Act and the Endangered Species Act. However, a number of federal and state laws are discussed. Section 4.3 introduces the numerous aquatic restoration programs such as grants and incentives provided that affect aquatic resources.

4.2 LAWS AND REGULATIONS

Introduction

This section summarizes the components of the Clean Water Act, the Safe Drinking Water Act and the Endangered Species Act. These are the three major pieces of federal legislation available to protect aquatic resources.

Clean Water Act

The Federal Water Pollution Control Act (commonly referred to as the Clean Water Act) was originally passed in 1948. That version and subsequent versions until 1965 basically only provided funds for building sewage treatment plants and supporting efforts for interstate cooperation. The 1965 Act directed states to set water quality standards establishing water quality goals for interstate waters. The greatest change, however, came with the reauthorization in 1972. This Act made discharging of effluent to waters of the United States a privilege, not a right, and a permit was required to do so. It also made it illegal to dredge or fill waters of the United States without a permit. Prior to this, states set water quality standards and dischargers were expected to meet them, but a direct responsibility of the discharger for the pollution had to be proven. This was often very difficult. The 1972 Act set goals of restoring and maintaining the biological, physical and chemical integrity of the nation's waters and no discharge of pollutants.

The Clean Water Act was reauthorized in 1977 and 1987. The 1987 reauthorization added Section 319, a program to deal with nonpoint source pollution. The following sections describe the programs under the Clean Water Act that deal with water quality standards, point source pollution, nonpoint source pollution and wetlands loss.

Water Quality Standards

Water quality standards consist of three elements. The first, designated uses, describes existing and/or potential uses of a waterbody. Uses include recreation, agriculture, drinking water supply and aquatic life protection. The second element, water quality criteria, are expressed as numeric pollutant concentrations or narrative requirements, that are designed to protect the designated uses. The third element, an antidegradation policy, maintains and protects the existing water quality (where water quality is better than minimally required by the water quality criteria) and existing uses, whether or not such uses have been designated.

States and tribes set water quality

standards and are required to review their standards every three years and revise them if necessary. States and tribes adopt the standards, which are submitted to the U.S. Environmental Protection Agency (EPA) for approval. If the EPA disapproves a standard, the changes necessary are communicated to the state or tribe. If the state or tribe fails to make the required changes, the EPA can promulgate a federal standard to replace it.

There are several important uses for water quality standards in the protection of the nation's waters. These include calculating permit limits for point source dischargers, calculating total maximum daily loads (TMDLs), issuing water quality certifications for actions affecting water quality and require a federal license or permit, preparing various reports that document current water quality conditions and developing, revising and implementing nonpoint source management plans.

Point Source Control

Under Section 402 of the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) established an approach in which dischargers to waters of the United States must at a minimum meet established technology-based effluent limitations. These limitations are developed for different categories of dischargers (mines, oil refineries, domestic wastewater treatment plants, etc.) and are based on best available technology. For example, all sewage treatment plants need to meet a certain limit for BOD, whereas mines have to meet certain limits for different metals. These limits were very successful in reducing much of the pollution to U.S. waters. However, a drawback was that technology-based limits did not take into account the waterbody receiving the discharge. These limits did not necessarily match what was necessary to protect aquatic life or drinking water uses. Also, technology-based limits do not exist for all potential pollutants. In the 1980s, the water quality-based permitting approach was overlaid onto the technology-based method, such that dischargers now must meet technology-based limits for their category and water quality based limits derived from the water quality standards for the waterbody, whichever is more stringent for a given pollutant. Water quality-based limits are derived from the water quality criteria for the waterbody to which the point source is discharging. There are additional complicating factors in converting the water quality criteria to permit limits, which include determining the dilution flow in the stream, mixing zones that may be used or any temporary modifications to the criteria.

NPDES permits are typically issued for five years in duration and in addition to the actual limits for individual pollutants, permits include monitoring and reporting requirements and may include compliance schedules (for construction of treatment facilities, etc.) to meet the limits in the permit. Compliance schedules only apply to water quality-based limits; they no longer apply to the technology-based limits because the time frames for compliance with these limits have passed. Individual states or tribes may apply for and receive the authority to administer the NPDES program, thereby issuing the permits directly, instead of EPA. Most states in the United States now are authorized to administer the NPDES program. There are some individual components of the NPDES program that are not delegated to all the states in the Northern Great Plains Assessment Area, which will be discussed, but all have the basic authority to issue permits for direct dischargers to surface waters. A discharger must apply to the state (or EPA if non-delegated) for a permit, and cannot discharge until one is received. To discharge without a permit is a violation of the Act.

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Research Triangle Park, NC 27711

The NPDES program contains several important programs within it in addition to the individual discharger controls. These are pretreatment, biosolids and storm water programs. The pretreatment program controls discharges from industrial facilities into the wastewater treatment system of municipalities through individual permits issued by the cities to the industries. The pretreatment program is run by EPA for all the states in the Northern Great Plains, except South Dakota and Nebraska. The biosolids program regulates the disposal or land application of sewage sludge from municipal wastewater treatment plants. Presently, none of the states in the Northern Great Plains have delegation to administer this program. The storm water program controls discharges to surface waters from industrial facilities, construction sites and larger cities as a result of storm water runoff. Certain industrial facilities and construction sites are permitted under large general permits, but each state is responsible for the program since it is considered part of the basic NPDES permitting program. The general permits contain requirements for developing a storm water pollution prevention plan and certain best management practices must be employed, depending on the industry. Currently, only cities with populations greater than 100,000 need individual permits. At present, there are no cities in the Northern Great Plains that are required to have a permit under the storm water program. However, phase II of the stormwater program will have lower population thresholds and will most likely include some cities in the NGPAA.

Important point sources within the NGPAA are municipal wastewater plants, oil wells and refineries, coal mines and feedlots with more than 1000 animal units. An animal unit is equivalent to one beef cow and other animals are set equal to this. For example, a confined animal feeding operation consisting of hogs would need 2500 animals to be regulated as a point source. Operations with less than 1000 beef cattle or less than 2500 hogs are considered to be nonpoint sources under the Clean Water Act unless they are designated as a point source due to a significant water quality impairment. Feedlots of eligible size are required to contain runoff from the site up to certain sized storms.

A distinction should be made for irrigation return flows as well. Although many irrigation returns may emanate from what would normally be considered distinct point sources, they are exempt from the definition of a point source by Section 502(14) of the Clean Water Act. Therefore, irrigation returns are not required to have NPDES permits and are considered nonpoint sources.

Additionally, some states have permitting programs with respect to discharges to ground water. For example, the South Dakota ground water discharge permit program requires permits when discharges are above ground water quality standards and the program includes three permits: a permit for construction, a water quality variance (which limits the area and quality of discharge) and the discharge permit (South Dakota Department of Environment and Natural Resources, 1996).

Nonpoint Sources

The 1987 amendments to the Clean Water Act added Section 319, a program designed to address nonpoint source pollution. Nonpoint source pollution is that which does not enter surface waters through a discrete point source or has been exempted from classification as a point source (i.e., irrigation return flows). Nonpoint source pollution can originate from a broad area and can be from sources that are intermittent (e.g. runoff from precipitation events). Nonpoint source pollution originates from atmospheric deposition, runoff from

agricultural lands (crops, range), runoff from land-disturbing activities, runoff from feedlots with less than 1000 animal units, poorly maintained on-site wastewater systems (septic tanks), runoff from road construction and maintenance, hydrologic modification and removal of riparian vegetation, as well as many other sources. Nonpoint source pollution is much more difficult to control because it is generally less visible and methods that would be employed to control point sources might not be effective (i.e., permits).

Nonpoint source pollution is a major threat to the nation's waters. The 1994 Report to Congress (305(b) Report) summarizing all the states' assessment efforts for that two-year cycle stated that 36% of streams and 37% of lakes had impaired water quality. Of the impaired streams, 60% of the impairment was due to agriculture, the leading (but not only) source of nonpoint source pollution (U.S. Environmental Protection Agency, 1995). Agriculture was responsible for 50% of the impairment of lakes in the country. Fully 22% of all assessed streams in the nation are impaired due to agriculture.

Section 319 required the states to identify nonpoint source problems, develop nonpoint source assessment reports, adopt nonpoint source management programs to control nonpoint sources and implement the management programs over multiple years (Council for Agricultural Science and Technology, 1992). The EPA is authorized under Section 319 to provide grants to states and tribes to assist them in implementing their programs. The programs are subject to approval by EPA and all states, including those in the Northern Great Plains, have EPA-approved programs. Approximately half of the funding provided to the states by EPA each year is available for statewide program activity (staffing, outreach, etc.) and the other half is for specific nonpoint source projects (Council for Agricultural Science and Technology, 1992). The nonpoint source projects to be funded within a state are chosen by state nonpoint source task forces, which are generally made up of representatives from public agencies and private groups.

Tribes with approved nonpoint source management programs are also eligible for funding under Section 319. The nonpoint source management plans should include, in part, an emphasis on a watershed approach, measures designed to remedy present problems and prevent future problems, and state identification of Federal lands which are not managed consistently with state nonpoint source objectives. Implementation of plans should include a mix of regulatory programs, non-regulatory programs and financial and technical assistance. Improvements in water quality affected by nonpoint sources are acheived through the implementation of best management practices (BMPs). These can be structural and/or nonstructural techniques to prevent or reduce the nonpoint source pollution. Examples, among many, include fencing or proper grazing sytems, sediment basins, irrigation water management (sprinkler systems, canal lining), grass buffer strips and installation of culverts to prevent erosion (Colorado Water Quality Control Division, 1990; State of Utah. 1995).

Wetlands Protection

Section 404 of the Clean Water Act prohibits the discharge of dredged or fill material into waters of the United States (e.g., rivers, lakes, streams, wetlands) without a permit from the U.S. Army Corps of Engineers. The removal of material is also regulated. Dredged or fill material includes soil, sand, gravel or other material. Wetlands are defined by the Corps of Engineers and the Environmental Protection Agency as "those

areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soils."

Common types of activities that are regulated include channel construction and maintenance, transportation improvements, construction of water resource projects (dams, levees, etc.) and fills to create development sites. Some activities that may destroy wetlands such as drainage and groundwater pumping may not be regulated because they often do not involve discharging dredged or fill material. Certain activities are exempt from needing a permit. These include (among others) normal farming or ranching of a wetland area (does not involve filling it); maintenance of damaged structures such as bridge abutments, dams, levees, etc.; construction or maintenance of farm or stock ponds or irrigation ditches; and maintenance (but not construction) of drainage ditches.

Discharges of dredged or fill material can be authorized by either an individual or general permit issued by the Corps of Engineers or an authorized state or tribe. No states or tirbes in the Northern Great Plains are presently authorized. Individual permits would apply to a specific action. General permits can be issued on state, regional or nationwide basis. General permits must cover actions that are similar in nature and will cause minimal adverse environmental effects individually or cumulatively. A permit for an action to discharge dredged or fill material must be denied if the action does not comply with the Section 404(b)(1) guidelines. The guidelines under this Section were developed by both the EPA and the Corps of Engineers and contain criteria used to evaluate the impacts of a proposed action. The guidelines include requirements that no discharge can be permitted if there is a practicable alternative with less adverse impact on the aquatic environment and no discharge can be permitted if it would violate other laws such as state water quality standards or the Endangered Species Act. In addition, under Section 401 of the Clean Water Act, states (and in some circumstances, EPA) can certify that the action will comply with water quality standards. The EPA does have the authority under Section 404(c) to "veto" a permit if the EPA finds that it will have unacceptable adverse effects.

Enforcement of the 404 program is carried out by both the EPA and the Corps of Engineers. The Corps has the lead on enforcement of violations of Corps-issued permits and also a significant amount of enforcement against unauthorized discharges. The EPA focuses its enforcement efforts on unpermitted discharges of dredged or fill material.

States have an important role in the 404 program under Section 401 of the Clean Water Act. The Corps cannot issue a 404 permit if the state denies certification that the action will not violate the state's water quality standards. This certification is necessary for many other federal permits as well (including EPA-issued NPDES permits).

Other Important Clean Water Act Provisions

Section 305(b) of the CWA requires states to submit a report to Congress every two years detailing the condition of the waters within that state, whether they are meeting the designated uses and what the causes and sources of the impairment are. Causes of impairment mean the individual parameters or actions such as nutrients, metals, thermal modifications or habitat alterations. Sources of impairment include things such as rangeland, municipal point sources or resource

extraction.

Section 303(d) requires that every two years that states send the EPA a list of every impaired waterbody. Impaired waterbodies are those that do not meet designated uses. Additionally, states must list impaired waterbodies for which a total maximum daily load (TMDL) will be performed. TMDLs are the total load of a particular pollutant that a stream or lake can assimilate from all sources and not exceed water quality standards. The TMDL process analyzes what the loading of a particular pollutant is from point and nonpoint sources and partitions what is allowed to be contributed from both. This has a direct effect on the NPDES permits for the stream or lake where a TMDL has been done, in that it may set the limits for that pollutant lower than might otherwise be calculated through a straight dilution calculation. This may happen because other sources (both point and nonpoint) are also contributing and using up part of the capacity of the waterbody to assimilate pollutants. In addition, for many TMDLs involving nonpoint sources, stream and riparian condition information are needed.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) was first passed in 1974, and most recently reauthorized in 1996. It regulates the quality and protects supplies of drinking water, both surface and ground water. It requires the EPA to set Maximum Contaminant Level Goals (MCLGs) for public water systems (not streams or lakes) and either Maximum Contaminant Levels or specific treatment techniques for the specific contaminants. MCLGs are nonenforceable goals set at the level where no known or anticipated adverse effects on the health of persons occur. MCLs are to be set as close to the MCLG as is feasible considering the best technology available with an allowance to consider costs. Treatment techniques are set only if it is not feasible to determine the level of a contaminant in drinking water.

SDWA also requires the preparation of Wellhead Protection Programs by each state to protect public water supply wells from contamination (Council for Agricultural Science and Technology, 1992). The Wellhead Protection Programs must include the following components: delineation of Wellhead Protection areas, source identification, description of management approaches, contingency plans and site controls for new wells (Council for Agricultural Science and Technology, 1992). South Dakota's wellhead protection program was approved by the EPA in 1992, although most efforts to date have been in the Big Sioux Aquifer area which is outside of the NGPAA (South Dakota Department of Environment and Natural Resources, 1996). Montana's program was submitted in 1993. North Dakota's program was approved by EPA in 1992 and as of 1994 there were 72 public water systems participating in the wellhead protection program, which is 25% of systems in the state and 40% of the population served by systems using groundwater (North Dakota Department of Health, 1994).

The Underground Injection Control Program (UIC) is another important component of the Safe Drinking Water Act. The Act requires states to develop a UIC program to prevent contamination of underground drinking water supplies by injection wells (Council for Agricultural Science and Technology, 1992). There are five categories of wells, which are listed below (from Pettyjohn, et al. 1991):

Class I - used to inject hazardous and non-hazardous waste beneath the lowermost formation containing an underground source of drinking water.

Class II - used to inject brine from oil and gas production.

Class III - used in conjunction with solution mining of minerals.

Class IV - used to inject hazardous or radioactive wastes into or above an underground source of drinking water (banned nationally).

Class V - none of the above but which typically inject non-hazardous waste into or above an underground source of drinking water (also known as shallow injection wells).

Class V wells include agricultural drainage wells receiving such inflows as field drainage, irrigation return flow and feedlot waste (Council for Agricultural Science and Technology, 1992). Class V wells can be authorized to operate if their existence was reported to the states or the EPA with the specified time and they do not cause the violation of an MCL in an underground drinking water source. Septic systems fall under this authority as well, however, those that serve single-family residences and those that are used only for sanitary waste and the capacity to serve 20 people or less are exempt.

The South Dakota UIC program presently regulates the underground injection of oil and gas wastes and has applied for the authority to regulate in situ mining and Class V wells (South Dakota Department of Environment and Natural Resources, 1996). South Dakota does presently have minimum construction requirements for septic systems (South Dakota Department of Environment and Natural Resources, 1996). The North Dakota program has permitted three Class I wells and with 75% of the state surveyed, there were 613 Class V wells in 1994, which are permitted by rule in North Dakota (North Dakota Department of Health, 1994).

The Underground Storage Tank (UST) and Leaking Underground Storage Tank (LUST) programs protect ground and surface water by remediating leaking underground storage tanks and establishing standards for new tanks. South Dakota was granted the UST program in 1995 and regulations include tank notification, performance standards, requirements for new UST systems, financial responsibility, upgrading of existing systems, release detection, reporting of spills and closure (South Dakota Department of Environment and Natural Resources, 1996). South Dakota also has Leaking Underground Storage Tank trust fund for identifying parties responsible for contamination and for cleanup when these parties cannot be found and a Petroleum Release Compensation Fund to help smaller tank owners with the costs of cleanup (South Dakota Department of Environment and Natural Resources, 1996). Wyoming has applied for primacy of the UST program and has similar requirements as South Dakota including a tax on mineral royalties to help pay for cleanups (Wyoming Department of Environmental Quality, 1996).

Endangered Species Act

The earliest version of the Endangered Species Act was passed in 1966. It allowed listing of species as endangered and directed the Departments of Interior, Agriculture and Defense to seek to protect listed species and attempt to preserve their habitats. The reauthorization of 1969 added the ability to list foreign species and prohibit their importation. However, it was the Endangered Species Act of 1973 that significantly changed how endangered species would be protected in the United States. The 1973 Act stated its purposes as providing "a means whereby the ecosystems upon which endangered species depend may be conserved..." and "...to provide a program for the conservation of such species...".

The Act (and its subsequent amendments in 1978, 1982 and 1988) defined categories of endangered and threatened. It included plants and invertebrates, along with vertebrates as being eligible for protection. It defines species as any species, subspecies, or variety of plant or species, subspecies or population of animal. It allowed for the designation of experimental populations of a species that could be subject to lesser restrictions.

The criteria for listing a species includes present or threatened destruction of habitat; overutilization by commercial, recreational, scientific or educational purposes; disease or predation; or inadequacy of existing regulatory mechanisms or other natural or man-made factors affecting its continued existence. The Act under Section 9 prohibits the taking of an endangered animal species by anyone and recent court cases have reaffirmed that destruction of habitat is a take, not just direct harm to the species. Section 4 requires critical habitat to be designated concurrently (when prudent) with the listing of a species and economic factors are required to be considered when designating critical habitat. Economics is not to be taken into account when listing. Anyone can petition the U.S. Fish and Wildlife Service (FWS) to add or remove a species from the list. The FWS has 90 days to decide whether more information is needed, whether the listing may be warranted and 1 year to make its finding. Previously, there were three categories of candidate species for listing. This has been reduced to one, which is a list of those where substantial information exists to support listing. The former category 2 species are no longer listed (those for whom information existed indicating listing may be appropriate, but further information was needed).

Section 7 of the Act requires all federal agencies to undertake programs for the conservation of endangered and threatened species and prohibits them from authorizing, funding or carrying out any action that would jeopardize a listed species or modify its critical habitat. An amendment in 1978, however, allowed a cabinet-level committee to convene and elect to allow a federal agency to undertake an action that would jeopardize a species. If an action by a federal agency may affect a listed species, it is required to consult with the U.S. Fish and Wildlife Service. The federal agency provides information to the FWS on whether it believes the action will jeopardize the species or adversely modify its habitat. The FWS issues an opinion on whether the action will jeopardize the species. In determining jeopardy, the FWS first looks at the present status of the species, and then adds to this baseline the effects of the proposed federal action, along with cumulative effects such as state and private actions reasonably certain to occur. The FWS identifies reasonable and prudent alternatives that can be implemented which would avoid jeopardy. An incidental take permit is issued with the Biological Opinion to allow some taking of individuals or habitat along with reasonable and prudent measures necessary to reduce the amount of incidental take.

Section 4 contains the requirements for recovery plans. A recovery plan outlines the major recovery actions that will be needed for the species.

Several states within the NGPAA have state endangered species laws. Nebraska has probably the most comprehensive in that it covers both animals and plants, recovery plans and state agency consultation is required and critical habitat designation is authorized (Center for Wildlife Law, 1996). Montana's act covers only animals, but recovery plans are required; state agency consultation and critical habitat designation is not required. South Dakota's act covers both plants and animals, but has no requirement for

recovery plans, consultation, or critical habitat. North Dakota and Wyoming do not have state endangered species acts, although management programs for endangered species are authorized under separate statutes in North Dakota (Center for Wildlife Law, 1996).

Other Laws

Table 4.2.1 lists other federal and state laws that have some impact on protection of water quality and aquatic habitat and describes the section(s) that relate to that issue.

There are other wetland protection statutes besides the Clean Water Act that are worth mentioning such as the Emergency Wetland Acquisition Act, the Farm Bills of 1985, 1990 and 1996 and Title IV of the Tax Reform Act of 1986 (Leitch and Baltezore, 1992). The Emergency Wetland Acquisition Act requires states to include wetland priority plans in their state comprehensive outdoor recreation plans. The Food Security Act of 1985 (and changes in 1990 and 1996), referred to as Swampbuster, discourages wetland conversion for agricultural purposes by denying farm program benefits, such as deficiency payments, Commodity Credit loans, and federal crop insurance, on all land the farmer manages if the operator converts any wetland on that land. This threat of ineligibility, when there are low crop prices, makes this act effective in limiting wetland damage; it loses its effectiveness to protect wetlands as crop prices rise. There are about 7.5 million acres of wetlands in the Northern Great Plains subject to the Food Security Act regulations (U.S. Natural Resources Conservation Service, 1996). The Tax Reform Act of 1986 removed the ability to deduct drainage expenses of wetland drainage costs not in compliance with the swampbuster provision and the gains on the sales of converted wetlands are treated as income rather than capital gains, which are taxed at a lower rate.

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) is another law which has some important provisions relating to the protection of aquatic systems. Under FIFRA, the EPA can require labeling to inform the pesticide applicator that the pesticide must be used in a manner that prevents water supply contamination (Council for Agricultural Science and Technology, 1992). In addition, the EPA may restrict, cancel, or temporarily suspend all or some pesticide uses that pose unreasonable risks to human health or the environment through contamination of water supplies. The EPA can also require states to develop chemical-specific state management plans for particular pesticides as a condition for continued use of that pesticide (Council for Agricultural Science and Technology, 1992).

4.3 AQUATIC RESTORATION PROGRAMS

This section describes the various federal funding sources available to restore or protect aquatic resources. All of these are nonregulatory and are available through a number of federal agencies such as the Forest Service, the Natural Resources Conservation Service, the Environmental Protection Agency, the Fish and Wildlife Service, the National Park Service and the Corps of Engineers to name a few. Much of this information was obtained from the following sources: U.S. General Accounting Office (1996), U.S. Environmental Protection Agency (1997b), U.S. Environmental Protection Agency (1997c) and U.S. Department of Agriculture (1996).

Table 4.2.1 A Summary of Other Statutes that have included provisions for the protection or maintenance of water quality, aquatic habitat or aquatic species.

Name	Purpose with respect to water quality and responsible agency
Water Resources Planning Act	prepares regional or river basin plans to conserve, develop and use water (Water Resources Council and OMB)
Rivers and Harbor Act	governs dumping of water into, and the excavation of, navigable waterways (COE)
Wild and Scenic Rivers Act	preserves rivers and their riparian areas of special recreational and aesthetic value
Executive Order 11190 (Wetlands)	governs conservation and use of salty and freshwater wetlands (DOI)
Migratory Bird Conservation Act Fish and Wildlife Coordination Act Fish and Wildlife Act	governs conservation of migratory waterfowl and fisheries (FWS)
National Environmental Policy Act	disclosure of environmental effects of federal projects (responsible federal agency)
Resource Conservation and Recovery Act	hazardous waste control (EPA, states)
Federal, Insecticide, Fungicide and Rodenticide Act	pesticides, registration (EPA, states)
Comprehensive Environmental Response, Compensation and Liability Act	superfund cleanups of abandoned waste sites (EPA)
Clean Air Act	atmospheric deposition - acid precipitation, toxics (EPA, states)
Executive Orders for wetland and federal floodplain management	requires wetland and floodplain values to be considered during planning of actions

Table 4.2.1 (cont.) A Summary of Statutes that have included provisions for the protection or maintenance of water quality, aquatic habitat or aquatic species.

Name	Purpose with respect to water quality and responsible agency
National Forest Management Act	National Forest System lands planning (USFS)
Surface Mining Control and Reclamation Act	reclamation of mined areas, mainly coal mine reclamation (OSM)
Soil and Water Resources Conservation Act	requires the identification and evaluation of alternative methods for conservation, protection and enhancement of soil and water resources
Toxic Substances Control Act	requires testing of existing chemicals for toxicity (EPA)
Federal Land Policy and Management Act	planning for BLM lands (DOI)
Wilderness Act	prohibits roads and vehicles in National Wilderness Preservation System (USFS, DOI)
National Parks and Recreation Act	sets aside national parks (DOI)
Executive Order 1014	establishes National Wildlife Refuges (DOI)
Executive Order 11644	controls use of off-road vehicles in public lands
Surface Mining and Reclamation Act	surface mine reclamation for coal mines (DOI)
Examples of State Statutes:	
North Dakota No-Net Loss	protects wetlands in watersheds greater than 80 acres
SDCL 34A-2 South Dakota General Water Pollution Control Statute	gives South Dakota the authority to regulate pollution, monitoring and cleanup of state waters, this includes ground water and above and underground storage tanks

Department of Agriculture

Cooperative State Research, Education and Extension Service

National Research Competitive Grants Program supports research on key problems of national and regional importance in biological, environmental, physical and social sciences relevant to agriculture and food and the environment, including water resources assessment and protection. This program was authorized by Section 2(b) of the Act of August 4, 1965, Public Law No. 89-106.

Sustainable Agriculture Research and Education Program, among other goals, supports investigations and education in the use of pesticides and fertilizers in agriculture. Grants are to universities, agriculture experiment stations, nonprofit organizations or federal or state governments.

Farm Service Agency

Environmental Quality Incentives Program establishes conservation priority areas to deal with water, soil, and related natural resource problems. It establishes five to ten year contracts to provide technical assistance and pay up to 75% of the costs of conservation practices, but is limited to $50,000 per contract. EQIP was authorized by the 1996 Farm Bill which provided for $200 million annual funding.

Conservation Reserve Program was authorized under the 1985, 1990 and 1996 Farm Bills. Its purpose is to improve soil and water quality by reducing soil erosion and sedimentation and establish wildlife habitat by providing direct cost-share payments, annual rental payments and technical support. Cost-share payments are limited to up to 50% of the cost to establish groundcover for erosion-reduction purposes. A total of up to 36.4 million acres are allowed to be enrolled at any one time.

Farm Debt Cancellation Conservation Program was authorized by 1985 Farm Bill (Food Security Act). Its purpose is to protect marginal and sensitive lands under federal farm loans by buying easements for conservation, recreation, and wildlife purposes. Program participants are given debt cancellation on outstanding loan balances in exchange for conservation measures. The 1996 Farm Bill took away easements and authorized the entering into of contracts for these measures.

Wildlife Habitat Incentives Program provides for $50 million to be cost-shared with landowners for developing habitat for upland wildlife, wetland wildlife, endangered species, fisheries and other wildlife.

Forest Service

Stewardship Incentive Program was authorized by the 1990 Farm Bill with the purpose of encouraging private landowners to manage their forest land in ways that improve water quality, including tree planting and the implementation of BMPs for stream crossings and streamside management. Assistance is provided in direct payments, technical support and education. The federal cost-share cannot exceed 75% of the total cost.

Natural Resources Conservation Service

Emergency Wetland Reserve Program was authorized by the 1990 Farm Bill and Emergency Supplemental Appropriation Acts of 1993 and 1994. Its purpose is to protect and restore wetlands affected by the 1993 Midwestern flood through acquisition of easements and provision of technical and restoration cost-share assistance. The assistance is provided in direct payments at

fair market agricultural land values for permanent easements and 30-year easements, payments for restoration costs of 100 percent for permanent easements and 50% for 30-year easements

River Basin Surveys and Investigations provides planning assistance to federal, state and local agencies for the development of coordinated water and related land resources programs, with priority given to solving upstream flooding of rural communities, improving the quality of water emanating from agricultural nonpoint sources, wetland preservation, drought management for agriculture and rural communities, and assisting state agencies in developing strategic water resource plans. Assistance is provided as studies, monitoring and technical support. It was authorized by the Watershed Protection and Flood Prevention Act, PL 83-566.

Rural Abandoned Mine Program was authorized by the Surface Mining Control and Reclamation Act of 1977, Section 406, PL 95-87. Its purpose is to protect people and the environment from the adverse effects of past coal mining practices and to promote the development of soil and water resources of unreclaimed mined lands. Assistance is provided in direct payments of up to 100% in cost-share funds for conservation practices determined to be needed for reclamation, conservation, and development of up to 320 acres per owner of rural abandoned coal mine land and waters affected by coal mining activities.

Soil and Water Conservation Program was authorized by the Soil Conservation and Domestic Allotment Act of 1936. Its purpose is to plan and carry out a national resource conservation program and to provide leadership in the conservation and use of the nation's soil, water and related resources. Assistance is provided in the form of technical soil and water conservation resource assistance to state and local governments and advisory and counseling services to the general public in order to promote total resource planning and management, improve water quality and natural resources, and reduce point and nonpoint source pollution.

Watershed Protection and Flood Prevention (Small Watershed Program) provides technical and financial assistance to state agencies and units of local government in planning and carrying out projects to protect, develop and utilize the land and water resources in small watersheds. This includes total resource management and planning to improve water quality and solve problems caused by flooding, erosion, and sediment damage, conservation, development, utilization and disposal of water. Assistance is provided in studies, monitoring, loans, cost-share grants, and technical assistance for the installation of land treatment measures. The cost-share rates depend on the type of measure, structural or nonstructural. Up to 100% is provided for construction costs for structural measures with flood prevention purposes, up to 50% for structural measures with other purposes and up to 75% for installation cost for nonstructural measures. This program was authorized by PL 83-566.

Wetlands Reserve Program was authorized by the 1990 Farm Bill. Its purpose is to protect and restore wetlands through acquisition of easements and provision of technical and restoration cost-share assistance. Assistance is provided by direct payments at fair market values for permanent easements and 30-year easements, payments for restoration costs of 100% for permanent easements and 50 to 75 percent for 30-year easements. The program has an enrollment cap of 975,000 acres.

Rural Utilities Service

Water and Waste Disposal Systems for Rural Communities was authorized by the Consolidated Farm and Rural Development Act. It finances new and improved rural water and waste disposal facilities through direct loans, loan guarantees and grants to construct or improve drinking water, sanitary sewer, solid waste and storm drainage facilities. The loans are made for useful life of the facilities, 40 years or state law limitation, whichever is shorter. Grants cannot exceed 75% of project costs.

Department of Defense

Army Corps of Engineers

Flood Plain Management Services provides information and data on floods and actions to reduce flood damage potentials, encourage prudent use of the nation's floodplains and support comprehensive flood plain management. Assistance is provided in the form of studies and technical support. This program was authorized by the Flood Control Act of 1960, Section 206.

Planning Assistance to States was authorized by the Water Resource Development Act of 1974. Its purpose is to cooperate with states and tribes in the preparation of plans for the development, utilization and conservation of water and related land resources within their respective boundaries by providing studies and technical support.

Department of the Interior

Geological Survey -

National Water Quality Assessment (NAWQA) Program's role is to assess the conditions and trends in quality of ground and surface water. The program consists of 59 study units in the United States. These include the Red River, Central Nebraska, North Platte River, Belle Fourche/Cheyenne Rivers and the Yellowstone/Powder Rivers in the Northern Great Plains.

Bureau of Reclamation

Irrigation Drainage Program. This is an initiative begun in 1986 with the purpose of developing coordinated remediation plans and implement corrective actions where irrigation drainage has affected endangered species, migratory birds and/or has caused water quality problems.

General Investigations Program. This was authorized by the Reclamation Act of 1902, PL 89-72 and PL 102-575. Its purpose is to conduct studies to meet current and future water quality, quantity and environmental needs through the management of water supplies by structural and nonstructural means. Assistance is provided in technical assistance to states and feasibility studies which require 50% cost-sharing from a nonfederal entity.

Water Treatment Technology Program works with the private sector and academic institutions to reduce the cost of water treatment and desalting technology in order to improve water supply. Assistance is provided in studies, monitoring and technical support. It was authorized by PL 57-161, 96-480 and 98-502.

National Park Service

Rivers, Trails and Conservation Assistance Program authorized by the Wild and Scenic Rivers Act, National Trails Act and the Outdoor Recreation Act. Its purpose is to advocate and assist community-based conservation action, including river restoration and water quality enhancement. Assistance is provided in the

form of short-term planning, including studies and technical assistance for the assessment of resources, identification of land protection strategies and organizational development. No federal funding is provided.

Fish and Wildlife Service

National Wetlands Inventory (NWI) coordinates the gathering, analysis, dissemination and evaluation of information regarding the location, quantity and ecological importance of wetlands (EPA, 1997b).

Contaminants Identification and Assessment was authorized by the Migratory Bird Conservation Act, the Federal Water Pollution Control Act, the Endangered Species Act, and the Comprehensive Environmental Response, Compensation and Liability Act (Superfund). Its purpose is to identify and assess the effects of contaminants on Fish and Wildlife Service lands, Trust Resources and other biological resources on and off Fish and Wildlife Service lands using short- and medium-duration studies of contaminant exposure and effect.

Contaminants Prevention was authorized by the same laws as the previous one. Its purpose is to prevent the adverse effects of contaminants to Trust resources using technical support. No federal funding is provided.

Natural Resource Damage Assessments were authorized by same laws as the previous two. Their purpose is to provide funding for the assessment of damage to water quality and Trust resources from oil spills and/or other hazardous substance releases, so that the restoration or replacement of these injured resources are paid for by responsible parties. Assistance is provided in the form of on-the-ground restoration activities paid for with damages collected from polluters.

Sport Fish Restoration/Pumpout Station Grants were authorized by the Clean Vessel Act of 1992 with the purpose of providing financial assistance to support state projects for the construction, renovation, operation, maintenance of pumpout and/or dump stations for sewage waste from recreational vessels. Assistance is provided in the form of grants and education.

Habitat Conservation Project Planning was authorized by the Fish and Wildlife Coordination Act, the Federal Water Pollution Control Act and the Federal Power Act. Its purpose is to pursue opportunities and cooperative efforts with other government agencies and private partnerships to protect, restore and enhance fish and wildlife habitats; provide technical assistance to the private sector to maximize wildlife conservation in wetlands, associated uplands and riparian areas; and advocate conservation and enhancement of fish and wildlife resources and habitats that may be affected by energy and water resource development. Assistance provided is technical assistance and advanced planning/consultation services.

North American Waterfowl Management Plan was authorized by the North American Wetlands Conservation Act of 1989. Its purpose is to support a strategy for cooperative public/private wetland habitat conservation that will reverse the decline in waterfowl and other wildlife species in the US, Canada and Mexico. Assistance is provided in the form of grants. Public and private partners must contribute an equal amount to what they receive.

Cooperative Endangered Species Conservation Fund-Grants to States provides assistance to states for the development of programs to conserve threatened and endangered species. States can receive up to 75% of the program costs. This was

authorized by the Endangered Species Act.

Partners for Wildlife Habitat Restoration Program provides financial and technical assistance to private landowners to restore habitat such as wetlands, riparian areas, and native grasslands. Federal monies make up no more than 60%. This program was authorized by the Fish and Wildlife Act of 1956 and the Fish and Wildlife Coordination Act.

North Dakota Wildlife Extension Program - This program is designed to enhance waterfowl production on private lands in North Dakota through contracts for wetland restoration and creation projects on land adjacent to CRP land.

Bureau of Indian Affairs

Fish, Wildlife and Parks Programs on Indian Lands promotes the conservation, development and utilization of fish, wildlife and recreational resources for Indian Tribes. Assistance is in the form of direct payments. The Indian Self-Determination and Education Assistance Act authorized this program.

Water Resources on Indian Lands Program assists Tribes with water resource projects and the associated planning. Assistance is in the form of direct payments. The Indian Self-Determination and Education Assistance Act authorized this program.

Department of Transportation

Wetland Mitigation was authorized by the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. Its purpose is to ensure that improvements developed for the surface transportation system do not adversely affect wetlands through grants, technical support, research and education.

Stormwater Mitigation was also authorized by ISTEA with the purpose of improving and protecting water quality from the potential adverse effects of nonpoint source discharges/stormwater runoff from highway and transit facilities. Assistance is provided with grants, technical support, research and education.

Environmental Protection Agency

Indian General Assistance Program Grants were authorized by the Indian Environmental General Assistance Program Act of 1992. The purpose is to provide general assistance grants and technical assistance to Indian tribal governments and intertribal consortia to develop and build capacity to administer regulatory and multimedia environmental programs on Indian lands. Assistance is provided in the form of grants, studies, monitoring, technical support, research, and training to support environmental program development and capacity building.

Indian Set-Aside Wastewater Treatment Grant Program was authorized by section 518(c) of the Clean Water Act with the purpose of assisting Indian tribes in planning, designing and building wastewater treatment systems. Assistance is provided with grants and technical support. This program pays up to 100% of the costs.

Nonpoint Source Implementation Grants, authorized by section 319(h) of the Clean Water Act, assist states in implementing agency-approved section 319 statewide nonpoint source management programs. Assistance is provided in the form of grants. A nonfederal match of at least 40 percent of project or program costs is required, except for tribes which may on a case-by-case basis receive approval for a lesser match.

Public Water Systems Supervision assists states and tribes in implementing National

Primary Drinking Water Regulations. Assistance is provided in grants to states and tribes with primary enforcement authority for the National Primary Drinking Water Regulations. Federal assistance is limited to 75% of eligible costs. This grant program was authorized by the Safe Drinking Water Act.

Research, Special Studies Demonstrations, Technical Assistance and Training authorized by the Safe Drinking Water Act, develops or expands the capabilities of state and municipal programs to protect groundwater sources of public water systems from contamination; provide technical assistance to small public water systems to achieve and maintain compliance with National Drinking Water Regulations. Assistance is provided in grants, studies, technical support, research and education.

