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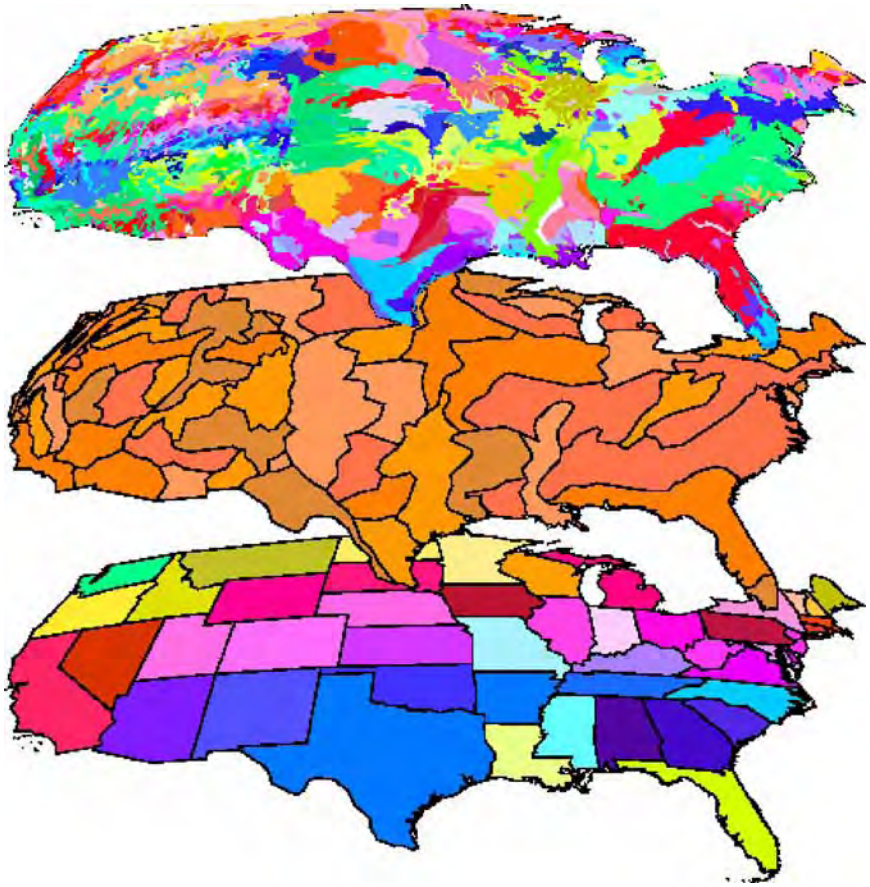
A Gap Analysis of North Dakota

April 2005 Final Report



A GEOGRAPHIC APPROACH TO PLANNING FOR BIOLOGICAL DIVERSITY

U.S. Department of the Interior
U.S. Geological Survey

THE NORTH DAKOTA GAP ANALYSIS PROJECT

FINAL REPORT

April 2005

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DEDICATION

We dedicate this first North Dakota gap analysis to past, present, and future individuals who value and work to conserve the biological resources of North Dakota.

EXECUTIVE SUMMARY

Gap analysis is a habitat-based planning method for biodiversity conservation that produces geospatial information about the kinds and amounts of natural land cover categories and potential habitat for native vertebrate species. Land cover categories and vertebrate species poorly represented on the existing network of conservation lands constitute conservation "gaps." One purpose of gap analysis is to provide geospatial information that land managers, planners, scientists, and policy makers can use to identify proactive habitat conservation actions that might preclude the need to list species as endangered or threatened (Scott et al 1993).

The North Dakota Gap Analysis Project (ND-GAP) was initiated in 1998 by Northern Prairie Wildlife Research Center with funding from the National Gap Analysis Program (GAP) of the U.S. Geological Survey. The project was a cooperative effort among more than 30 federal, state, Native American, and private conservation organizations in North Dakota (ND) (Table 1). The major objectives of the project were to (1) produce digital maps and associated databases for actual land cover, land stewardship, and potential distribution of terrestrial vertebrate species in ND; (2) describe the distribution of natural land cover categories and terrestrial vertebrate species among land stewards, and identify elements that currently are not represented or are underrepresented in areas managed for long-term maintenance of biodiversity; and (3) to facilitate cooperative development and use of information so that institutions, agencies, and private landowners may be more effective stewards of ND's natural resources. The ND-GAP is a preliminary step toward more detailed efforts and studies needed for long-term planning for biodiversity conservation in ND.

A map of the land cover of ND circa 1997 was prepared from the analysis of 42 Landsat-5 Thematic Mapper (TM) images acquired between August 1992 and May 1999 and digital National Wetlands Inventory data (Wilen and Bates 1995). The spatial resolution of the land cover map is the same as the TM imagery, 0.09 ha. The legend for the land cover map is hierarchical with eight general land cover categories at the upper level and 39 detailed land cover categories at the lower level. Approximately 118,760 km^2 (65%) of the surface area of ND has been tilled at some time with 30,543 km^2 of this land planted to perennial herbaceous vegetation at the time the map was made. Map estimates of the area of natural and semi-natural prairie, wetlands, and shrublands are 35,681 km^2 (19%), 16,297 km^2 (9%), and 5,281 km^2 (3%), respectively. The area of woodland (natural and anthropogenic) is estimated at 4,284 km^2 (2.3%). The area of sparsely vegetated land cover including natural badlands was estimated at 1,897 km^2 (1%) and the area of developed land covers at 953 km^2 (0.5%). An accuracy assessment of the land cover map has been conducted. The overall accuracy of the eight general land cover categories delineated was 62%.

Potential distribution maps were developed for 281 terrestrial vertebrate species comprising 184 species of breeding birds, 71 species of mammals, 11 species of amphibians, and 15 species of reptiles. Range limits of each species were delineated on a

grid of 635 km^2 hexagons using >200,000 locality records. Within the hexagons, species potential distributions were modeled based on species-land cover category affinities. The accuracy of the vertebrate potential distribution models was assessed by comparison with published species lists from six natural areas in ND. Percent agreement averaged 94% (range 84–98%, n= 5), 89.6 % (range 86–94%, n=3), and 92% (range 85–100%, n=3) for birds, mammals, and herptiles, respectively. Limitations and uncertainties in species distribution maps are discussed.

Approximately 6.4% of the land in ND is managed by public agencies with 4.3% under federal management and 2% under state jurisdiction. Approximately 4.2% of the land in ND occurs within the boundaries of lands governed by five Native American tribal governments. Lands managed by non-profit conservation organizations account for less than half of one percent of the land in ND. Private land owners are responsible for management of more than 90% of the land in ND. Lands were assigned to one of four management status classes to reflect the relative degree of stewardship for conservation of biodiversity. Status 1 signifies the highest degree of biodiversity conservation, e.g., national parks and Nature Conservancy preserves; status 4 denotes lands with no mandate to preserve biodiversity values. Status 1 and status 2 lands occupy 383 km^2 and 1566 km^2, respectively, in ND, which combined is slightly more than 1% of the state and 17% of the area in public and private conservation lands. Federal stewards are responsible for 97% of status 1 and 2 lands. Seventy-five percent of federal public lands were multiple-use and assigned a status of 3. Seventy-nine percent of lands managed by state government stewards were assigned a status of 4, and the remaining 21% of state public lands was assigned a status of 3.

All five of the general natural vegetation land cover categories (prairie, wetland, shrubland, woodland, and sparse vegetation) have their greatest abundance on private lands. Approximately 79% of the prairie land cover category occurs on private lands; the U.S. Forest Service (USFS), ND State Land Department (NDSL), and the U.S. Fish and Wildlife Service (USFWS) manage 5.9%, 5.1%, and 1.7% of prairie, respectively. Lands governed by the Native American Standing Rock Sioux and Three Affiliated Tribes (NATAT) account for 4.5% and 2.0% of the prairie land cover category. Nine individual stewards have less than 1% of the prairie land cover category on the lands they manage.

Private land owners are responsible for stewardship of approximately 77% of the wetland land cover category. The USFWS has responsibility for 5.9% of the wetland land cover category, with the Native American Spirit Lake Tribe and the NDSL responsible for 2% and 1%, respectively. Thirteen stewards individually have responsibility for less than 1% and together 3.5% of the wetland land cover category.

Approximately 69% of shrublands occurred on private lands. The USFS, NATAT and the NDSL manage approximately 13.4%, 6.5%, and 3.5%, of shrublands, respectively. Stewardship responsibilities for shrublands may be distorted due to the difficulty mapping shrublands.

Seventy percent of the woodland land cover category occurs on private lands. This is probably an overestimate of the proportion of natural woodlands on private lands as many woodlands in ND are planted. Stewards, in decreasing order of responsibility for natural woodlands, include the USFS, NATAT, Native American Turtle Mountain Chippewa, ND Game and Fish Department, USFWS, and U.S. Army Corps of Engineers.

Of all the prairie types in ND, the Bluestem-Needlegrass-Wheatgrass prairie may have the highest conservation concern because of its uniqueness at the national scale. This type has been identified as a transition between tallgrass prairie to the east and mixed prairie to the west (Kuchler 1964; Dix and Smeins 1967; Ricketts et al. 1999). Once the dominant prairie community in ND (Stewart 1975), much of this prairie has been lost through conversion to cropland. The order of the genera in the name of this prairie category was changed from that used by Kuchler (1964) to conform to observations by early plant ecologists (Clements 1920; Shantz 1923, 1924; Weaver and Fitzpatrick 1934) in the Dakotas and our field observations. Kuchler (1964) noted that his map units were large (encompassing portions of several states) and there was considerable geographic variability in species dominance within the map units. This species-rich prairie category occurs primarily on glacial till parent materials. Plant species have complex spatial distributions over short distances related to soil and topographic heterogeneity and its influence on availability of moisture and nutrients. Kentucky bluegrass (*Poa pratentis*) and smooth brome (*Bromus inermis*), two introduced grass species, and western snowberry (*Symporicarpos occidentalis*), a native shrub species, are highly successful competitors and serious threats to native grass and forb species in this prairie type (Whitman and Barker 1994). Wetlands are an important component of the Bluestem-Needlegrass-Wheatgrass landscape and the combination of prairie and wetland habitats results in a landscape with a high vertebrate species richness.

Mesic tallgrass prairie has experienced the largest percentage loss of all prairie categories in ND. The high percentage of mesic tallgrass prairie on lands classified as status 1 and 2 (24%) is largely the result of a decision by the USFS to designate portions of the Sheyene National Grassland as tallgrass prairie restoration areas in its 2002 management plan for Dakota Prairie Grasslands.

The other prairie types in ND have a small proportion of their area on lands classified as status 1 and 2 (1- 5%) and are components of mixed prairie or prairie with special soil characteristics (sand prairie and saline prairie). Most of these prairie categories have greater spatial extents in states and Canadian provinces adjacent to ND. For example, fescue prairie and needlegrass prairie have significant areas in the Canadian provinces and wheatgrass prairie is common in South Dakota and Montana.

Floodplain woodlands are another land cover category with a high conservation concern. Many floodplain woodlands on the Missouri and other rivers in ND are threatened by the elimination of natural hydrogeomorphic processes following the construction of dams. Dams have dramatically reduced the rate of river meandering by altering the magnitude of peak flows. Flow alteration and a decline in meandering rate has two major consequences for floodplain woodland: (1) a reduction in the amount of new alluvium

produced for tree and shrub regeneration, and (2) an increase in the successional ages of established woodlands due to an extension in their life spans (Johnson 2002).

Ponderosa pine woodlands in ND are at the northeastern-most extent of the species geographical range and have a small total area (~10 km^2). Twenty-three percent of the area mapped as ponderosa pine woodlands occurs on Research Natural Areas or Special Interest Areas by the USFS.

Palustrine temporary and palustrine seasonal wetlands have higher conservation priorities than other wetland types. Lacustrine and palustrine semi-permanent wetlands have much larger representation (12% and 5%, respectively) on lands classified as status 1 and 2 than palustrine temporary (2%) and palustrine seasonal wetlands (1%). Palustrine temporary and palustrine seasonal wetlands also have low representation, about 2 % of each category, on public lands classified as status 3.

Twenty-five percent of the terrestrial vertebrate species have 1% or less of their potential habitat distribution represented on status 1 or 2 lands. Ninety-five percent of the species have 5% or less of their potential habitat distribution represented in status 1 or 2 lands. Forty-three of the species with 5% or less of their potential habitat distribution in status 1 or 2 lands have been identified by the ND Game and Fish Department as having high (n=19) or moderate (n=24) levels of conservation concern.

Private land owners, by virtue of the large amount of the land in ND under their stewardship, bear an important responsibility for biodiversity conservation in ND. Wetland and prairie conservation easements on private lands could not be included in the gap analysis due to a lack of spatially explicit information on their locations. However, their contribution can be assessed in part with summary statistics available from the USFWS. In 2004, there were 3,349 km^2 of wetlands (about 27% of all wetlands on private lands) and 620 km^2 of prairie (about 2% of all prairie on private lands) protected by USFWS perpetual easements.

Although the ND-GAP does not provide all the information needed for biodiversity conservation, the spatially and thematically detailed statewide datasets for actual land cover, potential vertebrate species distributions, and land stewardship created by the ND-GAP should provide an excellent starting point for many important conservation decisions.

Table 1.1 Cooperators in the North Dakota Gap Analysis Project.

Federal Government
USDI Bureau of Indian Affairs
USDI Bureau of Land Management
USDI Bureau of Reclamation
USDI Fish and Wildlife Service
USDI Theodore Roosevelt National Park
USDI Geological Survey
USDA Farm Services Administration
USDA Natural Resources Conservation Service
USDA Forest Service Dakota Prairie Grasslands
USDD Army Corps of Engineers

Native American Governments
Three Affiliated Tribes
Standing Rock Sioux Tribe
Sprit Lake Sioux

State Government
ND Geological Survey
ND Forest Service
ND State Land Department
ND Natural Heritage Program
ND Information Technology Department
North Dakota State Water Commission
North Dakota Agricultural Statistics Service
North Dakota Department of Transportation
North Dakota Fish and Game
University of North Dakota
North Dakota State University
Minot State University
University of Montana, Wildlife Spatial Analysis Lab

Private Conservation Organizations
The Nature Conservancy
Nature Serve
Ducks Unlimited
The Audubon Society

Upper Mid-West State Gap Projects
South Dakota Gap Analysis Project
Iowa Gap Analysis Project
Nebraska Gap Analysis Project
Kansas Gap Analysis Project

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Portions of this report are standardized in all GAP project reports to provide continuity among the state reports. We acknowledge contributions to this report by Chris Cogan, Patrick Crist, Blair Csuti, Tom Edwards, Michael Jennings, and J. Michael Scott; as well as the previous GAP projects.

The ND-GAP Analysis Project benefited greatly from many discussions and collaboration with staff of the South Dakota (Jonathan Jenks, Vickie Smith, Chad Kopplin, Dorothy Fecske) , Iowa (Erwin Klaus, Kevin Kane, Katherine Anderson, Patrick Brown, Robin McNealy), Nebraska (Jim Merchant, Marlin Eve, Geoff Henebry) and Kansas gap projects (Jack Cully, Glennis Kaufman, Stephan Egbert, Todd Hoernemann, Christine Wooley, and Chris Lauver). All of these people were a constant source of support and encouragement for the ND-GAP analysis. Erwin Klaus deserves special acknowledgement for his efforts to lead discussions of the importance and conduct of accuracy assessments for the land cover maps.

Special acknowledgement is also due to Bill Waltman and Ron Luethe with the Natural Resources Conservation Service. Bill traveled from Nebraska to attend the first organizational meeting for the ND-GAP and presented an overview of geospatial data he and Ron had prepared for ND and other states in the Great Plains. Bill was a great motivator and source of encouragement for the ND-GAP analysis. Ron Luethe was unwavering in his support and contributed numerous data sets and assistance throughout the life of the ND-GAP analysis project.

Assembling and creating the data for a state gap analysis is a long and arduous task. Jason Heier, Michele Brewer, Dan Zerr, Mike Gerbig, Anne Coyle, and Rich Olsen were part of the ND-GAP analysis team at NPWRC for various amounts of time and helped to achieve the objectives. Special acknowledgement must be given to Jason Heier and Michele Brewer. Their long term contributions, inquisitive and positive attitude, and careful attention to details and accuracy in the performance of repetitive and tedious tasks are greatly appreciated. In addition we acknowledge the help of other staff at Northern Prairie Wildlife Research Center including Betty Euliss, Larry Igl, Marsha Sovada, Jeff Jundt, Wes Newton, Deb Buhl, Stephen Magill, Mike Schwartz, Keith Van Cleave, Pam Pietz, Gary Krapu, and Diane Larson. We thank Terry Shaffer and Doug Johnson for their administration of university research work orders. We are grateful to the directors Ron Kirby and Jay Hestbeck for their support, and to all other members of the administrative and maintenance staff for help with finances, personnel, and equipment. We appreciate the assistance of Mary Owens and Karen Dywer, Human Resource Specialists with the USGS Central Region, for their assistance with job announcements and the sometimes complicated hiring procedures.

Developing a ND vegetation classification scheme for use with Thematic Mapper imagery that incorporated the National Vegetation Classification System (NVCS) was a difficult task. Darla Lenz was valuable source of information about the various vegetation classification systems used in ND and her experiences with them. William Barker, Lee Manskse, and Harold Kantrud also shared their experiences with classifying the vegetation of ND. Shannon Mennard, Don Faber-Landendoen, and Jim Drake provided documents and discussions of the ND Portion of the NVCS.