Small Community Wastewater and Technical Assistance and Outreach Program, authorized by the Clean Water Act, provides on-site assistance to small communities with wastewater treatment facility operating problems. Assistance is provided in the form of grants.

State Revolving Funds Capitalization Grants, authorized by the Clean Water Act, provides a long-term source of financing to the states for the construction of wastewater treatment facilities and the implementation of other water quality management activities. Assistance provided is in the form of grants to states and loans to local communities, intermunicipal and interstate agencies and Indian Tribes.

Underground Injection Control Grants were authorized by the Safe Drinking Water Act with the purpose of assisting states and tribes in assuming the primary role in implementing and enforcing UIC regulations. Assistance is provided by grants to states and tribes with primacy. Federal assistance to states is limited to 75%.

Water Pollution Control - State and Interstate Program Support, authorized by section 106 of the Clean Water Act assists states, territories, interstate agencies and qualified tribes in establishing and maintaining adequate measures for prevention and control of surface water and ground water pollution. Assistance is provided in the form of grants. Funds cannot be used for construction, operation, or maintenance of wastewater treatment plants.

Water Quality Grants were authorized by section 104(b)(3) of the Clean Water Act. Their purpose is to stimulate the creation of unique and new approaches to meeting stormwater, sludge, pretreatment, point source control requirements. Assistance is provided by grants to states, tribes, organizations and individuals.

Wetlands Protection - State Development Grants were authorized by the Clean Water Act, with the purpose of encouraging the development of state and tribal wetland protection programs or to enhance those that already exist. Assistance is provided in grants and technical assistance. Funds must be used for the development, not operation, of a program and states and tribes must provide at least a 25% match.

Advance Identification of Wetlands is conducted by the EPA and the Corps of Engineers with state and local involvement for wetland areas that have important values and are under pressure from development. The result is a designation of areas as suitable or unsuitable for use as a discharge site and an anticipatory method of protecting the most valuable areas.

Clean Lakes Program, authorized by Section 314 of the Clean Water Act, is a grant program to provide assistance to States for restoration

of publicly-owned lakes. It has not been funded since Fiscal Year 1994.

Community-Based Environmental Protection is an EPA approach to manage the quality of air, water, land and living resources in a place as a whole while working with numerous partners, including the local community (EPA, 1997b). EPA's role varies in each area.

Sole Source Aquifer Protection is authorized under Section 1424(e) of the Safe Drinking Water Act of 1986.

Source Water Protection is a community-based approach to protecting sources of drinking water from contamination (EPA, 1997b).

Wellhead Protection Program protects groundwater sources of drinking water from contamination. The recharge area is delineated, nonpoint sources of pollution are identified and the community is informed and implements solutions (EPA, 1997b).

State of North Dakota

Environmental Easement Program - This program is designed to ensure long-term protection of environmentally sensitive land. Eligible land includes riparian corridors, CRP land coming out of retirement and critical wildlife habitat for threatened and endangered species. Land is protected using permanent or maximum duration easements.

North Dakota Habitat Stamp and Interest Money Programs - These programs provide 25 to 35 percent cost-sharing for wetlands restored or developed under the Agricultural Conservation Program or CRP. At least 21,000 acres have been restored or enhanced in North Dakota through this program.

Impacts of Human Activities

5.1 INTRODUCTION

Question 4 **What are the current and potential effects on aquatic resources from various human activities?**

The impacts to water quality, aquatic species and aquatic habitats from human activities is examined in this chapter. These include human population described in section 5.2, hydrologic modifications such as dams, diversions and channelization described in section 5.3, effects from point source dischargers such as cities and industries and nonpoint source effects such as runoff from cropland (section 5.4). Included as well are sections summarizing impacts to ground water (5.5) and aquatic species (5.6).

5.2 HUMAN POPULATION

Introduction

An overall indicator of impacts, though not necessarily directly, is human population. Human population throughout the NGPAA is generally low, with no cities having a population greater than 85,000. However, where population is concentrated, greater and different impacts can occur. This parameter is discussed up front due to the varying impacts population may have on aquatic systems.

Key Findings

•Human population in the NGPAA is mainly centered around a number of cities (Billings, Fargo, Bismarck, Rapid City, Casper, etc). Much of the area has a low population density.
•Human population growth is occurring fastest in counties with the larger cities, the area surrounding the Black Hills, southern Montana, northeastern Wyoming and in a number of Indian Reservations.

Data Sources

This information was obtained from U.S. Census Bureau data estimates for 1995 and changes in population was determined by comparing the 1980 Census figures and the 1995 estimates.

Spatial Patterns

Figure 5.2.1 shows the distribution of population in the Northern Great Plains. The counties with the largest population correspond to the largest cities such as Yellowstone County, Billings, MT; Cascade County, Great Falls, MT; Pennington County, Rapid City, SD; Natrona County, Casper, WY; Cass County, Fargo, ND; Grand Forks County, Grand Forks, ND; Burleigh County, Bismarck, ND and Ward County, Minot, ND. All of these counties have more than 50,000 people. Also important in gauging impacts and trends are the changes in population (Figure 5.2.2). The population changes between 1980 and 1995 from Census Bureau data are shown. Most of the counties in the Northern Great Plains are losing population. The counties that are gaining are those with most of the larger cities and those in or close to Indian Reservations. The largest percentage increases are in Cass and Burleigh Counties, ND; Pennington, Todd and Lawrence Counties, SD; Campbell County, WY; and Glacier, Lewis and Clark, Stillwater and Yellowstone Counties, MT. Change with regard to where people move effects the aquatic environment in a number of ways. Population increases in a certain area cam mean more development and therefore changes to the hydrologic regime of local streams, non point source pollution, more stormwater runoff, larger loadings to municipal treatment plants and sometimes an increase in the number of point sources (separate municipal discharges, new industrial discharges).

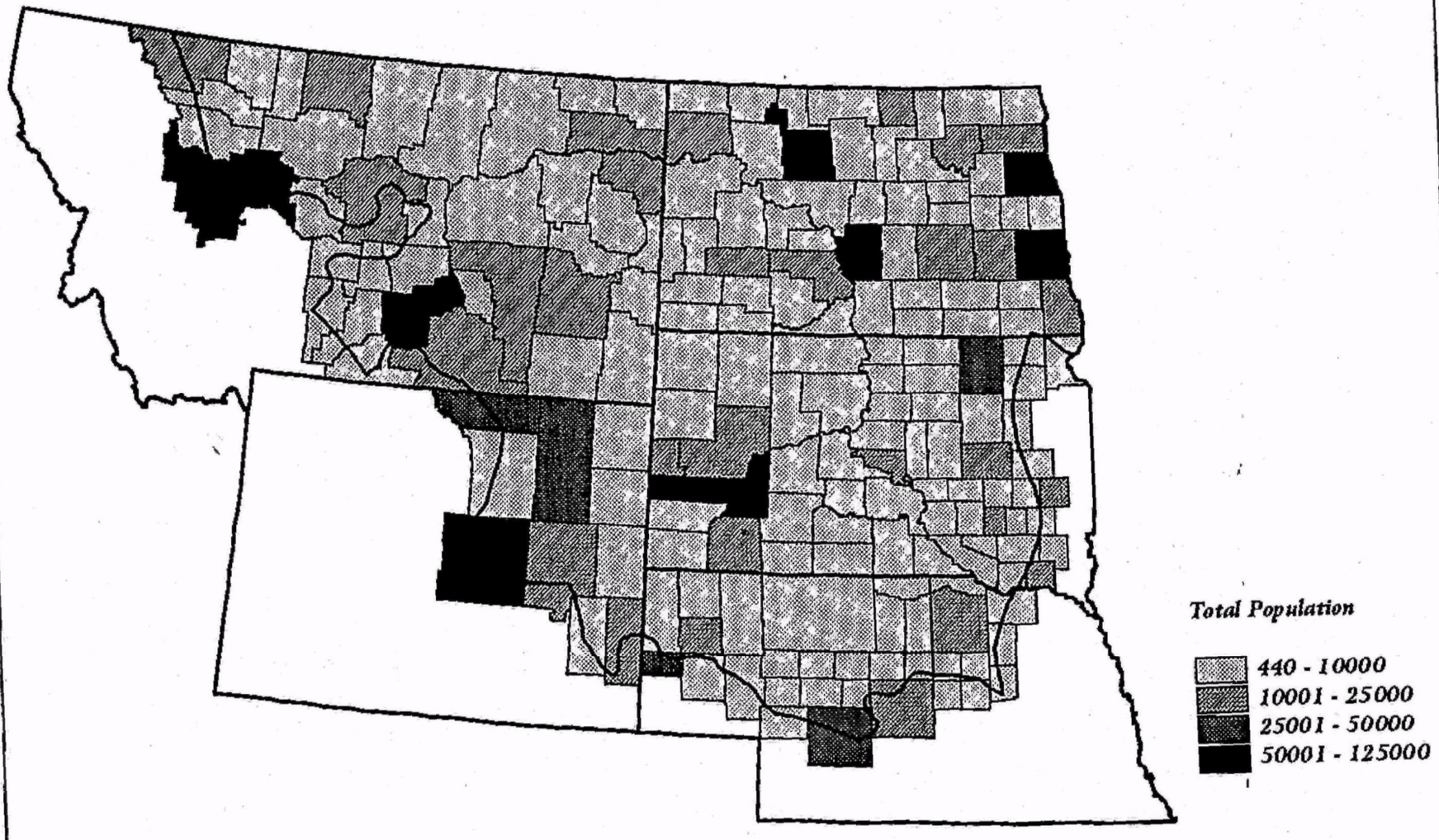

Figure 5.2.1 Total Population Per County in the Northern Great Plains

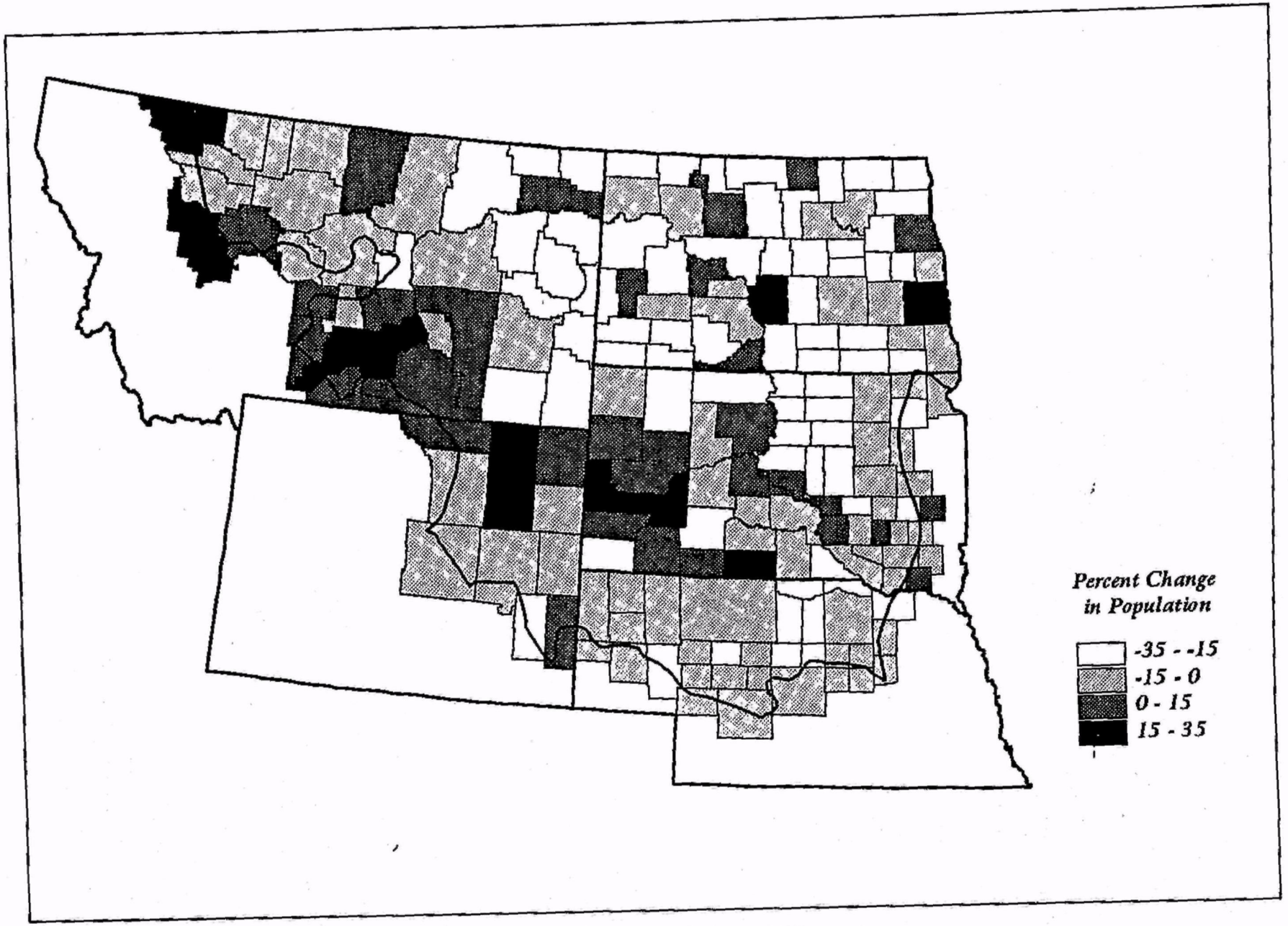

Figure 5.2.2 Percentage Change in Population by County from 1980 to 1995

5.3 HYDROLOGIC EFFECTS

Introduction

Hydrologic and aquatic habitat modifications occur throughout the Northern Great Plains under many different circumstances, especially in areas with cropland (irrigated and non-irrigated), livestock grazing, flood control and development.

Discussed in this section are modifications to both the habitat in and around waterbodies and modifications to flow. These include the removal of streamside vegetation, excavation of streambed material, alteration of the natural drainage pattern by development activities, channelization, dewatering and damming (U.S. Environmental Protection Agency, 1995). Removal of streamside vegetation increases erosion and destabilization of banks since roots are important in holding soil in place.

The removal of vegetation also causes stream temperatures to increase due to loss of shade. Temperature increases can be high enough to be detrimental to aquatic organisms. Excavation of streambed material can remove nesting and spawning habitat for fish. Development activities add pavement and, therefore, additional flow to nearby streams which increases the intensity, magnitude and energy of runoff (U.S. Environmental Protection Agency, 1995). These flow changes can lead to erosion and later deposition of sediment as the stream adjusts to the new hydrology. These runoff changes can also alter peak flows within nearby aquatic systems. Wetland drainage can also change the hydrology by adding additional flow that would have been released more slowly.

Channelization can lead to the loss of side channels, oxbows, backwaters and sandbars, all important habitat to native species and increase downstream flooding. The effects of dewatering through diversions for irrigation or other uses are important, since the reduction in flow at critical times or the loss of water entirely is devastating to the aquatic community.

Many of the effects of dams have been discussed previously in this report such as the trapping of sediment, changes in temperature downstream, blocking of migration patterns and the loss of high flood flows. The loss of high flood flows can cause the loss of spawning cues for fish, reduce cottonwood and willow regeneration and cut off fish and wildlife access to backwaters (U.S. Fish and Wildlife Service, 1994).

In the parts of the NGPAA with large amounts of row crops, runoff will be greater than from natural or pasture conditions, also affecting the hydrology of streams. Grazing of riparian areas in which large amounts of vegetation are removed will also change the flow regime, causing water to move more quickly through the system.

Key Findings

•Watersheds with the greatest number of stream miles impacted from channelization are the Middle Platte-Buffalo, the Upper Tongue, the Niobrara Headwaters, the Lower Souris River, the Maple River in North Dakota, the Lower Sheyenne, the Middle Musselshell and the Smith River.

•Watersheds with the greatest number of stream miles impacted from dams, diversions and wetland drainage are the Upper and Lower Tongue, the Lower Powder, the Sun River, the Upper Missouri-Dearborn, the Lower Bighorn, the Lower Souris, Upper Sheyenne, Pembina, Middle Sheyenne, Upper James, Lower Sheyenne, Maple River and the Western Wild Rice River.

•Watersheds with the greatest amount of

irrigated acreage are the Milk, Teton, Yellowstone, Platte, North Platte, Lower Loup, Niobrara, Elkhorn, Belle Fourche, Upper Tongue and Lewis and Clark Lake. Relatively little irrigated cropland occurs throughout much of North Dakota, South Dakota, the Sand Hills and outside of major river valleys in eastern Montana and northeastern Wyoming.

Data Sources

Information on water use changes for the years 1985, 1990 and 1995 was obtained from the U.S. Geological Survey's WATSTORE database. Most of the information regarding impacts to water quality from impoundments, channelization, diversions, etc. came from state 305(b) reports for 1994 and 1996, as well as the U.S. Army Corps of Engineers' Draft Environmental Impact Statement for the Missouri River operations and from literature reviews.

Data Quality and Gaps

As mentioned earlier, it is difficult to compare the information within state 305b reports across statelines and this should be done with caution. For example, differing definitions of impacts from hydrologic modification between states, leads to differing amounts of stream miles that are considered impacted by hydrologic modification. In addition, it must be stressed that these refer to *assessed* stream miles. The population surveyed in any given watershed may or may not be enough to draw conclusions about the entire watershed.

Spatial Patterns

Figure 5.3.1 shows the miles of assessed streams impacted by channelization in the NGPAA, that is, the miles of streams that are not fully supporting designated uses as a result of channelization. Watersheds with more than 50 miles of assessed streams impacted by channelization are the Middle Platte-Buffalo, the Upper Tongue, the Niobrara Headwaters, the Lower Souris River, the Maple River in North Dakota, the Lower Sheyenne, the Middle Musselshell and the Smith River. Figure 5.3.2 presents the miles of assessed streams impacted by hydrologic modifications such as dams, diversions and wetland drainage. Watersheds with more than 100 miles impacted by these activities are the Upper and Lower Tongue, the Lower Powder, the Sun River, the Upper Missouri-Dearborn, the Lower Bighorn, the Lower Souris, Upper Sheyenne, Pembina, Middle Sheyenne, Upper James, Lower Sheyenne, Maple River and the Western Wild Rice River.

The acreage of irrigated land per watershed in the Northern Great Plains is shown in Figure 5.3.3 and Figure 5.3.4 presents this information by county. This information is included here due to the effects irrigation has on the hydrology of streams as a result of dams and diversions. There are also water quality effects which are unique to irrigated areas, described in Section 5.4. The western and southern areas of the NGPAA have the most irrigated land, with the highest in the Platte, Teton and Yellowstone river basins. There is a total of 3,619,018 acres of irrigated cropland in the NGPAA (U.S. Natural Resources Conservation Service, 1992).

Future Trends

Wetland losses appear to be slowing or even reversing in some parts of the NGPAA, which will most likely contribute to an improved hydrology in those areas. It remains to be seen if any changes in the operations of various dams in the region will occur, therefore, improving the hydrologic regimes of the downstream stream reaches. Changes in the amounts of water used for irrigation are occurring in the NGPAA. For example, water

use (both ground and surface) for agriculture increased in the southern and western portions of the NGPAA, while it decreased in many areas in the central NGPAA (see Chapter 6). Changes in surface water use for agriculture will have corresponding effects on the aquatic systems in those areas.

5.4 POINT/NONPOINT SOURCE POLLUTION EFFECTS

Introduction

Point Sources

Point sources are discharges that originate from a distinct point such as a pipe or a ditch. They are regulated under the National Pollutant Discharge Elimination System (NPDES) and a permit is required to discharge to waters of the United States. The most important point sources within the Northern Great Plains are municipal facilities, agricultural processing facilities, mines, refineries, oil and gas production facilities and certain sized feedlots. It is important to note that stormwater runoff from industrial sites and from some cities is defined as a point source under the Clean Water Act.

While mines, refineries and oil and gas facilities may discharge metals and organic chemicals, most pollutants from the majority of point sources in the NGPAA are constituents such as biochemical oxygen demand (BOD), ammonia, fecal coliforms, suspended solids and pH. These are the most common pollutants controlled in Northern Great Plains NPDES permits.

Nonpoint Sources

Nonpoint source pollution includes runoff from animal feeding operations not required to have an NPDES permit, grazing areas, cropland, urban areas (not covered by stormwater regulations), septic tanks, roads and road construction, atmospheric deposition and irrigation return flows, which are exempt as a point source. Livestock feeding areas and grazing areas can contribute nutrients, sediment and pathogens to waterbodies. Cropland runoff can contain nutrients, sediment and pesticides. Irrigation return flows may contain most of these, in addition to salinity and sometimes toxics such as selenium.[1] Urban runoff can have nutrients, pathogens and other pollutants such as pesticides from lawns and organics from parking lots and other areas. Roads and road construction can contribute sediment to nearby streams. This includes roads constructed for natural resource exploration and extraction.

Nonpoint source pollution is the greatest water quality problem in the Northern Great Plains, both because of its prevalence and the lack of regulatory controls available. Its prevalence is due to agriculture's dominance in the region.

Key Findings

- Areas with the most major NPDES dischargers are in the Platte River basin, the Missouri River near Bismarck, the Black Hills and the Billings, Montana area.
- Watersheds with the greatest total number of NPDES dischargers (major and minor) are Lewis and Clark Lake, Upper Elkhorn, Middle Platte-Buffalo, Middle North Platte River-Scottsbluff, Lake Sakakawea, Little Powder River, Beaver Creek (Cheyenne River watershed), Lance Creek, Salt Creek (Powder River watershed) and the Middle North Platte River-Casper.
- Watersheds with the greatest number of assessed stream miles reported impacted by municipal point sources are in the Yellowstone, Milk, Platte, Loup, Powder and Cheyenne basins.
- Watersheds with the greatest number of

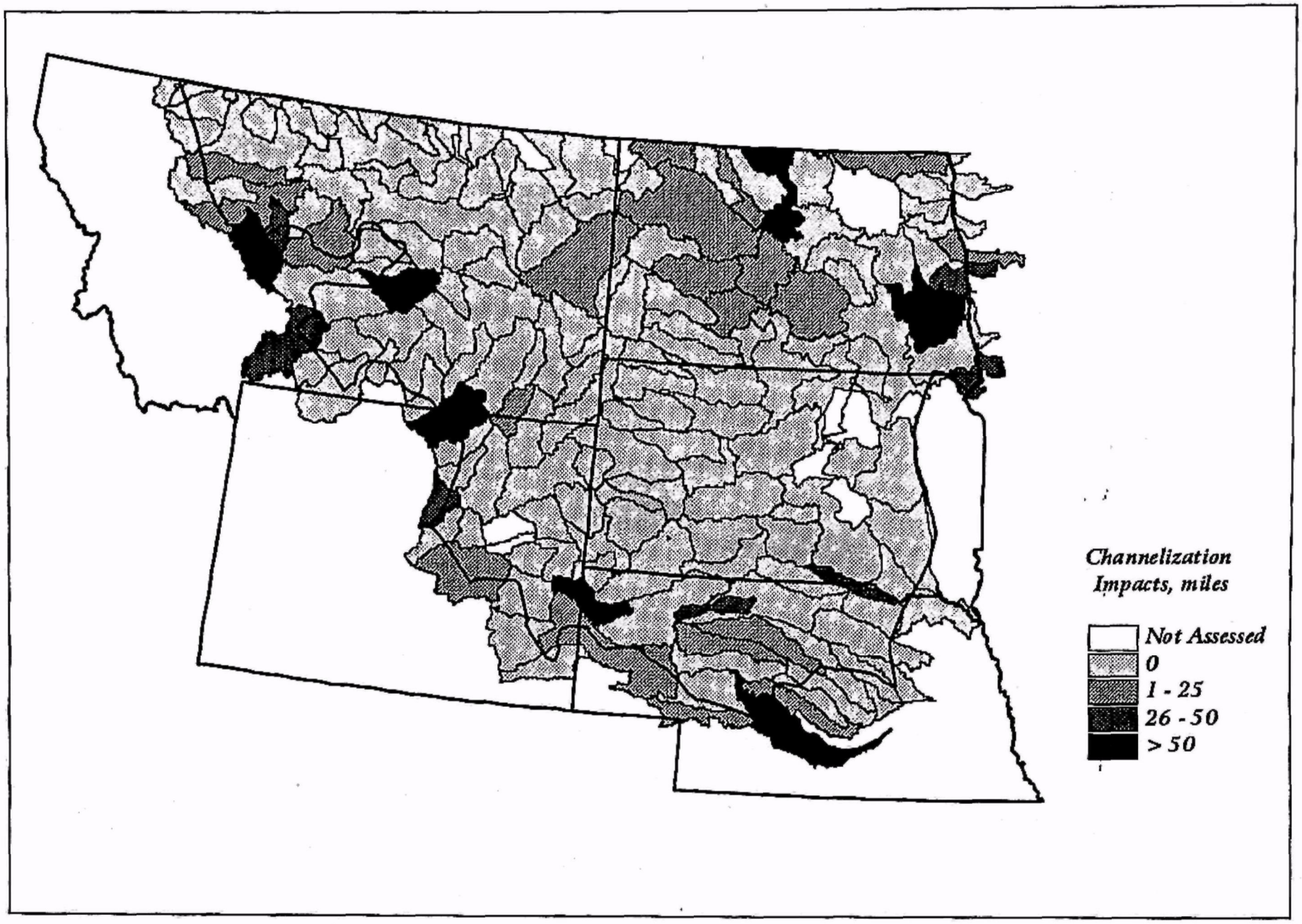

Figure 5.3.1 Miles of Assessed Streams in Each Watershed Impacted by Channelization

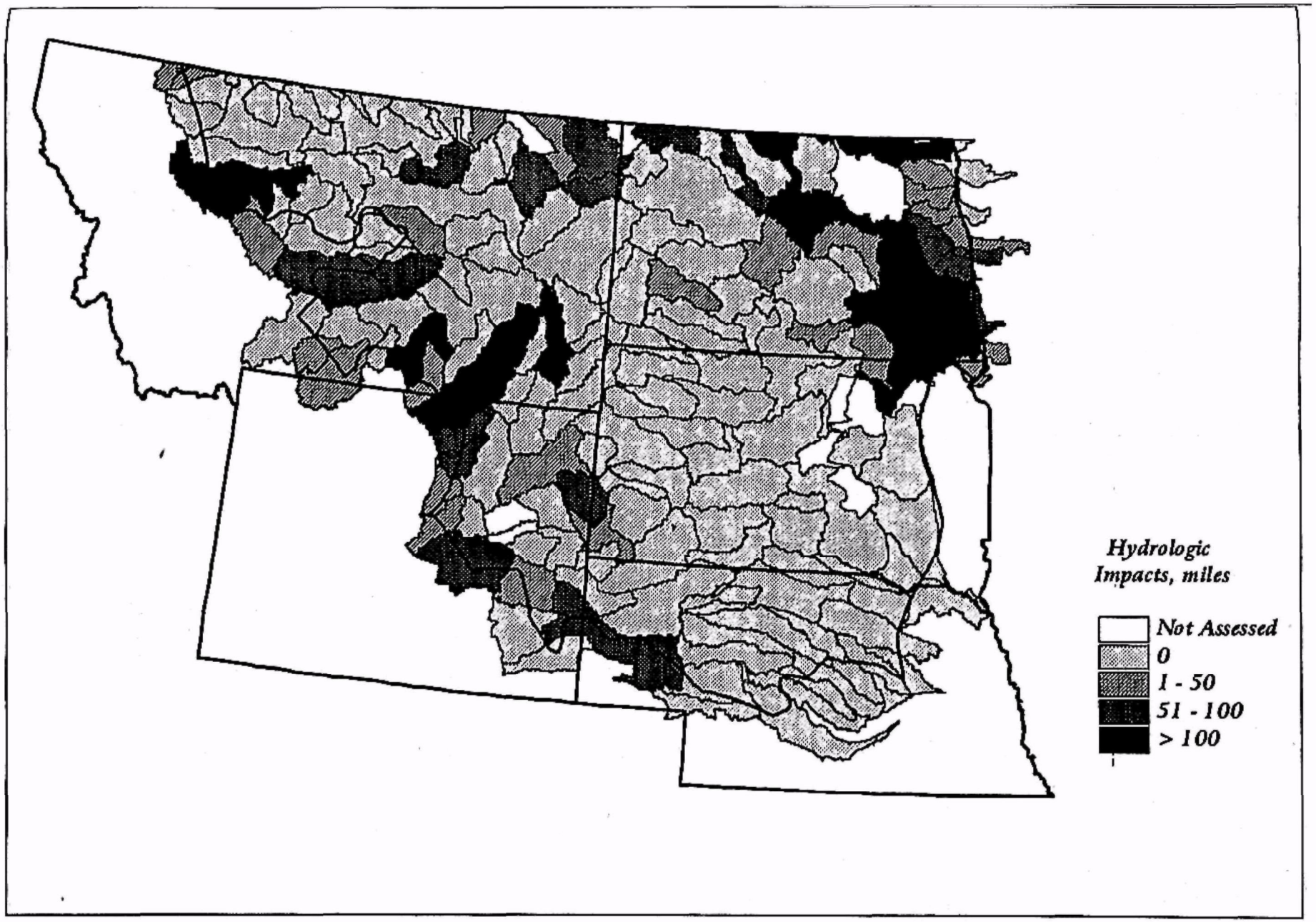

Figure 5.3.2 Miles of Assessed Streams in Each Watershed Impacted by Hydrologic Disturbance, such as Dams, Diversions and Wetland Drainage

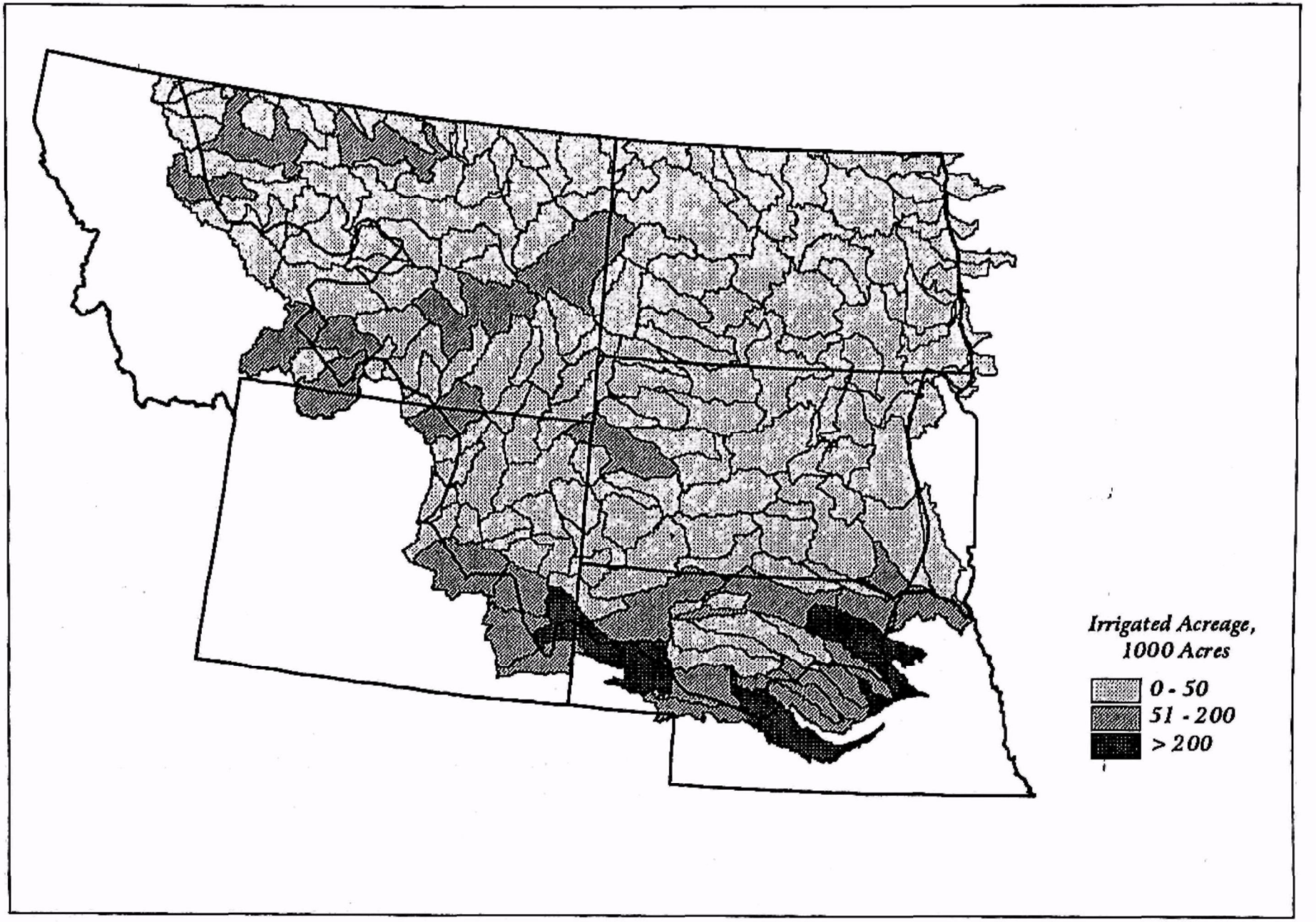

Figure 5.3.3 Irrigated Acreage by Watershed in the Northern Great Plains

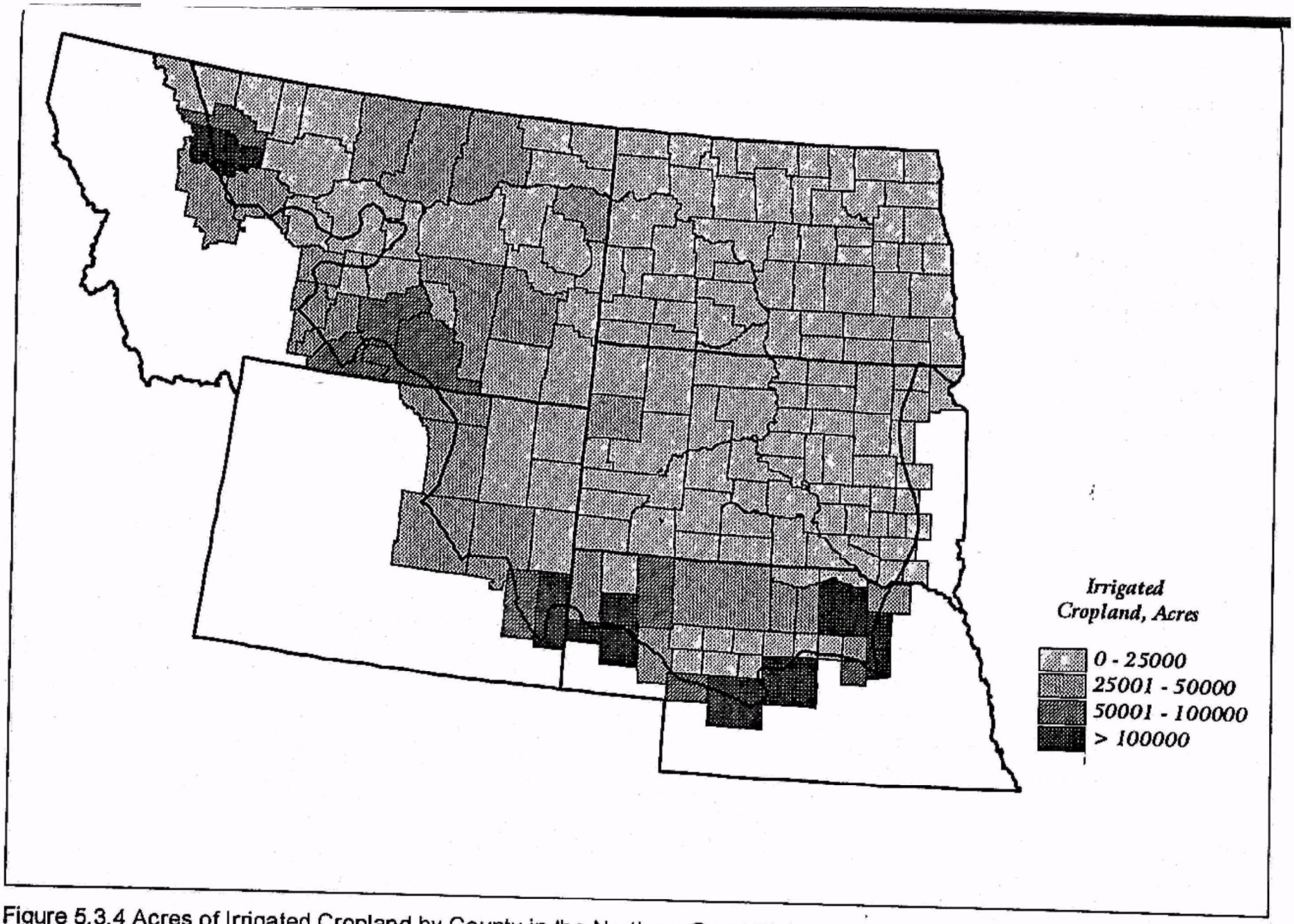

Figure 5.3.4 Acres of Irrigated Cropland by County in the Northern Great Plains

assessed stream miles impacted by pathogens (fecal coliforms) include Lake Sakakawea, Lower Heart River, Upper James, White River, Lower Yellowstone, Lower Powder, Fort Peck Reservoir, Lower Cheyenne and Middle Platte-Buffalo.

•Watersheds with the greatest number of assessed stream miles impacted by organic enrichment are the Lower, Middle and Upper James, the Upper Sheyenne and the Lower Souris.

•Watersheds with the greatest number of assessed stream miles impacted by metals are predominantly in the Yellowstone and Upper Missouri (including Lake Sakakawea) basins.

•Watersheds with the greatest number of assessed stream miles impacted by animal feeding operations are in the Sheyenne, James, White, Cheyenne, Souris, Lake Sakakawea, Knife, Heart and Cannonball basins.