The land cover mapping objective benefited greatly from recent land cover mapping activities in ND. Duane Pool and Chuck Loesch shared imagery and land cover maps for the Prairie Pothole Portion of ND developed in a joint project between Ducks Unlimited and the U.S. Fish and Wildlife Service. Rolly Redmond and Jeff DiBenedetto shared land cover maps for western ND developed by the University of Montana for the U.S. Forest Service. Rick Mueller and Dath Mita shared imagery and land cover maps developed by the National and ND Agricultural Statistical Services. We are also grateful to Jim Von Loh, Kathy Duttenhefner, Darla Lenz, Ron Luethe, and Patsy Chamrad for sharing land cover maps developed for smaller areas within the state.

The accuracy assessment of the land cover map was a huge undertaking. Al Cilurso, Jim Bredy and Brian Lubenski with the U.S. Fish and Wildlife Service acquired the aerial photography. Al Cilurso deserves special acknowledgement for his help in planning the photo mission. We are grateful to Brian Natwick with the USDA Farm Service Administration for facilitating and coordinating our request for 2001 FSA crop compliance slides and land cover maps for the sample units from the 53 county FSA offices in ND. Harold Kantrud performed ground surveys of land cover for a portion of the sample units. We are also indebted to the more than 600 private land owners who granted us trespass permission to collect the data used in the accuracy assessment of the land cover map.

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The quality of the ND-GAP data bases is due in a large part to the willingness of cooperators to share data and information. More than thirty organizations contributed data to the ND-GAP. This data sharing occurred prior to the recent explosion in the availability of information on ftp and web sites. Acquiring the data almost always required contacting an individual in an organization who was willing to find time in their busy schedules to help us. We were fortunate to have developed such relationships with a long list of professionals including Susan Rinehart, Phil Sjursen, Jerry Bird, Bernadette Braun, Dan Svingen, David Haugen, and Pat Miles with the U.S. Forest Service; Larry Edlin, Stephen Brady, Arnold Mendenhall, Ray Sinclair, Sharon Waltman, Dave Dewald, Dean Chamrad, Jeff Printz with the Natural Recources Conservation Service; Ralph Gabrysh, Coral Huber, and Gary Ledbetter with the Army Corps of Engineers; Gerry Anderson and Chad Prosser with the Agricultural Research Service; Steve Hager and Jim Von Loh with the National Park Service; Ron Wencl with the U.S. Geological Survey; Patsy Chamrad, and Amy Lieb with the Bureau of Reclamation; Ron Reynolds, Mike Estey, Stu Wacker, Roger Collins, Karen Smith, Bob Murphy, Todd Grant, Will Meeks, Dave Azure, Paulette Scherr, Mick Erickson, Gregg Knutson, Kim Santos, and Bill Wilen with the U.S. Fish and Wildlife Service; Pat Keatts and Tom Young with the Bureau of Indian Affairs; Marle Baker, Paul Danks, Jim Heckman, Carey Dreyer, and Delvin Driver, Jr. with the Three Affiliated Tribes; Annette Yellow Fat and Randy Whitebull with the Standing Rock Sioux; Si Ironheart, Jr. with the Spirt Lake Sioux; Kathy Duttenhefner, Darla Lenz, and Chris Dirk with the ND Natural Heritage Program; Mike Brand with the ND State Land Department; Mike Johnson, Jerry Gulke, Bill Jensen, Randy Kreil, and Brian Kietzman with the ND Department of Game and Fish; Bob Nutsch with the ND Information Technology Department; Dath Mita and Eric Waldhaus with the ND Agricultural Statistical Service; Bob Harsel, Tom Karch, Jason Weinerman, and Tom Nowatzki with the ND Forest Service; Ryan Waldkirch with the ND Geological Survey; Duane Pool and Jim Ringleman with Ducks Unlimited; Ed Madei and Eric Rosenquist of The Nature Conservancy; Paul Nyren, Jack Norland, William J.

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INTRODUCTION

How This Report is Organized

This report is a summation of a scientific project. While we endeavor to make it understandable for as general an audience as practicable, it reflects the complexity of the project it describes. A glossary of terms is provided to aid the reader in its understanding, and for those seeking a detailed understanding of the subjects, the cited literature should be helpful. The organization of this report follows the general chronology of project development, beginning with the production of the individual data layers and concluding with analysis of the data. It diverges from standard scientific reporting by embedding results and discussion sections within individual chapters. This was done to allow the individual data products to stand on their own as testable hypotheses and provide data users with a concise and complete report for each data and analysis product.

We begin with an overview of the GAP mission, concept, and limitations. We then present a synopsis of how the current biodiversity condition of the project area came to be, followed by land cover mapping, animal species distribution prediction, species richness, and land stewardship mapping and categorization. Data development leads to the Analysis section, which reports on the status of the elements of biodiversity (natural community alliances and animal species) for North Dakota (ND). Finally, we describe the management implications of the analysis results and provide information on how to acquire and use the data.

Gap Analysis Program Mission

The mission of the GAP is to prevent conservation crises by providing conservation assessments of biotic elements (plant communities and native animal species) and to facilitate the application of this information to land management activities. This is accomplished through the following five objectives (1) map actual land cover as closely as possible to the alliance level of the National Vegetation Classification System (FGDC 1997), (2) map the predicted distribution of those terrestrial vertebrates and selected other taxa that spend any important part of their life history in the project area and for which adequate distributional habitats, associations, and mapped habitat variables are available, (3) document the representation of natural vegetation communities and animal species in areas managed for the long-term maintenance of biodiversity, (4) make all GAP project information available to the public and those charged with land use research, policy, planning, and management, and (5) build institutional cooperation in the application of this information to state and regional management activities.

To meet these objectives, it is necessary that GAP be operated at the state or regional level but maintain consistency with national standards. Within the state, participation by a wide variety of cooperators is necessary and desirable to ensure understanding and acceptance of the data and forge relationships that will lead to cooperative conservation planning.

None of the databases needed for the ND-GAP analysis were available on a state-wide extent at the initiation of the ND-GAP analysis in 1998. The expertise of the federal, state, and private organizations using digital geospatial data for natural resources planning in ND varied greatly from well staffed and equipped organizations expanding the state-of-the-art to others with little or no staff and equipment. Coordination among the various organizations was primarily informal although a GIS technical committee to facilitate coordination of GIS activities among state agencies was established by an executive order in 1995. We worked closely but informally with a large number of cooperators to develop the products of the ND-GAP analysis (Table 1.1). The cooperation was primarily the sharing of data and information. The ND-GAP Analysis is the largest effort to date for a multi-institutional cooperative approach to the development, distribution, and use of digital geospatial data for habitat-based biodiversity conservation in ND.

Gap Analysis Concept

The GAP brings together the problem-solving capabilities of federal, state, and private scientists to tackle the difficult issues of land cover mapping, animal habitat characterization, and biodiversity conservation assessment at the state, regional, and national levels. The program seeks to facilitate cooperative development and use of information. Throughout this report we use the terms "GAP" to describe the national program, "GAP Project" to refer to an individual state or regional project, and "gap analysis" to refer to the gap analysis process or methodology.

Much of the following discussion was taken verbatim from Edwards et al. 1995, Scott et al. 1993, and Davis et al. 1995. The gap analysis process provides an overview of the distribution and conservation status of several components of biodiversity. It uses the distribution of actual land cover and predicted distribution of terrestrial vertebrates and, when available, invertebrate taxa. Digital map overlays in a GIS are used to identify individual species, species-rich areas, and vegetation types that are unrepresented or underrepresented in existing management areas. It functions as a preliminary step to the more detailed studies needed to establish actual boundaries for planning and management of biological resources on the ground. These data and results are then made available to the public so that institutions as well as individual landowners and managers may become more effective stewards through more complete knowledge of the management status of these elements of biodiversity. GAP, by focusing on higher levels of biological organization, is likely to be both cheaper and more likely to succeed than conservation programs focused on single species or populations (Scott et al.1993).

Biodiversity inventories can be visualized as "filters" designed to capture elements of biodiversity at various levels of organization. The filter concept has been applied by The Nature Conservancy, which established Natural Heritage Programs in all 50 states. The Nature Conservancy employs a fine filter of rare species inventory and protection and a coarse filter of community inventory and protection (Jenkins 1985, Noss 1987). It is postulated that 85-90% of species can be protected by the coarse filter without having to inventory or plan reserves for those species individually. A fine filter is then applied to

the remaining 15-10% of species to ensure their protection. Gap analysis is a coarse-filter method because it can be used to quickly and cheaply assess the other 85-90% of species. GAP is not designed to identify and aid protection of elements that are rare or of very restricted distribution; rather it is designed to help "keep common species common" by identifying risk far in advance of actual population decline. These concepts are further developed below.

The intuitively appealing idea of conserving most biodiversity by maintaining examples of all natural community types has never been applied, although numerous approaches to the spatial identification of biodiversity have been described (Kirkpatrick 1983, Margules and Nicholls 1988, Pressey and Nicholls 1989, Nicholls and Margules 1993). Furthermore, the spatial scale at which organisms use the environment differs tremendously among species and depends on body size, food habits, mobility, and other factors. Hence, no coarse filter will be a complete assessment of biodiversity protection status and needs. However, species that fall through the pores of the coarse filter, such as narrow endemics and wide-ranging mammals, can be captured by the safety net of the fine filter. Community-level (coarse-filter) protection is a complement to, not a substitute for, protection of individual rare species.

Gap analysis is essentially an expanded coarse-filter approach (Noss 1987) to biodiversity protection. The land cover types mapped in GAP serve directly as a coarse filter, the goal being to assure adequate representation of all natural vegetation community types in biodiversity management areas. Landscapes with great vegetation diversity often are those with high edaphic variety or topographic relief. When elevational diversity is very great, a nearly complete spectrum of vegetation types known from a biological region may occur within a relatively small area. Such areas provide habitat for many species, including those that depend on multiple habitat types to meet life history needs (Diamond 1986, Noss 1987). By using landscape-sized samples (Forman and Godron 1986) as an expanded coarse filter, gap analysis searches for and identifies biological regions where unprotected or underrepresented vegetation types and animal species occur.

More detailed analyses were not part of this project, but are areas of research that GAP as a national program is pursuing. For example, a second filter could combine species distribution information to identify a set of areas in which all, or nearly all, mapped species are represented. There is a major difference between identifying the richest areas in a region (many of which are likely to be neighbors and share essentially the same list of species) and identifying areas in which all species are represented. The latter task is most efficiently accomplished by selecting areas whose species lists are most different or complementary. Areas with different environments tend to also have the most different species lists for a variety of taxa. As a result, a set of areas with complementary sets of species for one higher taxon (e.g., mammals) often will also do a good job representing most species of other higher taxa (e.g., trees, butterflies). Species with large home ranges, such as large carnivores, or species with very local distributions may require individual attention. Additional data layers can be used for a more holistic conservation evaluation. These include indicators of stress or risk (e.g., human population growth,

road density, rate of habitat fragmentation, distribution of pollutants) and the locations of habitat corridors between wildlands that allow for natural movement of wide-ranging animals and the migration of species in response to climate change.

General Limitations

Limitations must be recognized so that additional studies can be implemented to supplement GAP. The following are general project limitations; specific limitations for the data are described in the respective sections:

1. GAP data are derived from remote sensing and modeling to make general assessments about conservation status. Any decisions based on the data must be supported by ground-truthing and more detailed analyses.

2. GAP is not a substitute for threatened and endangered species listing and recovery efforts. A primary argument in favor of gap analysis is that it is proactive: it seeks to recognize and manage sites of high biodiversity value for the long-term maintenance of populations of native species and communities before they become critically rare. Thus, it should help to reduce the rate at which species require listing as threatened or endangered. Those species that are already greatly imperiled, however, still require individual efforts to assure their recovery.

3. GAP data products and assessments represent a snapshot in time generally representing the date of the satellite imagery. Updates are planned on a 5-10 year cycle, but users of the data must be aware of the static nature of the products.

4. GAP is not a substitute for a thorough national biological inventory. As a response to rapid habitat loss, gap analysis provides a quick assessment of the distribution of vegetation and associated species before they are lost, and provides focus and direction for local, regional, and national efforts to maintain biodiversity. The process of improving knowledge in systematics, taxonomy, and species distributions is lengthy and expensive. That process must be continued and expedited, however, in order to provide the detailed information needed for a comprehensive assessment of our nation's biodiversity. Vegetation and species distribution maps developed for GAP can be used to make such surveys more cost-effective by stratifying sampling areas according to expected variation in biological attributes.

Study Area

North Dakota ranks 17th among the 50 states in area, 3rd in total cropland harvested, and 47th in human population with 642,200 residents in 2000 (NDASS 2001). Of the 70,702 miles^2 of surface area in ND, 2.5% is water and 4.3% is owned by the federal government. The 65,917 miles^2 of non-federal land in ND consists of 58.6% cropland, 24.5% rangeland, 2.8% pasture land, 1% forest land, and 3.2 % developed land (NRCS 2000).

ND is located in the center of the North American continent and includes roughly equal proportions of the Central Lowlands and Great Plains physiographic provinces (Fenneman 1931). The geological history and processes shaping the modern landscape of ND has been described in detail by Bluemle (2000). All but the southwestern corner of state has been glaciated at some time with the latest glacial epoch ending about 10,000 years ago. The flora and fauna of ND is dominated by species that have colonized the state from surrounding regions following glacial events (Dix 1962, Axelrod 1985, Hoffman and Knox 1970).

ND's climate is characterized by large temperature variation across all time scales, irregular light-to-moderate precipitation, plentiful sunshine, low humidity, and nearly continuous wind (Enz 2003). Cold, dry air masses originating in the far north; warm, humid air masses originating in tropical regions; and mild, dry air masses resulting from modification of northern Pacific air masses by the Rocky Mountains regularly overflow the state. The average length of the freeze-free period is about 110 days in the northeast and north-central regions, increasing to 120 days over most of the rest of the state, and reaching 130 days in the southeast and south-central. Average annual precipitation ranges from about 36-56 cm (14–22 inches) from northwestern to southeastern ND. This increase reflects the decreasing distance to the Gulf of Mexico which is the water source for most of the state's precipitation. On average, about 75% of the annual precipitation falls during April to September and 50–60% falls during April through July. Precipitation occurs on an average of 65 to 100 days during the year, but over 50% of these events produce less than 0.25 cm. Evaporation exceeds precipitation throughout ND with an annual precipitation/potential evapotranspiration ratio ranging from 0.90 in the east to 0.57 in the west. Thornthwaite (1931) categorized the climate as subhumid in eastern ND and semiarid in the west.

From a biological perspective, the climate of ND is better characterized by variation, extremes, and drought and wet periods than by temperature and precipitation averages. The ranges and abundance of flora and fauna contract and expand with changes in resource availability in response to variation in the climate.

Prairie and wetlands dominated the land cover of ND prior to the late 1800s; woody vegetation was restricted to forests along major river channels and to local sites with a favorable microclimate (Stewart 1975). Kuchler (1964) in his map of the potential natural vegetation of the conterminous United States identified four prairie types and three woodland types in ND. Three prairie types arranged along a decreasing precipitation gradient from east to west are (1) Bluestem Prairie (Andropon-Panicum-Sorghastrum), (2) Wheatgrass-Bluestem-Needlegrass (Agropyron-Andropogon-Stipa), and (3) Wheatgrass-Needlegrass (Agropygon-Stipa). Kuchler also included a small fragment of prairie that he identified as Nebraska Sandhills Prairie (Andropogon-Calamovilfa) along the border with South Dakota in southeastern ND. The woodland types included a Northern Floodplain Forest (Populus-Salix-Ulmus) along major rivers and streams, Oak Savanna (Quercus-Andropogon) in the Turtle Mountains, Sheyene Delta, and smaller patchs near Devils Lake, along the Souris River, and east of Pembina Gorge, and a small area of Eastern Ponderosa Forest (Pinus) in southwestern ND.

Hundreds of thousands of shallow ponds and lakes in the glaciated region of the state were also an important component of the natural land cover of ND (Stewart and Kantrud 1971, Kantrud et al. 1989).

The plight of the Great Plains has been the subject of several recent books (Bouzaher and Johnson 1995; Samson and Knopf 1996, Johnsgard 2003). Since the mid-1800's, wildlife populations in ND have undergone overwhelming changes at the hands of man of white European stock first as a result of excessive and unregulated hunting, and latter through changes in land cover and land use. In about six decades, the most spectacular large mammal concentrations on the continent were eliminated. The last great bison hunt in ND took place in 1882 on the headwaters of the Cannonball River, where 600 well-armed hunters on horseback killed 5,000 animals in two days (Bailey 1926). By 1886, American bison numbers in the Great Plains were reduced to a few hundred from an estimated 30–40 million. Large predators such as the grizzly bear and the Great Plains wolf suffered a similar fate. Although never very abundant, the last recorded observation of bighorn sheep in ND prior to their reintroduction was a ram shot in 1905. Elk and pronghorn antelope originally ranged over all of ND and their abundance and range has been greatly reduced.

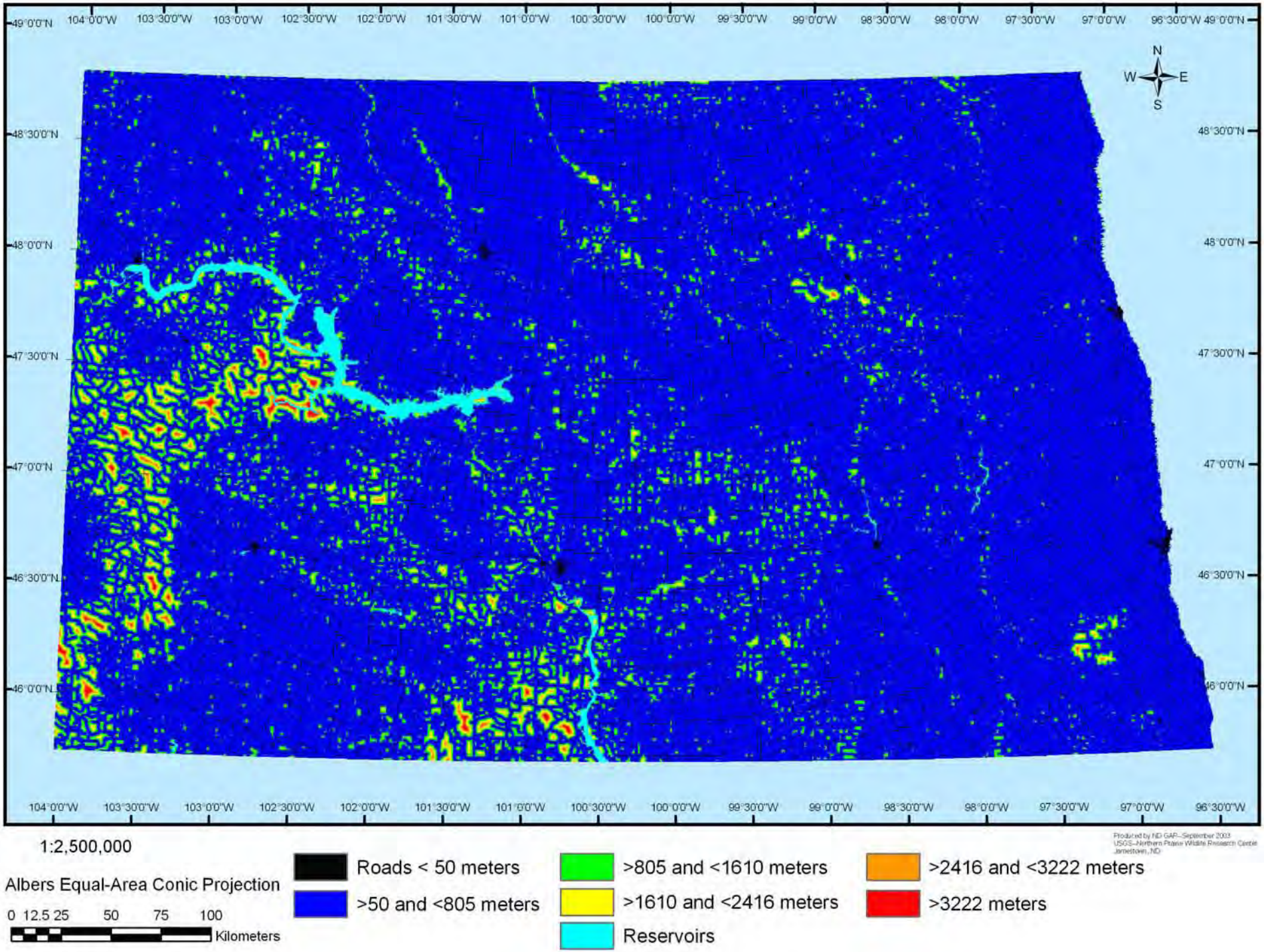
The history of the settlement of ND has been described in detail by Robinson (1966). The Dakota Territory was created in 1861 and opened to homesteading in 1863. Settlement of ND was slow until completion of the Northern Pacific Railroad provided dependable transportation. ND's population was recorded as 2,400 in 1870, increasing to 191,000 in 1890, 577,056 in 1910, and reached a peak population of 681,000 in 1930. This increase in population was a result of the rapid transfer of lands to private ownership through the cumulative effects of the Homestead Act, the Timber Culture Act, and the Preemption Act (Knue 1988). The homesteaders caused dramatic changes in land use. Large expanses of prairie were replaced by an almost equally endless sea of intensively cultivated fields. In 1919, ND was ranked 6th in the nation with respect to land in harvested crops with an estimated area of 19,760,741 acres or 44% of total land area (Shantz 1924). The drought of the 1930s and the failure of farming led to the creation of the Sheyene and Little Missiouri National Grasslands which are the largest contiguous blocks of public land in ND today. Concern with dwindling North American waterfowl populations in the early 20th century led to the Migratory Bird Treaty Act of 1918, the Migratory Bird Conservation Act of 1929 and the Migratory Bird Hunting Stamp Act of 1934. Most of the National Wildlife Refuges in ND were established in the 1930s and 1940s and an amendment of the Migratory Bird Hunting Stamp Act in 1958 resulted in the creation of the Small Wetlands Acquisition Program and the purchase of fee-title Waterfowl Production Areas (Krapu and Duebbert 1989).

In 2000, the area of harvested cropland in ND was estimated at 20,901,000 acres (47% of total land area) while the area of total cropland, lands that have been tilled at some time and could be put into crop production with minimal effort, was estimated at 27,025,000 acres (61% of total land area) (NDASS 2001). Although the state is sparsely populated, the area of public lands is small and wilderness and natural areas are almost non-existent. ND land surface is highly fragmented by roads. Ninety percent of the state's land area is

within 0.805 km (0.5 miles) of a road, 99% is within 3.28 km (2 miles) of a road, and the maximum distance from a road is 4.82 km (3 miles) (Map 1).

Tallgrass prairie has been reduced to remnant fragments in the Red River Valley. Most of the remaining prairie is mixed prairie located the Missouri Coteau and Missouri Plateau in areas where relatively rugged topography and reduced amounts and reliability of precipitation made the conversion to cropland more difficult than in the Drift Plain. Tens of thousands of wetlands in the glaciated portion of the state have been drained and farmed. Magnificent stands of floodplain forest along the Missouri and other rivers have been greatly reduced by water development projects and agriculture. Shelterbelts, tree claims, and field windbreaks have resulted in a large increase in woody vegetation in ND (Haugen et al. 1994).

These land use changes have had equally dramatic consequences for wildlife. Although croplands have resulted in abundant food supplies for many species of wildlife, they are comparatively sterile and bleak with respect to use by breeding vertebrates and general richness of biota (Stewart 1975). The abundance of food resources available to wildlife from croplands is decreasing with increases in the harvesting efficiency of farm equipment (Krapu et al. 2004). Grassland birds have shown more consistent and steeper widespread declines than any other group of North American bird species (Peterjohn and Sauer 1999). The decline in grassland nesting bird populations may be due in part to large changes in the distribution and abundance of predator species resulting from habitat alterations, human-inflicted mortality, and interspecific relations among predator species (Sargeant et al. 1993). Farm conservation programs that retire croplands from production and place the lands in an idle grassland cover for multiple years can have a huge positive effect on many grassland-nesting birds by virtue of the large areas involved in the programs (Johnson 2000, Reynolds et al. 2001). The Conservation Reserve Program is the most recent of these programs with over 3 million acres of perennial grass and legume cover established on previously tilled cropland in ND. Such large acreages make significant changes to landscape composition and configuration, and to vertebrate species distribution, reproduction, and survival.



Map1.1. Distance from roads and trails in North Dakota. Data from North Dakota Department of Transportation GIS Base Map Data, version 1.

LAND COVER CLASSIFICATION AND MAPPING

Introduction

Vegetation patterns are an integrated reflection of the physical and chemical factors that shape the environment of a given land area (Whittaker 1965). They also are determinants for overall biological diversity patterns (Franklin 1993, Levin 1981, Noss 1990), and they can be used as a currency for habitat types in conservation evaluations (Specht 1975, Austin 1991). A central concept of the gap analysis "coarse filter" approach to conservation biology is that the physiognomic and floristic characteristics of vegetation (and, in the absence of vegetation, other physical structures) across the land surface can be used to define biologically meaningful biogeographic patterns (Scott et al. 1993). The mapped extent and distribution of existing land cover is used in gap analysis to determine the representation of natural land cover categories within areas managed for biodiversity conservation, to model wildlife habitat and the potential distribution of terrestrial vertebrates, and to provide a land cover map which can be used to determine land cover trends by comparison with land cover maps developed at other times (Jennings 2000).

Vegetation classification and vegetation mapping are complex, distinct but intimately related, continually evolving activities which have received much attention and debate (Mueller-Dombois and Ellenberg 1974, Kuchler and Zonneveld 1988). Plant communities at various levels of geographic scale can be identified and described by the combined use of physiognomy, structure and floristics based on the principle of relative similarities and differences that underlies all systems of biological and ecological classification (Mueller-Dombois and Ellenberg 1974, Kuchler and Zonneveld 1988). Vegetation classification is the process of generalization and abstraction from individual stands of vegetation to a description of the kinds of plant communities. A common limitation of all vegetation classification systems is a certain amount of inflexibility with regard to the natural variability of vegetation. Vegetation mapping is the process of portraying the location and spatial pattern of plant communities in the landscape. A map can serve as a test of a vegetation classification because the mapper is forced to accommodate all of nature's kaleidoscopic arrangement of plants.

Land Cover Classification

The National Vegetation Classification System (NVCS) is a relatively recent attempt towards a unified vegetation classification system for the United States (FGDC 1997). The origin of this system is referred to as the UNESCO/TNC system (Lins and Kleckner 1996) because it is based on the structural characteristics of vegetation derived by Mueller-Dombois and Ellenberg (1974), adopted by the United Nations Educational, Scientific, and Cultural Organization (UNESCO 1973) and later modified for application to the United States by Driscoll et al. (1983, 1984). The Nature Conservancy, the Natural Heritage Network, and the Ecological Society of America Vegetation Classification Panel have worked to improve upon this system in recent years with partial funding supplied by GAP (Grossman et al. 1998, Jennings et al. 2003).

The NVCS is a hierarchal vegetation classification system based upon physiognomy and structure of vegetation at the higher levels and floristic composition at the lower levels (Grossman et al. 1998). Vegetation units at the lowest and most detailed level in the classification system are identified as associations. An association is a generalization or abstraction based upon the study of individual stands of vegetation and has a defined range of species composition, diagnostic species, habitat conditions, and physiognomy (Jennings et al. 2003). An alliance, the vegetation unit at the level above the association, involves an additional amount of abstraction. It is defined as a group of associations with a defined range of species composition, habitat conditions, and physiognomy, and which contains one or more of a set of diagnostic species, typically at least one of which is found in the upper most or dominant stratum of the vegetation (Jennings et al. 2003). At this early stage in its development, the NVCS does not contain quantitative information summarizing the variability in the species composition, structure and habitat characteristics within and among associations and alliances.

GAP guidelines call for mapping existing vegetation to the alliance level of the NVCS from analysis of Thematic Mapper imagery and ancillary data with individual alliance accuracy objective of 80% or greater. A review of the literature on vegetation and land cover mapping for rangeland ecosystems (Brown et al. 1983, Carneggie et al. 1983) and two recently completed land cover mapping projects in ND (EarthSat 1996, Redmond 1997) revealed this goal would be difficult to achieve.

The starting point for the development of the land cover classification system for the ND-GAP was a document prepared by the Nature Conservancy that identified and described 68 natural vegetation alliances in ND (Drake and Faber-Langendoen 1997). A provisional land cover classification system was prepared at the beginning of the ND-GAP by aggregating the 68 natural vegetation alliances into 33 natural and semi-natural land cover categories, and identifying an additional 8 land cover categories consisting of seven planted/cultivated land cover categories, and an urban land cover category (Appendix 2.1). Although, there was a concern that the number of land cover categories was still too ambitious given the limited potential to extract floristically defined land cover categories from digital analysis of remotely sensed imagery (Graetz 1990, Verstraete et al. 1996), acceptance of a provisional land cover classification system was needed so that the terrestrial vertebrate component of the project could proceed simultaneously with the land cover mapping component.

Methods

Overview

The land cover map for the ND-GAP was developed from a digital geospatial data base that included observations from spring, summer and fall Landsat Thematic Mapper imagery for all of ND. Each pixel in the data base was classified individually and independently of other pixels in the data base on the basis of its multi-temporal spectral reflectance measurements. Wetlands were mapped using National Wetlands Inventory (NWI) data (Wilen and Bates 1995). Urban and developed land cover categories were mapped using the 1992 ND National Land Cover data base (Vogelman et al. 2001). Ancillary data and manual editing were used during the analysis and classification process to reduce land cover classification errors. Data for the accuracy assessment was collected in a probability-based sampling design using ground surveys and aerial

photography. Software used in the land cover mapping process included MicroImages Map and Image Processing System (www.microimages.com), CART (www.salford-systems.com), and SAS (wws.sas.com).

Mapping Standards and Data Sources:
We maintained the 30 x 30 m (0.09 ha) cell size of the Landsat Thematic Mapper imagery in the construction of the land cover map. Most of the Thematic Mapper images used in the ND-GAP were acquired from the Multi-resolution Land Cover Characteristics Project (MRLC) (Loveland and Shaw 1996). The MRLC images were georegistered to a UTM map projection using 3-arc-second digital terrain elevation data and ground control points by the U.S. Geological Survey's EROS Data Center. The root mean square registration error for the MRLC TM images is less than 1 pixel (30 meters). Thematic Mapper images acquired from other sources were georegistered and resampled to the extents of an MRLC image for the orbit path and row using control points located in the image and the MRLC image. The root mean square registration error was less than 1 pixel.

A May, July, and September Landsat-5 Thematic Mapper image was acquired for each of fourteen orbit path and row combinations required for complete coverage of ND (Table 2.1). The dates of the May, July, and September images for rows 27 and 28 in path 31, rows 26, 27, and 28 in path 32, and rows 27 and 28 in path 34 were identical within the path and the data were combined for the analysis. This reduced the number of path and row defined data sets from fourteen to ten. The TM data for a path and row was clipped to the common spatial extent among the three dates of imagery. A vegetation and land cover map was derived independently for each of the ten subsections of ND. The vegetation and land cover database for the state was produced by mosaicking the ten independently derived land cover maps (Fig. 2.1). In the areas of overlap between the subsections, priority was given the path and row combination that had the most recent May TM image. Inspection of the state land cover mosaic revealed a 7.4 sq km area at the intersection of path 31 row 26, path 30 row 27 and the state boundary with Minnesota that did not have land cover data. Land cover data from the ND 1992 National Land Cover data set corresponding to the missing data location was translated to the categories of the ND-GAP land cover database and inserted into the state land cover mosaic to complete the coverage for ND.

Wetlands are an abundant and important land cover component in ND, particularly in the Prairie Pothole Region. Many of the temporary and seasonal wetlands are small relative to the pixel size of the TM imagery. Because of the difficulty mapping small wetlands using TM imagery (Ozesmi and Bauer 2002), wetlands for the ND-GAP land cover database were extracted from digital NWI data (Wilen and Bates 1995). NWI data for ND were developed from manual stereoscopic interpretation of ~1:60,000 scale aerial photography acquired from 1979-1984. NWI data for the Prairie Pothole Region of ND was obtained from the U.S. Fish and Wildlife Service (USFWS) Region 6 Habitat and Population Evaluation Team and NWI data for areas west and south of the Missouri river was obtained from the USFWS NWI.

Urban and developed land cover categories for the ND-GAP land cover map were extracted from the 1992 ND National Land Cover data base (Vogelman et al. 2001). The four categories included in the ND-GAP land cover database were Low Intensity Residential, High Intensity Residential, Commercial/Industrial/Transportation and Urban/Recreational Grasslands.

Table 2.1. Dates of Landsat 5 Thematic Mapper imagery used to create the ND-GAP land cover map. Rows within a path are grouped together when dates of May, July, and September images within the path are the same. A land cover classification was developed for each of the ten subsections of North Dakota.

Index Number	Landsat 5 path/row	Spring Image	Summer Image	Fall Image
1	Path 30 Row 27	26 May 1999	10 July 1998	10 August 1992
2	Path 30 Row 28	4 May 1997	26 July 1998	17 September 1994
3	Path 31 Row 26	1 May 1999	1 July 1998	8 September 1994
4	Path 31 Row 27	16 May 1993	14 July 1997	27 September 1995
	Path 31 Row 28	16 May 1993	14 July 1997	27 September 1995
5	Path 32 Row 26	26 May 1994	2 July 1996	2 September 1995
	Path 32 Row 27	26 May 1994	2 July 1996	2 September 1995
	Path 32 Row 28	26 May 1994	2 July 1996	2 September 1995
6	Path 33 Row 26	14 May 1993	9 July 1996	25 September 1995
7	Path 33 Row 27	12 May1998	15 July 1998	22 September 1994
8	Path 33 Row 28	12 May1998	15 July 1998	1 September 1998
9	Path 34 Row 26	3 May1998	30 July 1995	10 September 1993
10	Path 34 Row 27	3 May1998	30 June 1996	5 September 1997
	Path 34 Row 28	3 May1998	30 June 1996	5 September 1997

There were four primary sources of training data used for land cover mapping (Fig. 2.2). We conducted land cover surveys within 28, 28.6- x 28.6- km sample units in the summer of 1999. The location of the sample units was subjectively chosen after consideration of (1) access to public lands, (2) the amount of natural and semi-natural vegetation, and (3) surface geology, topography, and soils. Most of the sample units were located within the overlap area of adjacent TM orbit paths to make maximum use of the training data and our resources for land cover surveys. Additional sample units were located outside the overlap areas of TM images to include plant communities and environmental conditions which could not be represented within the overlap areas. Land cover within a sample unit was delineated on a 1:31,680 scale (2 inches per mile) color composite of TM imagery by a single observer for all 28 sample units. Land cover polygons were delineated primarily from roadside surveys because the logistics of obtaining trespass permission on private lands for an extensive land cover survey was prohibitive at this stage in the ND-GAP. The observer used the provisional ND-Gap land cover classification when assigning labels to the polygons. Many of the polygons for natural and semi-natural vegetation were labeled with multiple land cover categories as it was not possible to delineate the complexity of vegetation community boundaries at this scale and from the road.