•Watersheds with the greatest number of stream miles impacted by resource extraction (mining, oil and gas) activities are the Clarks Fork of the Yellowstone, Smith River, Lower Powder, Upper Powder, Clear Creek (Powder Basin), Lower Yellowstone, Upper Little Missouri and Cheyenne River-Angostura Reservoir.

•The greatest number of mines of all types are located in northeastern Wyoming, western South Dakota, the Black Hills region and mountain areas along the western edge of the NGPAA.

•Agricultural activities in general impact the ability of assessed streams to meet designated uses across large areas of the NGPAA.

•Watersheds with the greatest number of assessed stream miles impacted by nutrients are the Upper Powder, Lower Yellowstone-Sunday, Middle Milk, Cedar Creek (in North Dakota), Lower Souris, Upper James, Western Wild Rice River, Maple River and Lower Sheyenne.

•Watersheds with the greatest number of assessed stream miles impacted by siltation are the Western Wild Rice River, the Lower Sheyenne, Cedar Creek, Lower Heart, Upper Powder, Clarks Fork of the Yellowstone, Upper Missouri-Dearborn and the Smith River.

•Watersheds with the greatest number of assessed stream miles impacted by irrigated crop production are mainly in Montana and Wyoming.

•Watersheds with the greatest number of assessed stream miles impacted by nonirrigated crop production are primarily centered on North Dakota.

•Watersheds with the greatest number of assessed stream miles impacted by grazing and rangeland uses are in the Yellowstone basin, Upper Missouri-Dearborn, Middle Milk, Upper Powder, Cedar Creek, Lower Heart, Lower Souris, Lake Sakakawea, Lower Little Missouri and the Lower Sheyenne.

•Watersheds with the greatest number of assessed stream miles impacted by thermal modification are the Sun, Smith, Lower Belle Fourche, Lower Grand, Redwater and Poplar Rivers.

•Watersheds with the greatest number of assessed stream miles impacted by salinity are in the Yellowstone and Tongue basins.

•The Universal Soil Loss Equation predicts the greatest potential for erosion in the NGPAA to be in parts of western North Dakota and southeastern South Dakota.

•The greatest concentration of total animal units are in parts of Nebraska (due to cattle and hogs). The lowest concentrations are in a swath from northeastern Montana to northeastern North Dakota.

•The largest areas of harvested cropland are in eastern and central North Dakota, northeastern South Dakota, along the Platte River in Nebraska and northern Montana. The lowest amounts are in northeastern Wyoming, southeastern Montana and western South Dakota.

•Pesticide runoff potential is greatest in the Red River Valley, the lower James, lower Missouri, lower Loup and Middle Platte River

basins. The lowest is in western South Dakota, northeastern Wyoming and most of Montana.

•The greatest amounts of nitrogen fertilizer used are in eastern and northern North Dakota, the Platte River Valley and north-central Montana. The lowest amounts used are in western South Dakota and northeastern Wyoming. Nitrogen runoff potential is greatest in the Platte Valley, eastern South Dakota and southeastern North Dakota. It is lowest in northeastern Wyoming and scattered areas of Montana.

•Sediment delivery potential is greatest in parts of the Red River Valley, Elm River (James basin), Lewis and Clark Lake watershed and the Two Medicine River and the Teton River in the Upper Missouri basin. It is lowest in northeastern Wyoming, the Sand Hills and southeastern and eastern Montana.

•There are six superfund sites on the National Priority list in the NGPAA.

Data Sources

The information on point sources in this section was obtained from U.S. Environmental Protection Agency databases including the Permits and Compliance System (PCS) and a database of permits by watershed developed by EPA Region VIII. Data from the Index of Watershed Indicators was also used. Information on impacts from point sources came from state 305(b) reports. Information on the numbers of livestock was obtained from the National Resources Inventory of the U.S. Natural Resources Conservation Service.

Information on nonpoint sources was obtained from state 305(b) reports, the National Resources Inventory from the U.S. Natural Resources Conservation Service, the U.S. Environmental Protection Agency's Index of Watershed Indicators, the U.S. Geological Survey's information on pesticide application (based on pesticide use data from 1990 to 1993 and 1995 from the National Center for Food and Agricultural Policy and on crop acreage from the 1992 Census of Agriculture from NRCS).

Data Quality and Gaps

As was mentioned earlier with regard to the 305(b) reports, much of the assessments are not based on monitoring, but on evaluations using other data and methods for using available data, preparing the 305(b) reports and defining use support varies from state to state. Comparisons between states should be made with caution.

Spatial Patterns and Trends

Figure 5.4.1 shows the number of major point source dischargers by watershed and Figure 5.4.2 shows the total number, major and minor, dischargers per watershed. A major discharger is generally defined as a municipal facility that discharges an average of more than one million gallons per day or an industrial facility that meets certain discharge volume and effluent constituent criteria. The largest number of major NPDES dischargers are in the Platte River basin, the Missouri River near Bismarck, the Black Hills and the Billings, Montana area. The largest number of total dischargers (major and minor) are in the Lewis and Clark Lake, Upper Elkhorn, Middle Platte-Buffalo, Middle North Platte River-Scottsbluff, Lake Sakakawea, Little Powder River, Beaver Creek (Cheyenne River watershed), Lance Creek, Salt Creek (Powder River watershed) and the Middle North Platte River-Casper watersheds. It is important to note that sheer numbers of point source dischargers do not necessarily translate into larger effects than an area with fewer. This is because point sources are controlled under NPDES. However, a large number in an area can be a problem if effluent limits for each have not been developed in conjunction with other point

sources. In addition, a few large point sources can be more important than many small ones in terms of pollutant loading. Tables 5.4.1 and 5.4.2 list the watersheds with the most NPDES major permits and total permits.

The assessed miles of stream impacted by municipal point sources is shown in Figure 5.4.3. The watersheds with greater than 100 miles of streams impacted are in the Milk, Yellowstone, Powder and Platte basins. Significant impacts are also reported for the Cheyenne, Loup and Upper Elkhorn basins.

Figure 5.4.4 shows the location of mines of all types (coal, hard rock, sand and gravel, etc.) within the NGPAA. The areas with the greatest concentration are in the Black Hills, western North Dakota, northeastern Wyoming and in mountainous areas along the western boundary of the NGPAA. Information for mines in Nebraska was not available for this analysis. Figure 5.4.5 shows the miles of assessed streams in each watershed impacted by mining and oil and gas extraction. Those with more than 100 miles impacted are the Smith, Clarks Fork of the Yellowstone, Lower Powder, Upper Powder and Clear Creek (within the Powder River basin). Significant impacts also exist within the Upper Little Missouri, Lower Yellowstone, Cheyenne River-Angostura Reservoir, Belt Creek and Crazy Woman Creek watersheds.

Lake Sakakawea and the Lower Heart have more than 200 miles of impacts from pathogens, as measured by fecal coliforms (Figure 5.4.6). Other areas where pathogens are important contributors to impacting uses include Fort Peck Reservoir, the White River basin, Lower Cheyenne, Upper James, Lower Yellowstone, Middle Platte-Buffalo, Lower Little Missouri and the Knife River. Figure 5.4.7 shows the miles of assessed streams impacted by organic enrichment and low dissolved oxygen, with the James, Sheyenne and Souris basins having the greatest impacts. The greatest impacts from metals, including mercury, (Figure 5.4.8) are in some of the Upper Missouri tributaries, the Yellowstone basin (including the Tongue and Powder Rivers), Lake Sakakawea and the Upper Souris. Figure 5.4.9 shows the miles of assessed streams impacted by animal feeding and holding operations. Watersheds within the Sheyenne, James, White, Cheyenne, Souris, Lake Sakakawea, Knife, Heart and Cannonball basins are the most affected.

The miles of assessed streams impacted by agricultural uses, including both cropland and livestock impacts are shown in Figure 5.4.10. As is presented, impacts from agriculture on the ability of streams to meet designated uses is very widespread throughout the NGPAA. This is not surprising since agriculture is a major activity in this region. Figure 5.4.11 presents the miles of assessed streams whose beneficial uses are impacted by nutrient loadings. The Upper Powder, Lower Yellowstone-Sunday, Middle Milk, Cedar Creek (in North Dakota), Lower Souris, Upper James, Western Wild Rice River, Maple River and Lower Sheyenne River watersheds all have more than 200 assessed miles of streams not fully supporting uses due to nutrients. Figure 5.4.12 presents this situation with respect to siltation, with the Western Wild Rice River, the Lower Sheyenne, Cedar Creek, Lower Heart, Upper Powder, Clarks Fork of the Yellowstone, Upper Missouri-Dearborn and the Smith River most impacted.

Salinity impacts are presented in Figure 5.4.13. Areas where irrigation is important show up as areas with high salinity impacts, such as the Yellowstone and Powder basins, but also the Upper Missouri tributaries and northwestern South Dakota. The Yellowstone basin, Upper Missouri-Dearborn, Middle Milk, Upper Powder, Cedar Creek, Lower Heart,

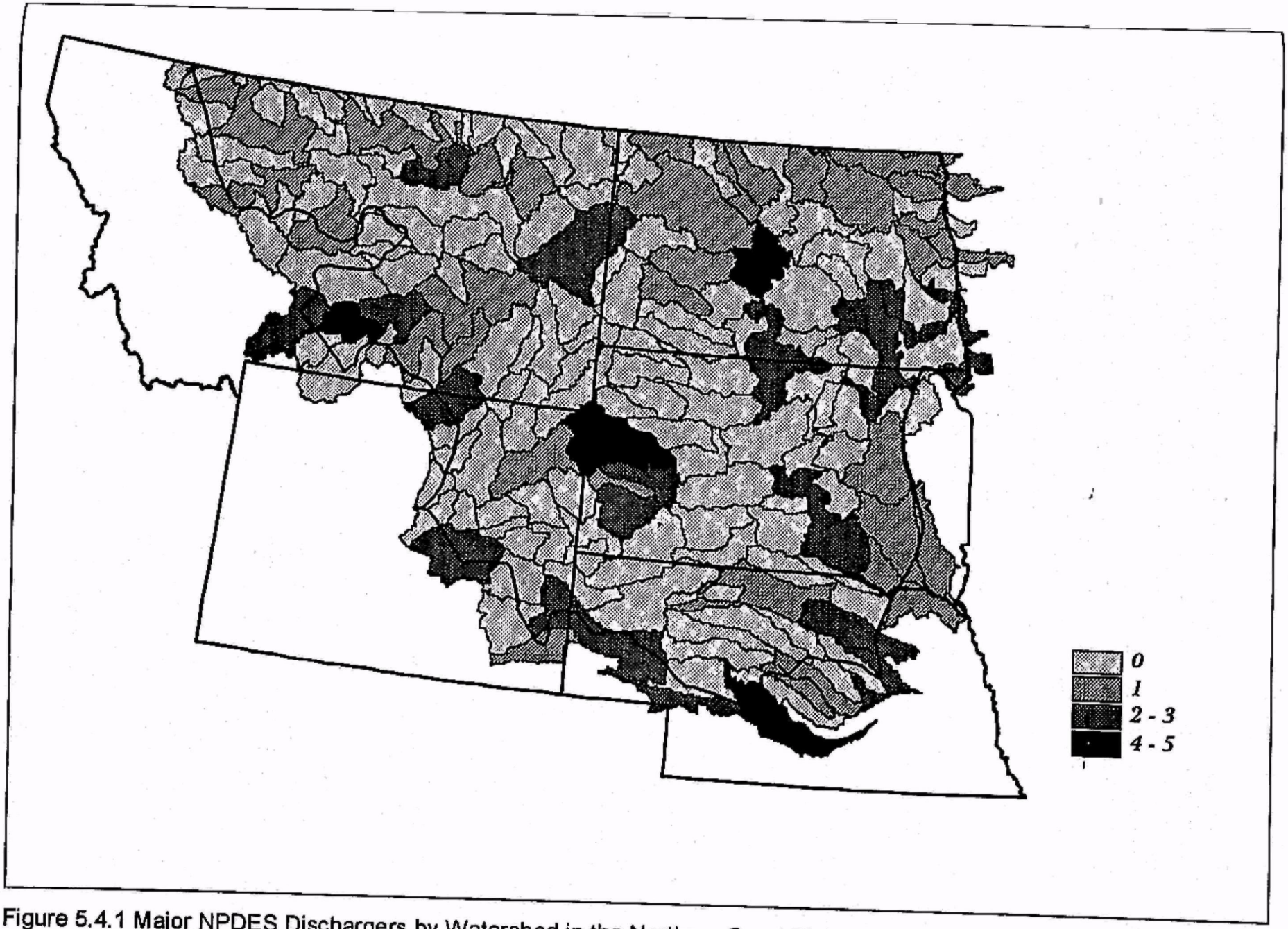

Figure 5.4.1 Major NPDES Dischargers by Watershed in the Northern Great Plains

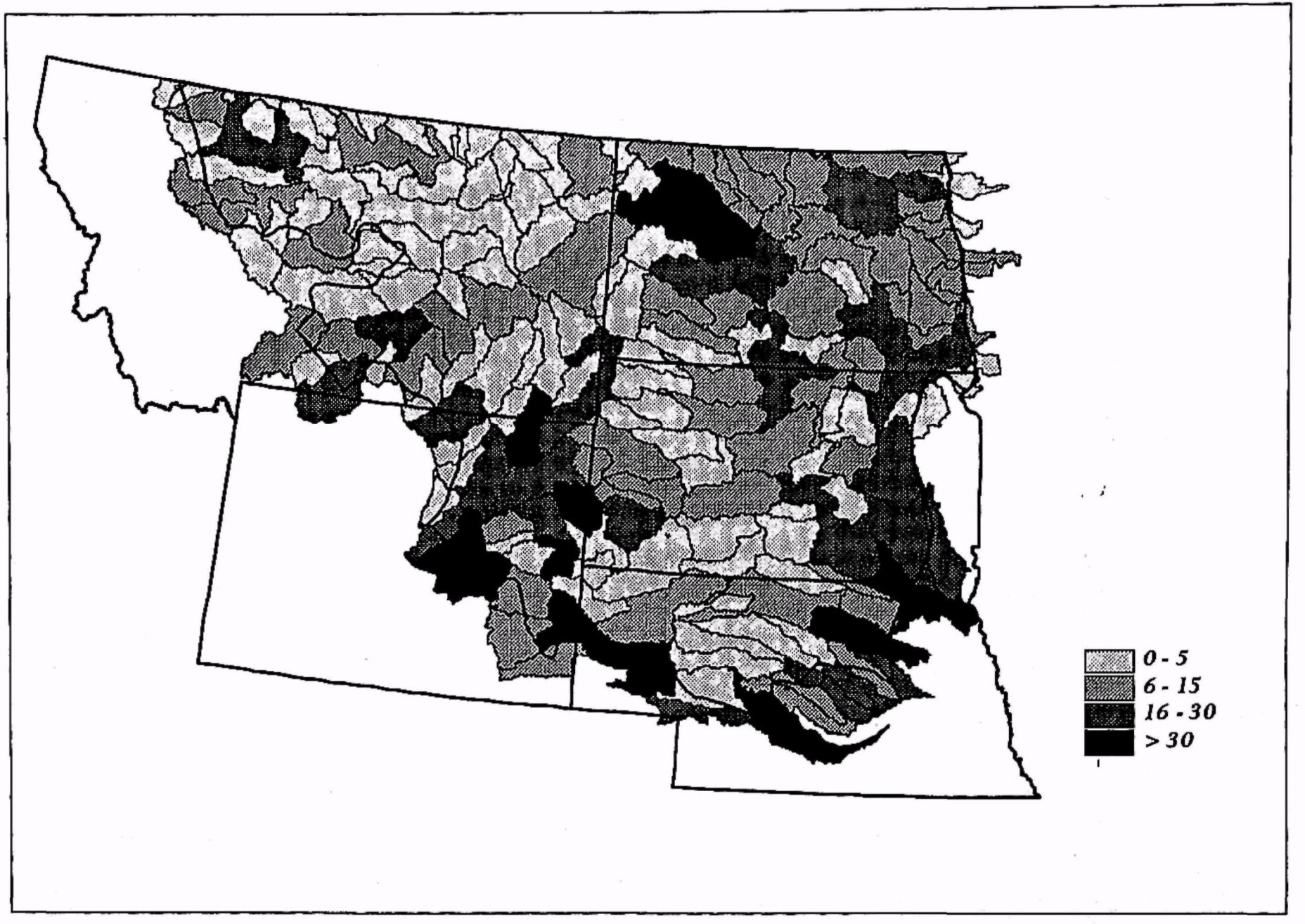

Figure 5.4.2 Total NPDES Dischargers (Major and Minor) by Watershed in the Northern Great Plains

Table 5.4.1 Watersheds in the Northern Great Plains Assessment Area with the Most Major NPDES Dischargers.

Code	Name	Major Dischargers
10130101	Missouri R (Painted Woods-Square Butte)	5
10070004	Upper Yellowstone-Lake Basin	5
10120202	Lower Belle Fourche River	5
10200101	Middle Platte River-Buffalo	4
10120203	Redwater River	4
10180009	Middle North Platte River-Scotts Bluff	3
10190018	Lower South Platte River	3
10100004	Lower Yellowstone River	3
All Others		2 or less

Table 5.4.2 Watersheds in the Northern Great Plains Assessment Area with the Most Total Number of NPDES Dischargers.

Code	Name	Total Dischargers
10120107	Beaver Creek	80
10200101	Middle Platte River-Buffalo	75
10180009	Lower South Platte River	47
10170101	Missouri River-Lewis and Clark Lake	46
10180007	Middle North Platte River-Casper	44
10110101	Missouri River-Lake Sakakawea	37
10090204	Salt Creek	35
10120104	Lance Creek	35
10220001	Upper Elkhorn River	32
10090208	Little Powder River	31

Lower Souris, Lake Sakakawea, Lower Little Missouri and the Lower Sheyenne have the greatest number of miles of assessed streams not supporting uses due to grazing (Figure 5.4.14). Figure 5.4.15 shows the miles of streams impacted by irrigated crop production with Montana and Wyoming showing most of the impacts. Figure 5.4.16 shows the miles of streams impacted by nonirrigated crop production with impacts centered on North Dakota, especially in the Cedar Creek, Lower Heart, Lower Souris, Western Wild Rice, Maple and Lower Sheyenne watersheds. Significant impacts also occur in northern Montana and eastern and northwestern South Dakota. Thermal modification impacts the largest areas in the Poplar, Redwater, Sun and Smith River watersheds in Montana and the Lower Belle Fourche and Lower Grand watersheds in South Dakota (Figure 5.4.17).

The amount of harvested cropland per county in the Northern Great Plains is presented in Figure 5.4.18. The largest areas of cropland occur in large areas of North Dakota (especially the eastern), northeast South Dakota, along the Platte in Nebraska and in north-central and northeastern Montana. There is a total of 42,055,081 acres of harvested cropland in the counties within the NGPAA (U.S. Natural

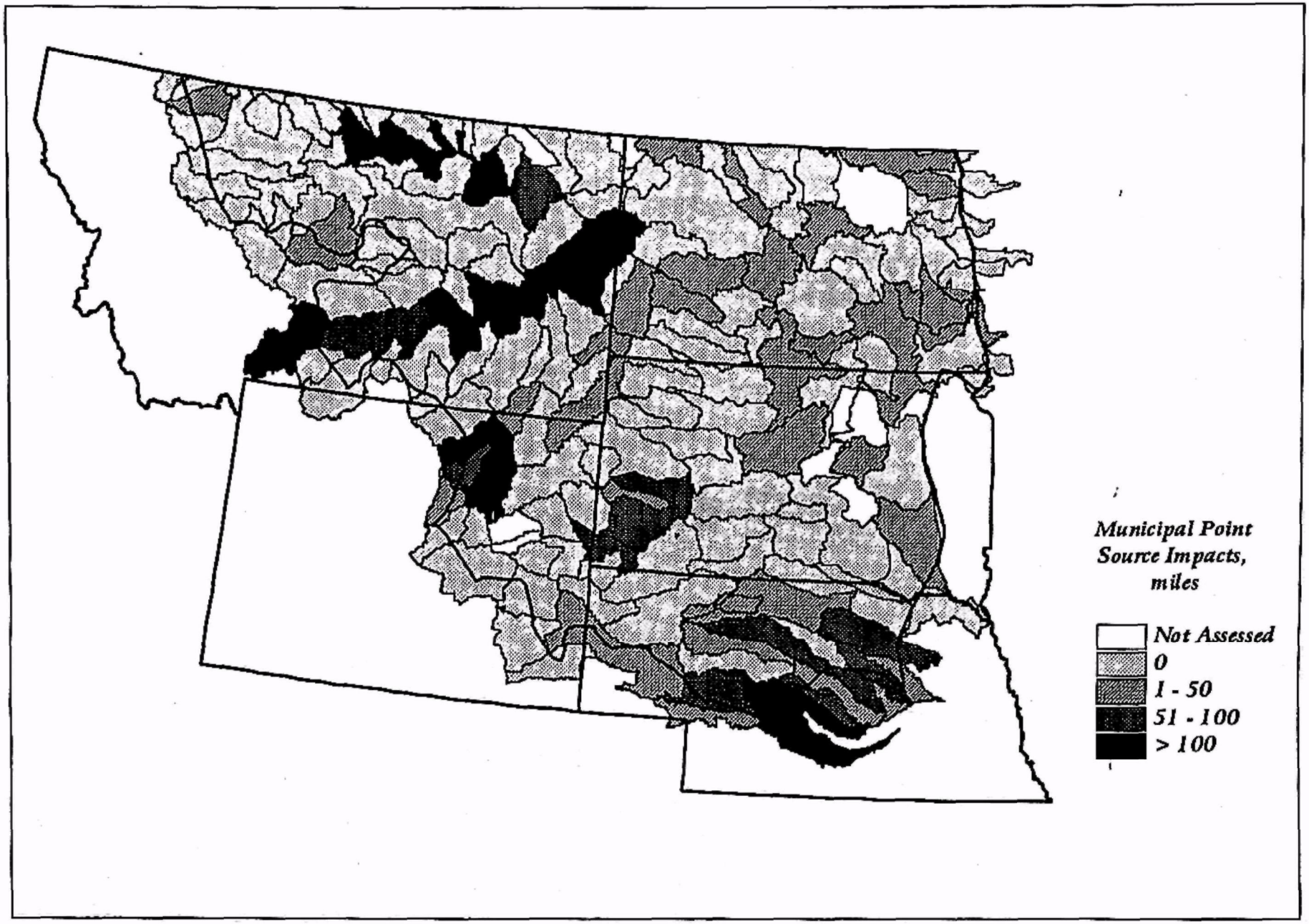

Figure 5.4.3 Miles of Assessed Streams in Each Watershed Impacted by Municipal Point Sources

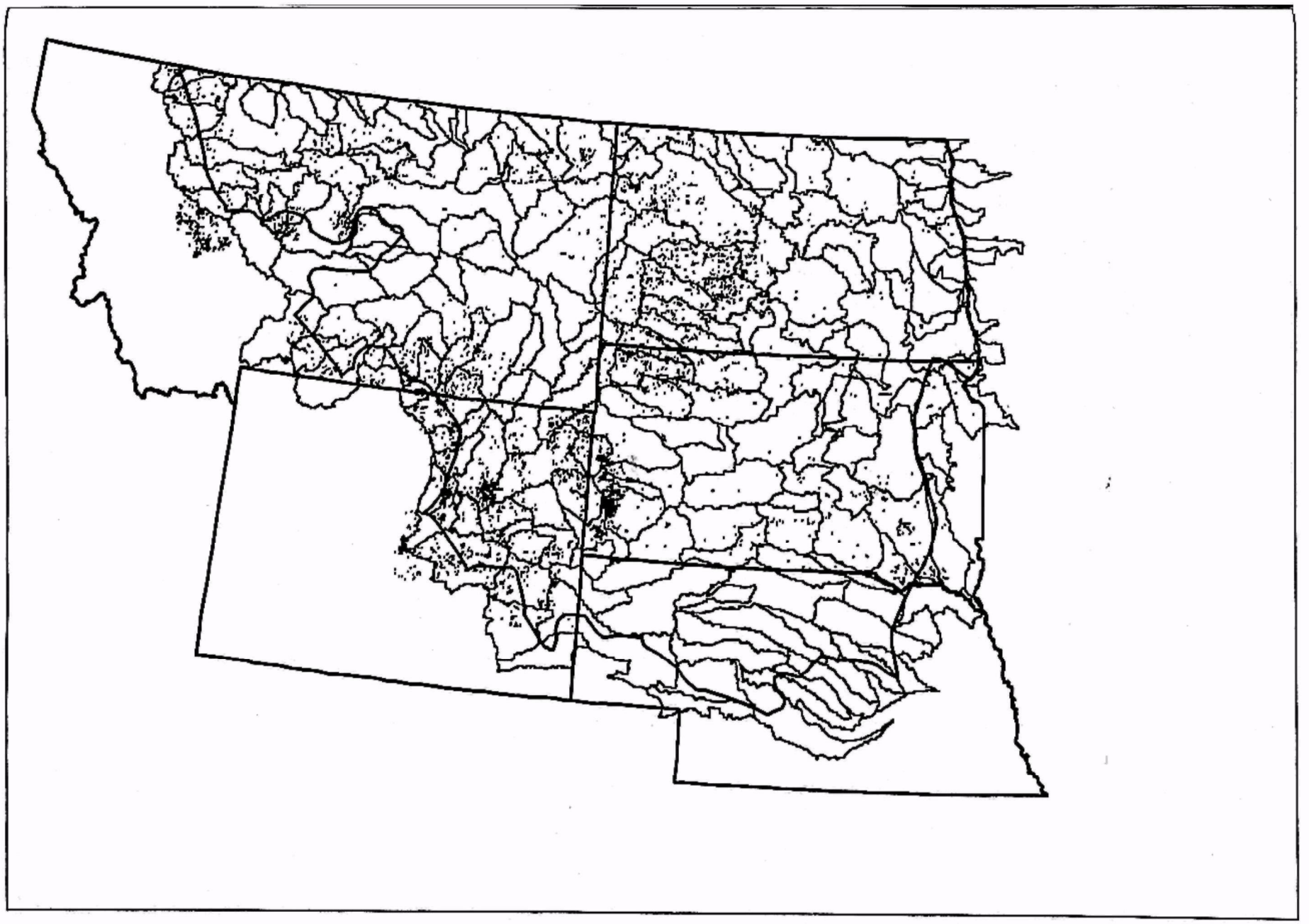

Figure 5.4.4 Location of Mines (All Types) in the Northern Great Plains

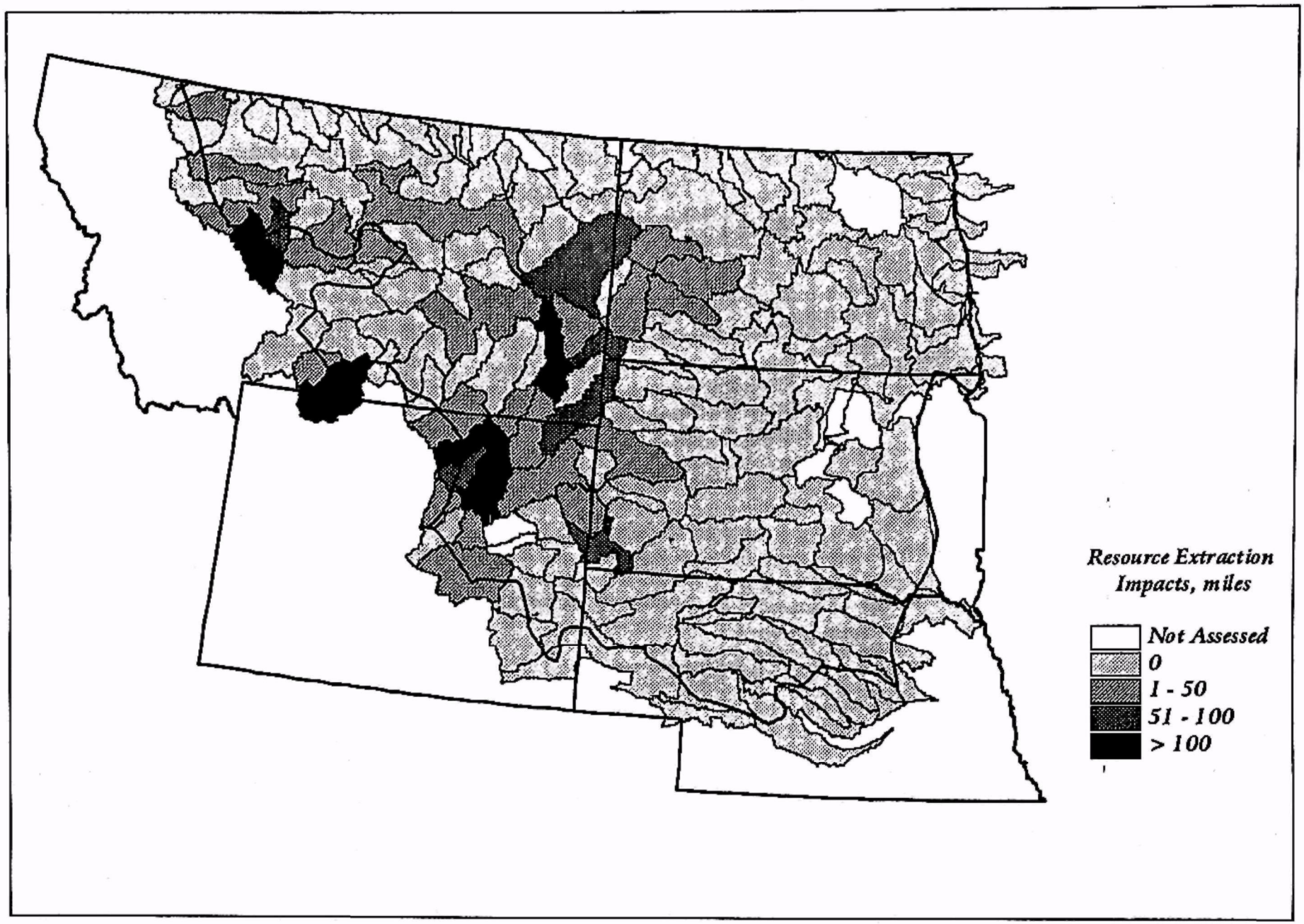

Figure 5.4.5 Miles of Assessed Streams in Each Watershed Impacted by Resource Extraction (Mines, Oil and Gas)

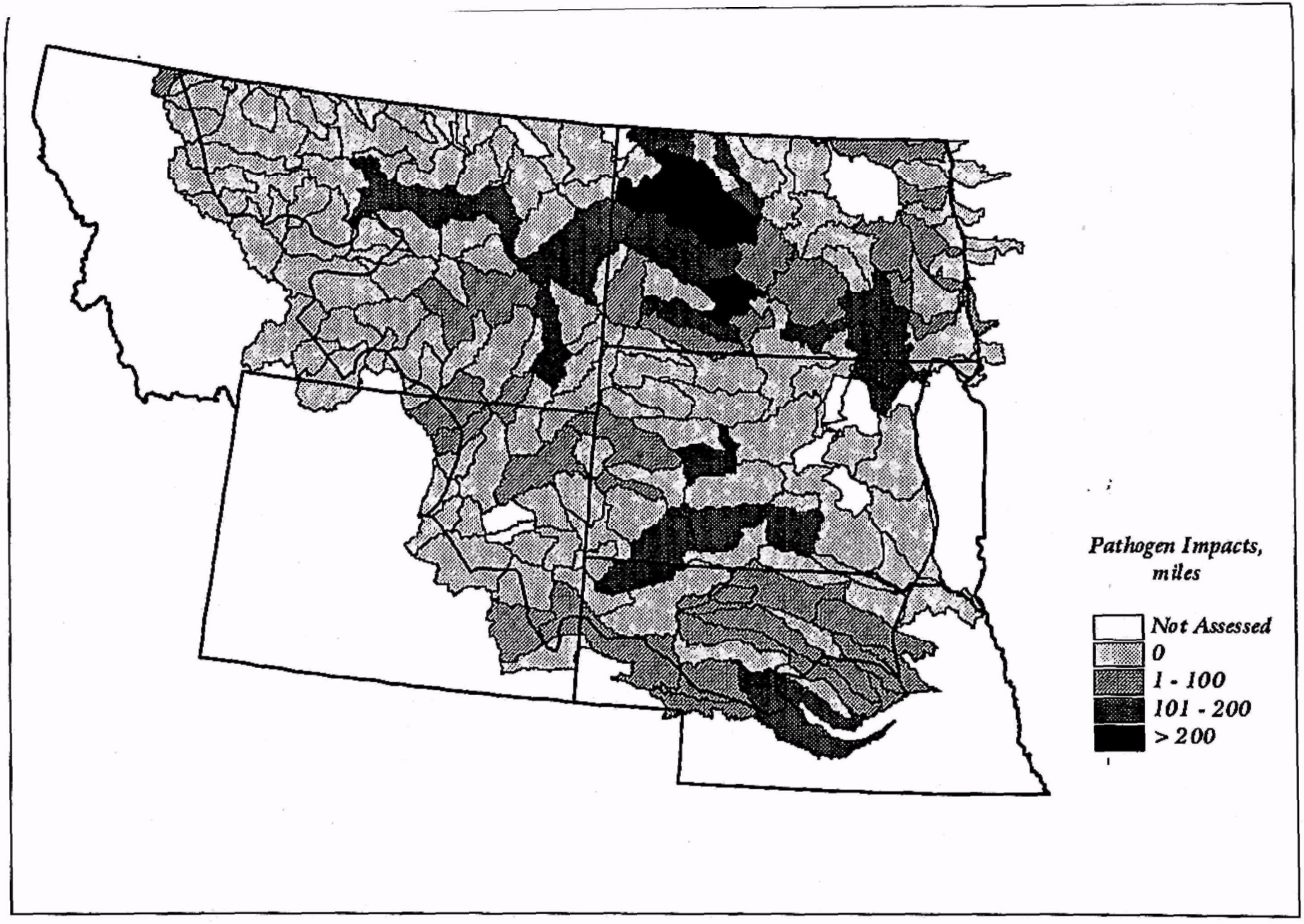

Figure 5.4.6 Miles of Assessed Streams in Each Watershed Impacted by Pathogens

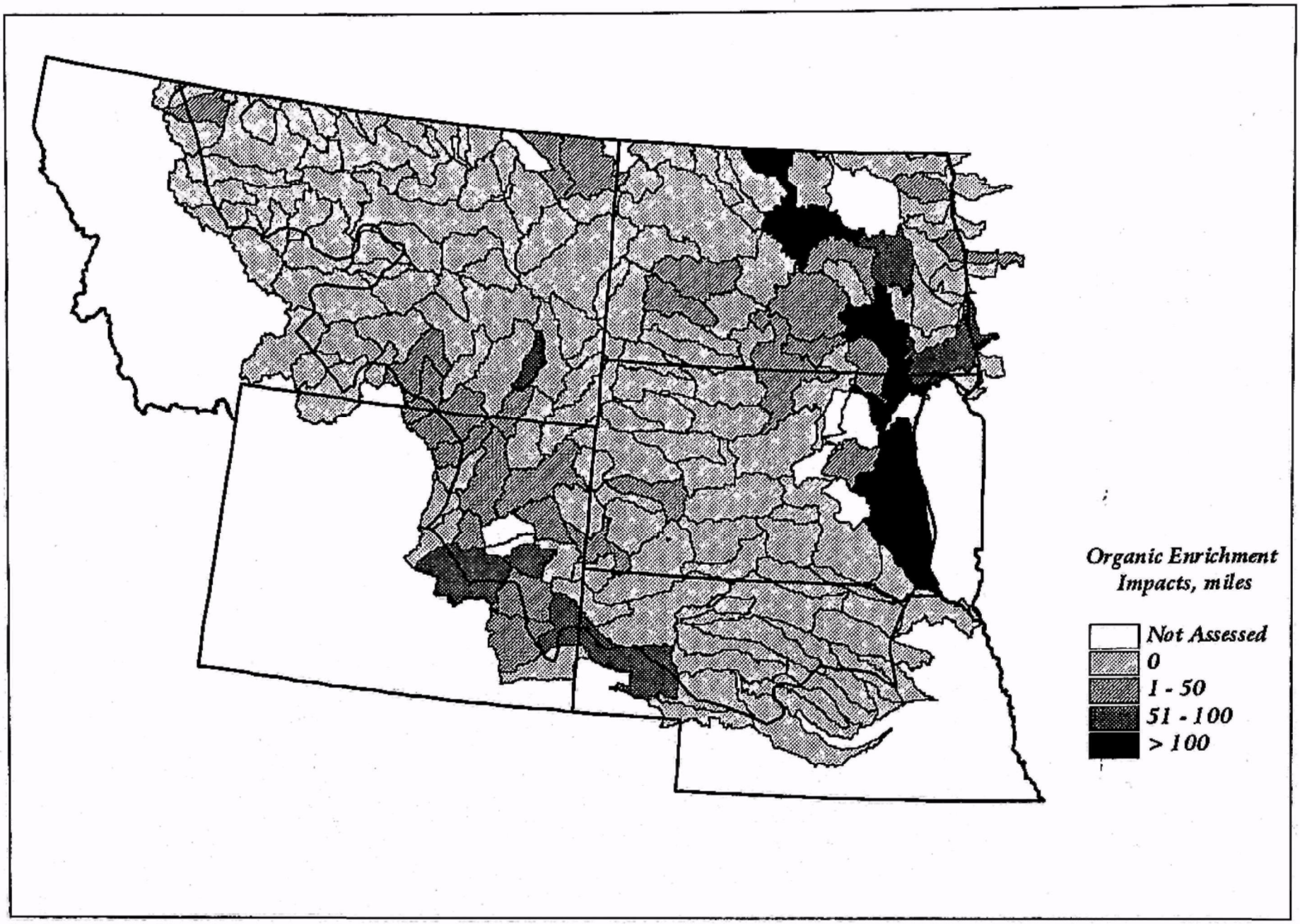

Figure 5.4.7 Miles of Assessed Streams in Each Watershed Impacted by Organic Enrichment or Low Dissolved Oxygen