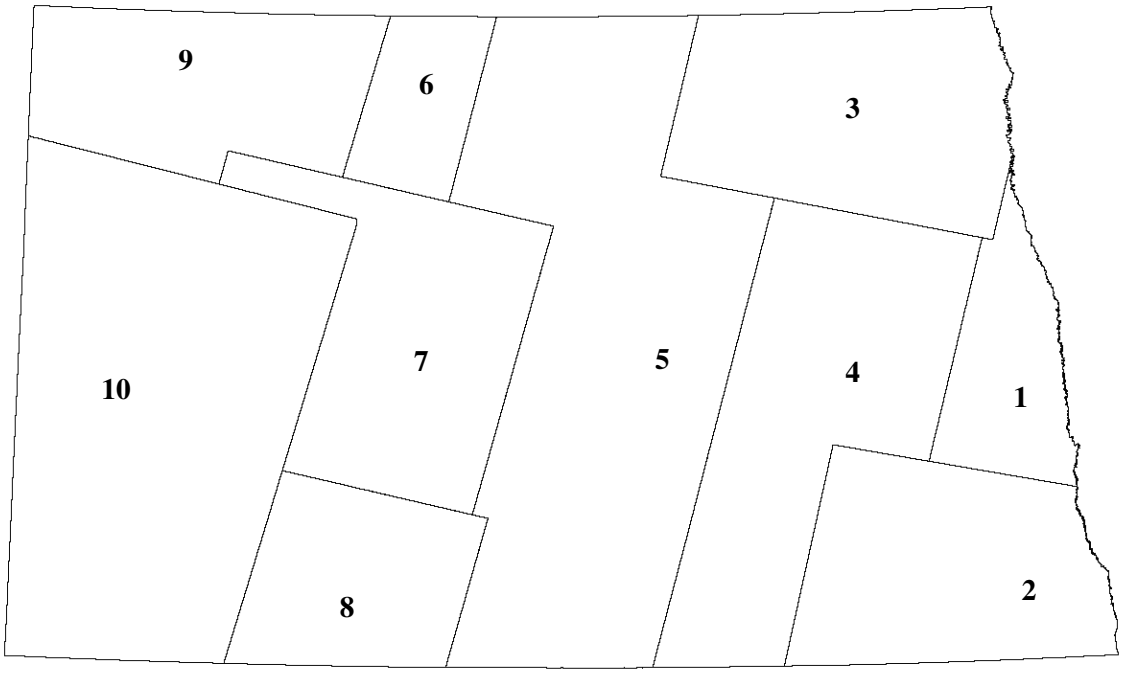


Fig. 2.1. The ND-GAP land cover map was produced from a mosaic of land cover maps developed independently for ten subsections of the state defined by the date of the TM images. The index numbers in the figure correspond to the path and rows of TM imagery in Table 1.

We also used a land cover data set prepared for 45 systematically spaced 40.5 km^2 hexagons in the Prairie Pothole Region. Land cover was created from interpretation of 1996 aerial photography by the Environmental Protection Agency and Northern Prairie Wildlife Research Center for a Prairie Pothole Region Wetland Environmental Monitoring and Assessment Project (EMAP) (Guntenspergen et al. 2002). The land cover classification included 14 land cover categories including natural grassland, planted hayland, planted grassland, cropland, woodland, shrubland, odd areas, barren, developed, and temporary, seasonal, semipermanent, permanent, and riverine wetlands.

Another source of training data for land cover mapping was obtained from Ducks Unlimited (DU) and the USFWS. The data was collected for training and accuracy assessment of their circa 1995 land cover map for the prairie pothole region of ND. The data set consisted of a combination of land cover from manual interpretation of aerial photographs and field surveys for a stratified random sample of 10.4 km^2 sample units (Cowardin et al. 1995) and additional land cover samples collected in a systematic sample design from roadside surveys. The land cover classification system was similar to the land cover classification of the EMAP data set.

The ND State Land Department was another source of training data. The Department is responsible for the management of approximately 714,000 acres of school trust lands, the majority of which is semi-natural grassland located in the western two-thirds of the state, and is leased for grazing by domestic livestock (Brand et al. 1988). Range inventory data was collected from 1980-1997 by three observers with many years of prior experience appraising range conditions in ND. The inventories were conducted on all State School Land tracts larger than 40

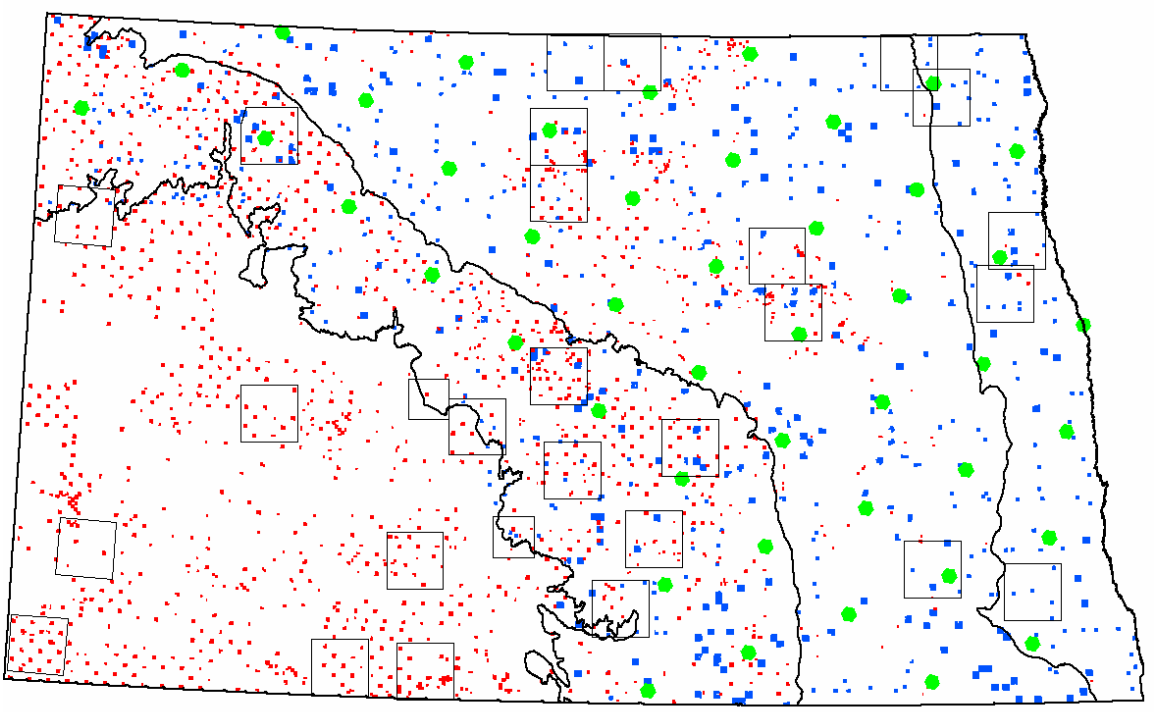


Fig. 2.2. Sources and distribution of training samples for land cover mapping. The boundaries of the 28, 818 km^2 sample units used for land cover surveys in 1999 are outlined in black. The solid green hexagons are 40.5 km^2 land cover sample units from the Prairie Pothole EMAP project. The solid blue features are land cover sample units from the USFWS and DU data set. The solid red features are state school lands.

acres with the exception of tracts managed by Grazing Associations in conjunction with National Grasslands. Using procedures similar to those in the National Range Handbook (USDA 1976), the observer made ocular estimates of the relative amount (%) of the total forage biomass by species for graminoids and by life form for forbs and shrubs for the primary range site of the tract. Surveys conducted in the latter years recorded data for more than one range site if the tract had large scale heterogenity in range sites. A total of 3,468 range worksheets were completed for the 2,864 school land tracts surveyed. The plant species composition and biomass data from the range surveys were transcribed from microfiche and word-processing files into a SAS data set. The data was exported as a dbase file and linked to a vector of the state school land tracts. The vector and the attached data base provided information about the range site(s), species composition and relative biomass of herbaceous plants, observations of woody plants, and topography of the tract.

We also obtained two additional sources of training data with smaller spatial extents. The ND Natural Heritage Program (NDNHP) recently completed tallgrass prairie inventories in Ransom, Richland, Sargent, and Barnes counties in southeastern ND (Shenk and Lenz 1998, Boe and Lenz 1999). Field surveys were conducted for areas of potential tallgrass prairie identified from interpretation of 1:7,920 scale enlargements of black and white National Aerial Photography Program photographs. Natural and semi-natural plant communities were classified to the association level of the NVCS and mapped on 1:24,000 scale topographic maps. We obtained vectors created by digitizing the maps. A land cover map for a 1493 km^2 area including

Theodore Roosevelt National Park and surrounding lands in western ND produced by the U.S. Geological Survey -U.S. National Park Service Vegetation Mapping Program was obtained (Von Loh et al. 2000). The map legend includes 29 natural and semi-natural land cover categories described using the NVCS and ten additional land cover categories.

Several other geospatial data bases were used in the analysis of the Thematic Mapper imagery (Table 2.2). Information about the data bases and how they were used is presented in the next section.

Table 2.2. Six geospatial data bases used in the analysis of Thematic Mapper imagery and the creation of the ND-GAP land cover map.

Omernik's Level IV Ecoregions of North Dakota (Bryce et al. 1998)
Geologic Map of North Dakota (Clayton et al. 1980)
1992 ND National Land Cover data base (Vogelmann 2001)
A circa 1992 land cover data base for the prairie pothole portion of ND (east and north of the Missouri River) available from Ducks Unlimited and the U.S. Fish and Wildlife Service (Earthsat 1996).
A circa 1992 land cover data base for western ND available from the U.S. Forest Service (Redmond et al. 1997).
ND State Soil Geographic (STATSGO) data base (NRCS 1994)

Land Cover Analysis and Mapping

The first step in the analysis of the TM imagery was the construction of cloud and water masks for the images. Cloud masks were created to determine if there were areas within the state which had cloud cover on all TM images for the area and thus would require additional imagery to map the land cover or the inclusion of a cloud category in the land cover classification. Cloud masks were created using a threshold on a TM channel 3 –TM channel 1 difference image, a threshold on the TM channel 1 image, and manual editing. Inspection of cloud masks in conjunction with extents of the TM images, including areas of overlap between paths and rows, revealed that it would be possible to map land cover for all areas of the state without acquiring additional images or the need for a cloud category. Cloud masks were used to exclude cloud pixels from train and test samples used in the classification tree analyses.

A water mask was constructed for each image using a threshold on TM channel 5. A water mask for the path and row was created by combining the individual image water masks using Boolean logic and identifying pixels that were identified as water on two or more dates. Requiring a pixel to be identified as water on a minimum of two image dates before it was included in the water mask for the path and row reduced water commission errors. Cloud shadows and other commission errors in the water mask were manually excluded. Water remaining after incorporating NWI data into the land cover classification was assigned to a generic wetland category.

The analysis of the TM imagery for each of the ten path and row subsections in ND began with binary classification tree analyses for the cropland, woodland, and planted herbaceous perennials land cover categories and for path 34 rows 27 and 28, which includes the Little Missouri Badlands, a sparsely vegetated land cover category. Each of the binary classification tree analyses separated the target land cover category from a composite category that included all other land cover categories. This binary sequential and hierarchical approach to land cover classification is an effective method for dealing with the high spectral dimensionality of multitemporal imagery (Lee and Richards 1985, Lozano-Garcia and Hoffer 1985). The spectral classification rules were developed using the classification tree algorithm in CART version 4.0 (Salford Systems 2000). Classification tree rules were output from CART, edited and imported as spatial manipulation language scripts (SML) into MicroImages Map and Image Processing System to create the land cover maps.

Multiple binary cropland/not-cropland classification tree analyses were performed using different combinations of image dates and spectral channel subsets. Different combinations of image dates were used because of the wide range in the dates of the TM images for some paths and rows. For example, the TM images available for path 30 row 28 included 4 May 1997, 26 July 1998, and 17 September 1994. The multiple binary classifications for cropland were combined to create a single image depicting all possible combinations of the binary cropland classifications. The pixel values in this image indexed classes of pixels whose member pixels had the same pattern of cropland classification among the multiple binary cropland classifications. For example, one pixel value identified a class whose pixels were classified as cropland on all of the classifications, another pixel value identified a class whose pixels were classified as cropland on all classifications except one, and so on. This cropland image was inspected by comparison with color composites of the TM imagery, digital orthophotographs, and the training data. Pixel values for classes in the image that contained a mixture of crop and not-cropland pixels were identified, and a mask was constructed for pixels belonging to these classes. A Kmeans clustering and maximum likelihood classification was performed using the mask with a subset of the TM images and spectral bands to subset the pixels into spectral classes which would reduce the classification errors for cropland. A provisional cropland mask was created by combining the cropland classes from the binary classification tree analyses and the cropland classes from the maximum likelihood analysis.

Next, the provisional binary cropland mask created in the previous step was combined with a binary cropland mask extracted from the 1992 ND National Land Cover dataset, and a binary cropland mask from either a DU/USFWS land cover classification (east and north of the Missouri River) or a U.S. Forest Service Land cover classification (west and south of the Missouri River) to depict all possible combinations of cropland as defined by the three sources. This image was inspected for cropland omission and commission errors in the provisional cropland mask and a final cropland mask was created that minimized cropland classification errors. Cropland commission errors for sparsely-vegetated badlands topography and sand dunes for path 30 row 28, path 32 rows 26,27,28, and path 34 rows 27 and 28 were reduced using thematic categories from the Ecoregions of ND and Geologic Map of ND data sets and manual editing.

Next binary woodland/not-woodland classification tree analyses were performed in a manner similar to that described for croplands. Extensive use of digital orthophotographs was used to inspect the woodland classifications. If sufficient training data was available, a woodland community type analysis was performed using classification tree analysis. Otherwise, an unsupervised Kmeans cluster analysis and maximum likelihood classification was performed for the woodland mask and correspondence of spectral classes to woodland types was determined from statistical summaries of the association of spectral classes with training samples (Homer et al. 1997). Ponderosa pine was mapped using conifer forest spectral classes with township, range, and section information for the four largest stands described in Potter and Green (1964a). The single stand of limber pine was mapped using conifer forest spectral classes with township, range, and section information for the stand described in Potter and Green (1964b).

Next binary planted herbaceous perennials/not-planted herbaceous perennials classification tree analyses were performed in a manner similar to that described for croplands and woodlands. In an effort to further reduce classification errors between planted herbaceous perennials and natural and semi-natural prairie due to their similarity in physiognomic structure and uses, a Kmeans cluster analysis and maximum likelihood classification were performed for pixels assigned to the planted herbaceous perennials mask. Statistical summaries of the association of spectral classes with planted herbaceous perennials and natural grassland training samples and manual inspection of the spatial patterns of the spectral classes were used to identify spectral classes as planted herbaceous perennials, mixtures of planted herbaceous perennials and natural grassland, and natural grassland. Spectral classes identified as planted herbaceous perennials were used to create a planted herbaceous perennials mask and spectral classes identified as mixtures of planted herbaceous perennials and natural grassland were combined to create a mask for analysis of natural and semi-natural prairie land cover categories.

National Wetlands Inventory data were quality checked for valid wetland attribute codes as defined in the Classification of Wetlands and Deepwater habitats of the United States (Cowardin et al. 1979) and an exhaustive list of the attribute codes was created. For our purpose, we aggregated wetlands to seven wetland categories on the basis of the attributes at the system and class levels, and the water regime modifier. The seven categories are Lacustrine (System Code L), Riverine (System Code R), Palustrine Forested (System and subsystem code PFO), Palustrine Scrub-shrub(System and subsystem code PSS), Palustrine Semi-permanent (System code P, subsystem code not FO or SS, water regime code F), Palustrine Seasonal (System code P, subsystem code not FO or SS, water regime code C,D, or E), and Palustrine Temporary (System code P, subsystem code not FO or SS, water regime code A, B). There were a small number of Palustine wetlands where the subsystem code is not FO or SS, and the water regime code is not A,B,C, D,E or F. Palustrine wetlands where subsystem code is not FO or SS with water regime G (intermittently exposed), H (permanently flooded), or K (artificially flooded) were classified as lacustrine wetlands. Wetlands which were complexes of 2 or more types are grouped for our purposes on the basis of the first wetland code. For example, a PSS/EMA wetland is identified as Palustrine Scrub-shrub. In the final land cover map, Palustrine Forested wetlands and Palustrine Scrub-shrub wetlands were included in the Floodplain Woodland and Lowland Deciduous Shrubland land cover categories, respectively.