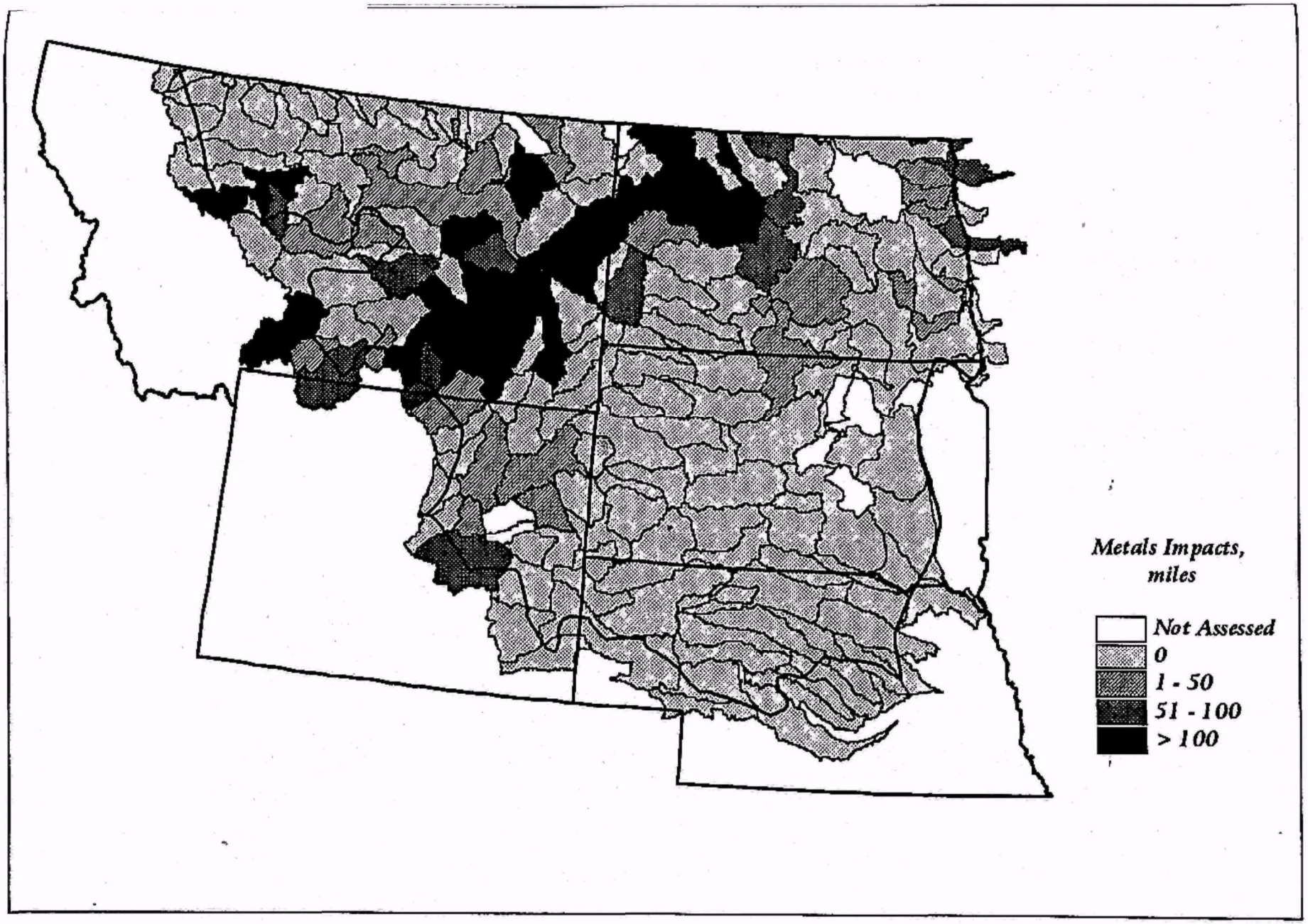

Figure 5.4.8 Miles of Streams in Each Watershed Impacted by Metals

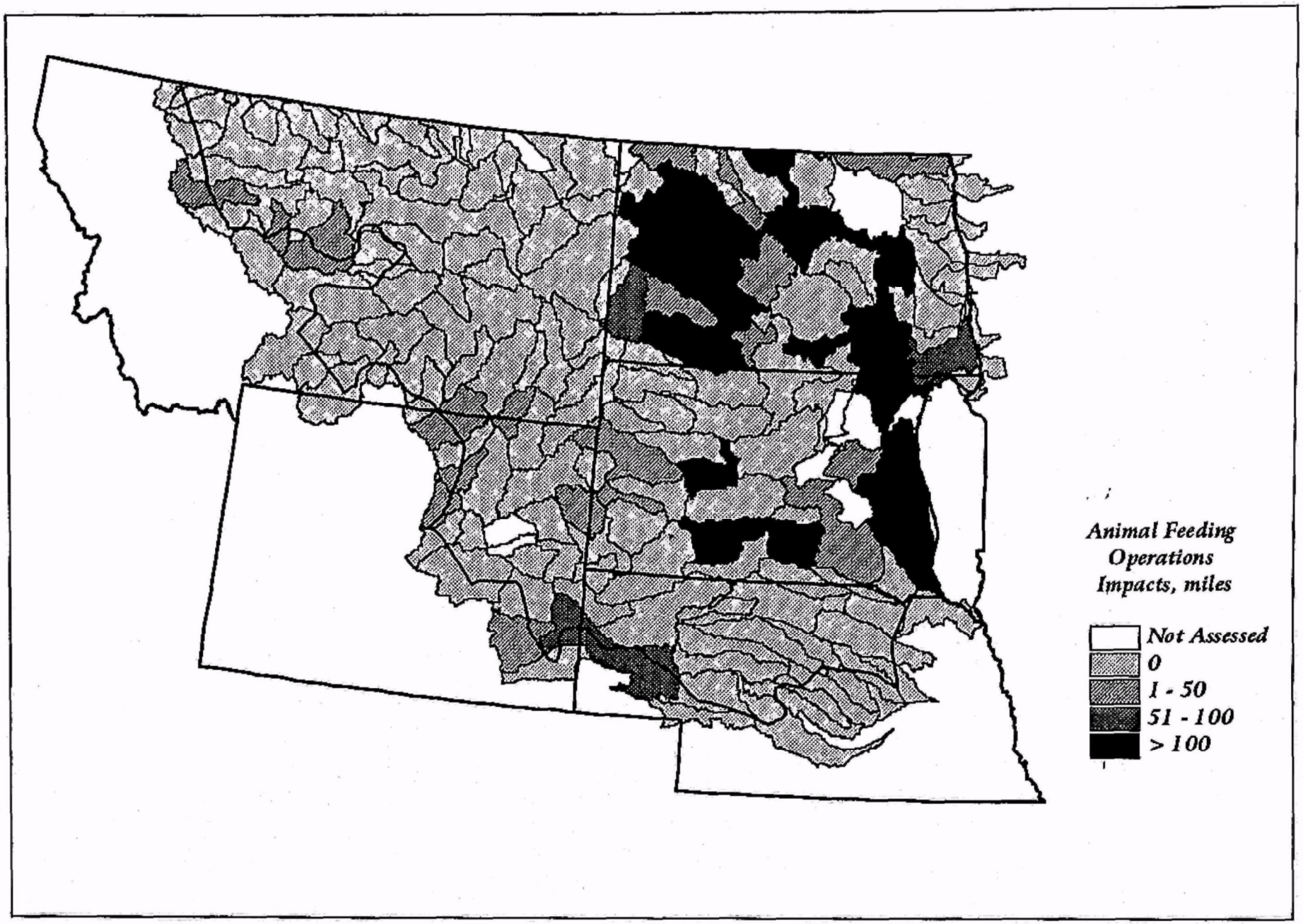

Figure 5.4.9 Miles of Assessed Streams in Each Watershed Impacted by Animal Feeding or Holding Operations

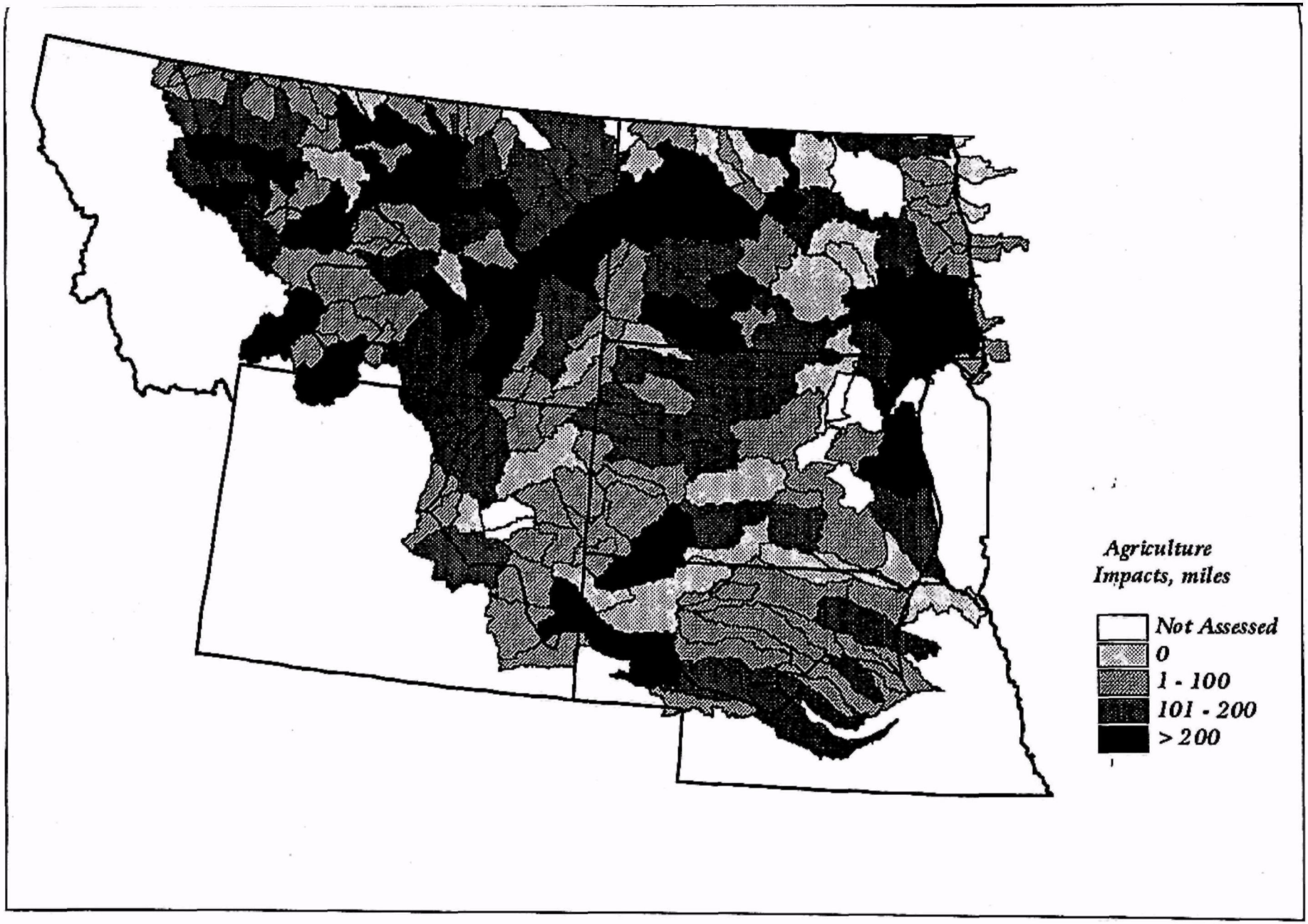

Figure 5.4.10 Miles of Assessed Streams in Each Watershed Impacted by Agriculture (Cropland and Livestock)

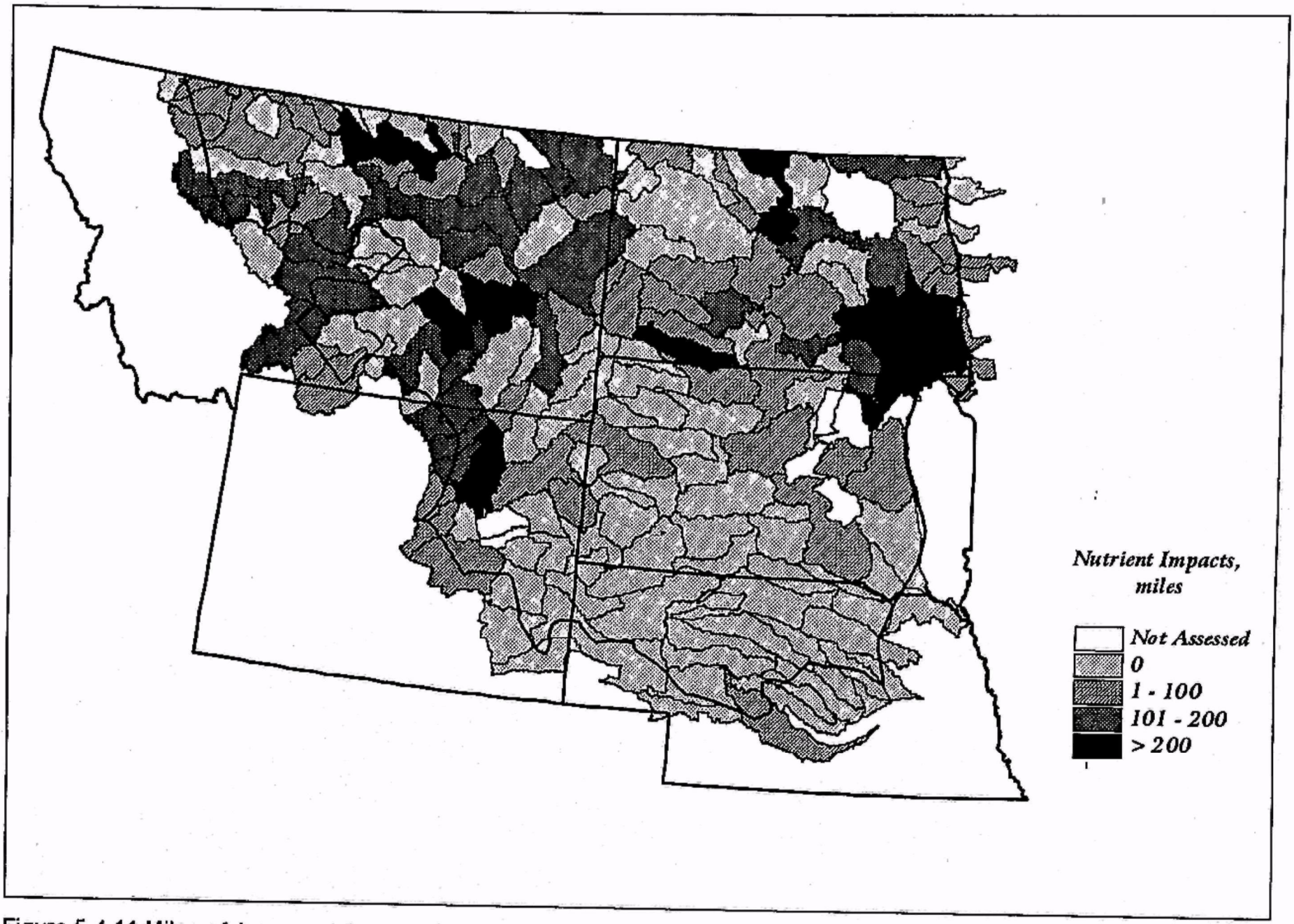

Figure 5.4.11 Miles of Assessed Streams in Each Watershed Impacted by Nutrients

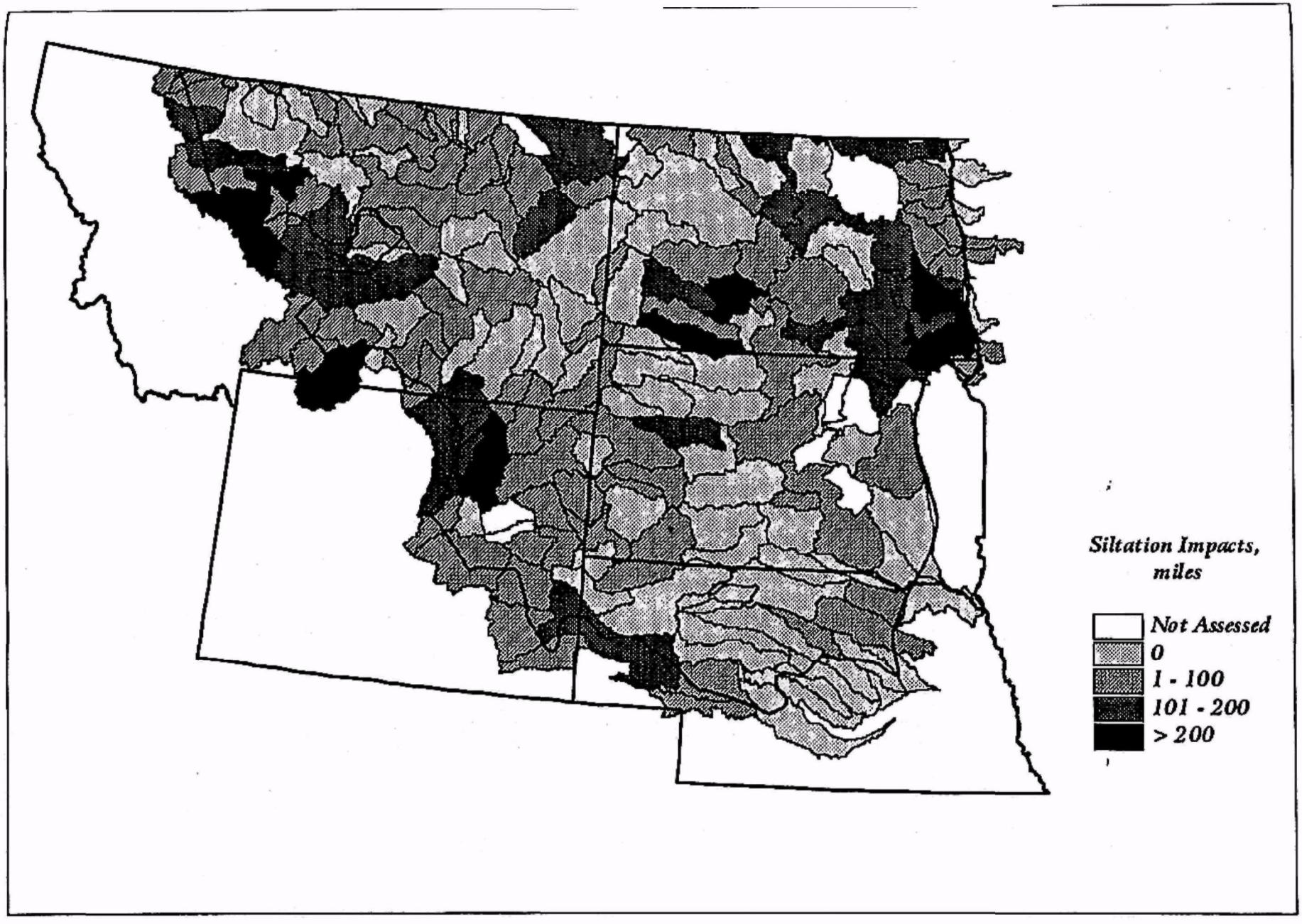

Figure 5.4.12 Miles of Assessed Streams in Each Watershed Impacted by Siltation

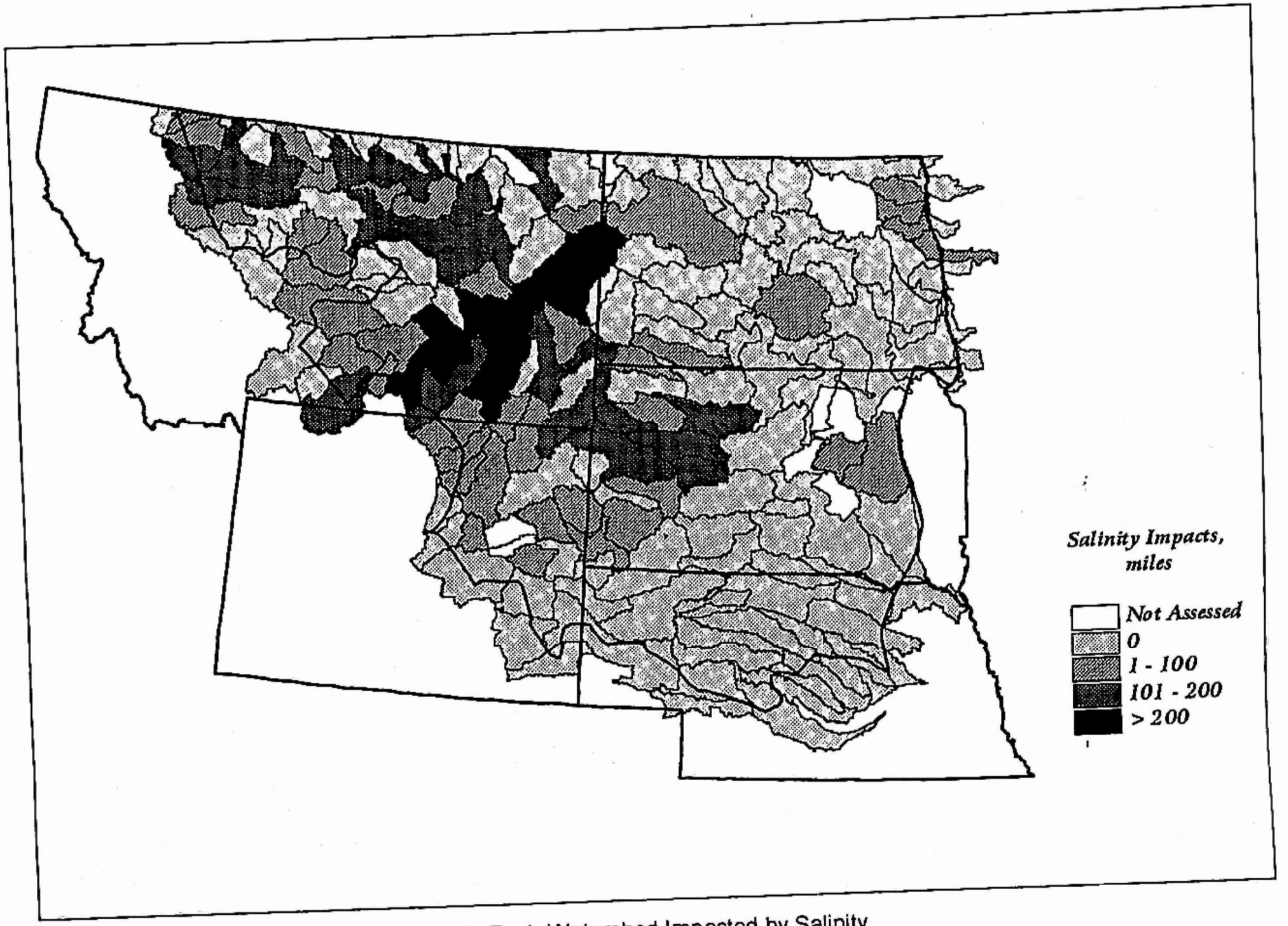

Figure 5.4.13 Miles of Assessed Streams in Each Watershed Impacted by Salinity

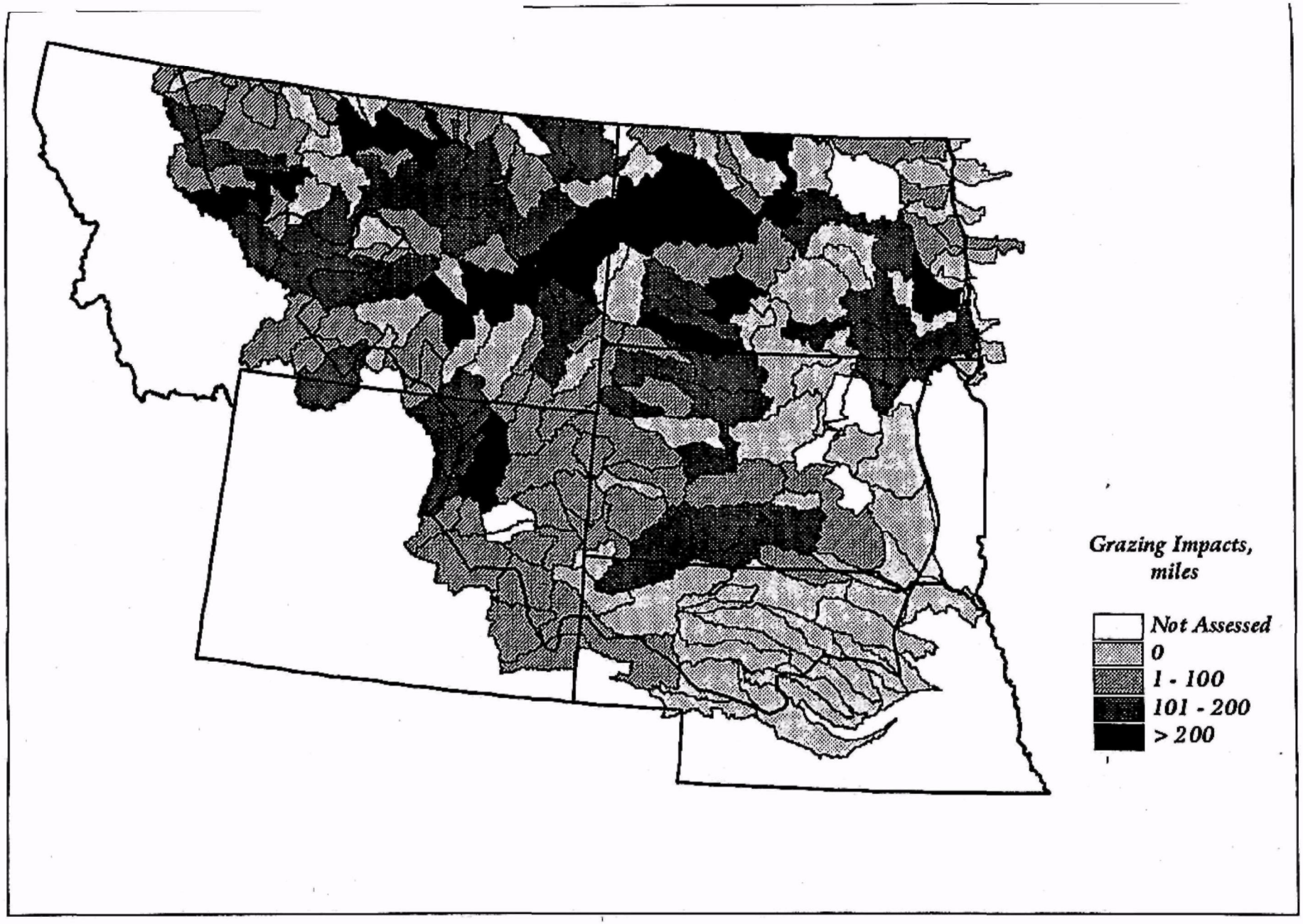

Figure 5.4.14 Miles of Assessed Streams in Each Watershed Impacted by Grazing and Rangeland Uses

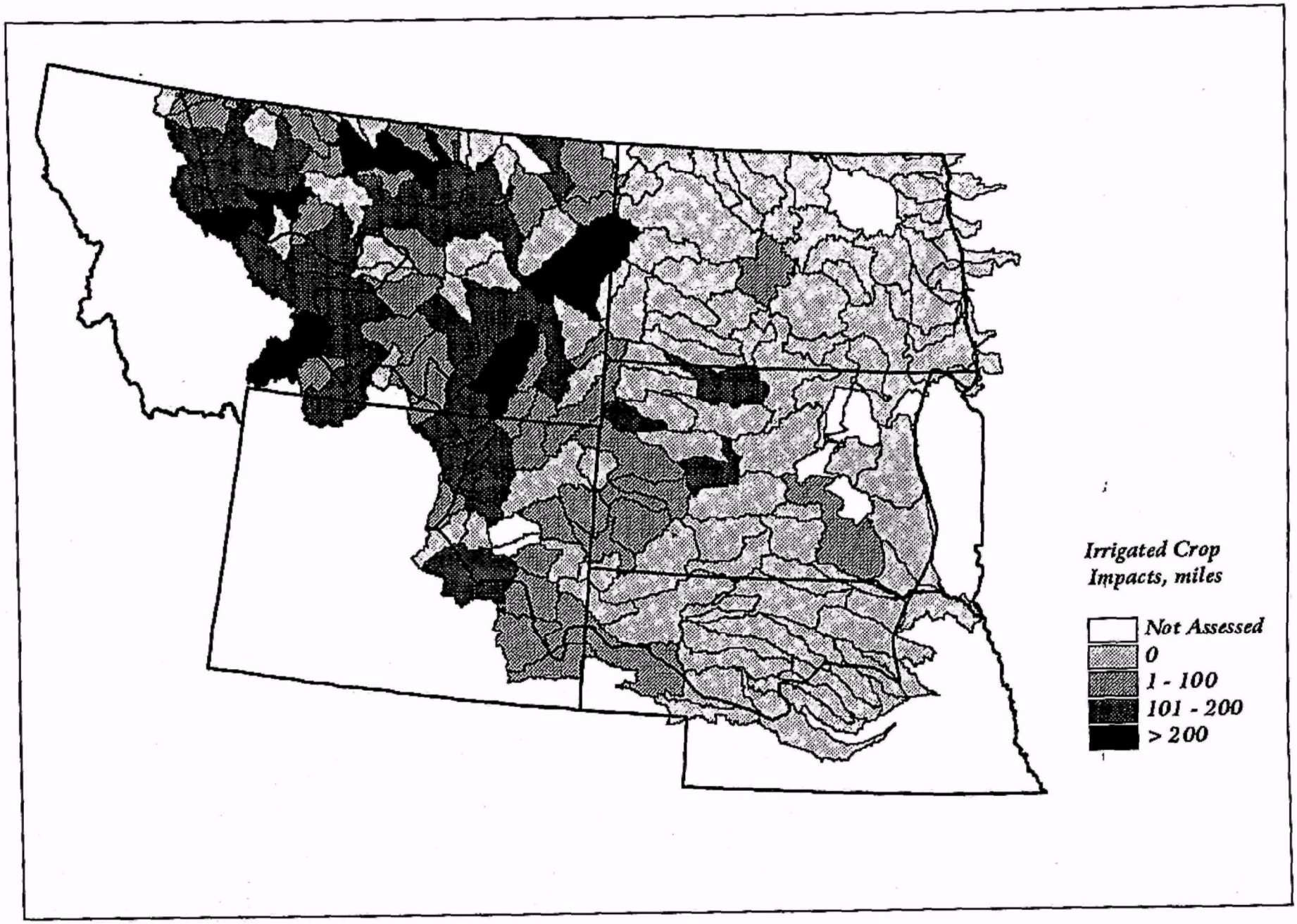

Figure 5.4.15 Miles of Assessed Streams in Each Watershed Impacted by Irrigated Crop Production

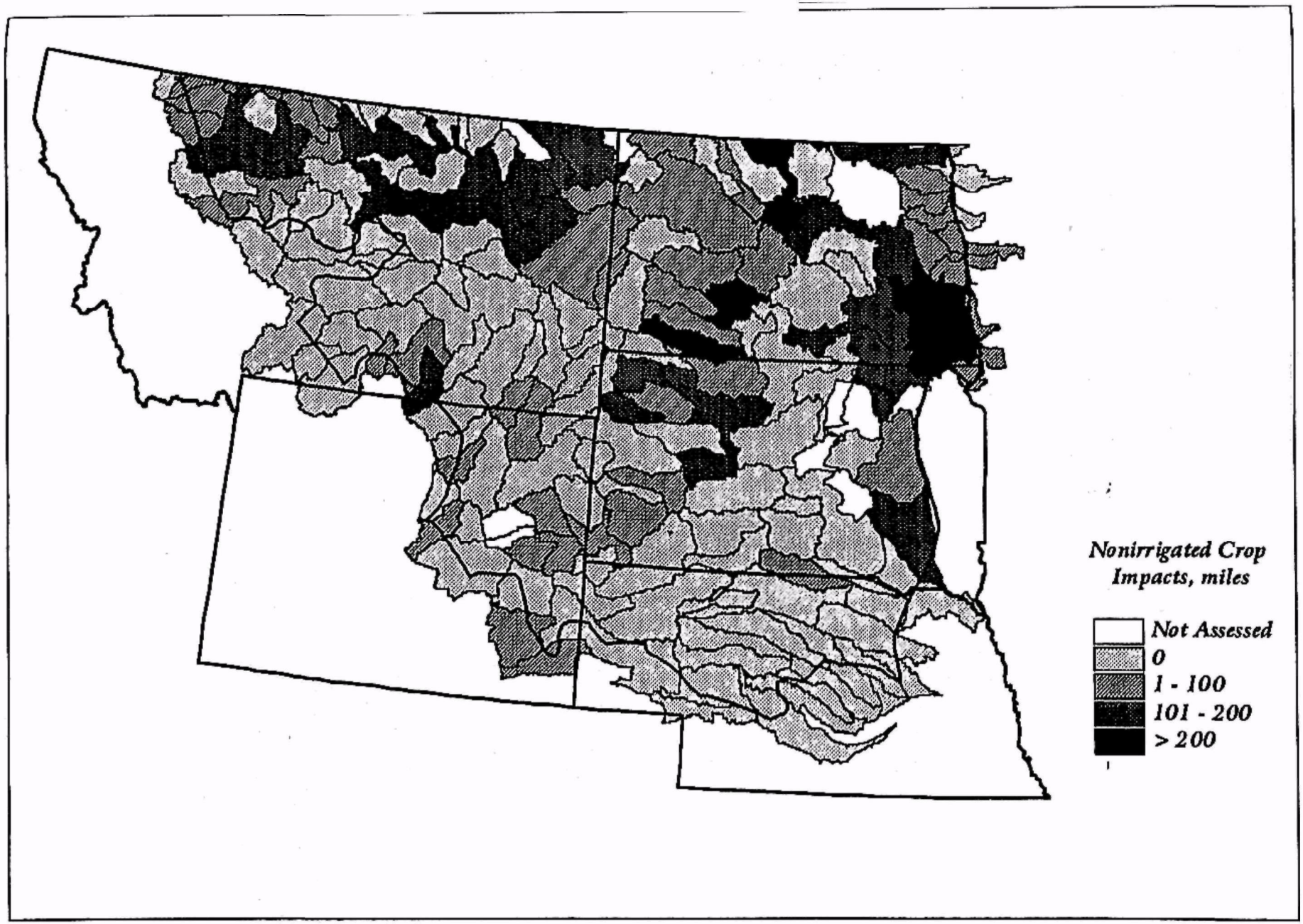

Figure 5.4.16 Miles of Assessed Streams in Each Watershed Impacted by Nonirrigated Crop Production

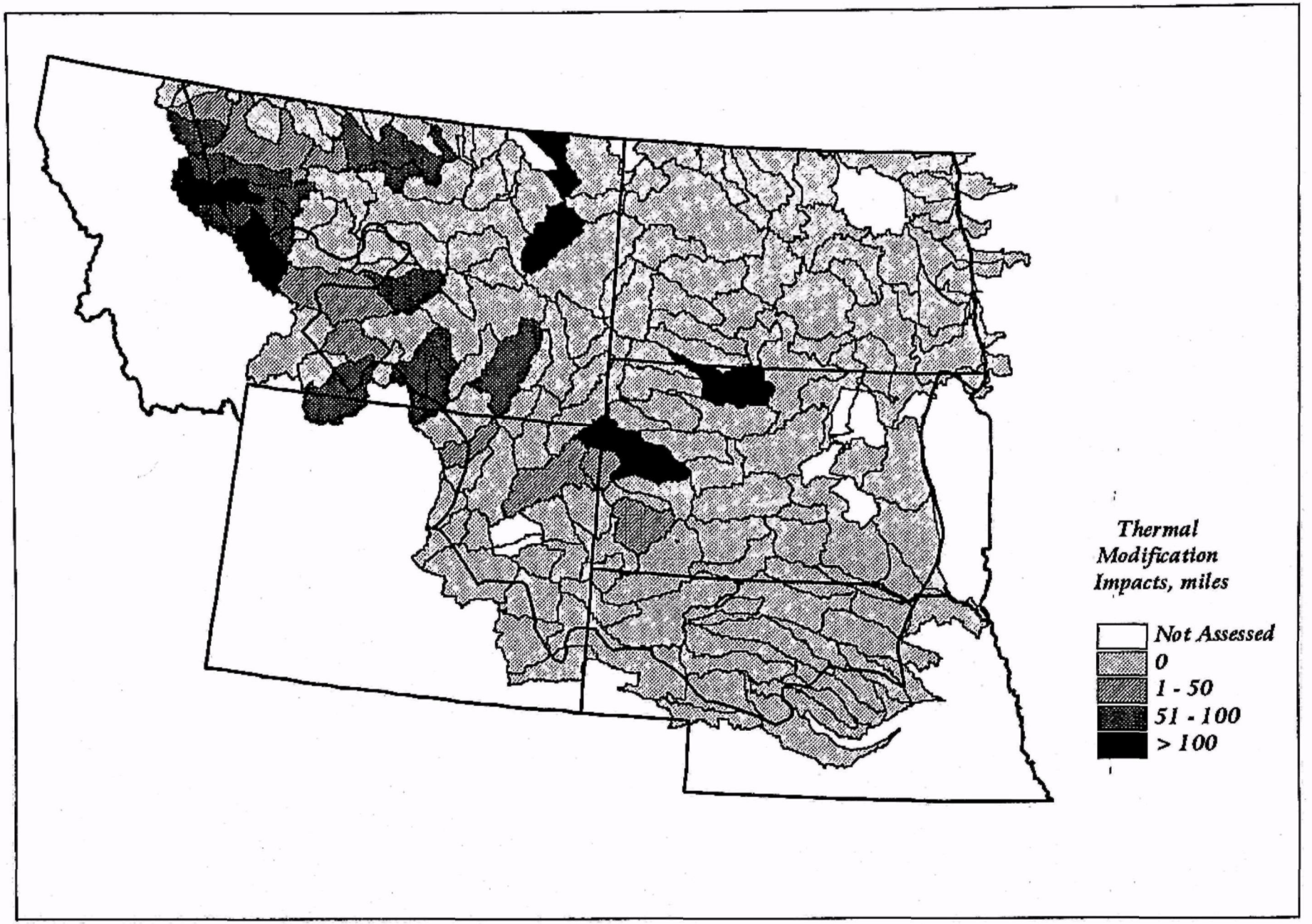

Figure 5.4.17 Miles of Assessed Streams in Each Watershed Impacted by Thermal Modifications

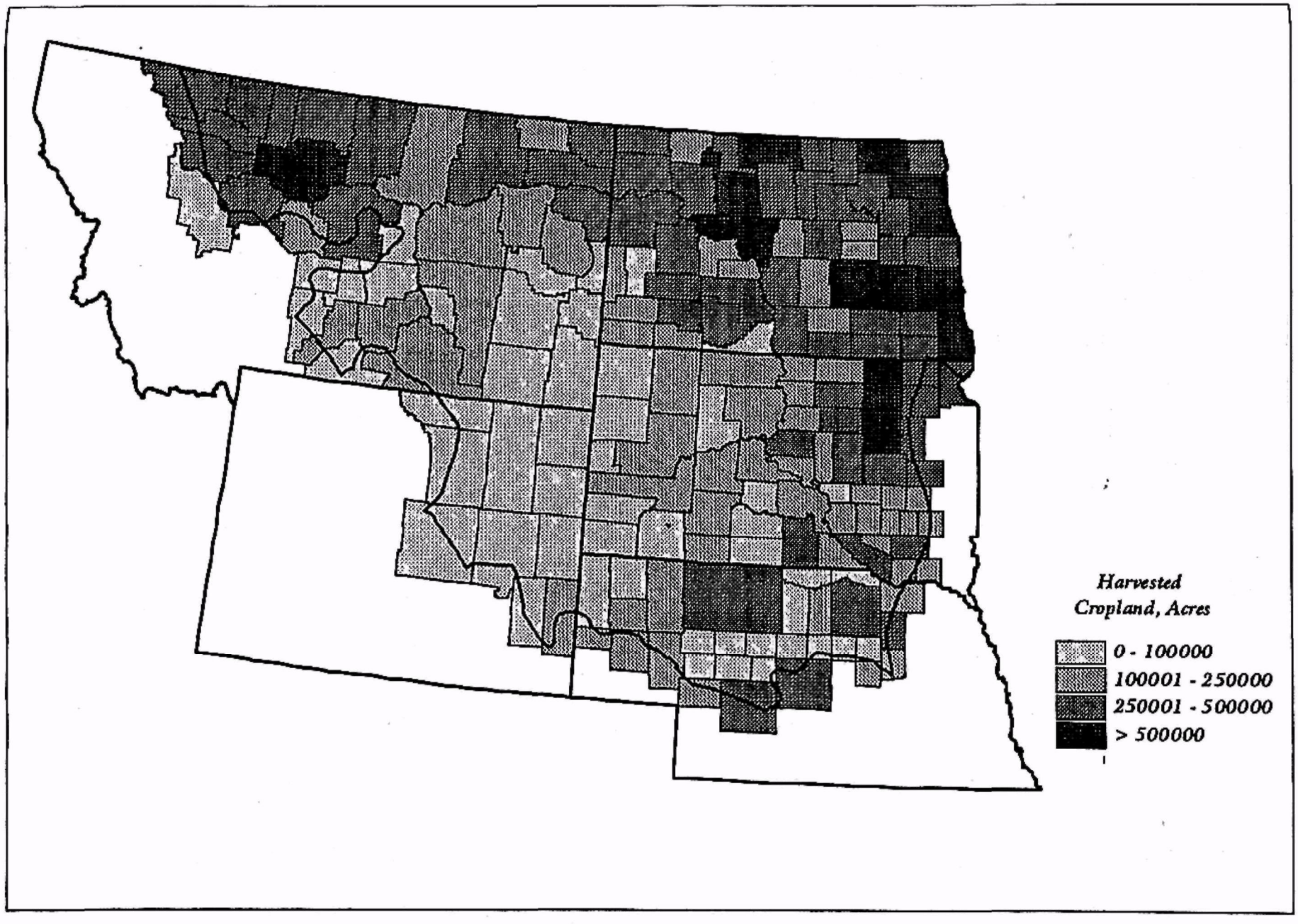

Figure 5.4.18 Acres of Harvested Cropland by County in the Northern Great Plains

Resources Conservation Service, 1992).

Figure 5.4.19 shows the amount of total animal units by county. Total animal units is a means of gauging the impact of livestock by setting the numbers of various livestock (hogs, sheep, etc.) equal to one beef cow in terms of the waste produced. Therefore, if one beef cow is the unit of measurement, ten sheep are equal to one beef cow. Additionally, 0.7 milk cows and 2.5 hogs are each equal to one beef cow. A larger number of hogs or sheep is needed to equal the potential impact of a smaller number of beef or milk cows. This follows the EPA regulations for concentrated animal feeding operations. A certain number of total animal units in a confined animal feeding operation is regulated as a point source. This is generally the equivalent of 1000 beef cattle (and therefore, 10,000 sheep, 2500 hogs or 700 milk cows). However, the regulations allow for controls on lesser numbers if water quality impacts are evident. Farms with lesser numbers are generally considered to be nonpoint sources and most operations are smaller.

There is a total of 6,367,614 total animal units (based on beef cattle, milk cows, hogs and sheep) in the NGPAA. Several counties in Nebraska stand out as areas with the highest number of total animal units, and therefore the highest potential impact from livestock operations. There is a general pattern of higher total animal units in the central, southern and western areas of the Northern Great Plains, with much less in the northeastern portions. The total number of beef cattle in the NGPAA is 4,803,302, with the greatest concentration in the Sand Hills of Nebraska and southern and central Montana. The total number of hogs is 2,794,254 and the greatest concentration is in eastern South Dakota, southeastern North Dakota and eastern Nebraska, with very low numbers elsewhere in the NGPAA. The total number of sheep is 1,847,398 with the greatest numbers in Garfield and Carter Counties in Montana, Harding and Butte Counties in South Dakota and Campbell, Johnson, Natrona and Converse Counties in Wyoming. It must be stressed that these numbers only indicate where potential impacts may be highest, a number of factors such as runoff potential, management practices, and proximity to streams, all affect how much manure reaches streams. Sheer numbers do not necessarily correlate to nitrogen loading, but do show an area to be at increased risk.

Figure 5.4.20 presents areas where the most nitrogen fertilizer was used for the year 1985. This data was developed by Alexander and Smith (1990) by disaggregating state-level fertilizer use to the county level in proportion to the amount of fertilized acreage in the counties. Eastern and northern North Dakota, the Platte River of Nebraska and portions of north-central Montana have the heaviest amounts of nitrogen fertilizer use. This matches the large amount of total harvested and irrigated cropland in those areas. Figure 5.4.21 presents information on fertilizer sales by county with data from 1991.

The Lower James, Vermillion, Lewis and Clark Lake, Middle Platte, Loup, Upper Elkhorn and several Red River watersheds are among the areas with the highest potential to deliver nitrogen to streams and rivers (Figure 5.4.22). This information is from the Index of Watershed Indicators (U.S. EPA, 1997a) and the National Resources Inventory (U.S. NRCS, 1992) and is based on the amount of nitrogen applied, the types of crops grown, the nitrogen uptake of the crops, rainfall and surface runoff potential. For this reason, the maps showing the amounts of nitrogen fertilizer applied and

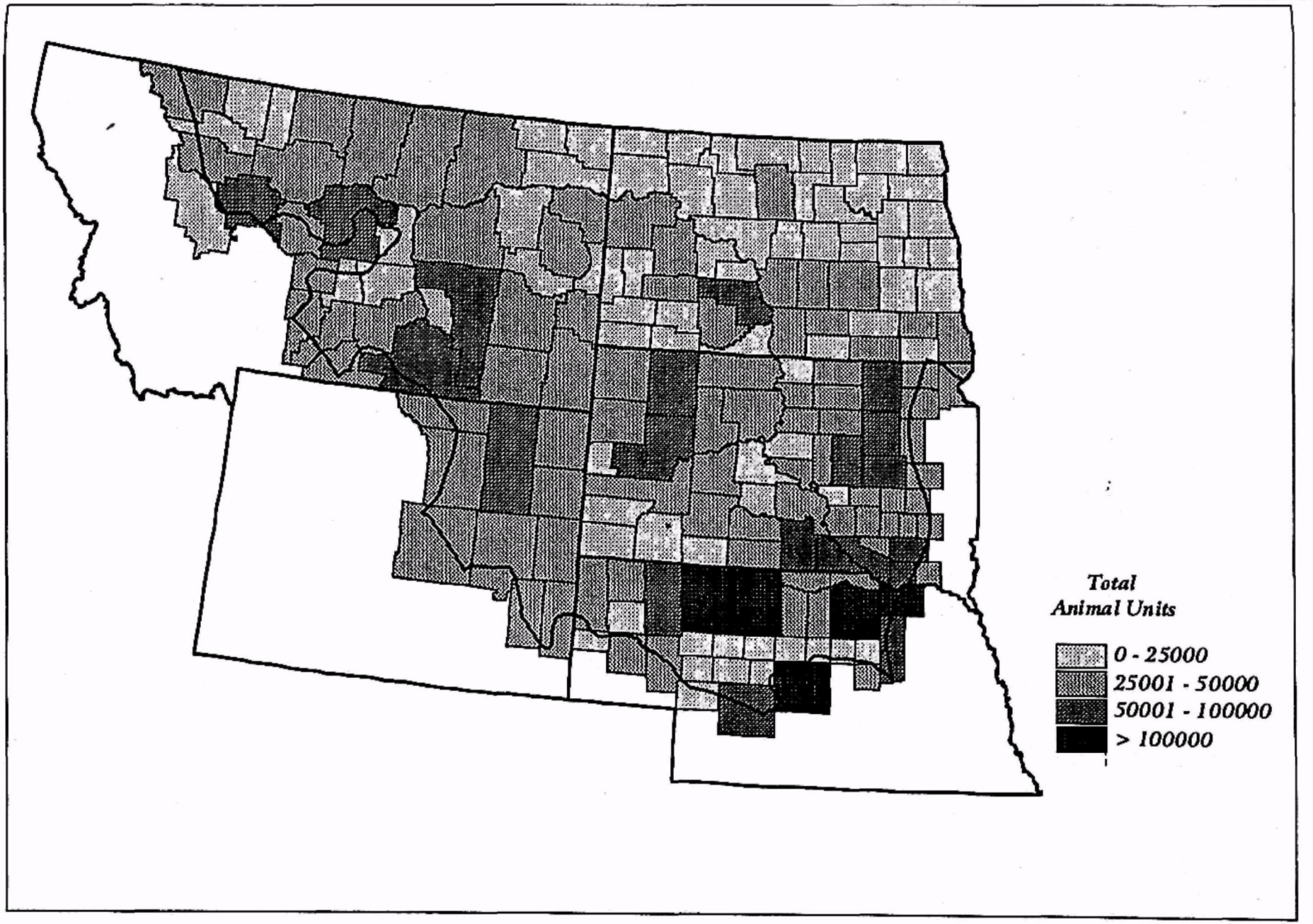

Figure 5.4.19 Total Animal Units by County in the Northern Great Plains (Beef Cattle, Milk Cattle, Hogs and Sheep)

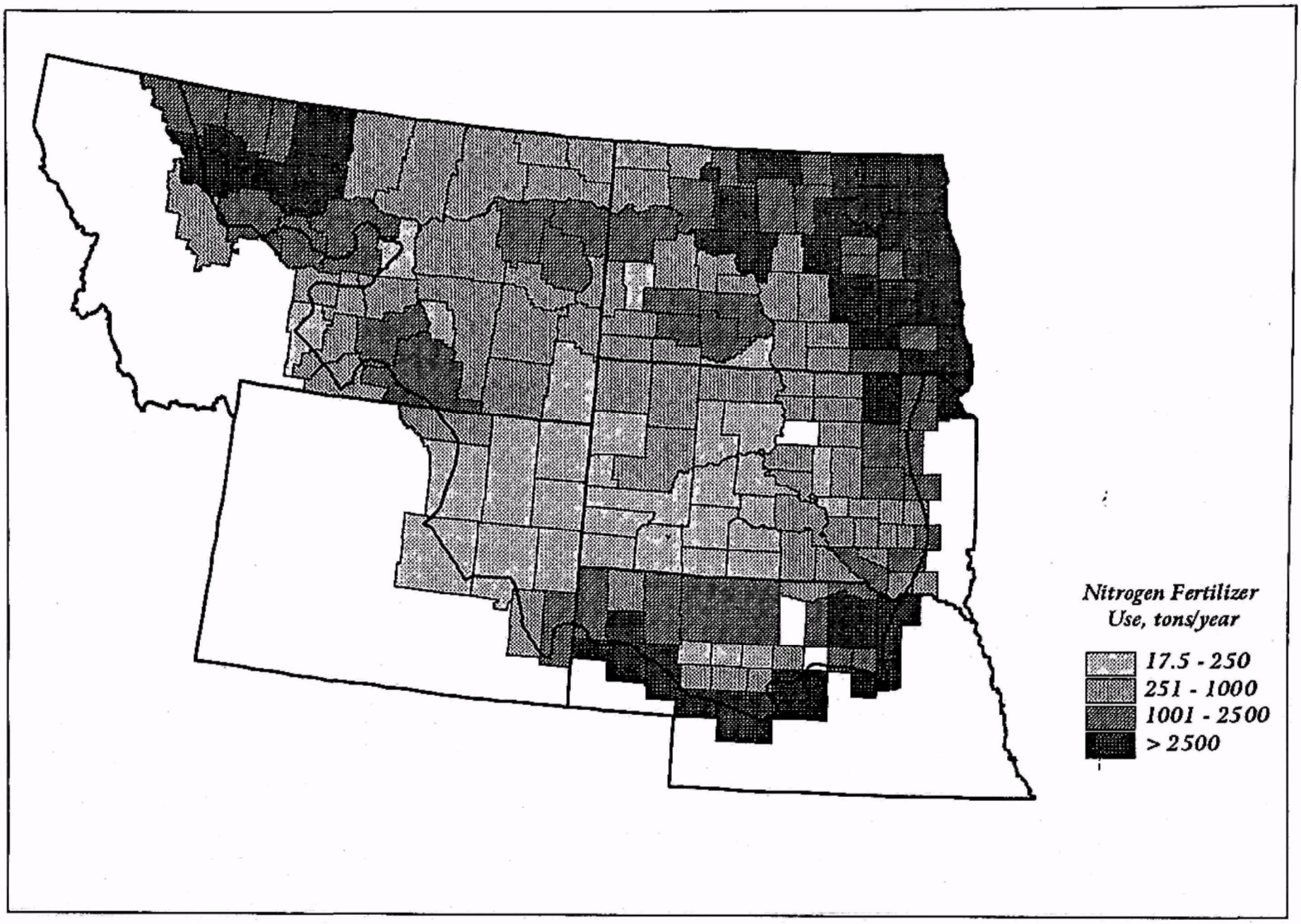

Figure 5.4.20 Nitrogen Fertilizer Use by County in the Northern Great Plains in 1985

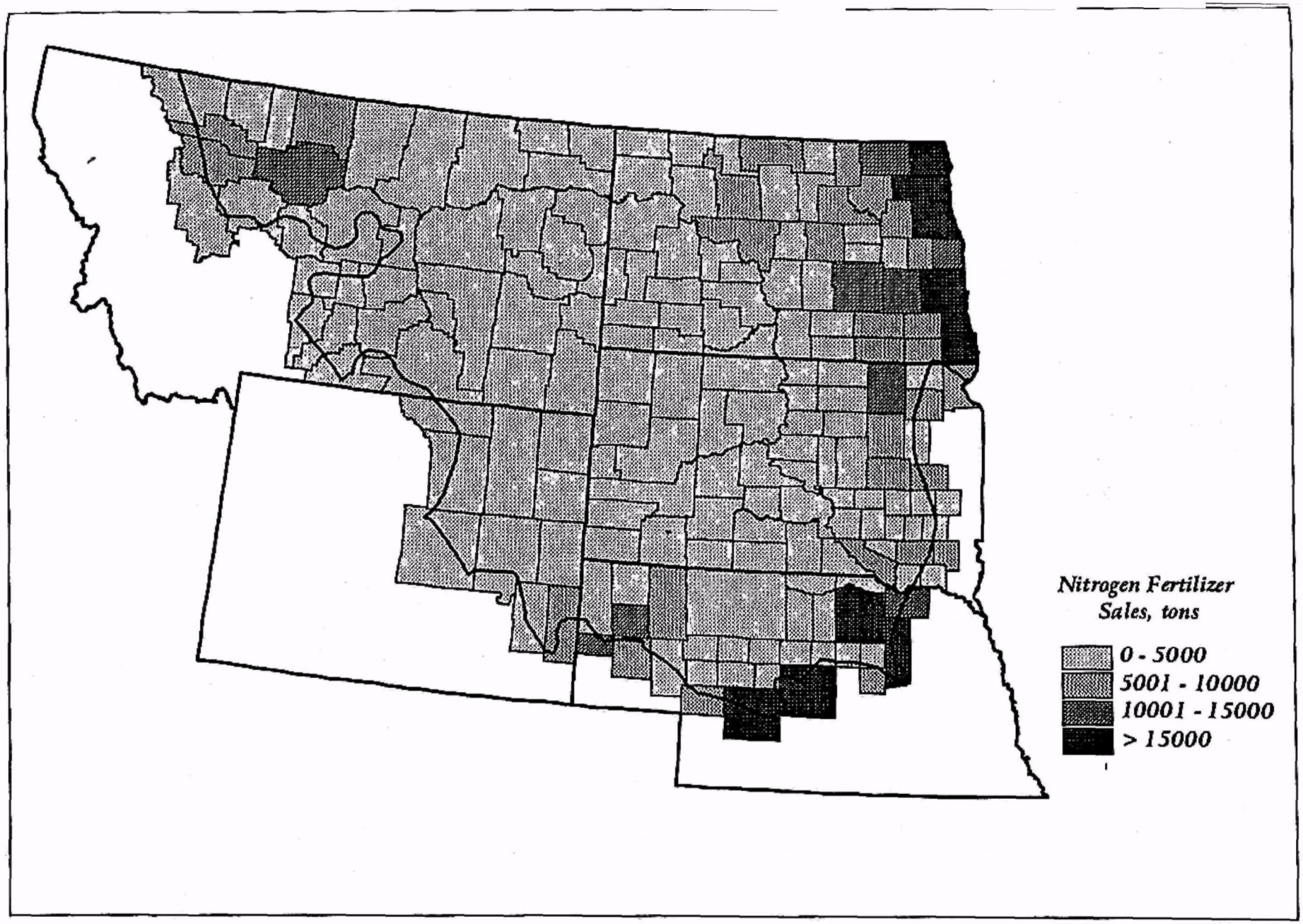

Figure 5.4.21 Nitrogen Fertilizer Sales Per County in 1991

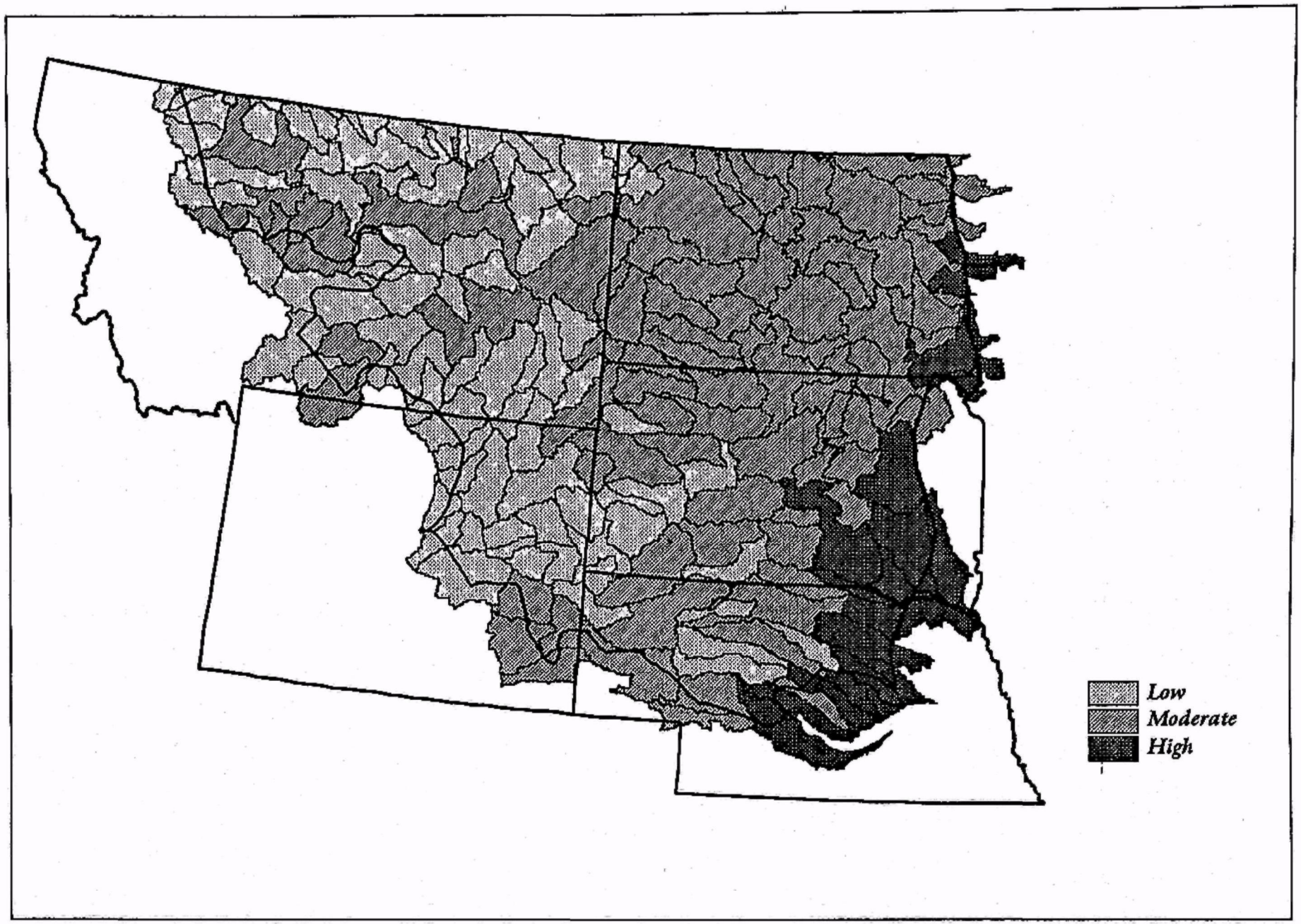

Figure 5.4.22 Nitrogen Runoff Potential from Farm Fields within the Northern Great Plains as Modified from the Index of Watershed Indicators

sold does not necessarily match the map of potential nitrogen runoff. Additionally, the runoff potential map is a relative ranking of where the potential is greatest within the NGPAA and it is modified from the Index of Watershed Indicators, which ranks on a national scale. For this reason, what is high in the Northern Great Plains may not be high nationally compared to other areas. This was meant to show where potential is highest or lowest relative to watersheds within the NGPAA. For the NGPAA, those watersheds with a national ranking in the top one-third were placed in the high potential category (the national ranking used the top 524 out of 2110 as high). Some of the watersheds in the NGPAA were high nationally as well. For example, out of 2110, the Lewis and Clark Lake watershed (10170101) ranked 124th and the Lower James (1016011) ranked 322nd.

Areas with the lowest nitrogen runoff potential are in the Upper Cheyenne, Powder and parts of the Milk and Musselshell watersheds. The Wild Horse Lake watershed (10050003) ranked the lowest in the entire NGPAA (2084th), with the Salt Creek (10090204), Antelope Creek (10120101), Dry Fork of the Cheyenne (10120102), Lightning Creek (10120105) and Snake River (10150005) watersheds just above it.

Figure 5.4.23 shows the potential runoff for pesticides, with the Lower and Middle James, Vermillion, Lewis and Clark Lake, Medicine Creek and Fort Randall Reservoir watersheds, as well as parts of the Red River watershed having the greatest potential. This map is also derived from the Index of Watershed Indicators information in a similar manner as the nitrogen runoff potential (i.e. national ranks rescaled into the Northern Great Plains). On a national scale there were 1577 watersheds ranked for pesticide runoff potential based on the amount of pesticides used, crops grown and rainfall amounts and those ranked 395 or greater were labeled as high potential. Those ranked as "high potential" within the NGPAA, were those that ranked roughly in the top third nationally. The top three watersheds in the NGPAA are Lewis and Clark Lake (10170101) which ranked nationally 124th out of 1577, the Vermillion watershed (10170102) at 127th and the Lower James (10160011) at 204th.

The lowest potential is for areas in southern Montana, western South Dakota and northeastern Wyoming. Wild Horse Lake (1005003), Boxelder Creek (10110202) and Frenchman Creek (10050013) all ranked near the bottom nationally for potential pesticide runoff.

The areas within the NGPAA where the largest number of pesticides are used in the heaviest amounts (more than 31 pounds per square mile) are eastern North Dakota with 12, eastern South Dakota with 8, western Nebraska with 5 and eastern Nebraska with 3 (U.S. Geological Survey, 1998). All other areas in the NGPAA use only one pesticide at levels greater than 31 lbs/square mile (though they may be different pesticides). Pesticides with the heaviest and most widespread use are 2,4-D, alachlor, atrazine, cyanazine, EPTC, and metalachlor (U.S. Geological Survey, 1998). Figures 5.4.24 and 5.4.25 show where the largest amounts of atrazine and 2,4-D are used, respectively, in the Northern Great Plains.

Figure 5.4.26 presents the sediment delivery potential by watershed. This also was adapted from the Index of Watershed indicators. The IWI integrated information on rainfall, crop growth, agricultural management practices and erosion potential (among others) to develop the sediment

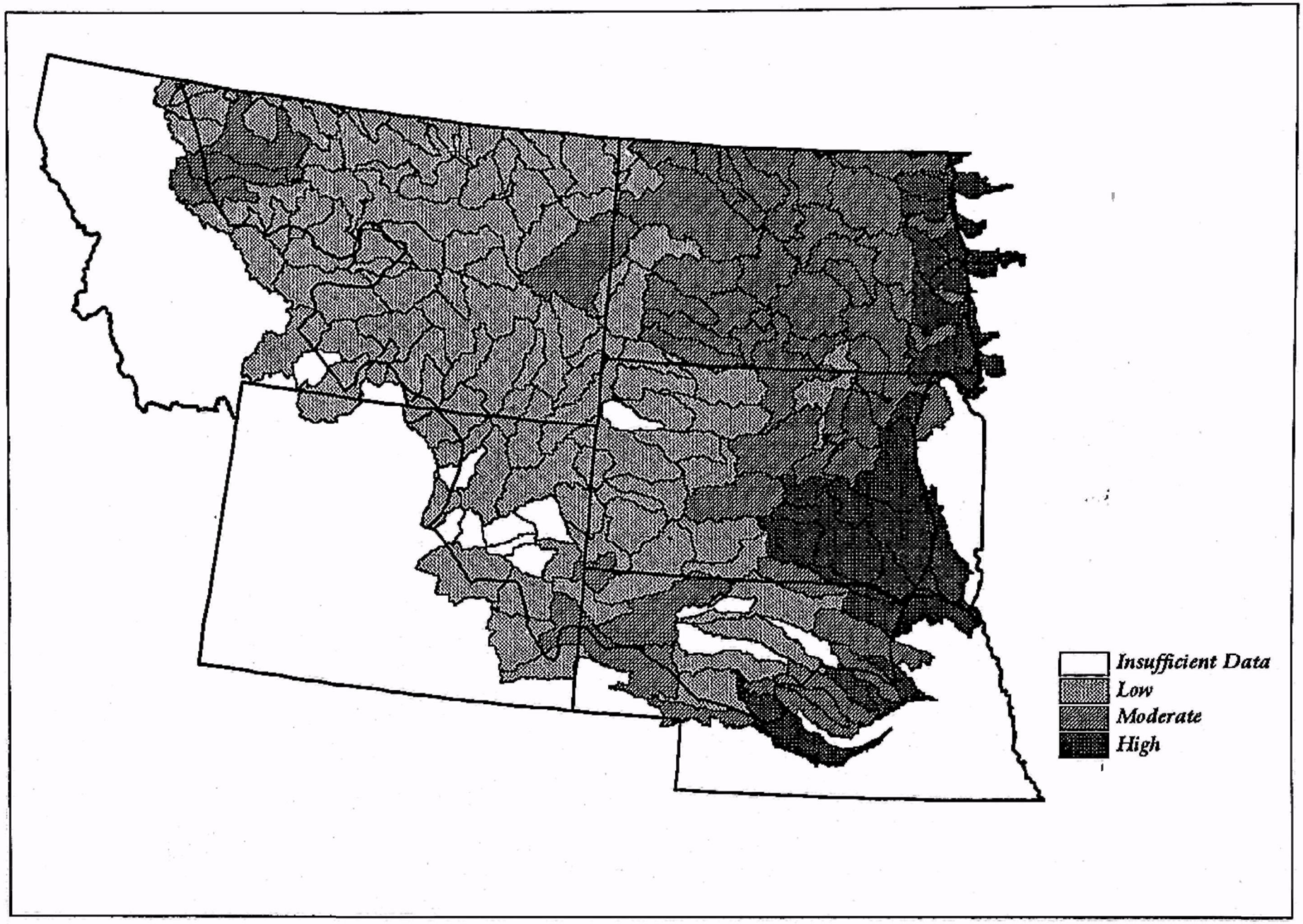

Figure 5.4.23 Pesticide Runoff Potential from Farm Fields within the Northern Great Plains as Modified from the Index of Watershed Indicators

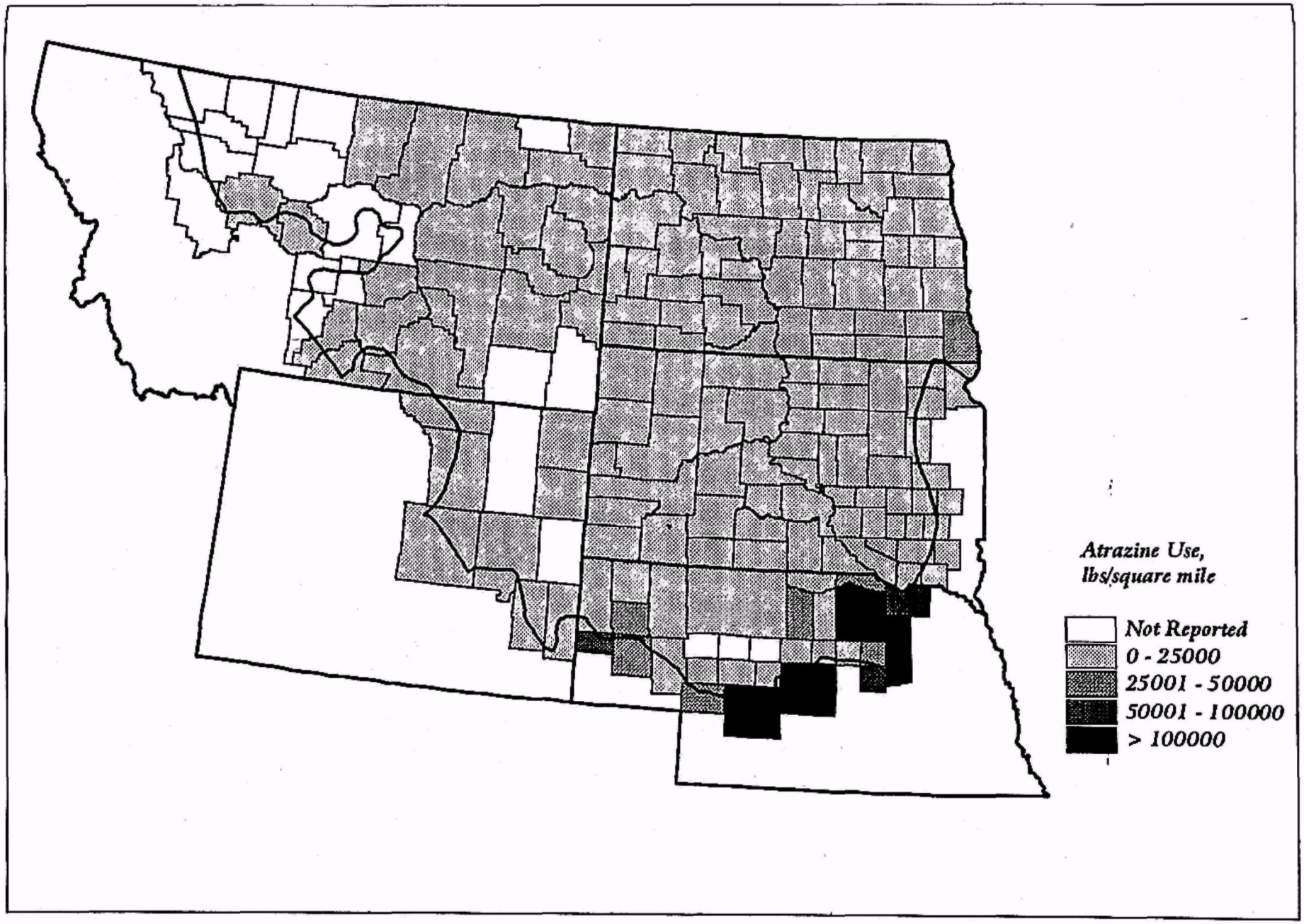

Figure 5.4.24 Use of Atrazine in the Northern Great Plains

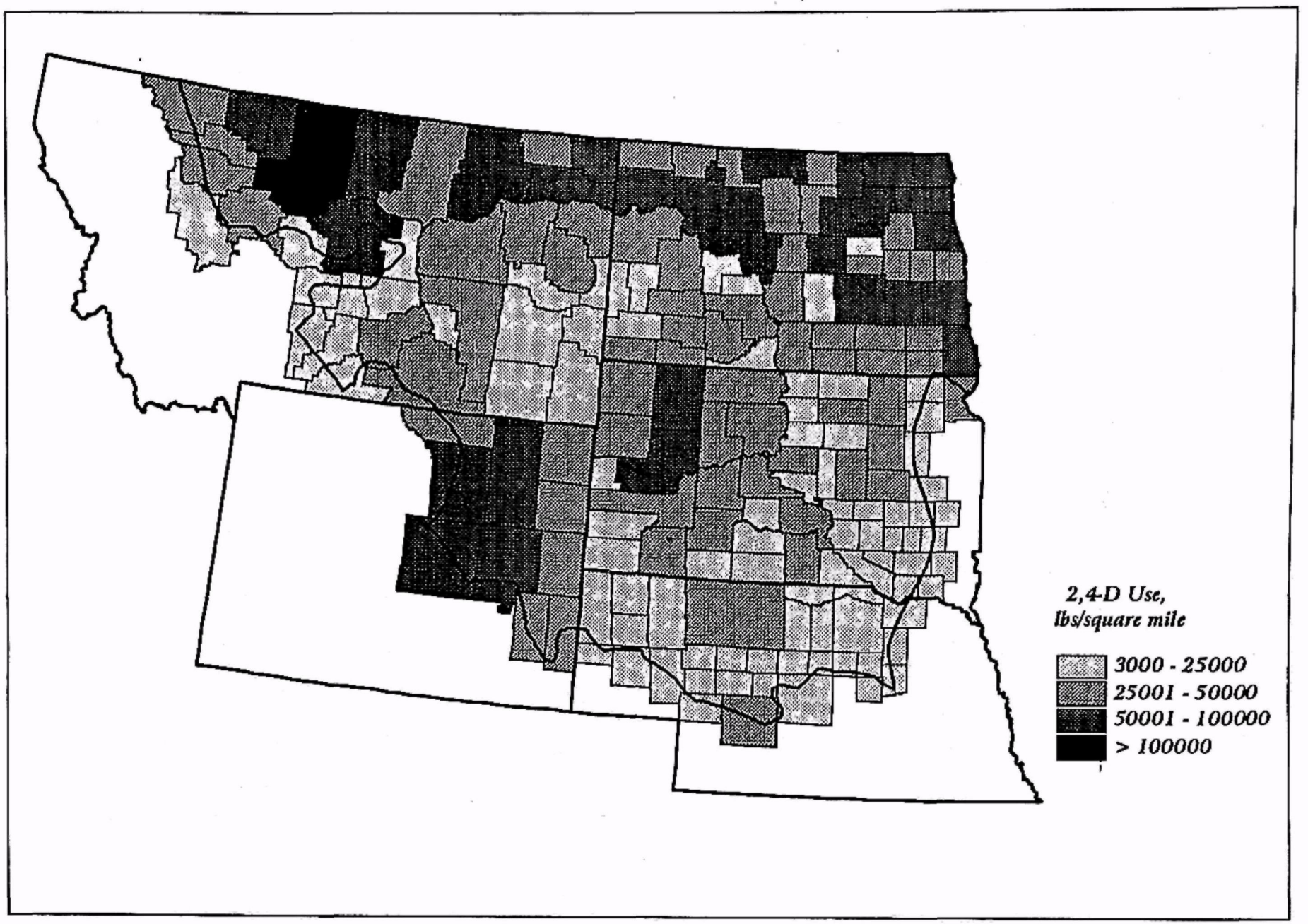

Figure 5.4.25 Use of 2,4-D in the Northern Great Plains

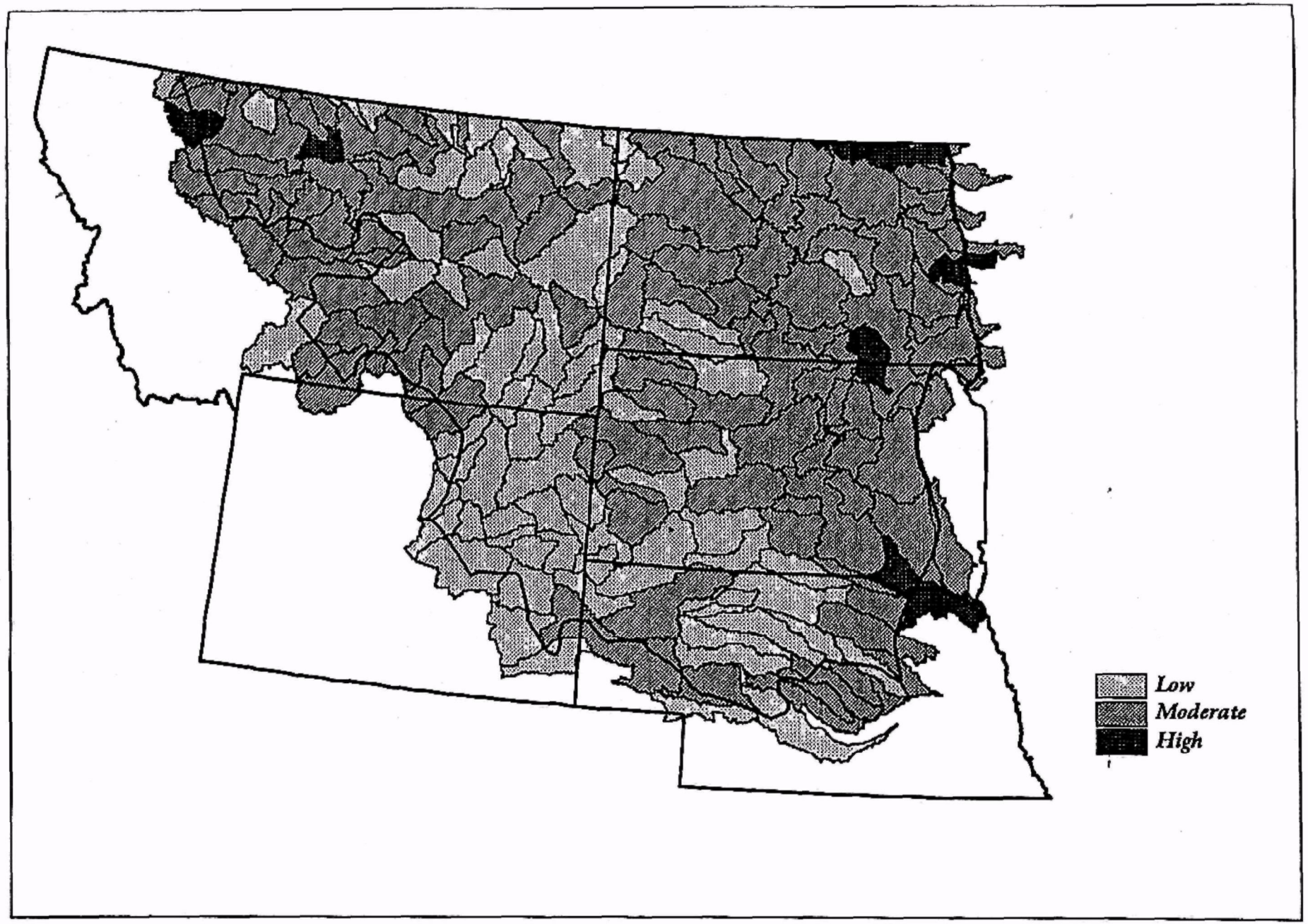

Figure 5.4.26 Potential for Sediment Delivery to Streams from Cropland and Rangeland within the Northern Great Plains as Modified from the Index of Watershed Indicators

delivery potential rankings. The entire NGPAA ranked as low to moderate on national scale, but this was adapted to show which areas had the highest potential within the NGPAA. A total of 2106 watersheds were ranked nationally (with 530 and above as high potential), but the highest potential in the NGPAA was defined as being roughly within the top third nationally. The watersheds that are within the top third nationally are the Pembina, the Red River (Elm-Marsh), Lewis and Clark Lake, the Elm River (James basin), the Two Medicine River and Big Sandy Creek (Milk basin). However, the highest of these, the Two Medicine River watershed (10030201) in Montana ranked only 533rd nationally, therefore, none were ranked high on a national scale.