The NWI vectors were converted to rasters with 5 m pixels and these rasters were resampled to rasters with 30 m pixels and spatial extents corresponding to the appropriate TM image. The conversion from vector to raster overestimated the area of wetlands particularly for small wetlands. The two-step vector to land cover data base raster conversion process reduced the overestimation of the area of wetlands.

In the land cover mapping process, a loss of wetlands was observed along the Missouri River and the current land cover for these areas was identified from analysis of TM imagery. Wetland losses may have occurred in other areas but were not detected. The water mask created from the TM imagery suggested there were also gains in the number and area of wetlands in response to an unusually wet period in ND which began in the summer of 1993 (Williams-Sether 1999). A NWI wetlands status and trend report for the period 1986-1997 also observed wetland gains in the prairie pothole region (Dahl 1997).

Urban and developed land cover categories for the ND-GAP land cover data base were extracted from the 1992 ND National Land Cover data base. The four categories included in the ND-GAP land cover database were Low Intensity Residential, High Intensity Residential, Commercial/Industrial/Transportation and Urban/Recreational Grasslands. Recent urban development in Fargo, Bismarck, Grand Forks and Minot and an omission of urban land cover in and surrounding Williston, ND was mapped using a combination of 1990 U.S. Census Block Group housing density data, a urban category from a 1998 land cover classification for ND produced by the ND Agricultural Statistical Service and TM imagery.

Pixels remaining after constructing and combining the cropland, woodland, planted herbaceous perennials, wetlands, water, and developed land masks were assigned to the prairie land cover category. An analysis of prairie community types was performed using classification tree analyses with training data developed from range inventories for ND school lands. Insufficient School Land training samples were available for path 30 row 27, path 30 row 28, and path 31 row 26. A Kmeans cluster analysis and maximum likelihood classification was performed for path 30 row 28 and prairie community type labels were assigned to the spectral classes by reference to prairie community maps for Richland, Sargent, Barnes and Ransom Counties in ND by the ND Natural Heritage Program. A prairie type analysis was not attempted for path 30 row 27 and path 31 row 26 because of insufficient data training data and the small amount of prairies in this portion of the state.

The assignment of classification tree nodes to prairie types was evaluated using statistical summaries of the association of node members with prairie community type and planted herbaceous perennials training samples and by reference to landscape position and association as determined from manual inspection of TM color composites, and digital orthophotographs. Changes in assignment of prairie community type labels to classification tree nodes were made when evaluation of the classification suggested a different prairie community type or planted herbaceous perennials would be more appropriate label for the node.

Development of a shrubland land cover category was challenging because of the difficulty defining training areas for small, sparsely distributed, and irregular shaped shrub patches, the spectral similarity of shrublands with other land cover categories, and temporal change in

snowberry (*Symphoricarpos occidentalis*) shrubland communities between the date of the TM imagery and ground surveys due to haying and fire. Because of these difficulties, we were not able to create a shrubland category for all areas of the state. The shrubland category was developed, when possible, during the analysis of the woodland and prairie land cover categories. Spectral classes for the shrubland category were identified when they were detected during the process of inspecting the woodland classifications using the digital orthophotos and using a threshold on a near infrared/red ratio for the July TM image for areas identified as prairie. The logic behind the use of the July near infrared/red ratio procedure was that the grass and forb component of the vegetation would be experiencing a water deficit at this date, while the shrub component with its deeper roots would have access to water and would have a canopy with more actively growing green leaves than grasses and forbs. These phenologic conditions did not appear to be met for many of the July images as attempts to define a shrubland category resulted in excessive shrubland commission error and hence a shrubland land cover category was not created. A shrubland land cover category was developed for paths 34 rows 27 and 28, path 33 row 27, path 33 row 28, path 31 rows 27 and 28, and path 31 row 26 (See Fig. 2.1 and Table 2.1). The shrubland category for path 31 rows 27 and 28 was extended into the overlap areas for path 30 row 28 and path 32 rows 27 and 28. The shrubland category was subset into an upland deciduous shrubland category, a sagebrush shrubland category (only for areas in path 34 rows 27 and 28), and a lowland shrubland category by cross-tabulation with training area polygons.

Five post-classification stratifications using ancillary data were performed to increase the information content of the land cover map and to reduce land cover classification errors.

First, a floodplain woodland land cover category was created by intersecting a binary mask created from the Geologic Map of ND with the woodland land cover category. The initial binary geologic mask was created from two geologic categories, Holocene River Sediment, Qor, and Holocene to Pre-Wisconsin Uncollapsed River Sediment, Qcrf. The initial intersection of this mask with a binary image of the woodland land cover category revealed numerous commission errors for floodplain woodland. The binary geologic map was manually edited to exclude these commission errors. A final floodplain woodland land cover category was constructed after several iterations of manually editing the binary geologic map and inspection of its intersection with the woodland land cover category.

Second, an area of saline prairie in the northern portion of the Glacial Lake Agassiz physiographic region near Grand Forks, ND, was created by intersecting a binary mask of soil map unit ND073 from the ND State Soil Geographic (STATSGO) data base with planted herbaceous perennials and prairie land cover categories.

Third, the area of the sand prairie land cover category was increased by intersecting a binary mask of the prairie land cover category for path 31 rows 27 and 28 and path 31 row 26 with a binary mask of the Holocene Windblown Sand, Qod, category from the Geologic Map of ND.

Fourth, a fescue prairie land cover category was created in north-western ND by intersecting a binary mask of the Bluestem – Needlegrass-Wheatgrass prairie category from path 34 row 26 with a binary mask of a Fescue Prairie land cover category developed from regression tree analyses predicting the relative abundance of *Heterostipa curtiseta* and *Agropyron dasystachyum*

from environmental variables (unpublished data presented at a poster session at the 55th Annual Meeting of the Society for Range Management, L. L. Strong, Integration of GIS and remote sensing for mapping rangeland plant communities of the Northern Great Plains).

Finally, the prairie land cover category was reduced by changing pixels classified as prairie to planted herbaceous perennials if the pixels were classified as cropland on five or more years in a six year land cover data base constructed from annual land cover classifications produced by the ND Agricultural Statistical Service.

Results

The classification system for the ND-GAP land cover map is hierarchical with eight general land cover categories at the upper level and 39 detailed land cover categories at the lower level (Table 2.3, Map 2.1). A description of the 39 land cover categories is in Appendix 2.2. Forty-eight percent (88,165 km^2) of the total surface area of ND was mapped as cropland. An additional 30,543 km^2 was mapped as lands planted to herbaceous perennial plants bringing to a total 118,760 km^2 or 64.9 % of ND that has been tilled at some time. These estimates appear reasonable when compared with a 1997 estimate of harvested cropland (82,775 km^2) and a 1969 estimate of total cropland area (119,216 km^2) (USDA 1999).

Ten prairie land cover categories were mapped and combined account for 35,681 km^2 (19%) of ND. Wheatgrass Prairie, Needlegrass Prairie, and Bluestem-Needlegrass-Wheatgrass Prairie accounted for 23, 21 and 16 % of lands mapped as prairie, respectively. Little Bluestem and Sand Prairie each account for 12% of lands mapped as prairie. Wet-mesic Tallgrass Prairie, Mesic Tallgrass Prairie, Mesic Tall and Mixed Prairie, Fescue Prairie, and Sand Prairie each account for 6 % or less of the lands mapped as prairie.

Three shrubland land cover categories (Upland Deciduous, Lowland Decidous, and Sagebrush) accounted for 5,281 km^2 (2.9%) of the ND. As explained in the methods section, shrublands were difficult to map and shrublands were not mapped for all areas of the state and thus are underestimated. Shrubland omission errors are likely commission error for prairie, planted herbaceous perennials and woodland land cover categories. Previous small scale vegetation maps for ND have not included a shrubland land cover category and only some of the recent vegetation maps developed using remotely sensed imagery have included a shrubland land cover category. Refinement of the shrubland land cover category should be a high priority in future land cover maps.

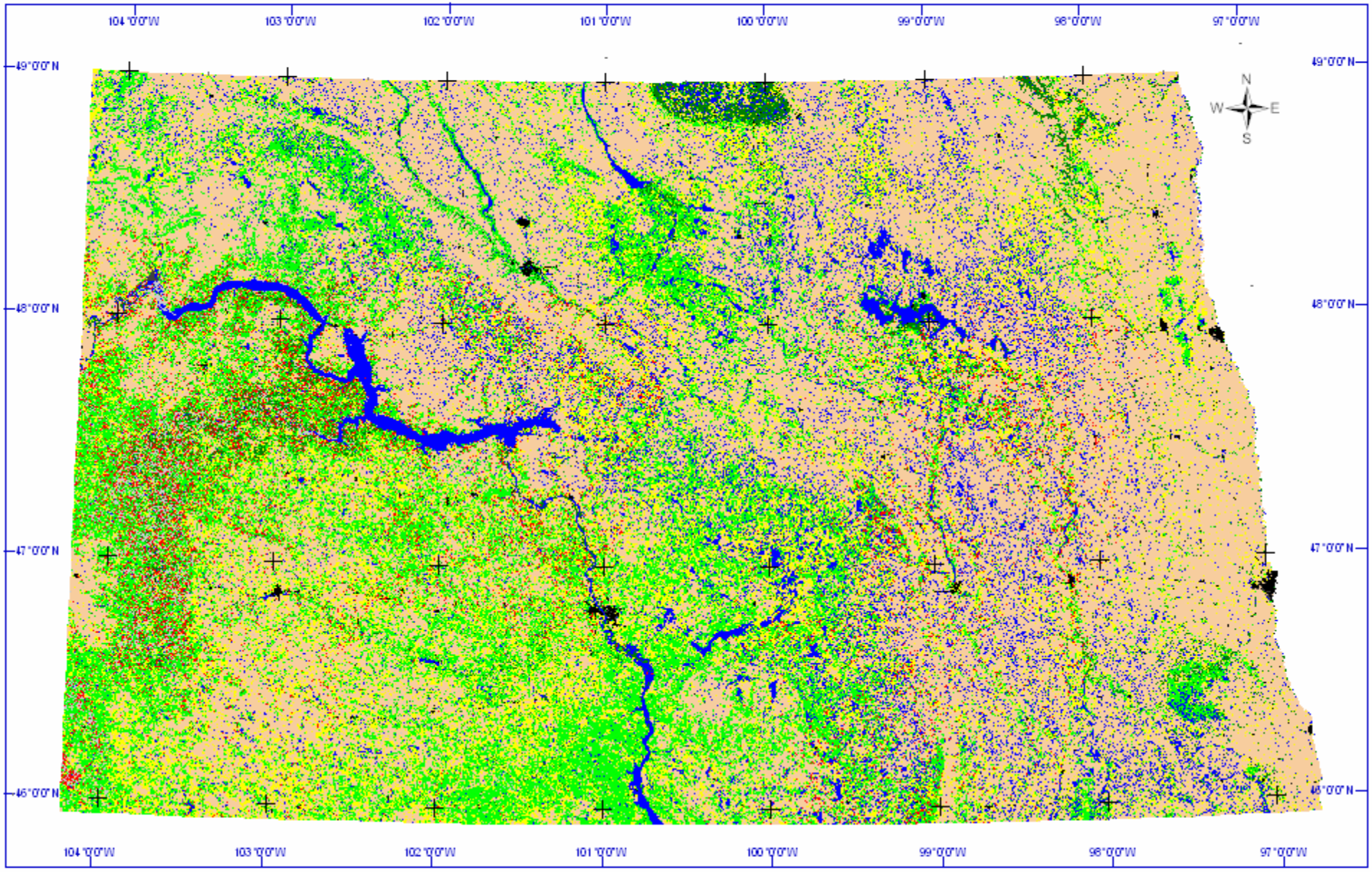
Wetlands accounted for 16,297 km^2 (9 %) of ND. The area of wetlands is likely overestimated because the process of converting NWI vectors to rasters exaggerated the area of small polygons. Seasonal wetlands accounted for the largest proportion, 32%, of wetlands. Lacustrine, Temporary, and Semipermanent wetland had roughly similar proportions accounting for 21.4, 18.9, and 17.4 % percent of wetlands, respectively. Eight percent of the wetland land cover category (1329.2 km^2) is identified as wetland based on the detection of surface water on two or more dates of TM imagery at locations not identified as wetland in the NWI data. Some of this increase in wetland area is a real increase in the area of wetland (Dahl 1997) and some

Table 2.3. Raster cell value, land cover category, area (km^2), percent of general land cover category, percent of the area of North Dakota, and area in $miles^2$, hectares and acres for 39 land cover categories in the ND-GAP land cover map.

Cell value	Land cover category	Area (sq km)	% of state	% of general land cover category	Area (sq miles)	hectares	acres
1	**cropland**	**88165.9**	**48.1511**		**34040.8**	**8816588**	**21785788**
2	**planted herbaceous perennials**	**30542.7**	**16.6807**		**11792.6**	**3054274**	**7547110**
	prairie	**35681.4**	**19.4871**		**13776.6**	**3568140**	**8816874**
10	prairie - wet-mesic tallgrass	1402.3	0.7659	3.930	541.4	140232	346513
11	prairie - mesic tallgrass	156.2	0.0853	0.438	60.3	15616	38587
12	prairie - mesic tall and mixed	2054.3	1.1219	5.757	793.2	205429	507615
13	prairie - bluestem-needlegrass-wheatgrass	5851.7	3.1959	16.400	2259.4	585172	1445961
14	prairie - wheatgrass prairie	8291.1	4.5281	23.236	3201.2	829110	2048730
15	prairie - needlegrass prairie	7392.0	4.0371	20.717	2854.1	739203	1826570
16	prairie - little bluestem	4298.5	2.3476	12.047	1659.6	429849	1062157
17	prairie - fescue	444.4	0.2427	1.245	171.6	44436	109802
18	prairie - sand	4267.7	2.3308	11.961	1647.8	426772	1054555
19	prairie - saline	1523.2	0.8319	4.269	588.1	152321	376384
	shrubland	**5281.1**	**2.8842**		**2039.0**	**528112**	**1304965**
20	shrubland - upland deciduous	4299.2	2.3480	81.407	1659.9	429920	1062333
21	shrubland - lowland deciduous	79.1	0.0432	1.498	30.5	7911	19549
22	shrubland - sagebrush	902.8	0.4931	17.095	348.6	90280	223083
	woodland	**4284.2**	**2.3398**		**1654.1**	**428418**	**1058621**
30	woodland - ponderosa pine	9.6	0.0053	0.225	3.7	962	2378
31	woodland - limber pine	0.3	0.0001	0.006	0.1	25	62
32	woodland - rocky mountain juniper	193.6	0.1057	4.520	74.8	19363	47845
33	woodland - mixed conifer and deciduous woodland	450.2	0.2459	10.508	173.8	45017	111236
34	woodland - floodplain	688.2	0.3758	16.063	265.7	68816	170045
35	woodland - deciduous	1601.9	0.8749	37.391	618.5	160191	395833
36	woodland - green ash	498.7	0.2724	11.640	192.5	49870	123229
37	woodland - aspen	290.1	0.1584	6.772	112.0	29011	71687
38	woodland - bur oak	234.4	0.1280	5.471	90.5	23441	57921
39	woodland - aspen and bur oak	317.2	0.1732	7.404	122.5	31722	78385

Table 2.3. (continued) Raster cell value, land cover category, area (km^2), percent of general land cover category, percent of the area of North Dakota, and area in $miles^2$, hectares and acres for 39 land cover categories in the ND-GAP land cover map.

Cell value	Land cover category	Area (sq km)	% of state	% of general land cover category	Area (sq miles)	hectares	acres
	wetland	**16297.5**	**8.9007**		**6292.4**	**1629746**	**4027101**
40	wetland - lacustrine	3482.5	1.9020	21.369	1344.6	348254	860535
41	wetland - riverine	442.0	0.2414	2.712	170.7	44199	109215
42	wetland - palustrine temporary	3086.6	1.6857	18.939	1191.7	308656	762688
43	wetland - palustrine seasonal	5162.5	2.8195	31.677	1993.2	516252	1275658
44	wetland - palustrine semipermanent	2794.7	1.5263	17.148	1079.0	279466	690561
45	wetland - water	1329.2	0.7259	8.156	513.2	132919	328443
	sparse vegetation	**1896.7**	**1.0359**		**732.3**	**189667**	**468667**
50	sparse vegetation - others	310.9	0.1698	16.391	120.0	31088	76819
51	sparse vegetation - badlands	1479.0	0.8077	77.979	571.0	147900	365460
52	sparse vegetation - riverine	106.8	0.0583	5.630	41.2	10679	26388
	urban	**953.2**	**0.5206**		**368.0**	**95318**	**235531**
60	developed - high intensity residential	89.3	0.0488	9.371	34.5	8932	22071
61	developed - low intensity residential	232.8	0.1271	24.420	89.9	23277	57518
62	developed - commerical/industrial/transporation	475.7	0.2598	49.904	183.7	47567	117538
63	developed - urban grasslands	108.6	0.0593	11.389	41.9	10856	26825
64	developed - recently developed or omissions in 1992 NLC	46.9	0.0256	4.916	18.1	4686	11579
		183102.6			70695.9	18310262	45244657



Map 2.1. North Dakota 8 Category General Land Cover, circa 1997

proportion is likely due to differences in spatial registration and representation of wetland using TM imagery and NWI data.