Low potential for sediment delivery exists in the Sand Hills of Nebraska and much of northeastern Wyoming. The South Fork of the Powder River (10090203) and Salt Creek 10090204) ranked 2091st and 2090th, respectively, nationally.

The potential agriculture erosion rate by major land resource area in tons per acre per year estimated from NRCS' Universal Soil Loss Equation (USLE) is presented in Figure 5.4.27. The USLE is used to predict soil loss from sheet and rill erosion from a specific area taking into account rainfall, cropping management systems or ground cover and applied conservation pracitices. The USLE does not estimate sediment yield to given point in a watershed, it estimates only what is lost to erosion, not what is deposited downstream. Parts of western North Dakota (MLRA 58A) and southeastern South Dakota (MLRA 102B) are the areas with the highest potential erosion rates, with the Black Hills, the Sand Hills, eastern Montana and northeastern North Dakota as the lowest (MLRAs 55A, 58A, 60B, 64, 65, 66 and 62).

Figure 5.4.28 shows the miles of assessed streams not fully supporting designated uses due to highway construction and maintenance. The Upper Musselshell, Upper Yellowstone, Lower Tongue, Smith and Belt River watersheds have the greatest impacts from these sources. Road construction and maintenance can affect water quality because often soil is exposed to erosion. The amount of road length near streams can indicate potential impacts.

There are six superfund sites on the National Priority List within the NGPAA. These are the Arsenic Trioxide Site in Richland County, North Dakota; the Minot Landfill in Ward County, North Dakota; Ellsworth Air Force Base in Pennington County, South Dakota; Whitewood Creek in Lawrence County, South Dakota; Mouat Industries in Stillwater County, Montana and the Mystery Bridge/US Highway 20 Site in Natrona County, Wyoming. The Whitewood Creek site is actually in the Black Hills but has effects downstream in the plains.

Future Trends

Population growth in certain areas may lead to more point source impacts from increased discharges, a greater number of discharges and stormwater runoff during and after construction. Any increases in the number and size of animal feeding operations or resource extraction activities will also create new point source impacts. The number of Superfund sites is unlikely to grow significantly, and those that exist will have localized effects.

Agriculture is the greatest, though by no means the sole, contributor of nonpoint source pollutants in the NGPAA. Therefore, changes in the extent and type of agricultural operations, as well as efforts to alleviate present sources, could have dramatic

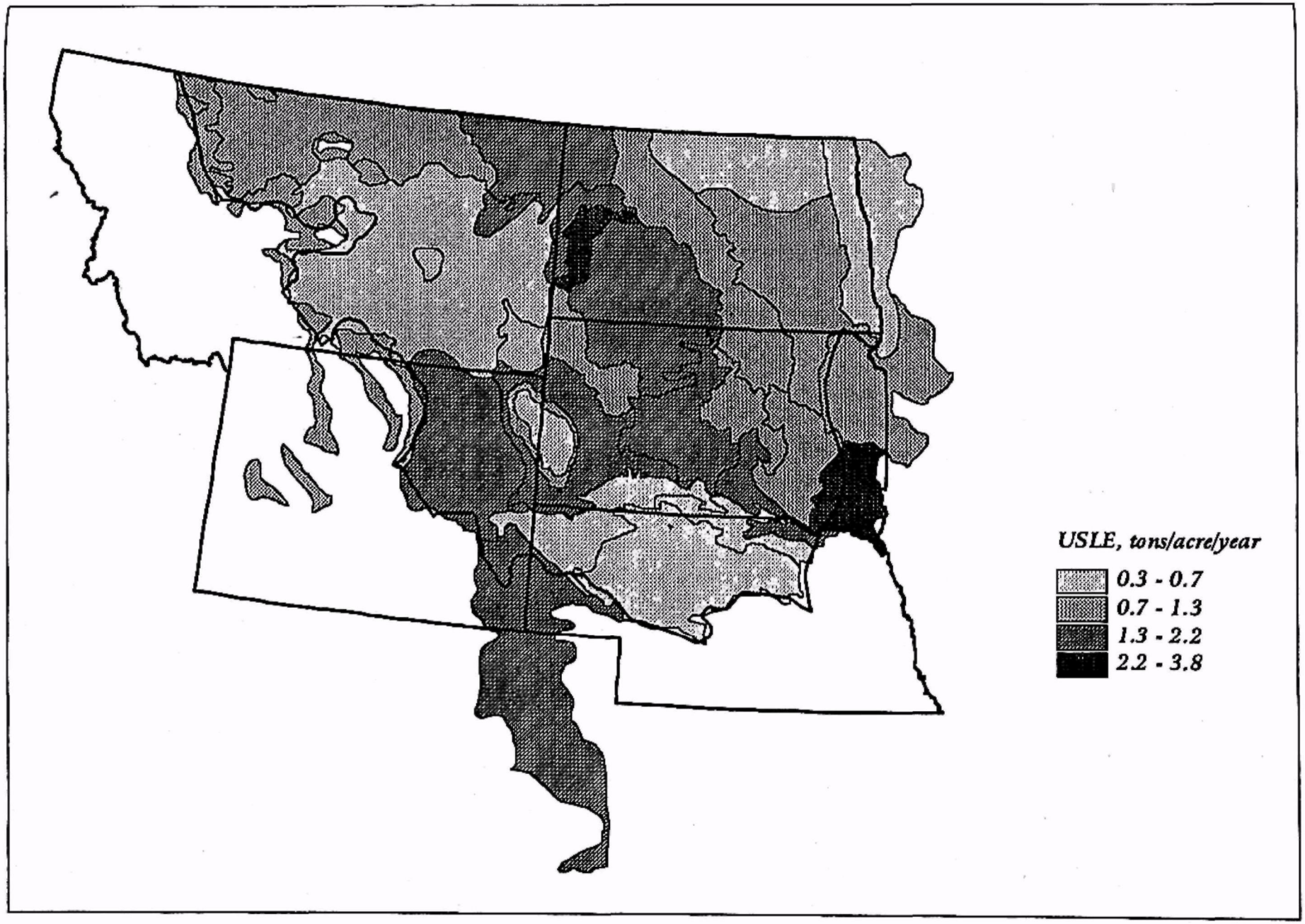

Figure 5.4.27 Soil Loss by Major Land and Resource Area as Calculated by the Universal Soil Loss Equation

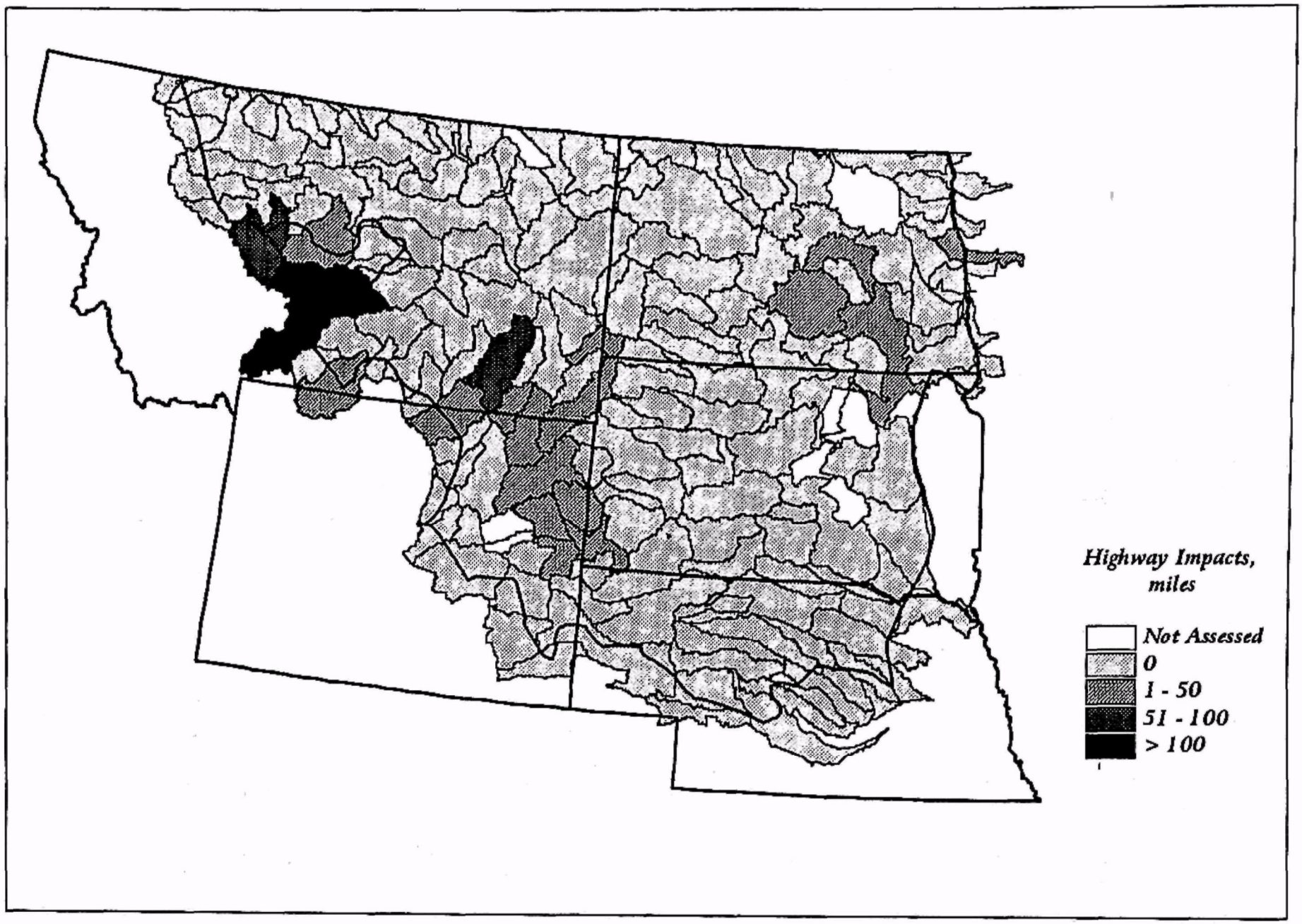

Figure 5.4.28 Miles of Assessed Streams in Each Watershed Impacted by Highway Construction/Maintenance

impacts on nonpoint source pollution to aquatic systems.

5.5 IMPACTS TO GROUND WATER

The water quality of ground water, much like that of surface water can be affected both by localized and very widespread sources. In the case of ground water, however, movement is generally much slower and any pollutants reaching it will be much more difficult to remove. Localized impacts could include landfills, spills or injection wells; while widespread impacts occur from fertilizer and pesticide applications.

Wyoming lists fertilizer application, landfills, mines, pesticide application, shallow injection wells, storage tanks, surface impoundments, transportation of materials, waste tailings and oil and gas exploration and production as the major sources of anthropogenic ground water contamination (Wyoming Department of Environmental Quality, 1994). Not all of these are necessarily important within the NGPAA.

In South Dakota the ten highest priority sources of ground water contamination are agricultural chemical facilities, animal feedlots, fertilizer applications, storage tanks (aboveground and underground), surface impoundments, landfills, septic systems, mining and mine drainage and mine waste tailings, and pipelines and sewer lines (South Dakota Department of Environment and Natural Resources, 1996).

Montana states that mining and mine drainage, septic tanks, shallow injection wells and above and below ground storage tanks as the highest priority major sources of ground water contamination (Montana Department of Environmental Quality, 1994). Dryland farming in Montana has caused saline seeps in the eastern part of the state (U.S. Geological Survey, 1988). These are wet salty areas that are discharge zones for shallow water-table aquifers.

Ground water use is discussed in Chapter 6 and the areas of greatest use are outlined there. Within the NGPAA, Nebraska by far has the greatest ground water use. This is concentrated within the Platte basin and its tributraries and is mainly drawn from the Ogallalla Formation of the High Plains Aquifer.

5.6 IMPACTS TO AQUATIC SPECIES

The impacts described in this chapter, from hydrologic modifications, habitat modifications, point and nonpoint source pollution can all affect the survival of aquatic plant and animal populations. In the Northern Great Plains, fish species are threatened specifically by diversions for irrigation, changes in hydrology due to dams, loss of riparian vegetation, the introduction of non-native species and channelization (Ostlie, et al. 1997).

There are several Great Plains fish species that were common 30 years ago that are now seriously threatened (Ostlie, et al. 1997). Declines are occurring in both small stream fish and those adapted to large turbid rivers. Small, cool, spring-fed stream habitats are now becoming rare (Ostlie, et al. 1997) and the flow modifications to the larger turbid rivers are leading to the decline in native fishes. Fish species that are the best adapted to plains rivers habitats are in the most danger, while those less adapted to fluctuating, turbid rivers have increased (Ostlie, et al. 1997).

Dams and channelization of the Missouri River have altered or eliminated sandbars, floodplain forests and underwater aquatic

habitats (Ashton and Dowd, 1991). Only 80 miles of forested floodplain remain along the Missouri River out of an original 500 miles of riparian bottomland timber and this change has affected the breeding habitat of the piping plover, interior least tern, whooping crane and wintering habitat of the bald eagle (Ashton and Dowd, 1991). In addition, the spawning habitats and migrations of pallid sturgeon, paddlefish, sturgeon chub, sicklefin chub and finescale dace have been altered or eliminated, as well as habitats for the spiny softshell and false map turtles (Ashton and Dowd, 1991).

Other major impacts to aquatic species are nonpoint sources from agriculture and wetland drainage. The addition of sediment to waters is a major impact from agricultural and other practices. Draining of wetlands eliminates habitat outright for a number of species. The northern redbelly dace, banded killifish, trout-perch and central mudminnow are included in those fish species that have lost habitat (Ashton and Dowd, 1991).

Richter, et al. 1997 found through a survey of biologists that fishes in the western united states are primarily suffering both historically and currently from competition with exotic species and secondarily from habitat removal and damage and altered hydrologic regimes due to agricultural surface water depletions and augmentations as well as altered hydrology and habitat removal from agricultural and hydroelectric impoundments.

Water Usage

6.1 INTRODUCTION

Question 5 **What are the status and apparent trends in water usage and supplies within the Northern Great Plains Assessment Area?**

This chapter examines the use of both surface water and ground water in the Northern Great Plains, specifically, how much is used for various types of activities. These include public water supply, thermoelectric cooling, agriculture and irrigation, to name a few. The trends over a ten-year period for total use, use by source (ground and surface) and by type of use are examined.

6.2 WATER USAGE AND SUPPLIES

Key Findings

•The greatest total water use in the NGPAA is in the Platte Valley of Nebraska and the Missouri River near around Bismarck. Surface water use is greatest in the Missouri near Bismarck, in the Yellowstone, Platte and Milk River basins. Ground water use is greatest in the Platte, Niobrara, Loup and Elkhorn basins (Ogallala Aquifer - High Plains Aquifer System). Watersheds which use more than 25 million gallons per day of ground water are predominantly restricted to Nebraska.
•Overall, irrigation is the greatest single type of use for water in the NGPAA. The greatest total use (surface and ground) for irrigation is in the Yellowstone, Platte, Milk, Niobrara, Lower Loup and Elkhorn basins.
•The greatest uses for thermoelectric use are in the Missouri River near Bismarck and the Lower South Platte.
•The greatest uses for public supply are, not surprisingly, in watersheds with the largest population.
•Water use for agriculture (irrigation and livestock) declined during the period 1985 to 1995 in much of South Dakota, North Dakota, northern Nebraska and eastern Montana, with the greatest decreases seen in the Lower Belle Fourche and the Middle Niobrara watersheds. The greatest increases were seen in parts of the Platte, Loup, Powder, Tongue, Upper Yellowstone and Marais River basins.
•Total water use changes during the period 1985 to 1995 closely match the changes in agricultural water use.

Data Sources

Most of the water use information was obtained from the Water Resources Division of the U.S. Geological Survey's WATSTORE database. Information from the years 1985, 1990 and 1995 was used. Streamflow information was obtained from Storet and covers the period 1980 to 1995.

Data Quality and Gaps

WATSTORE provided good coverage of the NGPAA, with all of the watersheds represented with detailed data categorized by types of use, as well as totals for ground and surface water usage. Categories such as livestock, mining, irrigation, public supply, thermoelectric cooling and a number of others are in the database. The system has information in five year increments, allowing for the trend information presented in this report on changes between 1985 and 1995.

Spatial Patterns and Trends

Table 6.2.1 lists the amounts of water supplying domestic, industrial and agricultural uses in the Northern Great Plains by watershed in 1995. Table 6.2.2 lists the total amounts of ground water, surface water and both used by watershed in 1995.

Table 6.2.1 Water use in million gallons per day for each watershed in the Northern Great Plains Assessment Area.

Code	Name	Domestic	Industrial	Agriculture
09010001	Upper Souris R	3.36	0.44	0.85
09010002	Des Lacs R	0.57	0.05	0.26
09010003	Lower Souris R	0.54	0.09	18.06
09010004	Willow Cr	0.54	0	0.96
09010005	Deep R	0.65	0.02	0.44
09020101	Bois de Sioux R	0.82	0.03	0.3
09020104	Upper Red R	5.18	1.06	0.42
09020105	Wild Rice R	0.55	0.08	7.72
09020107	Red R (Elm-Marsh)	0.26	0	1.71
09020109	Goose R	0.6	0.01	1.04
09020201	Devils Lake	2.31	0.01	1.61
09020202	Upper Sheyenne R	0.49	0	0.32
09020203	Middle Sheyenne R	0.45	0	2.62
09020204	Lower Sheyenne R	1.69	0.77	8.40
09020205	Maple R	0.91	0	0.42
09020301	Red R (Sandhill-Wilson)	3.23	0.02	0.35
09020306	Red R (Grand Marais-Red)	0.02	0.01	0.14
09020307	Turtle R	0.27	0.02	3.65
09020308	Forest R	0.33	0	1.51
09020310	Park R	0.85	0.01	0.14
09020311	Lower Red R	0.32	0.1	0.16
09020313	Pembina R	1.42	0.18	0.25
10010002	St. Mary R	0.07	0	1.97
10030102	Upper Missouri-Dearborn	8.44	0.63	49.99
10030103	Smith R	0.22	0.11	213.56
10030104	Sun R	0.77	0	433.01
10030105	Belt Cr	0.07	0	1.69
10030201	Two Medicine R	0.15	0	91.57
10030202	Cut Bank Cr	1.16	0.3	70.47
10030203	Marais R	1.24	0.22	167.80
10030204	Willow Cr	0.15	0	6.63
10030205	Teton R	0.59	0.02	210.92
10040101	Missouri R (Bullwacker-Dog)	0.18	0	7.18
10040102	Arrow Cr	0.12	0	33.13
10040103	Judith R	1.23	0.11	73.24
10040104	Missouri R (Ft Peck Reservoir)	0.08	0	42.61
10040105	Big Dry Cr	0.11	0	5.68
10040106	Little Dry Cr	0.05	0	3.36
10040201	Upper Musselshell R	0.36	0	400.49
10040202	Middle Musselshell R	0.66	0.01	72.97
10040203	Flat Willow Cr	0.06	0	18.32

Table 6.2.1 Water use in million gallons per day for each watershed in the Northern Great Plains Assessment Area.

Code	Name	Domestic	Industrial	Agriculture
10040204	Box Elder Cr	0.16	0	56.11
10040205	Lower Musselshell R	0.09	0	12.61
10050001	Milk R Headwaters	0.07	0	4.43
10050002	Upper Milk R	0.31	0	3.47
10050003	Wild Horse Lake	0.04	0	2.31
10050004	Middle Milk R	1.69	0.02	284.98
10050005	Big Sandy Cr	0.2	0	3.17
10050006	Sage Cr	0.08	0	6.88
10050007	Lodge Cr	0.04	0	9.38
10050008	Battle Cr	0.05	0	26.79
10050009	Peoples Cr	0.08	0	34.52
10050010	Cottonwood Cr	0.09	0	12.22
10050011	Whitewater Cr	0.04	0	6.21
10050012	Lower Milk R	0.78	0.08	90.64
10050013	Frenchman Cr	0.03	0	7.07
10050014	Beaver Cr	0.14	0	69.41
10050015	Rock Cr	0.06	0	12.70
10050016	Porcupine Cr	0.15	0	1.00
10060001	Missouri R (Prairie Elk-Wolf)	0.57	0	72.84
10060002	Redwater R	0.39	0	15.87
10060003	Poplar R	0.49	0	7.44
10060004	West Fork Poplar R	0.06	0	2.50
10060005	Missouri R (Charlie-Little Muddy)	0.29	0.05	54.38
10060006	Big Muddy Cr	0.6	0	10.70
10060007	Brush Lake	0.14	0	1.84
10070002	Upper Yellowstone R	1.62	0.05	422.66
10070004	Upper Yellowstone R-Lake Basin	11.47	0	320.74
10070005	Stillwater R	0.27	0	71.91
10070006	Clarks Fork of the Yellowstone R	1.07	0.12	603.72
10070007	Upper Yellowstone R-Pompeys Pillar	0.92	9.68	104.14
10070008	Pryor Cr	0.19	0	14.49
10080015	Lower Bighorn R	0.62	0.02	226.30
10080016	Little Bighorn R	0.2	0	176.73
10090101	Upper Tongue R	4.27	0.06	552.08
10090102	Lower Tongue R	0.23	0	40.71
10090201	Middle Fork Powder R	0.07	0	70.98
10090202	Upper Powder R	0	0	134.9
10090203	South Fork Powder R	0	0	44.40
10090204	Salt Cr	0.08	0	28.45
10090205	Crazy Woman Cr	0	0	63.19
10090206	Clear Cr	0.84	0.01	218.74
10090207	Middle Powder R	0.11	0	17.95

Table 6.2.1 Water use in million gallons per day for each watershed in the Northern Great Plains Assessment Area.

Code	Name	Domestic	Industrial	Agriculture
10090208	Little Powder R	0.11	0	3.16
10090209	Lower Powder R	0.06	0	10.48
10090210	Mizpah Cr	0.03	0	6.76
10100001	Lower Yellowstone R-Sunday	1.65	0.14	254.44
10100002	Big Porcupine Cr	0.03	0	8.69
10100003	Rosebud Cr	0.33	0	8.59
10100004	Lower Yellostone R	2.4	0.96	411.82
10100005	O'Fallon Cr	0.31	0.01	6.17
10110101	Missouri R (Lake Sakakawea)	2.23	4.2	8.94
10110102	Little Muddy Cr	0.18	0	3.16
10110201	Upper Little Missouri R	0.19	0	13.65
10110202	Boxelder Cr	0.04	0	2.27
10110203	Middle Little Missouri R	0.18	0.05	2.49
10110204	Beaver Cr	0.23	0.01	1.22
10110205	Lower Little Missouri R	0.34	0.21	1.49
10120101	Antelope Cr	0	0	7.13
10120102	Dry Fork Cheyenne R	0	0	5.25
10120103	Upper Cheyenne R	0	0	6.52
10120104	Lance Cr	0	0	11.63
10120105	Lightning Cr	0	0	9.23
10120106	Cheyenne R (Angostura Resevoir)	0.17	0.07	3.93
10120107	Beaver Cr	1.38	0	6.24
10120108	Hat Cr	0.07	0	12.91
10120109	Middle Cheyenne R-Spring	1.49	0.39	35.52
10120110	Rapid Cr	5.94	1.69	2.59
10120111	Middle Cheyenne R-Elk	1.2	0.22	1.43
10120112	Lower Cheyenne R	0.27	0	1.97
10120113	Cherry Cr	0.51	0	0.77
10120201	Upper Belle Fourche R	3.12	0.09	19.01
10120202	Lower Belle Fourche R	2.78	1.06	94.02
10120203	Redwater R	1.23	0.16	7.26
10130101	Missouri R (Painted Woods)	1.08	4.13	7.77
10130102	Missouri R (Upper Lake Oahe)	1.14	0.1	10.06
10130103	Apple Cr	6.93	0.11	9.93
10130104	Beaver Cr	0.41	0	1.15
10130105	Missouri R (Lower Lake Oahe)	0.8	0	19.08
10130106	Western Missouri Coteau	0.53	0	3.46
10130201	Knife R	1.01	0.02	3.02
10130202	Upper Heart R	4.07	0.11	1.38
10130203	Lower Heart R	3.07	0.07	7.57
10130204	Upper Cannonball R	0.35	0	0.82

Table 6.2.1 Water use in million gallons per day for each watershed in the Northern Great Plains Assessment Area.

Code	Name	Domestic	Industrial	Agriculture
10130205	Cedar Cr	0.29	0	1.10
10130206	Lower Cannonball R	0.21	0	0.85
10130301	North Fork Grand R	1.71	0.04	0.99
10130302	South Fork Grand R	0.09	0.02	0.57
10130303	Grand River	0.22	0	0.89
10130304	South Fork Moreau R	0.07	0	0.33
10130305	Upper Moreau R	0.08	0	0.78
10130306	Lower Moreau R	0.32	0	0.6
10140101	Missouri R (Ft Randall Reservoir)	3.58	0.4	29.45
10140102	Bad R	0.61	0.05	1.44
10140103	Medicine Knoll Cr	0.15	0	1.64
10140104	Medicine Cr	0.16	0	0.65
10140105	Crow Cr	0.23	0	2.11
10140201	Upper White R	2.18	0.14	18.36
10140202	Middle White R	0.21	0	2.63
10140203	Little White R	0.51	0	6.48
10140204	Lower White R	0.78	0.01	2.59
10150001	Ponca Cr	0.41	0.03	2.59
10150002	Niobrara River Headwaters	0.6	0.02	17.69
10150003	Upper Niobrara R	2.98	0.29	266.66
10150004	Middle Niobrara R	1.17	0.12	53.34
10150005	Snake R	0.08	0	63.28
10150006	Keya Paha R	0.46	0.01	16.39
10150007	Lower Niobrara R	0.64	0.04	127.51
10160001	James R Headwaters	0.64	0.07	0.55
10160002	Pipestem Cr	0.2	0	1.96
10160003	Upper James R	5.25	2.81	17.17
10160004	Elm Cr	0.72	0	1.40
10160005	Mud Cr	0.29	0	0.58
10160006	Middle James R	1.99	1.76	13.16
10160007	Eastern Missouri Coteau	0.12	0	0.82
10160008	Snake Cr	0.48	0.07	1.64
10160009	Turtle Cr	0.53	0	2.92
10160010	Northern Big Sioux Coteau	0.52	0	1.49
10160011	Lower James R	4.41	0.26	7.02
10170101	Missouri R (Lewis & Clark Lake)	4.93	0.75	111.42
10170102	Vermillion R	3.25	0.13	17.84
10180007	Middle North Platte R-Casper	7.89	0.1	91.89
10180008	Middle North Platte R (Glendo Res)	1.4	0.03	60.40
10180009	Middle North Platte R-Scotts Bluff	8.53	5.6	630.21
10180011	Lower Laramie R	1.09	0	109.12
10180012	Horse Cr	0.43	0.01	71.02

Table 6.2.1 Water use in million gallons per day for each watershed in the Northern Great Plains Assessment Area.

Code	Name	Domestic	Industrial	Agriculture
10180014	Lower North Platte R	2.07	0.32	169.25
10190018	Lower South Platte R	3.33	0.48	175.28
10200101	Middle Platte R-Buffalo	8.25	1.58	1021.15
10210001	Upper Middle Loup R	0.39	0.03	8.86
10210002	Dismal R	0.23	0	14.01
10210003	Lower Middle Loup R	1.3	0.14	228.24
10210004	South Loup R	0.96	0.07	103.19
10210005	Mud Cr	0.93	0.21	83.73
10210006	Upper North Loup R	0.22	0	45.96
10210007	Lower North Loup R	0.91	0.09	163.21
10210008	Calamus R	0.13	0	9.94
10210009	Loup R	2.89	0.32	150.47
10210010	Cedar R	0.55	0.04	65.17
10220001	Upper Elkhorn R	3.71	1.91	193.23

Table 6.2.2 Total Water Use by Source for each Watershed in the Northern Great Plains Assessment Area

Watershed Code	Ground Water	Surface Water	Total
09010001	3.09	0.62	3.71
09010002	0.78	0.17	0.95
09010003	10.33	12.85	23.18
09010004	2.56	0.35	2.91
09010005	0.99	0.18	1.17
09020101	0.48	0.17	0.65
09020104	4.35	11.81	16.16
09020105	10.53	0.46	10.99
09020107	1.95	0.04	1.99
09020109	1.67	0.49	2.16
09020201	3.15	0.63	3.78
09020202	1.37	0.25	1.62
09020203	3.28	0.39	3.67
09020204	8.00	2.66	10.66
09020205	1.38	0.36	1.74
09020301	0.41	6.79	7.20
09020306	0.02	0.14	0.16
09020307	4.95	0.21	5.16
09020308	1.73	0.21	1.94
09020310	0.43	0.26	0.69
09020311	0.12	1.43	1.55
09020313	1.09	0.98	2.07
10010002	0.06	1.98	2.04
10030102	1.92	64.24	66.16
10030103	0.54	213.47	214.01
10030104	3.40	430.65	434.05
10030105	0.17	1.58	1.75
10030201	2.07	90.62	92.69
10030202	1.61	71.11	72.72
10030203	3.77	166.71	170.48
10030204	0.33	6.55	6.88
10030205	1.29	210.51	211.80
10040101	0.42	6.95	7.37
10040102	0.53	32.92	33.45
10040103	3.40	72.03	75.43
10040104	1.07	41.81	42.88
10040105	0.61	5.21	5.82
10040106	0.34	3.07	3.41
10040201	3.50	397.46	400.96
10040202	1.71	72.34	74.05
10040203	0.24	18.14	18.38
10040204	1.00	55.32	56.32

Table 6.2.2 (cont.) Total Water Use by Source for each Watershed in the Northern Great Plains Assessment Area

Watershed Code	Ground Water	Surface Water	Total
10040205	7.07	12.32	19.39
10050001	0.07	4.43	4.50
10050002	0.23	3.68	3.91
10050003	0.24	2.11	2.35
10050004	7.08	280.57	287.65
10050005	0.45	3.00	3.45
10050006	0.39	6.68	7.07
10050007	0.27	9.15	9.42
10050008	0.62	26.22	26.84
10050009	0.76	33.84	34.60
10050010	0.29	12.02	12.31
10050011	0.11	6.14	6.25
10050012	3.22	88.80	92.02
10050013	0.12	6.98	7.10
10050014	1.15	68.39	69.54
10050015	0.43	12.33	12.76
10050016	0.30	0.93	1.23
10060001	2.13	71.57	73.70
10060002	0.77	15.59	16.36
10060003	2.34	5.93	8.27
10060004	0.62	1.94	2.56
10060005	0.63	54.17	54.80
10060006	4.83	6.91	11.74
10060007	1.22	0.77	1.99
10070002	4.35	421.17	425.52
10070003	1.38	175.01	176.39
10070004	5.18	342.04	347.22
10070005	2.78	69.47	72.25
10070006	2.08	604.04	606.12
10070007	2.87	113.01	115.88
10070008	0.45	14.23	14.68
10080015	5.12	222.51	227.63
10080016	2.14	175.01	177.15
10090101	1.69	556.71	558.40
10090102	2.43	39.75	42.18
10090201	1.16	70.89	72.05
10090202	2.09	135.19	137.28
10090203	2.76	44.88	47.64
10090204	1.52	29.10	30.62
10090205	0.38	63.22	63.60
10090206	2.56	217.13	219.69

Table 6.2.2 (cont.) Total Water Use by Source for each Watershed in the Northern Great Plains Assessment Area

Watershed Code	Ground Water	Surface Water	Total
10090207	0.89	17.77	18.66
10090208	10.00	5.37	15.37
10090209	0.39	10.15	10.54
10090210	0.28	6.51	6.79
10100001	3.44	270.40	273.84
10100002	0.19	8.53	8.72
10100003	1.90	8.25	10.15
10100004	6.43	410.47	416.90
10100005	5.43	5.58	11.01
10110101	5.24	22.05	27.29
10110102	2.46	0.90	3.36
10110201	2.53	13.12	15.65
10110202	0.30	2.01	2.31
10110203	1.16	1.97	3.13
10110204	0.47	1.09	1.56
10110205	1.43	0.91	2.34
10120101	6.53	8.68	15.21
10120102	0.66	5.26	5.92
10120103	18.83	7.37	26.20
10120104	11.32	0.47	11.79
10120105	2.99	7.16	10.15
10120106	2.92	1.32	4.24
10120107	5.45	4.32	9.77
10120108	2.07	10.95	13.02
10120109	2.90	43.55	46.45
10120110	14.23	3.37	17.60
10120111	2.01	2.09	4.10
10120112	0.45	1.76	2.21
10120113	0.63	0.54	1.17
10120201	21.46	22.45	43.91
10120202	5.95	97.27	103.22
10120203	4.96	11.75	16.71
10130101	4.94	884.38	889.32
10130102	1.84	13.38	15.22
10130103	10.65	5.76	16.41
10130104	1.34	0.28	1.62
10130105	4.61	15.86	20.47
10130106	2.88	1.51	4.39
10130201	1.67	8.48	10.15
10130202	0.76	4.79	5.55
10130203	1.34	8.06	9.40
10130204	0.86	0.53	1.39

Table 6.2.2 (cont.) Total Water Use by Source for each Watershed in the Northern Great Plains Assessment Area

Watershed Code	Ground Water	Surface Water	Total
10130205	0.76	0.63	1.39
10130206	0.59	0.49	1.08
10130301	0.71	1.31	2.02
10130302	0.33	0.35	0.68
10130303	0.68	0.58	1.26
10130304	0.20	0.20	0.40
10130305	0.28	0.58	0.86
10130306	0.66	0.36	1.02
10140101	6.99	31.18	38.17
10140102	2.17	2.73	4.90
10140103	1.75	0.47	2.22
10140104	0.28	0.63	0.91
10140105	1.50	0.75	2.25
10140201	10.13	15.47	25.60
10140202	0.86	1.97	2.83
10140203	7.47	0.48	7.95
10140204	2.64	1.69	4.33
10150001	1.25	1.47	2.72
10150002	12.21	6.69	18.90
10150003	249.08	24.90	273.98
10150004	48.41	6.90	55.31
10150005	1.83	61.53	63.36
10150006	14.02	3.10	17.12
10150007	118.02	12.36	130.38
10160001	1.12	0.38	1.50
10160002	1.99	0.18	2.17
10160003	21.66	5.25	26.91
10160004	2.63	0.46	3.09
10160005	0.35	0.38	0.73
10160006	12.01	5.35	17.36
10160007	1.02	0.36	1.38
10160008	1.18	0.66	1.84
10160009	2.57	0.83	3.40
10160010	1.41	0.49	1.90
10160011	6.81	5.81	12.62
10170101	101.30	25.82	127.12
10170102	18.98	2.12	21.10
10180007	15.04	271.38	286.42
10180008	12.98	50.91	63.89
10180009	163.76	487.92	651.68
10180011	16.40	110.50	126.90

Table 6.2.2 (cont.) Total Water Use by Source for each Watershed in the Northern Great Plains Assessment Area

Watershed Code	Ground Water	Surface Water	Total
10180012	30.20	41.60	71.80
10180014	70.67	103.01	173.68
10190007	0.20	4.88	5.08
10190018	152.64	734.80	887.44
10200101	596.81	456.63	1053.44
10210001	8.63	3.69	12.32
10210002	14.06	0.21	14.27
10210003	80.42	150.83	231.25
10210004	100.10	6.07	106.17
10210005	81.37	4.28	85.65
10210006	17.92	28.30	46.22
10210007	51.01	116.28	167.29
10210008	9.46	0.72	10.18
10210009	145.97	14.71	160.68
10210010	62.46	4.13	66.59
10220001	195.23	15.56	210.79

The total amount of water used in 1995 in million gallons per day by watershed is presented in Figure 6.2.1. The Missouri River near Bismarck, the Middle Platte-Buffalo, the Lower South Platte, the North Platte-Scottsbluff, Clarks Fork of the Yellowstone and the Upper Tongue are watersheds where more than 500 million gallons per day are withdrawn. A little over a billion gallons of water per day are used in the Middle Platte-Buffalo watershed (much the use is outside of the NGPAA). Water use for thermoelectric cooling and irrigation drive these amounts. The Yellowstone, Milk and Loup Rivers are also important areas for total water use. Total consumptive use of water (Figure 6.2.2) is greatest in the Platte watershed and other irrigated areas. Some high total use areas such as the Missouri River in central North Dakota fall out since it is not consumptive.

Examining the source of the water used as shown in Figures 6.2.3 and 6.2.4 presents some obvious regional differences. By far, most of the groundwater use is in Nebraska in the Platte, Niobrara and Loup watersheds. Several watersheds have withdrawals of more than 100 million gallons per day of ground water. In contrast, while very large amounts of surface water are also used in the North Platte basin, some areas where little groundwater is used show large amounts of surface water use. These include central North Dakota, mainly a result of large thermoelectric cooling uses and the Yellowstone, Clarks Fork of the Yellowstone, the Milk and the Marais Rivers for irrigation.

Irrigation and thermoelectric cooling overwhelm most other uses of water in the Northern Great Plains. Figure 6.2.5 shows the total water use for irrigation, and the map, with a few exceptions, is very similar to the map of the total water use. Irrigation is done in the western and southern portions of the Northern Great Plains, with surface water supplying much of the irrigation water in the west (along with the North Platte) and ground water supplying the watersheds in Nebraska

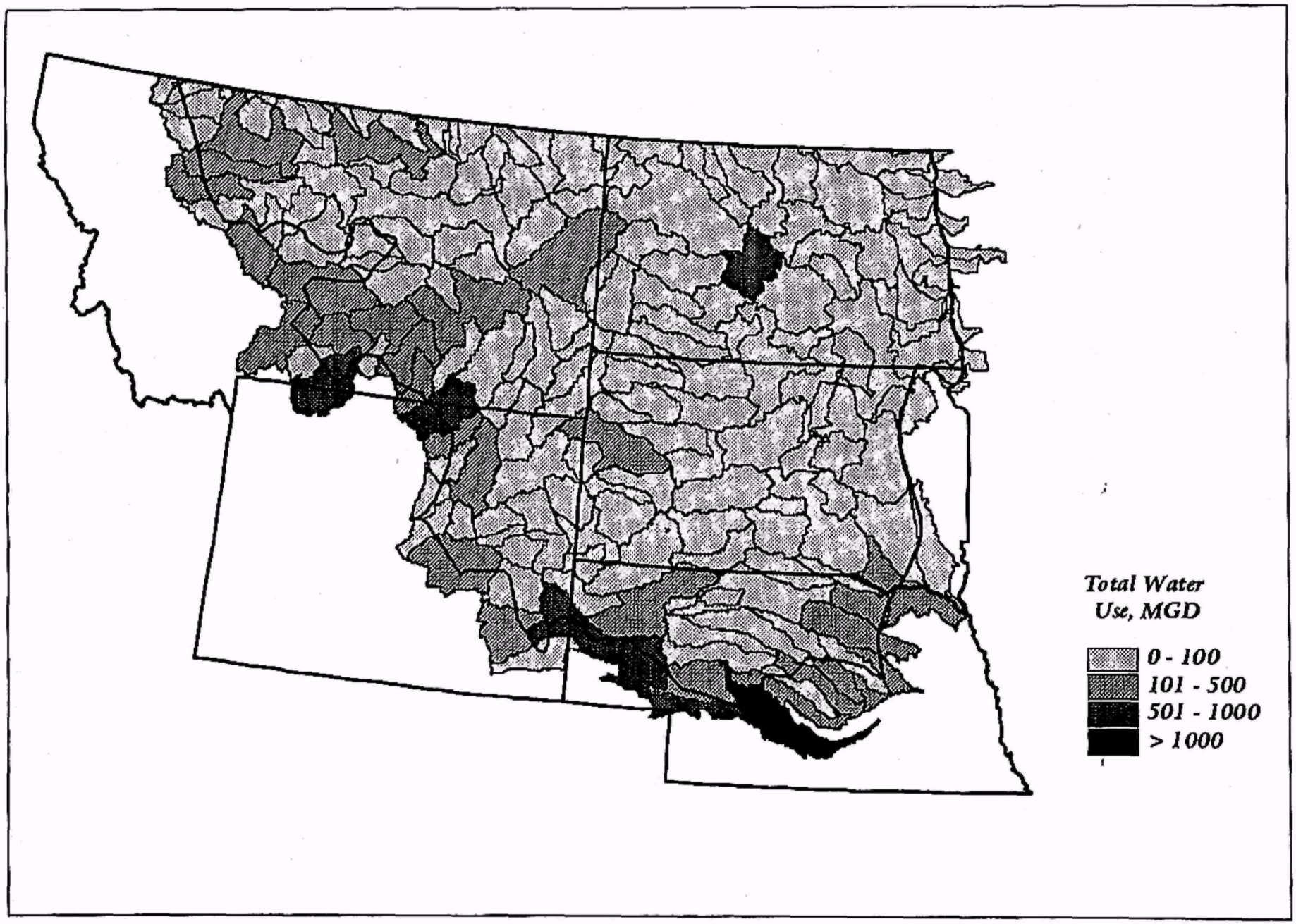

Figure 6.2.1 Total Water Use in 1995 in the Northern Great Plains

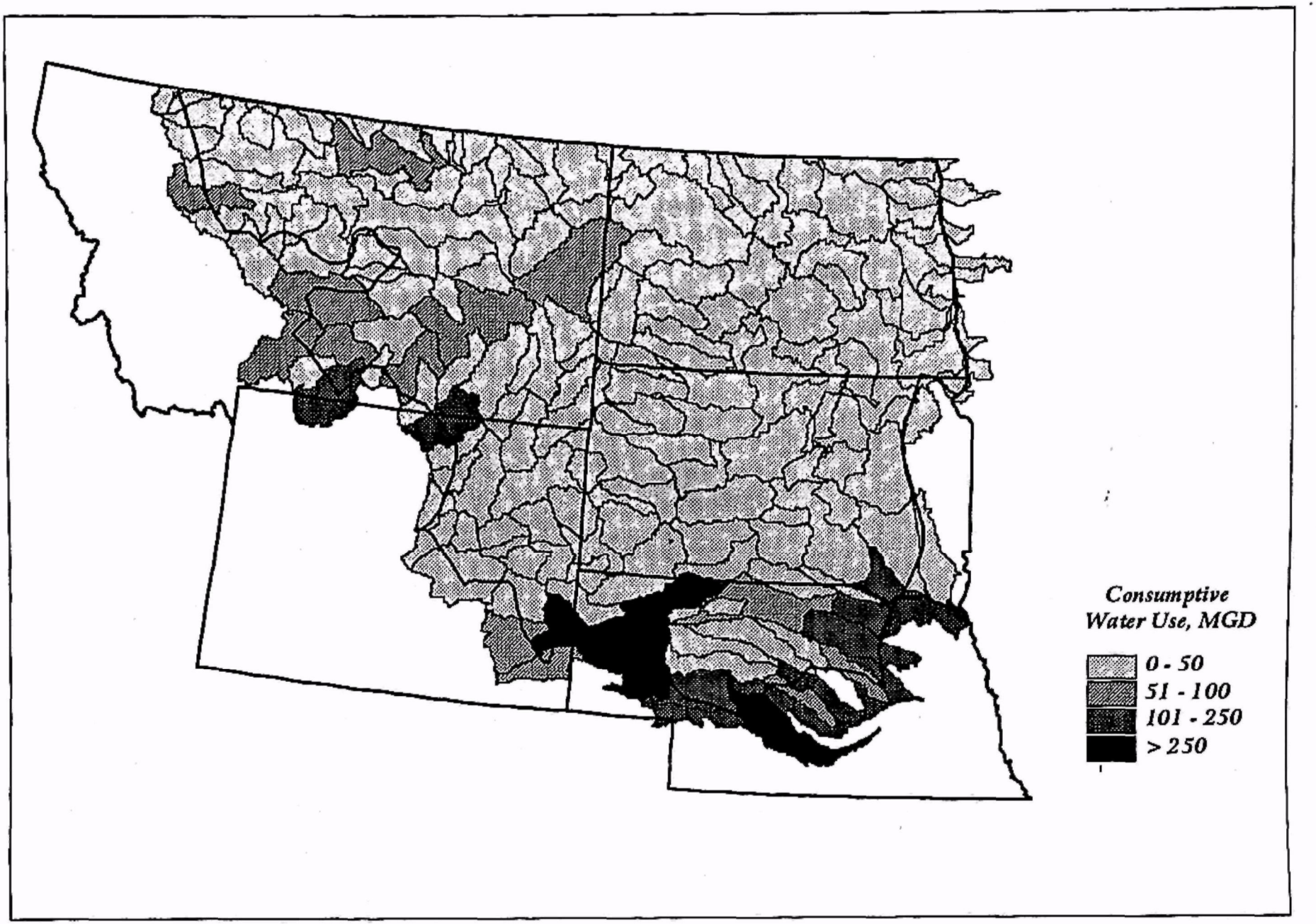

Figure 6.2.2 Total Consumptive Water Use in 1995 in the Northern Great Plains

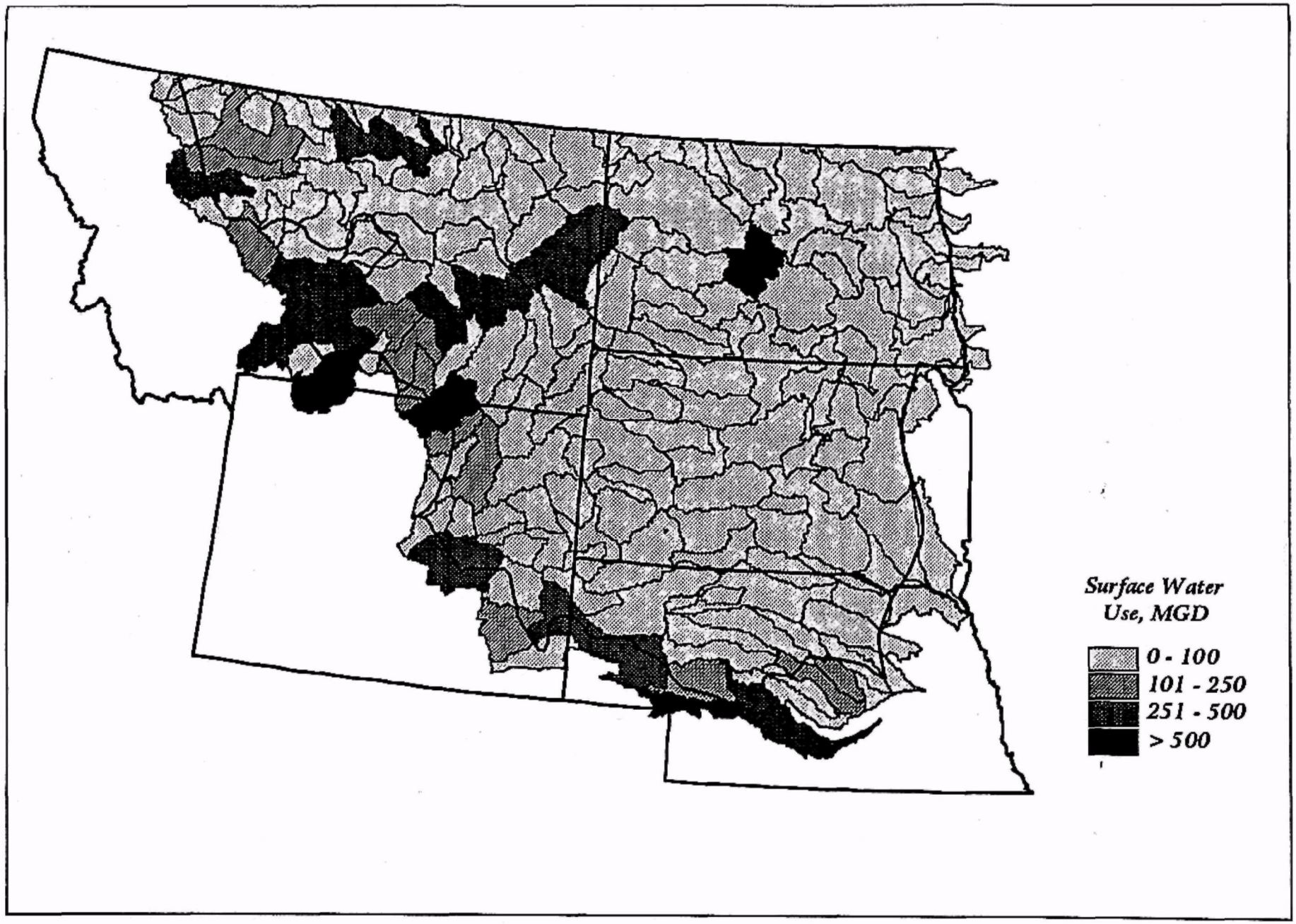

Figure 6.2.3 Total Surface Water Use in 1995 in the Northern Great Plains

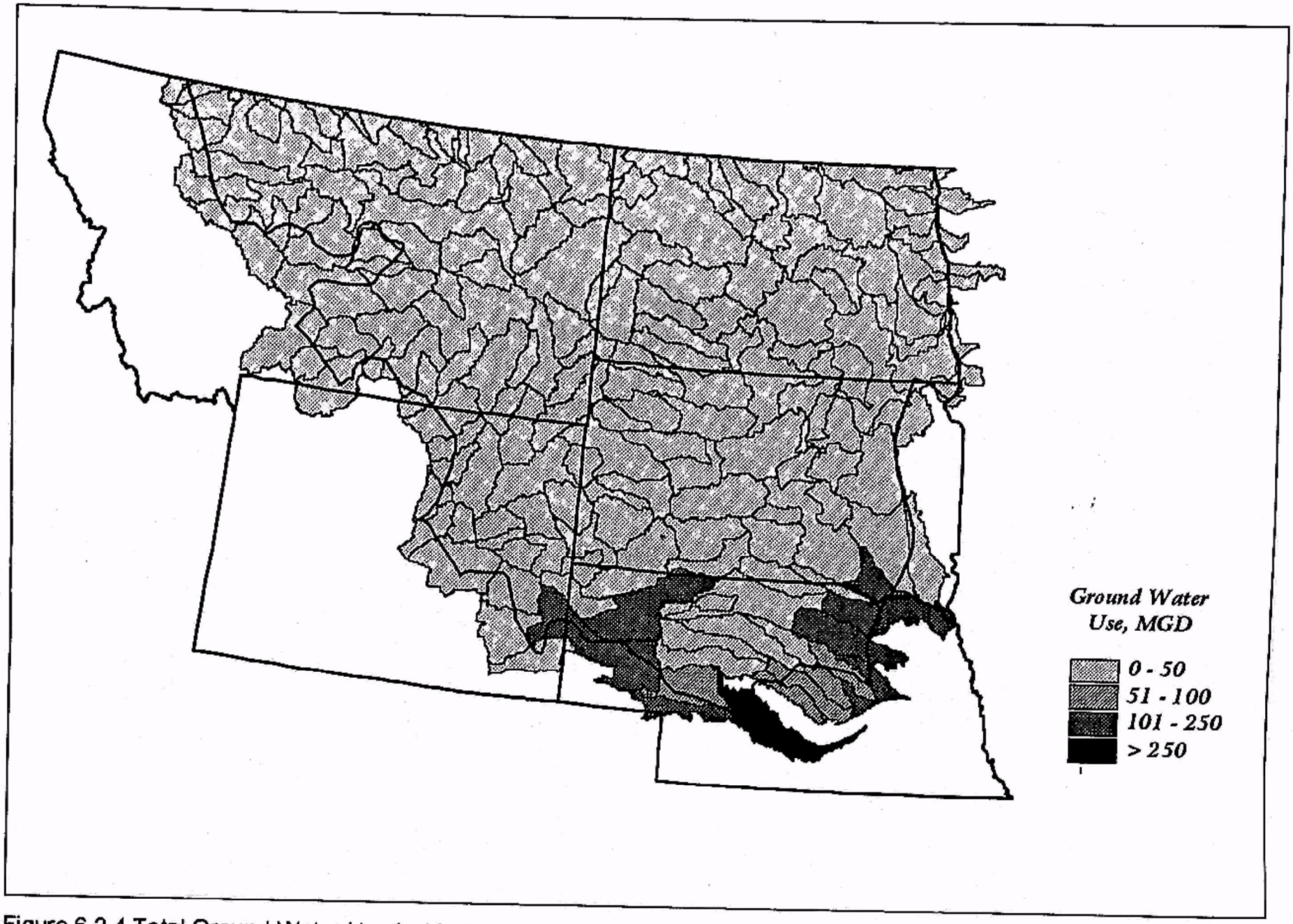

Figure 6.2.4 Total Ground Water Use in 1995 in the Northern Great Plains

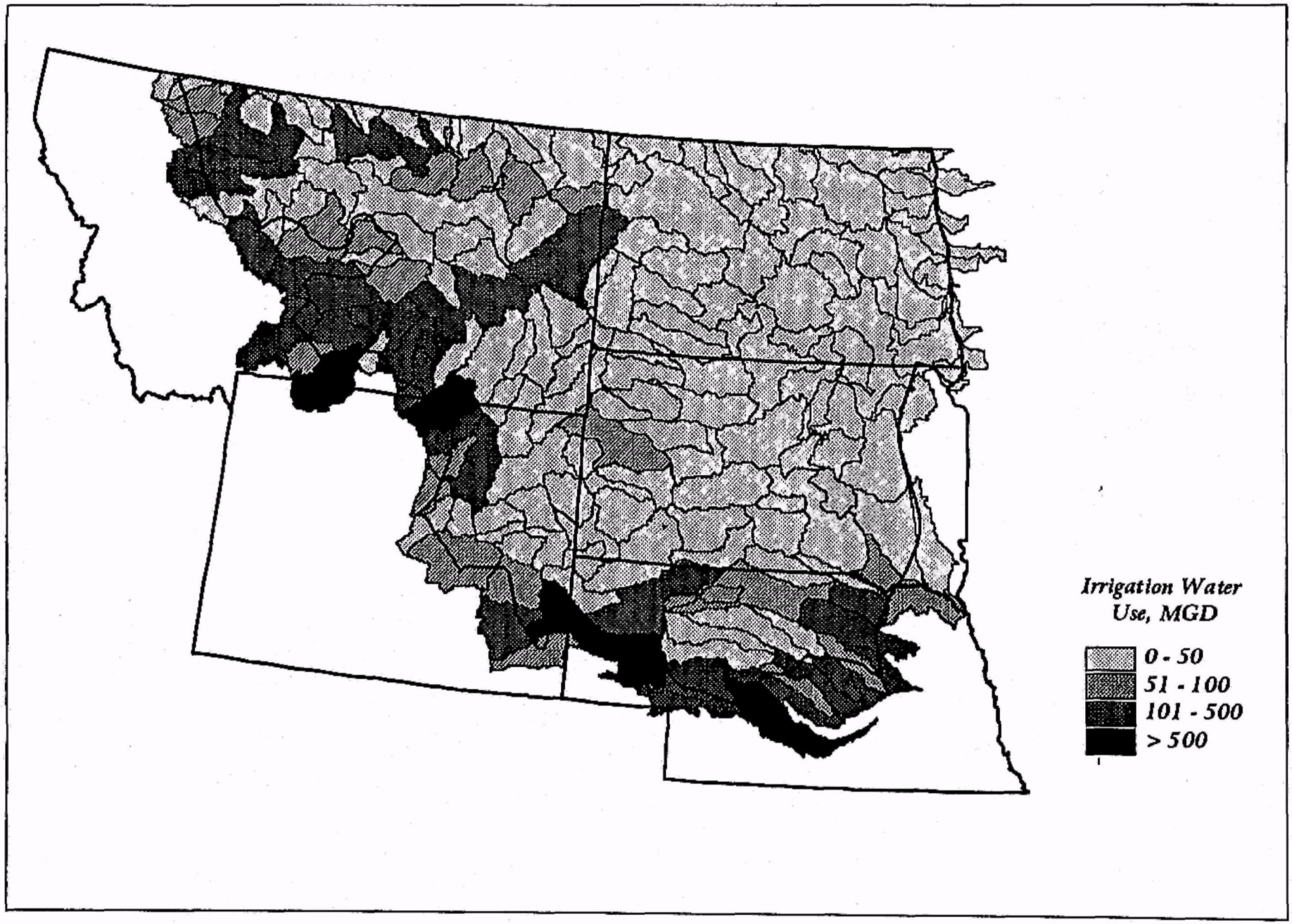

Figure 6.2.5 Total Water Use for Irrigation in 1995 in the Northern Great Plains

with irrigation water (see Figures 6.2.6 and 6.2.7). Sufficient rainfall in the north and east reduces the need for irrigation in those areas. Figure 6.2.8 presents amounts of water lost in irrigation, with again, the Platte, Loup and Yellowstone basins standing out. More than 200 million gallons of water per day are consumed in the Middle North Platte and Middle Platte watersheds. The map of total consumptive loss of water looks very similar to the consumptive use map for irrigation water, indicating that this activity is the greatest consumptive user of water. Figure 6.2.9 presents the largest use of water for thermoelectric cooling, with more than 500 million gallons per day used in central North Dakota and the Lower South Platte. The North Platte near Casper also has significant uses of water for thermoelectric cooling. In general, the vast majority of this water is returned to the river after use and very little is consumed.

Other uses of water in the Northern Great Plains include public water supply, mining and hydroelectric generation. Figure 6.2.10 shows where the greatest withdrawals for public water supply occur. Not surprisingly, these match where the largest cities and towns are located. Only seven watersheds withdraw more than 10 million gallons per day for public supply and they are mainly on the margins of the NGPAA. Large portions of the NGPAA are dependent upon ground water for domestic supply, even though these may not be large, they are significant. For example, according to the North Dakota Department of Health, groundwater provides drinking water for 60% of the state's population (95% of all rural residents) and 47 billion gallons are withdrawn annually from North Dakota aquifers (North Dakota Department of Health, 1994). In South Dakota as well, more than three-fourths of the population uses groundwater for domestic use and almost 50% of the 450 million gallons of water used per day in South Dakota is groundwater (South Dakota Department of Environment and Natural Resources, 1996).

Figures 6.2.11 and 6.2.12 show the greatest withdrawals for ground water and surface water, respectively, for mining. The large ground water withdrawals in Wyoming represent coal mining activities, while the large surface water withdrawals represent sand and gravel operations in Nebraska and hard rock mining in the Black Hills. Figure 6.2.13 represents the water use for hydroelectric facilities. This matches the location of the largest dams on the Missouri River, with other important hydroelectric facilities on the North Platte and Platte Rivers. An average of more than 10 billion gallons per day of water is used for hydropower generation on the mainstem dams of the Missouri River (with the exception of Fort Peck, which is somewhat lower).

Figure 6.2.14 presents the changes in water use for agriculture between 1985 and 1995. Large increases in agricultural water use have occurred in Loup, Platte, Tongue, Powder, Upper Yellowstone and Marais River basins watersheds. Decreases have occurred in much of the central NGPAA, especially in the Lower Belle Fourche and Middle Niobrara basins. Figure 6.2.15 shows the changes in ground water use between 1985 and 1995. The Middle Platte-Buffalo and Lewis and Clark Lake show the greatest increases in ground water use. The Middle-Platte-Buffalo had by far the greatest increase with more than 233 million gallons per day more of ground water use in 1995 than in 1985. Figure 6.2.16 presents changes in surface water use between 1985 and 1995. This map and the total water use map (Figure 6.2.17) are similar to the change in agricultural water use map, showing the

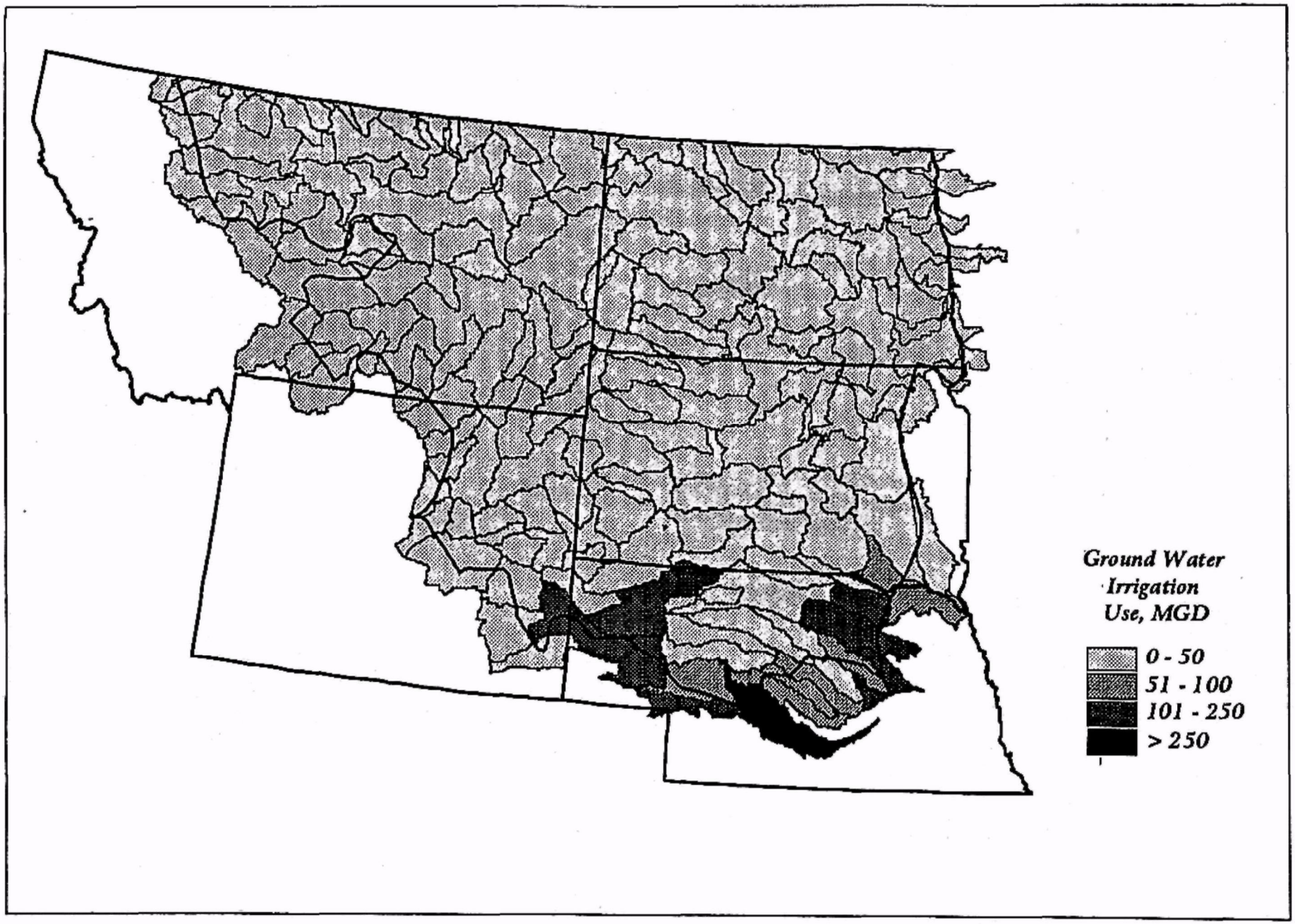

Figure 6.2.6 Ground Water Irrigation Use in 1995 in the Northern Great Plains

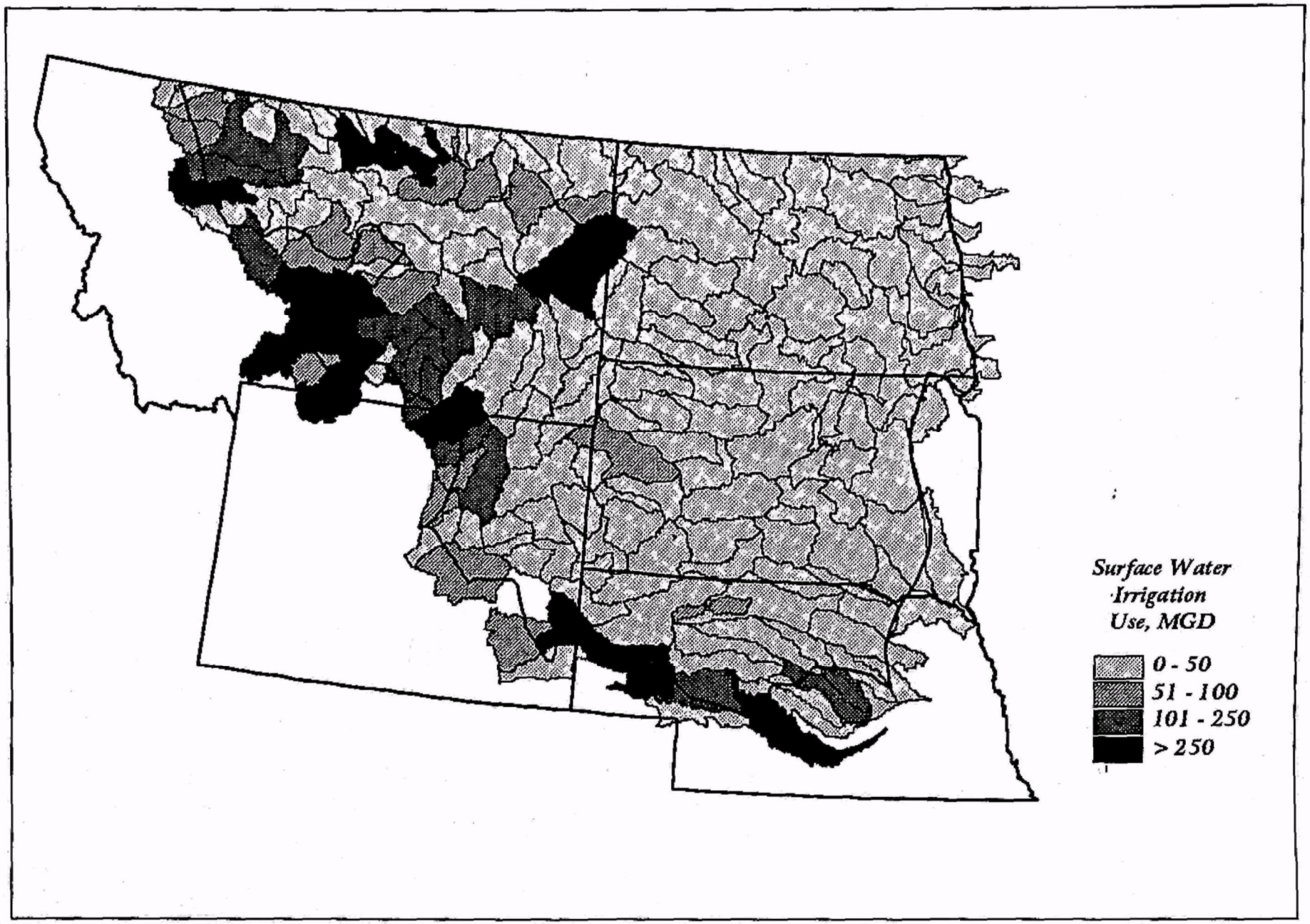

Figure 6.2.7 Surface Water Use for Irrigation in 1995 in the Northern Great Plains