Ten woodland land cover categories accounted for 4,284 km^2 (2.3 %) of ND. A generic deciduous woodland category that includes farm shelterbelts, field windbreaks, other planted woodlands and natural deciduous woodlands accounts for 37% of lands mapped as woodlands. Floodplain Woodland accounted for 688 km^2 (16 %) of the lands mapped as woodlands. Green Ash Woodland and Mixed Conifer and Deciduous Woodland (woodland mixtures of Green Ash and Rocky Mountain Juniper) accounted for 939 km^2 (22%) of woodlands. Aspen and Aspen Bur Oak woodland mixtures accounted for 608 km^2 (14%) of woodlands. Bur oak had the smallest area of the deciduous woodland types with 234 km^2. Natural conifer woodlands accounted for less than 5 % of woodlands in ND with Rocky Mountain Juniper Woodland accounting for 193.6 km^2 (95%) of the area mapped as conifer woodland.

The sparsely vegetated land cover category that includes natural badland landforms and riparian sandbars account for 1% of ND.

Accuracy Assessment

Introduction

GAP land cover maps are primarily compiled to answer the fundamental question in gap analysis: what is the current distribution and management status of the nation's natural land cover types and wildlife habitats? Besides giving a measure of overall reliability of the land cover map for gap analysis, the assessment also identifies which land cover categories do not meet the accuracy objectives for the GAP. Thus the assessment identifies where additional effort will be required when the map is updated. We report the results of the accuracy assessment, believing that the map is the best map currently available for the project area.

The purpose of accuracy assessment is to allow a potential user to determine the map's "fitness for use" for their application. It is impossible for the original cartographer to anticipate all future applications of a land cover map, so the assessment should provide enough information for the user to evaluate fitness for their unique purpose. This can be described as the degree to which the data quality characteristics collectively suit an intended application. The information reported includes details on the database's spatial, thematic, and temporal characteristics and their accuracy.

Assessment data are valuable for purposes beyond their immediate application to estimating accuracy of a land cover map. The reference data is therefore made available to other agencies and organizations for use in their own land cover characterization and map accuracy assessments (see Data Availability for access information). The data set will also serve as an important training data source for later updates.

Even though we have reached an endpoint in the mapping process where products are made available to others, the gap analysis process should be considered dynamic. We

envision that maps will be refined and updated on a regular schedule. The assessment data will be used to refine GAP maps iteratively by identifying where the land cover map is inaccurate and where more effort is required to bring the maps up to accuracy standards. In addition, the field sampling may identify new classes that were not identified during the initial mapping process.

Methods

We used a probability based sampling design and design-based inference to assess the accuracy of the ND-GAP land cover map (Stehman 2001). We had four objectives for the accuracy assessment: (1) estimates of land cover category omission and commission error for four physiographic regions (a) Glacial Lake Agazzi, (b) Drift prairie, (c) Missouri Coteau, and (d) Missouri Plateau, (2) unbiased area estimates for land cover categories in each of the four physiographic regions, (3) estimates of land cover category omission and commission error for ND, and (4) estimate of overall proportion correctly classified for ND.

The first step in conducting an accuracy assessment is specification of the sampling unit (Stehman and Czaplewski 1998). We considered four primary factors when deciding upon the characteristics of the sample unit: (1) the likelihood of obtaining a sufficient sample of observations to estimate omission errors for all of the 39 land cover categories at the finest thematic resolution of the land cover classification scheme, (2) the potential to partition classification error into attribute and location error components, (3) samping units that would be minimize the complexity of the analysis if an assessment was performed for different versions of the map or for different aggregations of the land cover categories, and (4) the logistics of travel to and obtaining trespass permission for the sample units. After careful consideration of these 4 factors, we concluded the use of large area based sample units would meet our needs with respect to the first 3 factors and decided the use of sections, 1 $mile^2$, in the public land survey system (PLSS) (Clawson 1968) would satisfy our needs with respect to the 4^{th} factor. We considered each sample unit as a maplet (Stoms 1996) and created an exhaustive land cover map for each sample unit using observations of land cover from ground surveys and aerial photo interpretation.

The sample design was a stratified random single-stage cluster sample. Sixteen strata were defined by a combination of four physiographic regions and four anthropogenic land cover proportion classes. The population frame for the accuracy assessment was created by merging a PLSS vector for ND with a vector of Omernik's level III ecoregions of ND (Omernik 1987). The population frame consisted of 71,533 sections or sample units after editing for polygon slivers which occurred primarily along the Red River because of the convoluted eastern border of ND and the different representations of border in the physiographic region and the PLSS vector. Sample units which were split by a physiographic region boundary were assigned to the physiographic region which occupied the greatest area of the sample unit. We used a provisional version of the ND-GAP land cover map to calculate the proportion of anthropogenic land cover defined as cropland and developed land cover categories in each sample unit. The anthropogenic land cover proportion classes were defined as class 1 (0-25%), class 2 (26-50%), class 3

(51-75%), and class 4 (76-100%) (Fig. 2.3). We excluded 657 sample units from the population because the area of water in the sample unit (as determined by the ND-GAP

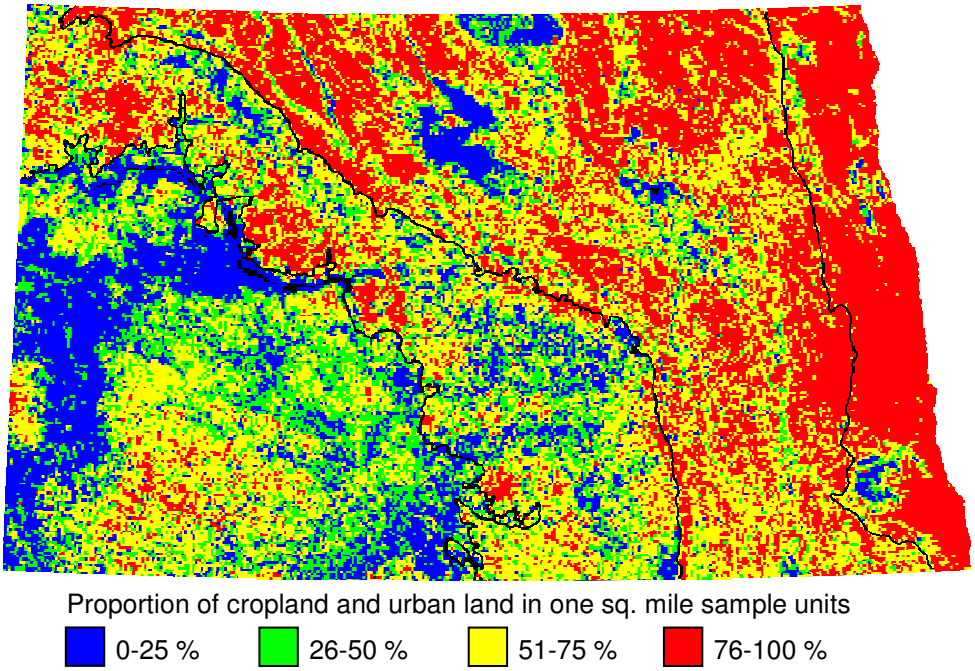


Fig. 2.3. Anthropogenic land cover proportion strata used in the accuracy assessment of the ND-GAP land cover map. The proportion of anthropogenic land cover (sum of cropland and developed land cover categories) in each sample unit was calculated from a provisional version of the ND-GAP land cover map.

land cover map) was greater than 89% of the sample unit. This resulted in a population frame of 70,876 sample units used to select the sample of sections for the accuracy assessment. The purpose of the stratification was to obtain a good geographic distribution of the sample units and an expectation that the stratification would yield observations of all of the common natural land cover categories in ND.

Samples were allocated to the 16 strata as follows. Ten sample units were allocated to anthropogenic land cover proportion class 4 (76-100% anthropogenic land cover) in each of the four physiographic regions. The decision to allocate ten sample units to these four strata was based on the maximum effort and the minimum sample size we wished to devote to these strata which are composed primarily of cropland. Two hundred sample units were allocated with unequal probability among the twelve remaining strata proportional to the square root of the number of sample units in a stratum. The number of sample units allocated to the anthropogenic land cover proportion classes 1 and 2 for the Glacial Lake Agassiz physiographic region was increased to 10 observations because the proportional allocation yielded too small of a sample. The distribution of the 253 sample units among the four physiographic units is shown in Fig. 2.4 and among strata in the population frame and in the ground sample is shown in Table 2.4.

We attempted to acquire a 1:10,000 scale color infrared (CIR) aerial photograph centered on a sample unit from 23-30 July 2002. CIR photographs were acquired for only 150 (59 %) of the sample units due to weather and the availability of aircraft and photographers. Aerial natural color 35 mm slides acquired in summer of 2001 by the Farm Service

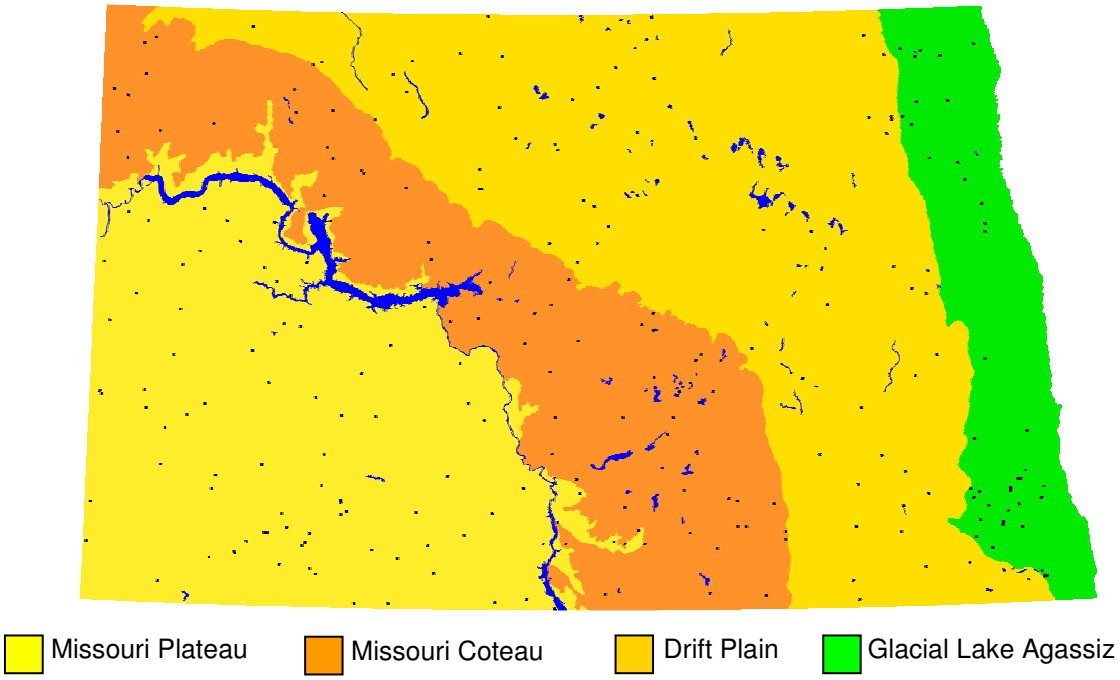


Fig. 2.4. Four physiographic regions with location of 253 one mi^2 sample units used in the accuracy assessment of the ND-GAP land cover map.

Administration and 1995-1997 ND black-and-white digital orthophotoquads were used for sample units without a 2002 color infrared photograph. A print from one of the sources of photography was used during the ground surveys of the sample units to delineate the boundaries of the land cover types observed. Ground surveys of land cover of the sample units was completed from 26 June to 16 September 2002 using an aerial photograph, 1:24,000 scale county soil map, and Farm Service Administration land use maps. Not all land cover type boundaries were delineated in the field. For example, some sample units had a large number of small wetlands and only a portion of the wetlands were delineated in the field. The remaining wetlands were delineated later in the lab from interpretation of the photograph.

The aerial photographs were scanned, georeferenced using digital orthophotographs and resampled to create rasters with 0.5 m grid cells. Observations of the land cover from the ground surveys and aerial photo interpretation were used to create an exhaustive land cover vector for each sample unit from on-screen digitizing using the georeferenced aerial photograph as a base. Land cover vectors for the sample units were merged into a single vector and converted a raster with 30 m grid cells using the ND-GAP land cover

map as the reference image. Data from the accuracy assessment sample units were exported to SAS for statistical analysis.

Table 2.4. Distribution of sample units among 16 strata defined by a combination of four physiographic regions and four anthropogenic land cover proportion classes in the population frame and for the 253 sample units selected for ground surveys to assess the accuracy of the ND-GAP land cover map.

	Anthropogenic Land Cover Proportion Class				
Population Frame	**1 (0-25%)**	**2 (26-50%)**	**3 (51-75%)**	**4 (76-100%)**	**Total**
Physiographic Region					
Missouri Coteau	2397	3236	7465	2992	16090
Missouri Plateau	7255	6047	6890	818	21010
Drift Prairie	1691	1989	10595	12366	26641
Glacial Lake Aggassiz	195	222	1137	5581	7135
					70876
Ground Sample					
Missouri Coteau	14	17	25	10	66
Missouri Plateau	25	23	24	10	82
Drift Prairie	12	13	30	10	65
Glacial Lake Aggassiz	10	10	10	10	40
					253

We used design-based inference (DBI) procedures as it is appropriate to assessing the accuracy of a particular map, in this case the ND-GAP land cover map, and requires fewer assumptions than model based inference procedures (Stehman 2001). In DBI, the response observed at a pixel is viewed as a fixed value, not a random variable, and concern with the correlation among with observations within a cluster is not warranted for rigorous estimation. Accounting for chance agreement is also not necessary for describing the accuracy of a particular map because such correct classifications are a windfall gain to the map and should not be subtracted from the map's reported accuracy.

We used the SAS SURVEYMEANS procedure with estimators appropriate to our sample design to estimate the accuracy parameters for the ND-GAP land cover map (Stehman 2001, 1997). The accuracy parameters are collective properties characterizing the proportion of correctly classified or misclassified pixels in the population. These parameters can also be interpreted as probabilities. The overall proportion correctly classified, P, is interpretable as the probability that a randomly selected pixel is correctly classified. Producer and users accuracy or their complements omission and commission errors respectively, are interpretable as conditional probabilities. Producers accuracy is interpretable as the probability that a randomly selected pixel identified as category A on the ground, is classified as category A in the map. Users accuracy is interpretable as the probability that a randomly selected pixel classified as category A by the map, is actually type A on the ground. The Taylor expansion method was used to estimate the variances. Known pixel totals for each land cover map category in the strata were incorporated into the variance estimators for overall correct classification and omission error to improve the precision of the estimates (Card 1982, Zhu et al.2000). The accuracy probabilities apply to the process of selecting a pixel at random, not to a pixel at a specific location

(Stehman 2000). These accuracy parameters are often referred to as global parameters because they do not provide information on the spatial distribution of errors. Much work remains for characterizing the spatial distribution of classification errors (McGwire and Fisher 2001, De Bruin et al. 2004). We also calculated estimates of the true proportions for land cover categories for ND and physiographic regions (Card 1982).

Results

An accuracy assessment of the eight general land cover categories has been completed for 238 sample units. The results of this analysis follow. A more detailed accuracy assessment, including the additional 15 units, is planned and will be submitted for publication in Remote Sensing of Environment.

Table 2.5. Relationship of 238 sample units which have been analyzed in relation to the 253 sample units and their distribution among 16 strata.

	Percent Anthropogenic Land Cover				
Physiographic Region	0-25	26-50	51-75	76-100	Total
Missouri Coteau	14	17	25 (24)	10	66 (65)
Missouri Plateau	25 (16)	23 (21)	24	10	82 (71)
Drift Prairie	12 (11)	13	30	10	65 (64)
Glacial Lake Agassiz	10	10 (9)	10 (9)	10	40 (38)
Total	61 (51)	63 (60)	89 (87)	40 (40)	253 (238)

The error matrix provides information about what land categories are being confused (Table 2.6). The cell entries are numbers of pixels with the total number of observations equal to the number of pixels summed over all 238 sample units. Observations along the diagonal are the number of pixels correctly classified. The off-diagonal cell entries are omission errors for the land cover category in the row and commission errors for the land cover category in the column. The confusion among the land cover categories is more easily visualized if we view the cell values as proportions of the row and columns. Table 2.7 has the error matrix cell values expressed as proportions of the row totals.

Inspection of the row and column totals reveals that the proportions of the land cover categories from the map, the column totals, are within 3 % of the land cover proportions from the ground survey, the row totals. Thus, at the state scale, the map appears to be a reasonable model for these eight simple land cover categories. Inspection of the row labeled prairie reveals that the planted herbaceous perennials land cover category accounted for the largest proportion of prairie omission errors. This is not surprising since both land cover types are dominated by perennial grasses and forbs and can have similar land uses and disturbances, grazing by large herbivores, haying, and fire. Estimates of the accuracy parameters, e.g., prairie omission error, for the map cannot be directly calculated from the error matrix as this summary of the data does not take into account

Table 2.6. Error matrix from data for 238 of 253 sample units used in the accuracy assessment of the ND-GAP land cover map.