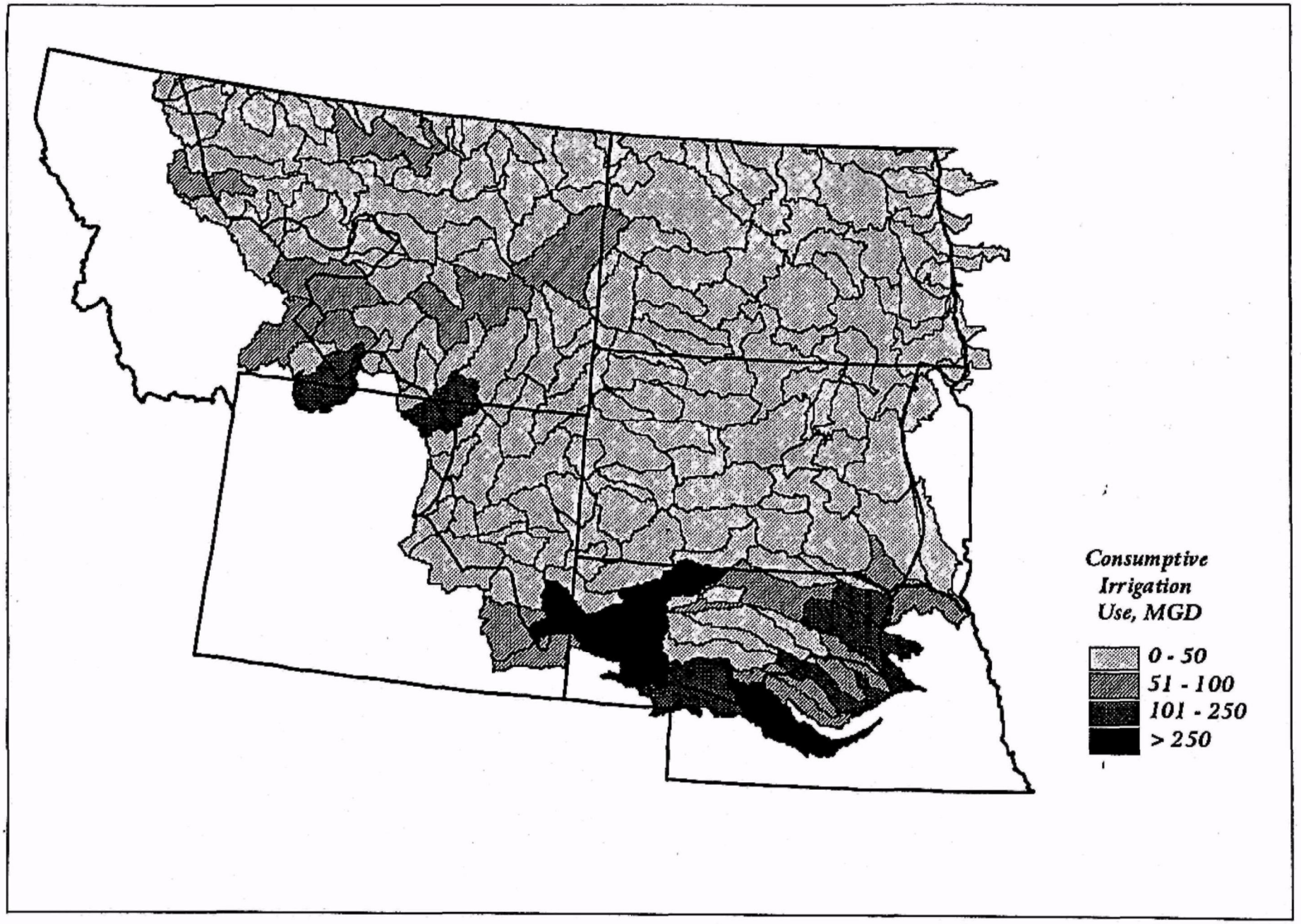

Figure 6.2.8 Consumptive Irrigation Use in 1995 in the Northern Great Plains

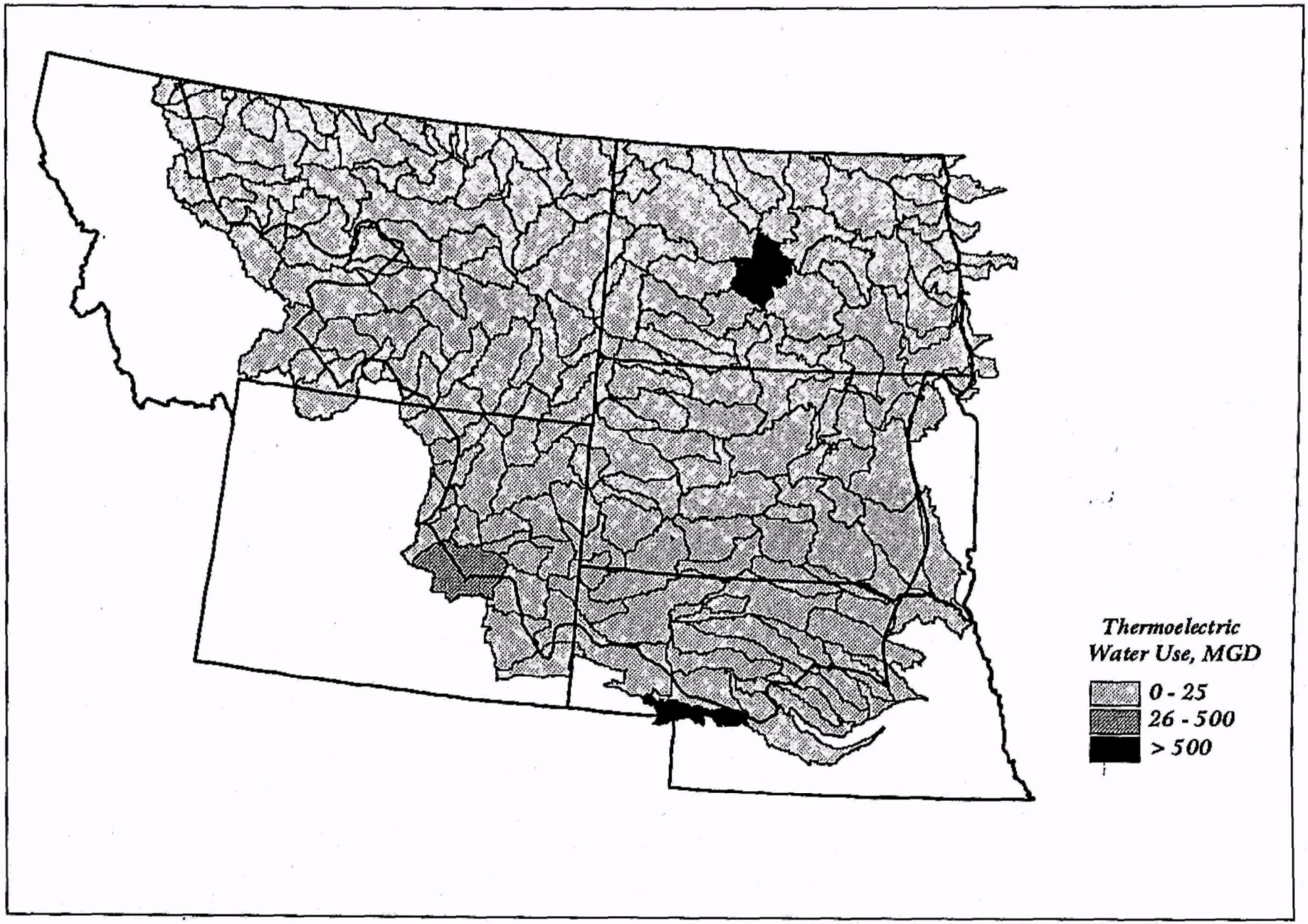

Figure 6.2.9 Thermoelectric Water Use in 1995 in the Northern Great Plains

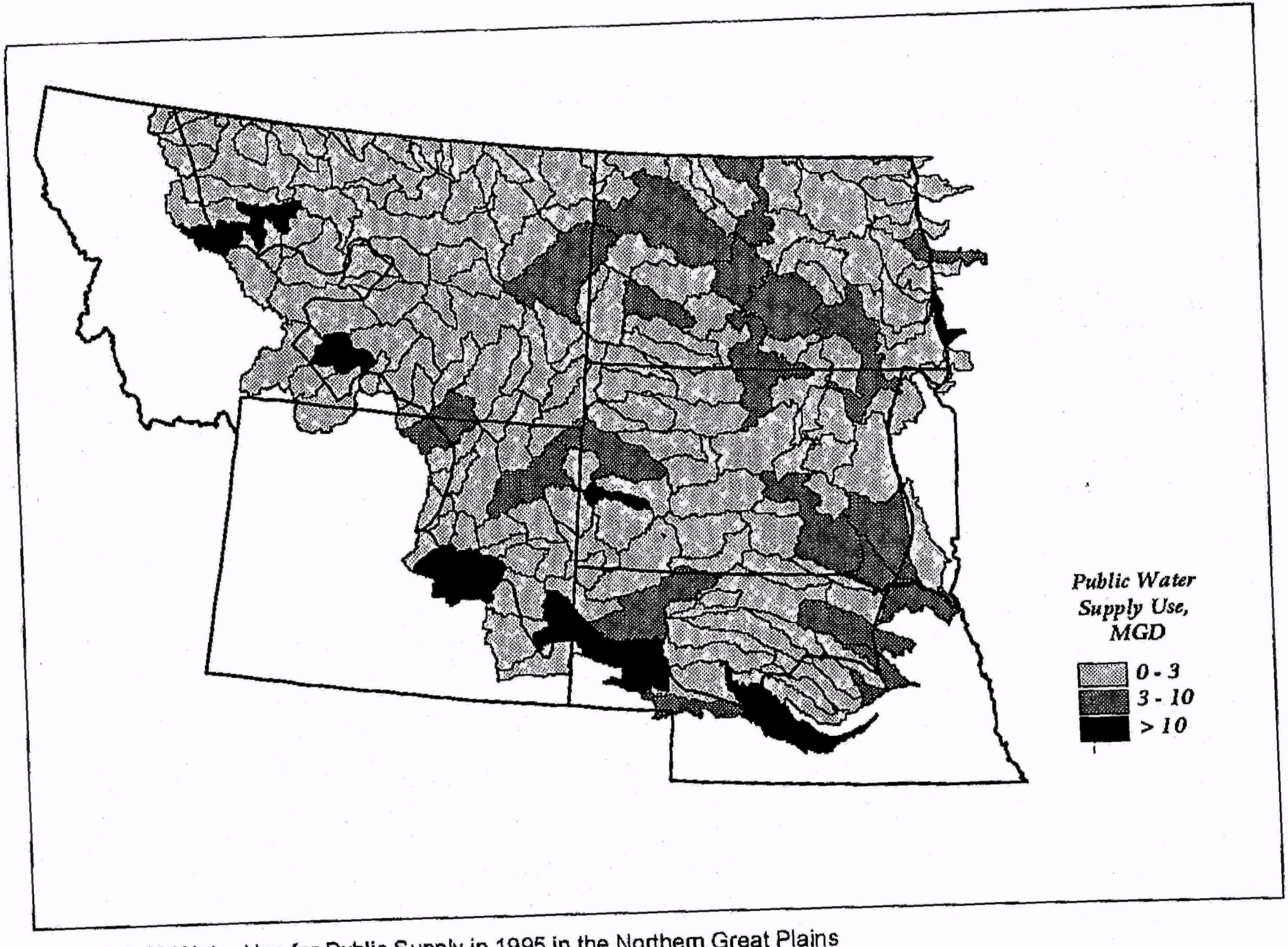

Figure 6.2.10 Water Use for Public Supply in 1995 in the Northern Great Plains

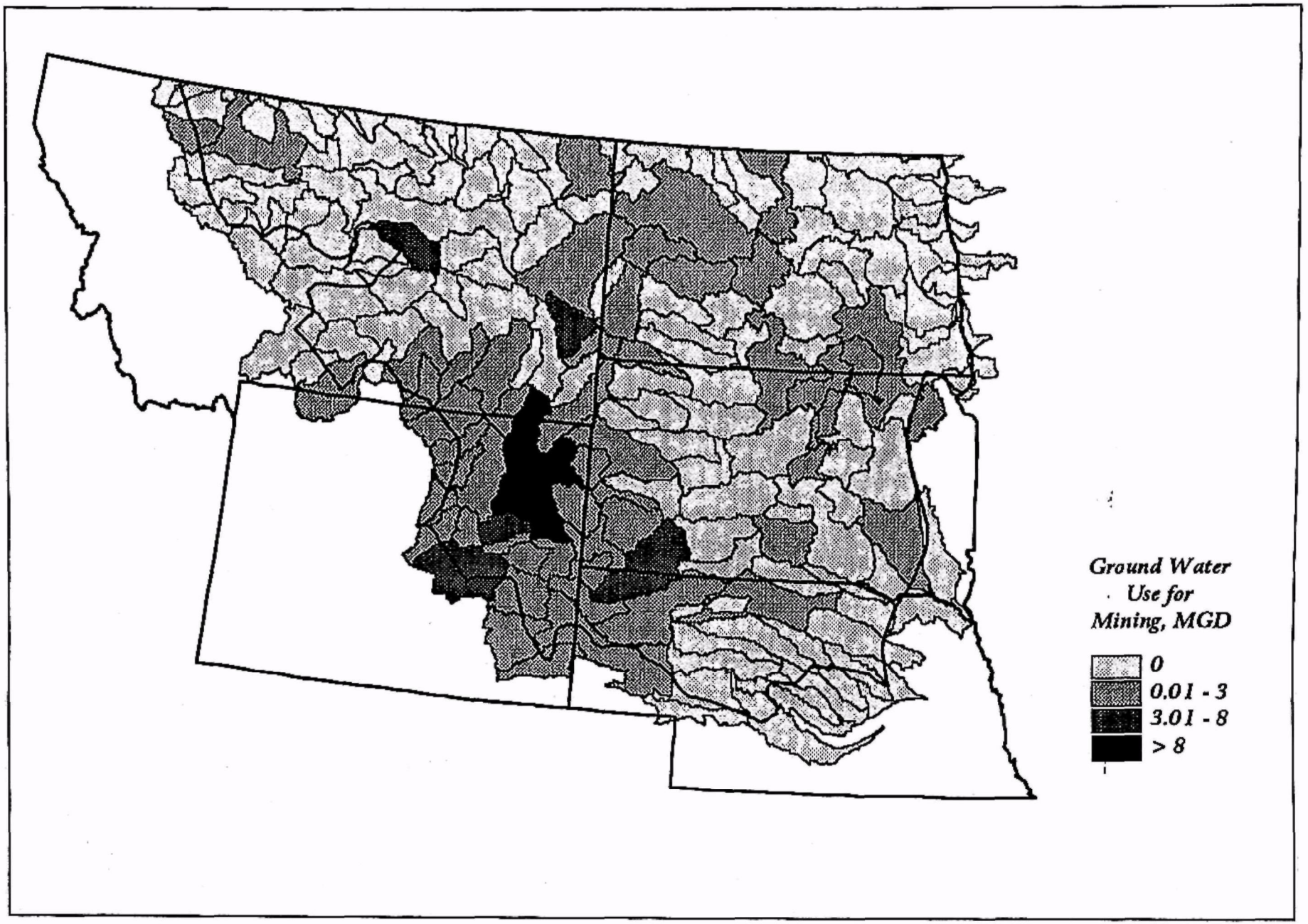

Figure 6.2.11 Ground Water Use for Mining in 1995 in the Northern Great Plains

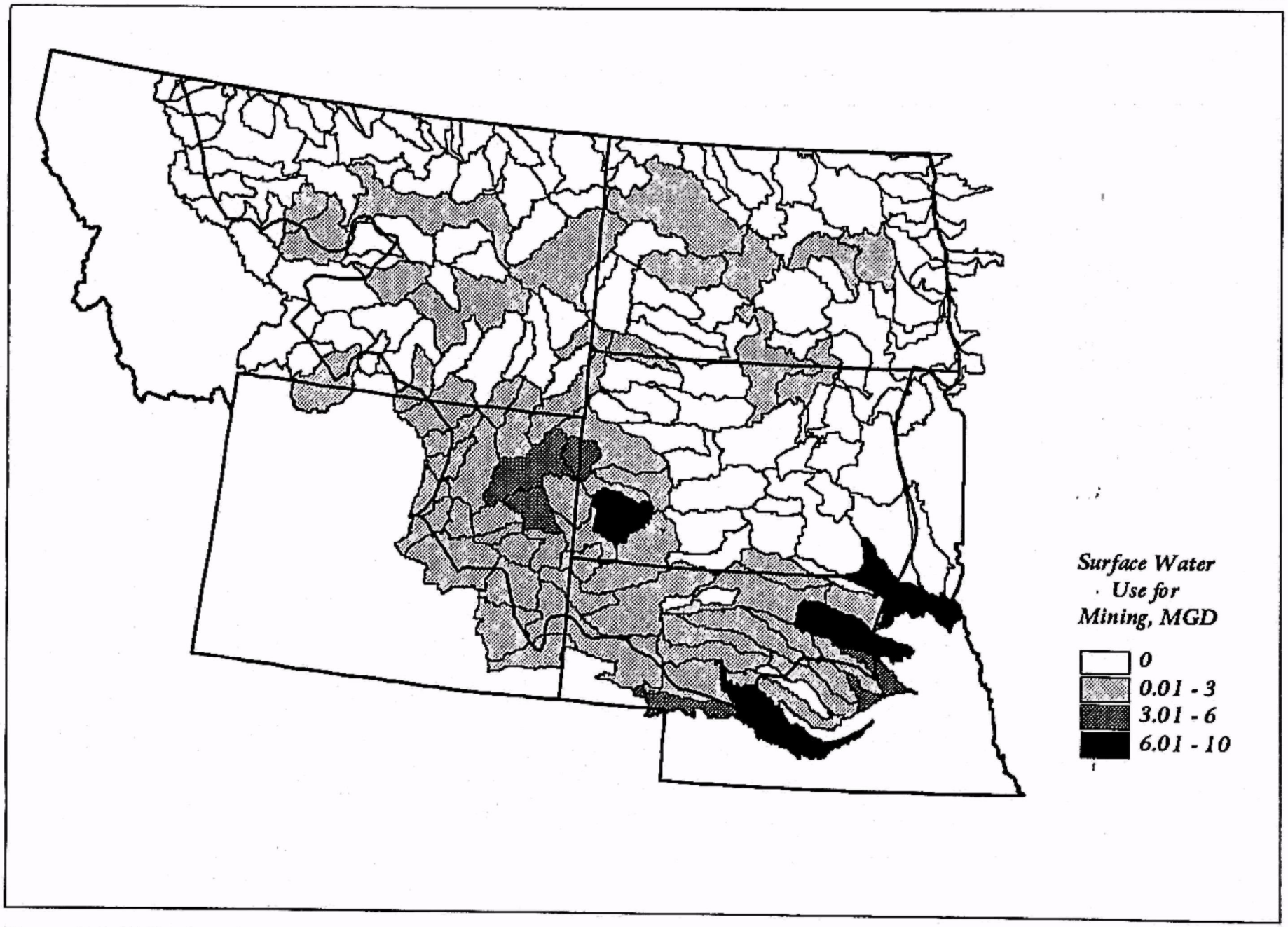

Figure 6.2.12 Surface Water Use for Mining in 1995 in the Northern Great Plains

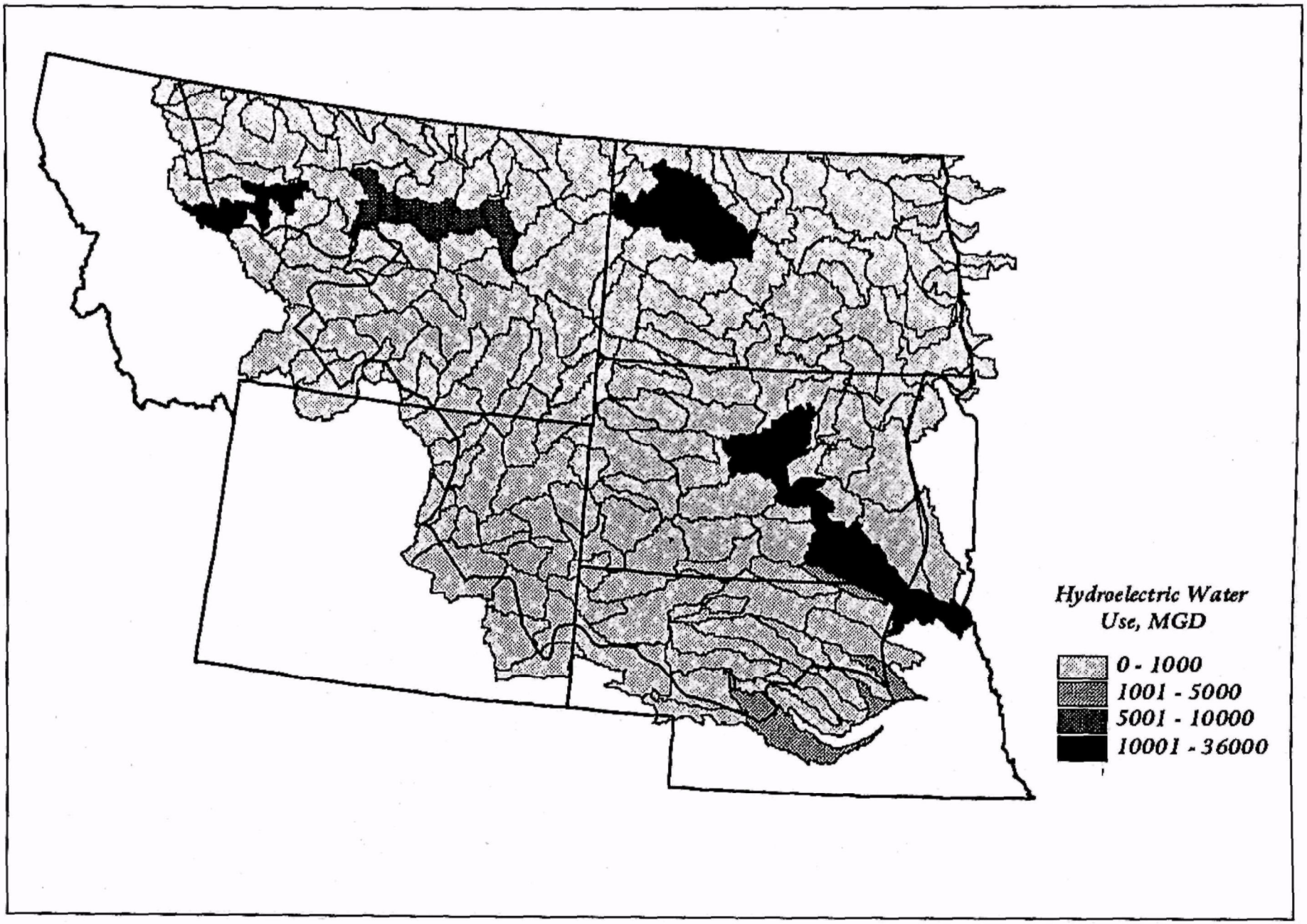

Figure 6.2.13 Water Use for Hydroelectric Facilities in 1995 in the Northern Great Plains

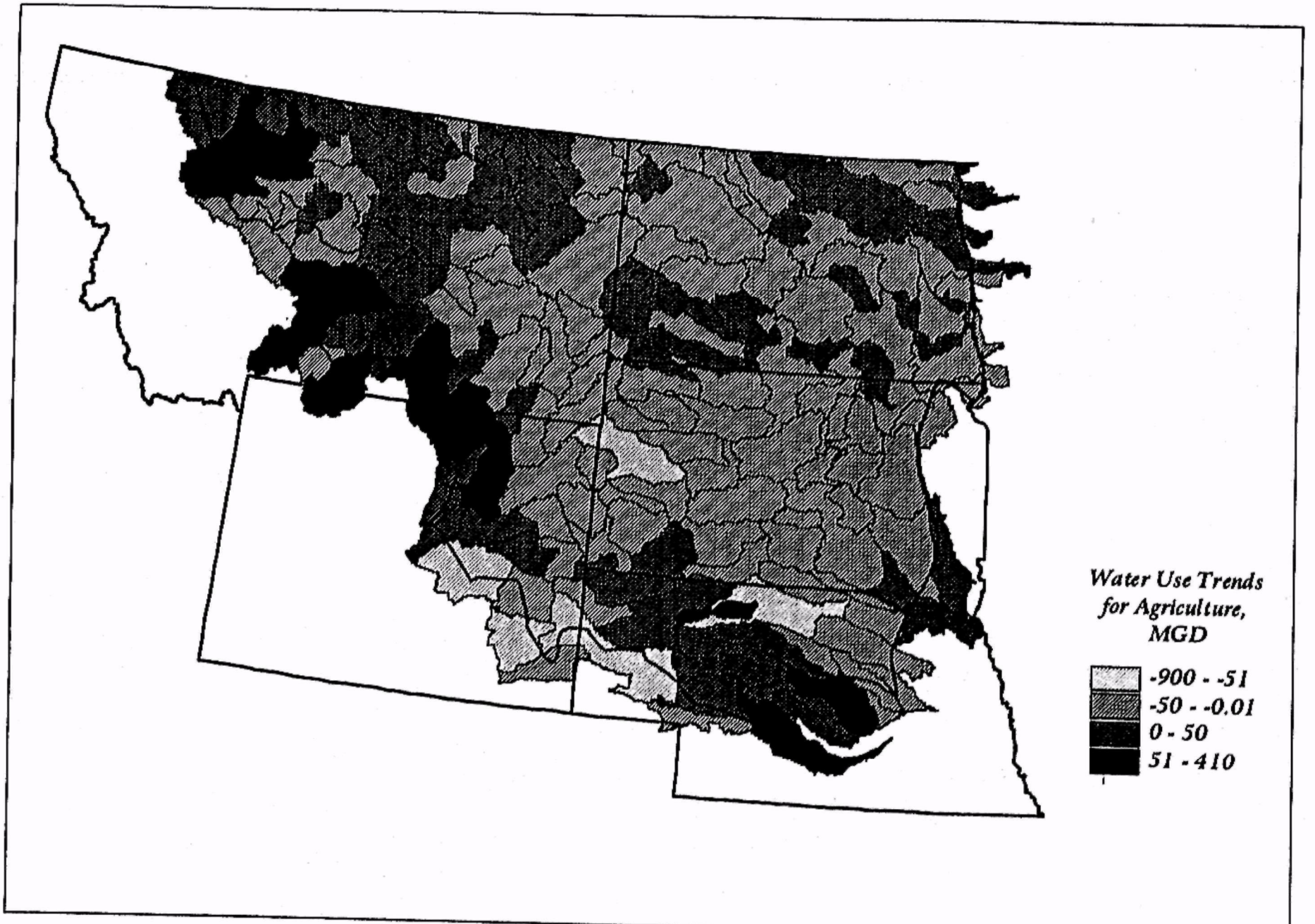

Figure 6.2.14 Changes in Agricultural Water Use between 1985 and 1995 in the Northern Great Plains

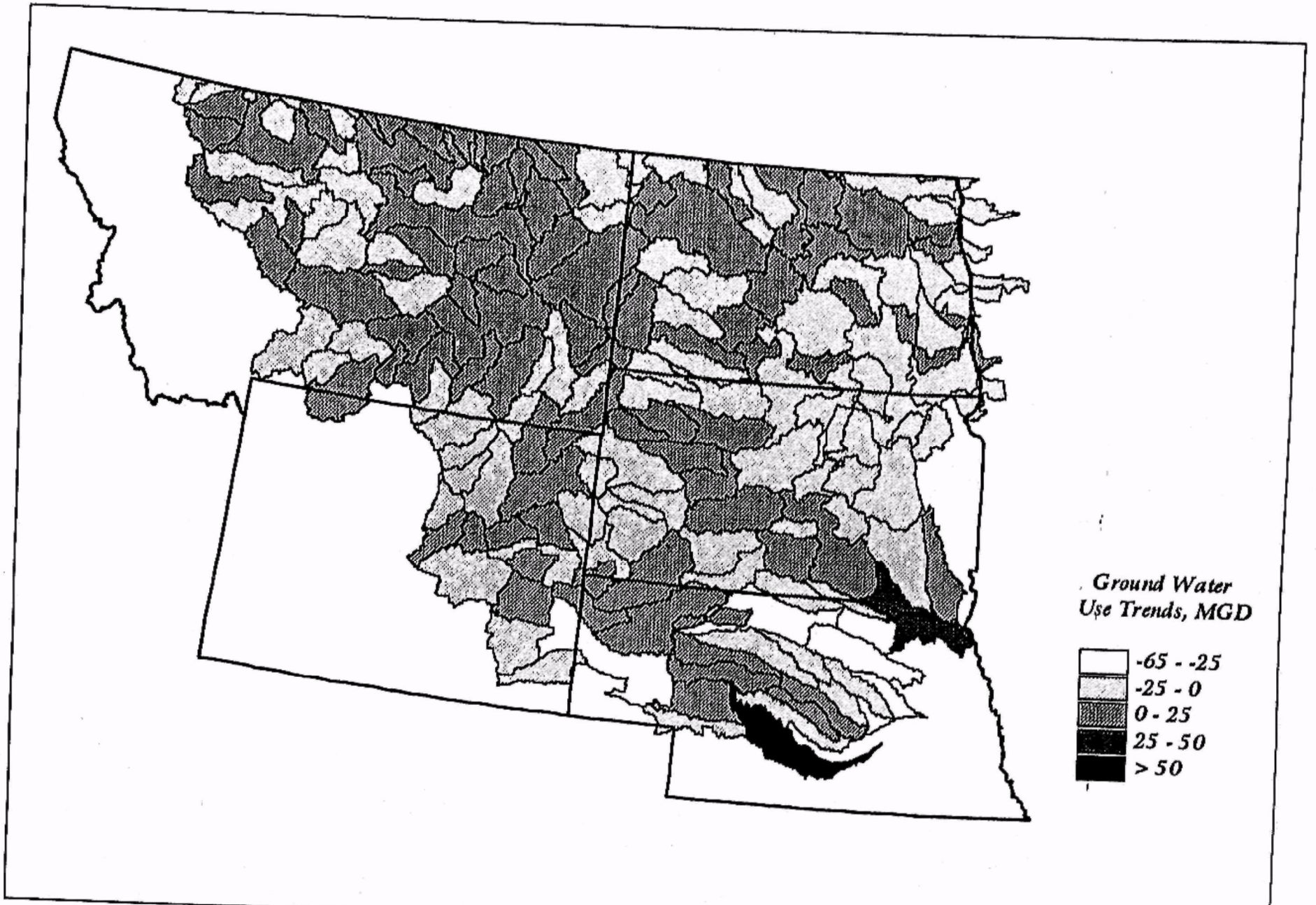

Figure 6.2.15 Changes in Ground Water Use between 1985 and 1995 in the Northern Great Plains

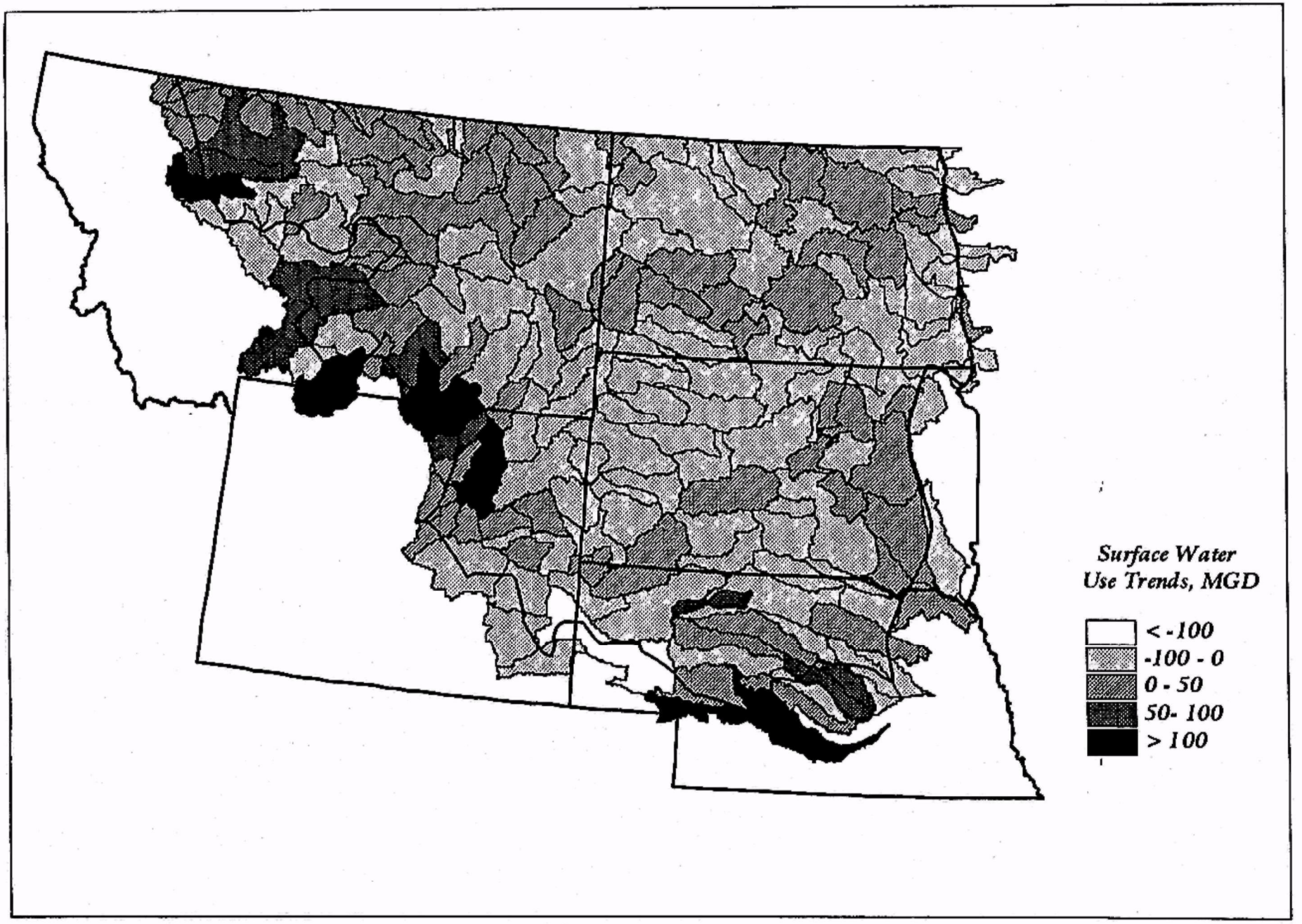

Figure 6.2.16 Changes in Surface Water Use between 1985 and 1995 in the Northern Great Plains

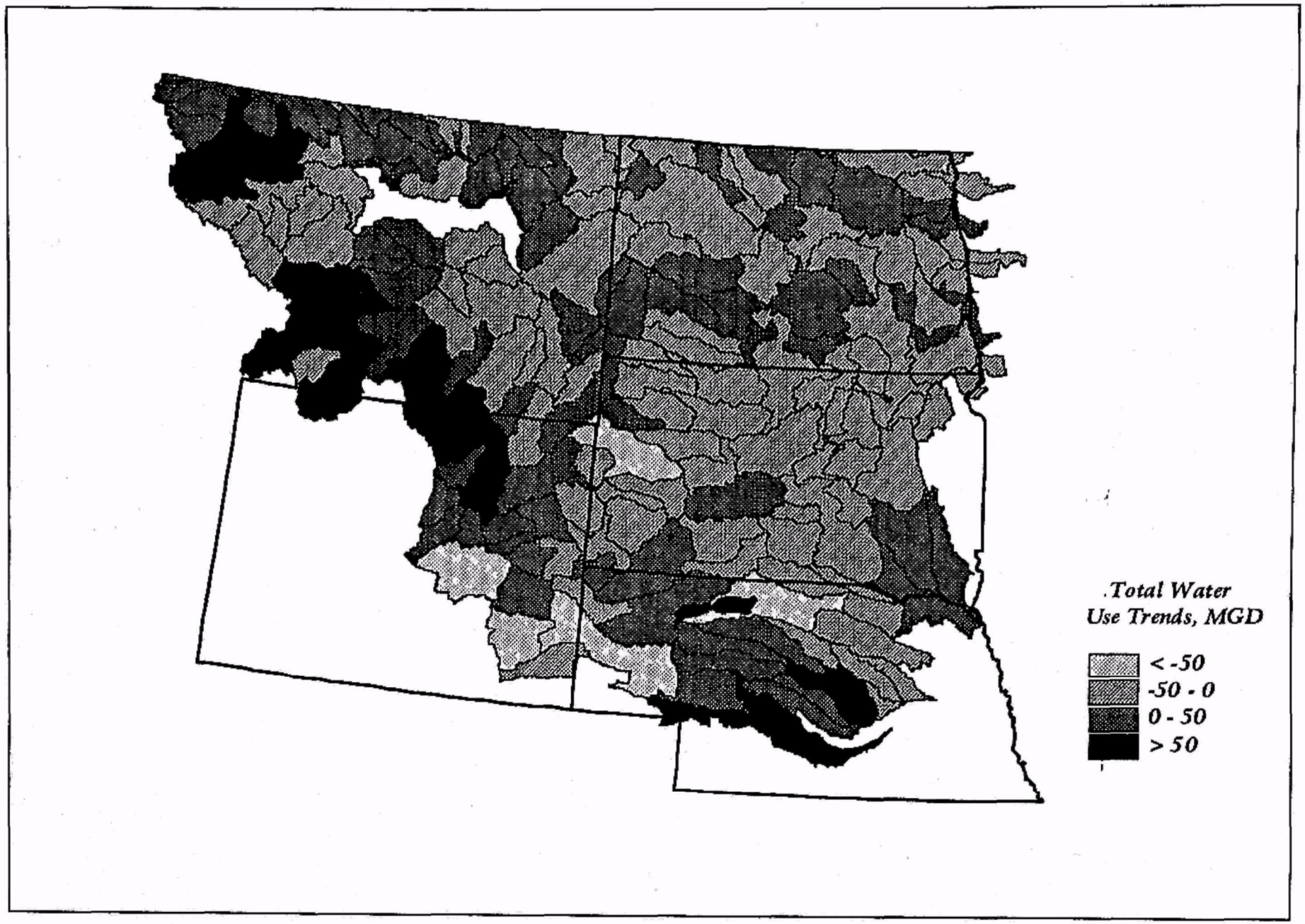

Figure 6.2.17 Changes in Total Water Use (Ground and Surface) between 1985 and 1995 in the Northern Great Plains

significance of irrigation and other agricultural uses to the region. When agricultural use increases or decreases in a watershed, it is heavily reflected in the total usage.

Water Uses On National Forest Lands

Water use on the National Grassland Units primarily consists of primarily for livestock uses. The Forest Service generally only applies for water rights for drilling wells and surface water for dams, both of these to serve mainly livestock.

Some new pressures are beginning to occur, however. One example is in the Sheyenne National Grassland where the underlying ground water is being requested for domestic use due to contaminated ground water surrounding it.

Future Trends

In some parts of the NGPAA, water use and demands are on the increase, mainly in areas where agriculture and growth of cities are occurring. In some areas, however, the opposite is happening, with agricultural and public water use declining. Even in areas where it is declining, however, lower quality of sources may drive the need for new supplies.

Evaluation of the Assessment, Data Gaps and Future Work

The Northern Great Plains is a vast area containing many different types of aquatic resources ranging from small isolated wetlands to large reservoirs and from small streams to large rivers and vast aquifers. This assessment only begins to reach into a basic understanding of the condition of these resources. There is both much more data that could have been analyzed and many data gaps that still need to be filled in the knowledge of this region.

Considering the large scale of this effort, there was much more depth that could have been covered. Many more stations with water quality and quantity data could be analyzed rather than one station from each watershed. However, greater detail at this scale was not possible in the time frame for the assessment. It is hoped that information presented at the scale in the report will lead to further investigation of those areas that obviously need a closer look. The report also suffered from a necessary reliance upon 305b report data. There are numerous problems with reporting this data across a region, as was discussed in Chapter 2, including differing definitions of impaired, differing uses of source or cause categories and especially great variability in number of miles assessed in any given watershed. In order to get a sense of the condition of water quality across this region, however, there was little alternative to this data.

There are, however, large gaps in data for this region. This probably results from both the great distances and limited funds for sampling and from the perception that the problems are not as great in this region as in others. There is a lack of water quality data for a number of parameters for many stations in the region probably for the reasons mentioned. The data used for certain water quality parameters came mostly from the Storet database and errors were found. Storet is undergoing modernization and hopefully in the future this database will be more reliable. However, sampling has to be done in these areas, much of the problem with Storet was lack of data. There are needs for more biological sampling to assess biological and ecological condition of many areas within the region. Much work has been done, but it is generally limited to a few particular areas. That is beginning to change, however, as a number of agencies begin to focus resources on the Missouri River and the larger basin. Other types of monitoring that would be valuable in the region are fish tissue monitoring, possibly greater groundwater sampling efforts and a more regional analysis of riparian condition.

Another area in the assessment that could have used more development was the functional analysis described in Section 2.7. This assessment was only able to analyze six fish species, comparing their physiological needs with the measured conditions in the watersheds they inhabit. In future work, many more species used in the analysis (including species other than fish), as well as more parameters and especially more stations. As was discovered, the station chosen to represent a particular watershed may not represent the best habitat for a given species, while others in the watershed may be fine, giving the impression of problems that may not exist. Conversely, the one station chosen may be the best habitat for a given species and its condition in the watershed may not be as healthy as presented.

Future work planned for this region includes several large-scale monitoring efforts. One is the U. S. EPA's

Environmental Monitoring and Assessment Program's (EMAP) Western Initiative which will focus on the Upper Missouri River Basin. Another is the U. S. EPA Region 8 Regional-EMAP project centered on development of indices of biological integrity for small streams in eastern Montana and riverine wetlands in North Dakota. In addition, a number of federal and state agencies have put forth a proposal called the Missouri River Environmental Assessment Program to carry out monitoring and research studies for the mainstem of the Missouri River. Many of these agencies have been involved for the past few years in a study of the benthic fishes of the Missouri River from Montana to Missouri. The work by The Nature Conservancy and Natural Heritage Programs on critical areas of biological significance will help focus on where the areas in the best condition are. All of these studies and others will begin to shed light on a system that has been neglected in terms of environmental monitoring.

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