	Map Samples								
Ground Samples	Barren	Crop-land	Grass-land	Prairie	Shrub-land	Urban	Wet-land	Wood-land	Total
Sparse vegetation	**1425**	979	700	1637	821	17	139	265	5983
Cropland	629	**207096**	25947	7933	1227	244	6601	1774	251451
Planted grassland[1]	390	40368	**71698**	35008	3796	577	7219	2664	161700
Prairie	1479	7372	22814	**87440**	7974	117	8988	3883	140067
Shrubland	607	1045	4115	13999	**3137**	16	1336	1284	25539
Urban	93	466	834	1145	199	**260**	156	161	3314
Wetland	261	6478	8225	7969	1898	145	**34033**	1753	60762
Woodland	234	4443	5892	5873	1813	434	2227	**19253**	40169
Total	5118	268247	140225	161004	20865	1790	60699	31037	**688985**

[1] Planted grassland is used as a shorthand for planted herbaeous perennials.

Table 2.7. Error matrix with data for 238 of 253 sample units expressed as proportions of row totals.

	Map Samples								
Ground Samples	Barren	Crop-land	Grass-land	Prairie	Shrub-land	Urban	Wet-land	Wood-land	Total
Sparse vegetation	**28.82**	16.36	11.70	27.36	13.72	0.28	2.32	4.43	0.87
Cropland	0.25	**82.36**	10.32	3.15	0.49	0.10	2.63	0.71	36.50
Planted grassland[1]	0.24	24.96	**44.34**	21.65	2.35	0.34	4.46	1.65	23.47
Prairie	1.06	5.26	16.29	**62.43**	5.69	0.08	6.42	2.77	20.33
Shrubland	2.38	4.09	16.11	54.81	**12.28**	0.06	5.23	5.03	3.71
Urban	2.81	14.06	25.17	34.55	6.00	**7.85**	4.71	4.86	0.48
Wetland	0.43	10.66	13.54	13.12	3.12	0.24	**56.01**	2.89	8.82
Woodland	0.58	11.06	14.67	14.62	4.51	1.08	5.54	**47.93**	5.83
Total	0.74	38.93	20.35	23.37	3.03	0.26	8.81	4.50	**100.00**

[1] Planted grassland is used as a shorthand for planted herbaeous perennials.

the sample design. Table 2.8 has the error matrix cell values expressed as proportions of the column totals and can be used to examine sources of confusion for land cover category commission errors.

Table 2.8. Error matrix with data for 238 of 253 sample units expressed as proportions of column totals.

	Map Samples								
Ground Samples	Barren	Crop-land	Grass-land	Prairie	Shrub-land	Urban	Wet-land	Wood-land	Total
Sparse vegetation	**27.84**	0.36	0.50	1.02	3.93	0.95	0.23	0.85	0.87
Cropland	12.29	**77.20**	18.50	4.93	5.88	13.63	10.87	5.72	36.50
Planted grassland[1]	7.62	15.05	**51.13**	21.74	18.19	31.12	11.89	8.58	23.47
Prairie	28.90	2.75	16.27	**54.31**	38.22	6.54	14.81	12.51	20.33
Shrubland	11.86	0.39	2.93	8.69	**15.03**	0.89	2.20	4.14	3.71
Urban	1.82	0.17	0.59	0.71	0.95	**14.53**	0.26	0.52	0.48
Wetland	5.10	2.41	5.87	4.95	9.10	8.10	**56.07**	5.65	8.82
Woodland	4.57	1.66	4.20	3.65	8.69	24.25	3.67	**62.03**	5.83
Total	0.74	38.93	20.35	23.37	3.03	0.26	8.81	4.50	**100.00**

[1] Planted grassland is used as a shorthand for planted herbaeous perennials.

Producer and user accuracies for prairie by anthropogenic land cover proportion strata within physiographic region are shown in Table 2.9. In general, there is considerable variation in the mean accuracy among the strata, and the means tend to be inversely related to the proportion of anthropogenic land cover. For example, the mean producer accuracy in the Drift Prairie physiographic region is 74% in the strata with less than 25 % anthropogenic land cover and only 5% in strata with more than 75% anthropogenic land cover. Roughly similar trends are apparent for users accuracy. Many of the prairie commission errors for the strata with more than 75% anthropogenic land cover are the herbaceous portions of farm yards. The high omission error for prairie in the strata with more than 76% anthropogenic land cover may be small patches of idle prairie that have a spectral signature similar to planted herbaceous perennials and also have a high proportion of edge pixels that are subject to positional errors. These results show that the accuracy of the land cover maps varies spatially and a single number for an entire map is of limited value. Tables for overall accuracy for ND and physiographic regions are in Appendix 2.3. Tables of producer and users accuracy for ND are in Appendix 2.4 and 2.5. Tables of producer and users accuracy for physiographic region are in Appendix 2.6 and 2.7. Tables for producer and users accuracies for the all eight general land cover categories by anthropogenic land cover proportion strata within physiographic region are presented in Appendix 2.8 and 2.9.

One exciting outcome from our sampling design is the ability to produce maps of the spatial distribution of the accuracy parameters by applying the estimates to the strata maps. For example, Fig. 2.5 shows the spatial distribution of producers accuracy for prairie. The analyses presented have been based on an assessment at the pixel scale which is a very stringent test. For example, a narrow woodland draw offset by one pixel in the ground and map representations of land cover would be identified as classification errors in the analysis at the pixel scale. Figures 2.6 and 2.7 show the relationship between map and ground estimates of area of prairie and woodland at the sample unit scale where classification error due to positional error has been eliminated. We have

Table 2.9. Sample size, mean, and standard error for producer and user accuracies for the prairie land cover category by anthropogenic land cover proportion strata within physiographic regions.

Physiographic Region	Anthropogenic Strata	P n	P mean	P SE	U n	U mean	U SE
Missouri Plateau	0-25%	16	0.588	0.0520	16	0.620	0.0479
Missouri Plateau	26-50%	20	0.622	0.0528	21	0.620	0.0549
Missouri Plateau	51-75%	24	0.520	0.0364	24	0.610	0.0528
Missouri Plateau	76-100%	7	0.062	0.0231	8	0.061	0.0348
Missouri Coteau	0-25%	11	0.813	0.0350	14	0.550	0.0847
Missouri Coteau	26-50%	15	0.710	0.0262	17	0.449	0.0510
Missouri Coteau	51-75%	24	0.611	0.0449	24	0.476	0.0350
Missouri Coteau	76-100%	6	0.732	0.1548	10	0.329	0.1793
Drift Prairie	0-25%	9	0.740	0.0844	11	0.652	0.1069
Drift Prairie	26-50%	13	0.368	0.0676	13	0.390	0.0833
Drift Prairie	51-75%	22	0.469	0.0551	30	0.290	0.0530
Drift Prairie	76-100%	5	0.054	0.0269	9	0.099	0.0420
Glacial Lake Agassiz	0-25%	10	0.706	0.0402	10	0.665	0.1281
Glacial Lake Agassiz	26-50%	9	0.735	0.0501	9	0.661	0.0829
Glacial Lake Agassiz	51-75%	7	0.366	0.0761	9	0.198	0.0668
Glacial Lake Agassiz	76-100%	5	0.095	0.0328	10	0.097	0.0449

plans to conduct the accuracy assessment at multiple spatial scales intermediate to the pixel and 1 mile^2 sample unit scales using methods recently described by Kuzera and Pontius (2004). Information about the accuracy of land cover categories as a function of scale would be useful for identifying appropriate uses of the land cover map.

The data collected in the accuracy assessment can also be used to calculate unbiased estimates with confidence intervals for the proportion and area of land cover categories by physiographic region. Table 2.10 shows the map proportion of prairie calculated from simple pixels counts and the mean and 95% confidence interval for the estimated true proportion of prairie by physiographic region. The map proportion of prairie falls within the 95% confidence interval for the estimated true proportion of prairie in all physiographic regions except the Missouri Coteau where it exceeds the confidence interval.

Limitations and Discussion

From the beginning of the ND-GAP, we recognized that it would be difficult to achieve the GAP goal of mapping natural land cover categories to the floristically defined alliance level of the NVCS with an overall probability correct of 80% or greater. Our approach to this ambitious goal was to construct a two-level hierarchical legend for the

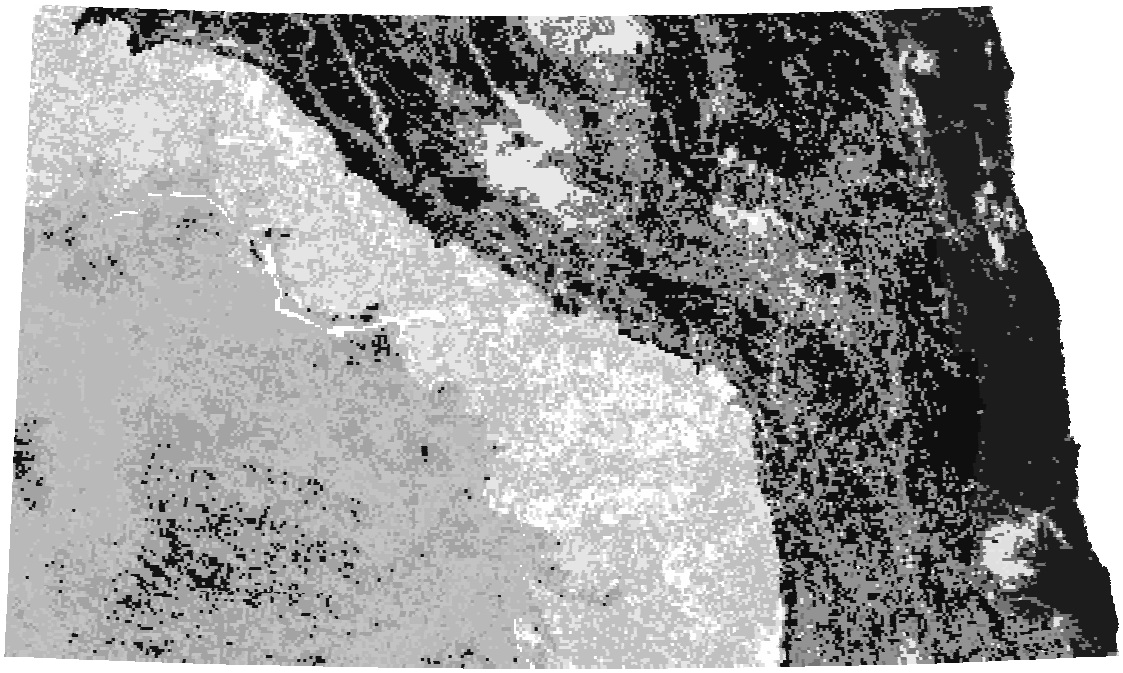


Fig. 2.5. Spatial distribution of prairie producer accuracy. Stratified mean prairie producer accuracies (Table 2.9) applied to strata maps; the brighter the intensity the higher the accuracy.

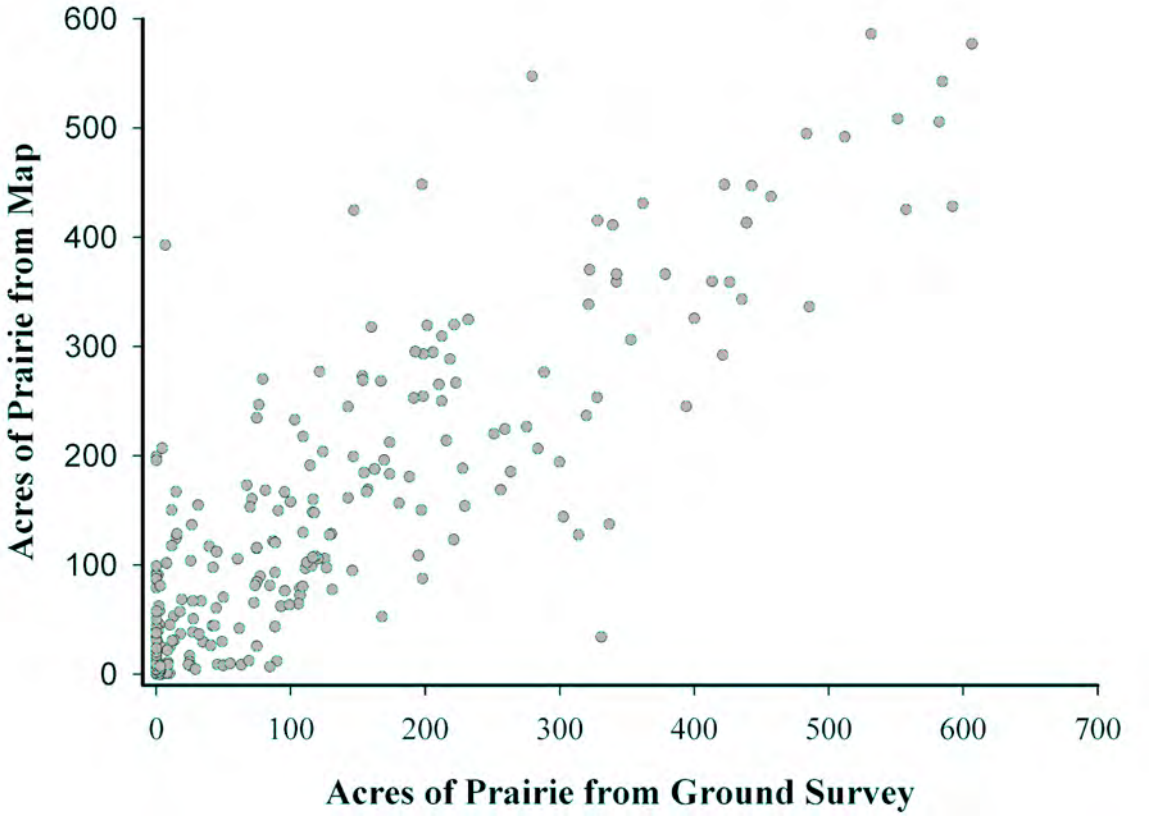


Fig 2.6. Relationship between map and ground estimates of area of prairie at the sample unit scale.

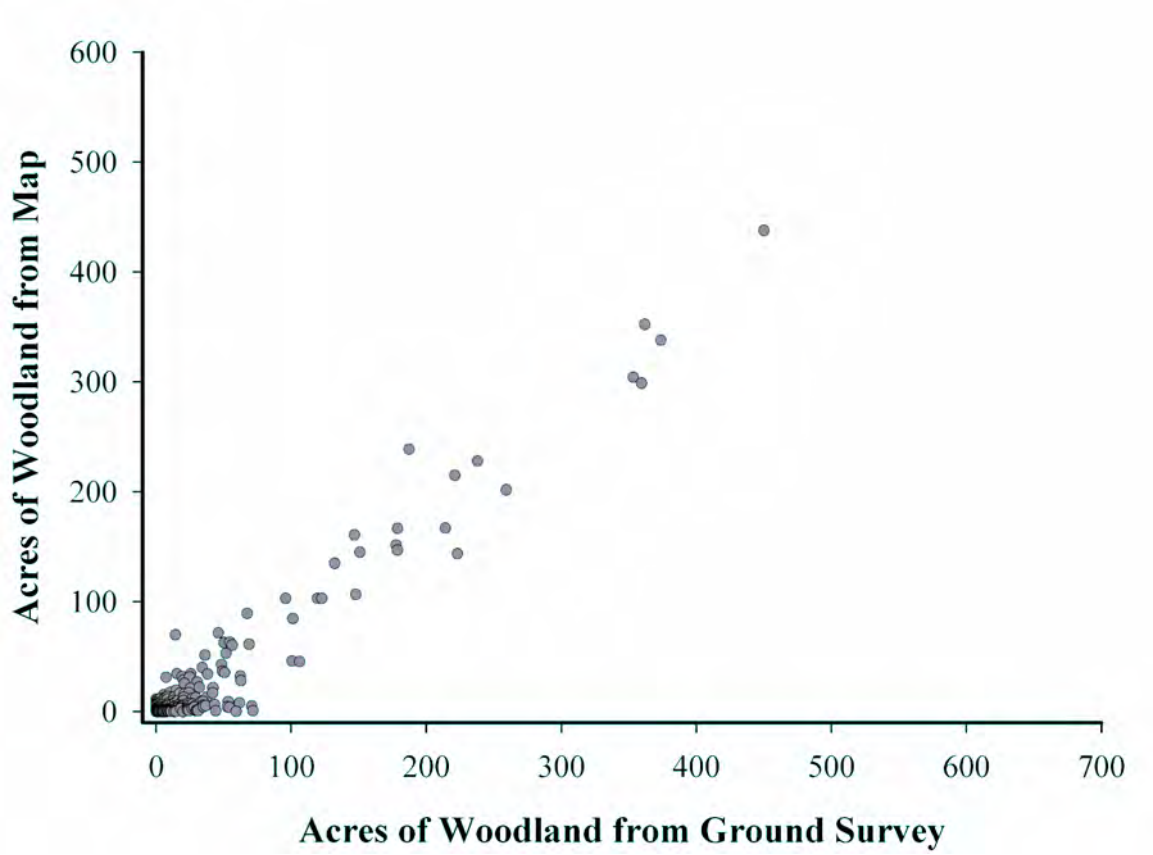


Fig 2.7. Relationship between map and ground estimates of area of woodland at the sample unit scale.

Table 2.10. Confidence intervals for the proportion of prairie by four physiographic regions.

PRegion	Map Proportion	L95CL	U95CL	TRUE Proportion	sq mi low	sq mi high
Missouri Coteau	0.248	0.131	0.218	0.174	2152	3583
Missouri Plateau	0.322	0.276	0.364	0.320	5927	7822
Drift Prairie	0.104	0.059	0.140	0.100	1612	3792
Glacial Lake Agassiz	0.057	0.006	0.134	0.070	42	960

land cover map. Natural vegetation categories were defined by physiognomic characteristics at the upper level and by floristic characteristics at the lower level. Even at the level of the eight physionomically defined land cover categories, we had difficulty consistently mapping a shrubland category. The shrubland category was not mapped for some portions of the state due to spectral similarity of shrublands with prairie. Shrublands are inclusions within the prairie land cover category for those portions of the map without a shrubland category. Inspection of the error matrix from the accuracy assessment (Table 2.6) reveals that prairie accounts for 54% of the omission

errors for shrublands. The planted herbaceous perennials, wetland, and woodland categories account for 16%, 5%, and 5% of the omission errors for shrubland, respectively. Previous small-scale vegetation maps for ND have not included a shrubland category. Only some of the recent land cover maps for ND developed using remotely sensed imagery have a shrubland land cover category. Vogelman (2001) also apparently had difficulty mapping shrublands as the category is missing from large portions of the state in their 1992 ND National Land Cover Map. Refinement of the shrubland category should be a high priority for future land cover maps of ND.

We combined the forest and woodland physiognomic classes of the NVCS into a single woodland category for the ND-GAP land cover map. Application of the NVCS tree canopy cover criteria for forest (>60%) and woodland (25–60%) is not meaningful when the classification procedure is performed on a 30-m × 30-m pixel. Distinguishing between forest and woodland would require an evaluation of canopy cover and the spatial extent of the stand. The woodland category in the ND-GAP land cover map identifies areas where trees are a dominant component of a pixel.

Our ability to map floristically defined plant communities at the alliance level of the NVCS varied with physiognomic class in relation to the amount and spatial distribution of training data and the difficulty discriminating among floristically defined plant communities using spectral reflectance measurements. We allocated the greatest effort to prairie land cover categories because of their importance and abundance in ND. We were able to create a relatively complete and consistent map of 10 prairie land cover categories using training data constructed from range surveys on school lands managed by the ND State Land Department. Training data for the woodland land cover category was much sparser than for prairie. As a result of the sparse training data, the floristic detail for woodland land cover categories is not consistent across the state. Aspen and bur oak stands, for example, may be mapped as separate categories in some portions of the state, but elsewhere they are mapped as a generic woodland category.

The overall accuracy for the eight land cover categories at the upper level of the land cover map legend was 62%. Factors influencing the accuracy assessment include (1) temporal changes in land cover between 1992–1999 (when TM images were acquired) and the 2002 when data for the accuracy assessment were collected, (2) spatial registration of the map and the reference data, (3) differences in class generalizations including definitions and inclusions arising from ground and satellite methods for observing land cover, and (4) the accuracy of the reference data. The accuracy assessment revealed that classification accuracy is spatially variable and a single number for an entire map is of limited value. One exciting outcome from our sampling design is the ability to produce maps of the spatial distribution of the accuracy parameters by applying the estimates to the strata maps. The accuracy assessment was conducted at the pixel scale, which is the most stringent test possible. An accuracy assessment is in progress at multiple spatial scales intermediate to the pixel and sample unit (1 mi^2) scales for the 39 land cover categories at the lower level of the map legend.

The use of natural land cover categories is a coarse surrogate for information about plant species and plant communities. Biodiversity conservation plans and actions need to give

more consideration to native plant species, the composition of plant communities, and the threats posed by introduced and invasive species. Research is needed on the use of fire and grazing interactions to create and maintain heterogeneity in mixed prairie (Fuhlendorf and Engle 2004). The role of below-ground biological processes including the roles of invertebrates, bacteria, fungi on the population dynamics of native species needs research.

PREDICTED ANIMAL SPECIES DISTRIBUTIONS AND SPECIES RICHNESS

Introduction

All species range maps are predictions about the occurrence of those species within a particular area (Csuti and Crist 1998). Traditionally, the predicted occurrences of most species begin with observations or samples collected at individual point locations. Most species range maps are coarse scale (e.g., >1:10,000,000) and derived primarily from point data to construct field guides that are suitable, at best, for approximating distribution at the regional or county level for example. The purpose of the GAP vertebrate species maps is to provide more precise information about the current predicted distribution of individual native species according to actual habitat characteristics within their general ranges. With this information, better estimates can be made about the amount of existing habitat, its location, and its configuration.

GAP maps are produced at a nominal scale of 1:100,000 or larger and are intended for applications at the landscape or "gamma" scale (i.e., heterogeneous areas generally covering 1,000-1,000,000 ha and consisting of more than one type of natural community). Applications of these data to site- or stand-level analyses (site; a microhabitat, generally 10-100 m^2; stand; a single habitat type, generally 0.1-1,000 ha; Whittaker 1977, also see Stoms and Estes 1993) will likely be compromised by the finer-grained patterns of environmental heterogeneity that are resolved at those levels.

Gap analysis uses the predicted distributions of animal species to evaluate their conservation status relative to existing land management (Scott et al. 1993). In addition, the maps of species distributions may be used to answer a wide variety of management, planning, and research questions relating to individual species or groups of species. In addition to the maps, great utility may be found in the consolidated specimen and observational records and literature that were assembled into databases and used to produce the maps. Perhaps most importantly, as a first effort in developing such detailed distributions, the maps should be viewed as testable hypotheses to be confirmed or refuted by data collected in the field.

Previous to this effort, there were no maps available, digital or otherwise, showing the likely present-day distribution of species by habitat type across their ranges in North Dakota. Because of this, ordinary species (i.e., those that are not threatened with extinction or not managed as game animals) are generally not given sufficient consideration in land-use decisions in the context of large geographic regions or in relation to their actual habitats. Population declines of ordinary species resulting from incremental habitat loss can and often does result in one threatened or endangered species after another. Frequently, the records that do exist for an ordinary species are truncated

by political boundaries (e.g., state boundary). Simply creating a consistent spatial framework to store, retrieve, manipulate, analyze, and update the existing knowledge about the status of each vertebrate species is one of the most necessary and basic elements to prevent further erosion of biological resources and diversity.

Mapping Standards

Potential distribution maps for terrestrial vertebrate species were prepared in accordance with procedures outlined in the vertebrate analysis chapter of the GAP Handbook (Csuti and Crist 1998) and described by Csuti (1996) and Boone and Krohn (2000).

Methods

Overview

The modeling approach used to predict vertebrate distributions in North Dakota consisted of seven steps. First, criteria were developed to identify the species to be included in the analysis, and then a list of species was developed. Second, sources of species location records were identified, and the data were collated and organized into a geospatial database. Third, the range of each species was defined by recording the species presence or absence within a hexagon grid system developed by the U.S. Environmental Protection Agency (White et al. 1992). Fourth, a Wildlife-Habitat Relationships (WHR) database was developed to define the affinities of terrestrial vertebrate species in relation to habitat features including land cover types, ecotones between land cover types, land cover juxtaposition, and soil characteristics. Fifth, the hexagon and WHR databases were used in a GIS-modeling process to produce potential distribution maps for each species. Sixth, range maps, WHR models, and potential distribution maps for the species were reviewed by biologists familiar with the distribution of North Dakota's wildlife. Finally, we conducted an accuracy assessment of the potential distribution maps.

Species List

A list of 281 vertebrate species was compiled for the North Dakota GAP using published literature, including the *Revised Checklist of North Dakota Birds* (Faanes and Stewart 1982), *Reptiles and Amphibians of North Dakota* (Hoberg and Gause 1992) and *Mammals of the Northern Great Plains* (Jones et al. 1983) (Appendix 3.1). Bird, mammal and herptile lists were reviewed, and species that occur only rarely (< 5 confirmed records), transients, extirpated species, or introduced exotics were not modeled. The bird species list was limited to breeding birds with five or more confirmed observations during the last 20 years. The taxonomy and nomenclature used to describe species were the Integrated Taxonomic Information System (http://www.itis.usda.gov/index.html) for herptiles and mammals and American Ornithologists' Union, seventh edition, for birds (AOU 1998).

Mapping Range Extent

Several sources of information were used to document the distribution of terrestrial vertebrate species in North Dakota (Appendix 3.2). We mapped the distributional limits of species using 648 km^2 hexagons, which are part of a global hexagonal grid system developed by the EPA (White et al.1992). Advantages to using the hexagon grid system include its equal-area sampling structure, its independence from political and administrative boundaries (resulting in more consistent mapping of animal distributions), and its hierarchical structure which can facilitate increasing or decreasing grid densities in future analyses (White et al. 1992).

Three primary sources of information were used to document the occurrence (or expected occurrence) of a species within a hexagon: (1) species locality records, (2) published range maps, and (3) the knowledge of experts. Each species location dataset was converted to point vector. Many of the species locations were recorded by township, range, and section using the Public Land Survey System; in these cases the centroid of the section was used as the point location for these records. All location datasets were then transferred to a polygon vector of the hexagon grid. Hexagons encompassing a locality record were coded as "confirmed". Hexagons occurring adjacent to a confirmed hexagon were coded as "probable".

Some species of mammals (Table 3.1) and all herptile species had insufficient locality records to generate a comprehensive range map. Range maps published by Jones et al. (1983), Conant and Collins (1991), and Hoberg and Gause (1992) were used to create range maps for these species. The geographic range of each species was manually transferred to the hexagon grid system by selecting the hexagons that overlapped with existing range maps. Hexagons populated in this manner were coded as probable.

A range map for each species was provided to experts that were cognizant of the species and their ranges in North Dakota (Appendix 3.3). These experts were asked to review, and if necessary, identify omission and commission errors for the hexagons that defined a species range. Reviewers also were given the opportunity to provide comments. Reviewer revisions and comments were incorporated into the final range map for a species.

Wildlife Habitat Relationships

No database of WHR existed for North Dakota at the start of this project. Primary sources of habitat information came from the *Birds of North America* series, the American Society of Mammalogists *Mammalian Species* accounts, Conant and Collins (1998) and Collins (1993) for herptiles, and additional peer-reviewed publications for individual species or groups of species in the region and the state. North Dakota GAP

Table. 3.1 List of 21 mammal species that had an insufficient number of locality records to construct a range map. Hexagon grid representations of species ranges for these species and all herptile species were created using published range maps.

Scientific Name	Common Name
Sorex arcticus	Arctic Shrew
Microsorex hoyi	Pigmy Shrew
Myotis evotis	Long-eared Myotis
Myotis keenii	Keen's Myotis
Myotis leibii	Small-footed Myotis
Myotis lucifugus	Little Brown Bat
Myotis volans	Long-legged Myotis
Lasionycteris noctivagans	Silver-haired Bat
Lasiurus borealis	Eastern Red Bat
Lasiurus cinereus	Hoary Bat
Sylvilagus audubonii	Desert Cottontail
Eutamius minimus	Least Chipmunk
Marmota monax	Woodchuck
Spermophilus richardsonii	Richardson's Ground Squirrel
Glaucomys sabrinus	Northern Flying Squirrel
Perognathus fasciatus	Plains Pocket Mouse
Neotoma cinerea	Bushy-tailed Woodrat
Microtus ochrogaster	Prairie Vole
Urocyon cinereoargenteus	Common Gray Fox
Mustela erminea	Ermine
Spirogale putorius	Eastern Spotted Skunk
Lutra Canadensis	River Otter

collaborated with Iowa GAP and South Dakota GAP on the WHR models to reduce the redundancy of effort for species found in all three states and to increase the consistency of WHR models across states in the Central and Northern Great Plains. The species lists that were assembled by the three states were combined, and the species that were present in all three states were equally divided among the vertebrate modelers in each state. Species that occurred in only one or two states were modeled by those respective states. We used the database system that was developed by Kansas GAP (Cully et al. 2002) in Microsoft Access to enter, organize, and assign species habitat affinities described in the literature to vegetation alliances defined in the NVCS and other habitat features including anthropogenic land cover categories, ecotones, soil texture characteristics, and juxtaposition of habitats. By modeling at the alliance level, species could be modeled, and the models could be reviewed before completion of the final land cover map for the state.

Models for both regional and local species were peer reviewed by local reviewers or reviewers that were familiar with the habitat requirements or the species range within the three states. Each reviewer was provided with the range maps, WHR models (NDBIRDMOD.XLS, NDHERPTILEMOD.XLS, NDMAMMALMOD.XLS), a subset

of the NVCS that describes vegetation alliances and associations in North Dakota (NatureServe 2001), and a table showing the relationship of vegetation alliances to land cover categories in the provisional land cover classification system for the North Dakota GAP land cover map.

Distribution Modeling

Creating potential distribution maps for each vertebrate species required a geospatial representation of the habitat characteristics included in the WHR models. Modeling of each species was conducted using raster representations of the habitat. The North Dakota GAP land cover data, with a minimum mapping unit of 0.09 ha (30×30 m pixels) was the primary source of data for vertebrate modeling. A raster was created for each land cover category in the North Dakota GAP land cover map (Map 2.1 and Table 2.3). Two additional rasters were created to represent ecotones between woodland and grassland (prairie and planted herbaceous land covers combined) and shrubland and grassland land covers. Ecotone rasters were created from the intersection of the land cover category rasters after applying an outside buffer of 90 m. For example, the woodland-grassland ecotone was six pixels wide representing three pixels into the woodland and three pixels into the grassland.

Some species required the creation of rasters representing the juxtaposition of land cover types. For example, the WHR models identified habitat requirements for the waterfowl genus *Anas* as wetlands and adjacent grasslands and shrublands within 1.5 miles of the wetlands. The comment field in the databases NDBIRDMOD.XLS, NDHERPTILEMOD.XLS and NDMAMMALMOD.XLS contains the details of habitat juxtaposition rasters created for a species distribution model.

The North Dakota STATSGO soil vector was used to produce two soil rasters with 30-m grid cells for use in mapping the distribution of fossorial mammals and herptiles. Both rasters were created using the surface soil texture variable (surftex) in the STATSGO components table. The components table identifies the soil components or types in a soil map unit. The first raster identified map units where the surface soil texture was sand, loam, or sandy loam for the soil component with the largest area in the map unit. To create the second raster which identified map units with a surface soil texture containing greater than 50% sand, the surface soil texture categories were assigned a value for percent silt, sand and clay based on data presented in Cosby et al. (1984). An estimate of percent sand, silt, and clay for each map unit was calculated as a weighted average of the soil types in each map unit using the areas of soil types in the map unit as the weights.

National Hydrography data (NHD) were used to create a raster for riparian habitat (http://nhd.usgs.gov/). Reach data including artificial canals and drains, were analyzed and assigned a stream order attribute. The line file was buffered by reach order to the following values: orders 2 and 3 at 90 m, orders 4 and 5 at 60 m and order 6 and above at 30 meters. Then the line file was converted to a 30 m raster representing riparian habitat. Values for the buffer distance were determined from visual inspection of a sample of the

NHD data using Digital Orthoquarterquads and a follow-up comparison using a slope raster derived from the National Elevational Dataset (NED).

A raster was created that showed the range extent for each species whose range within the state was smaller than the entire state. To minimize the effect of having a predicted distribution stop abruptly at an artificial range boundary, GAP has in the past adopted the practice of extending a species distribution beyond the range boundary to include patches of suitable habitat partially within the species' range. This practice was adopted when the majority of GAP land cover maps were created with minimum mapping units that were 100 ha. The land cover minimum mapping unit for North Dakota GAP was 0.09 ha and rendered the procedure unnecessary for distribution maps for most species. However, there are a few vertebrate species whose distribution maps have an abrupt boundary at Lake Sakakewea, a large manmade reservoir. Extending the distribution map to include the contiguous water habitat would have extended these species distributions beyond their accepted ranges. Therefore, distribution maps for all species were terminated at the range boundary even if a habitat extended outside the range boundary.

Species potential distribution maps were created using the rasters in TNTmips Spatial Manipulation Language (SML) (MicroImages 2003). With the completion of the North Dakota GAP land cover map, the correspondance of vegetation alliances to the final categories in land cover map (NDVERTALLIANCEXREF.XLS) was developed in the WHR data base. The WHR models were exported from Microsoft Access and imported into a SAS program that built an SML script to automate creation of the species potential distribution maps. Species distribution maps were initially created at a 30-m pixel size. To reduce the number of compact disks required to distribute the data, the species distribution maps were resampled using the nearest neighbor method to 90-m pixels.

Results

Distribution Maps

Potential distribution maps were produced for 281 breeding terrestrial vertebrate species comprised of 184 bird species, 71 mammal species, 15 reptile species, and 11 amphibian species. Land cover was the only variable used in 70-78 % of the models across the three taxonomic groups (Table 3.2). Seventy-three percent of the models for breeding birds used land cover only, 16% used a combination of land cover and ecotones or riparian zones, and 11% used a combination of land cover, ecotone, riparian and juxtaposition of habitats. Seventy-eight percent of the mammal models used land cover only, 6% used land cover and ecotone or riparian zones, 8% used land cover and soils, and 8% used land cover and juxtaposition of habitats. Seventy percent of the herptile models used land cover only, 15% of the models used land cover and soils, and 15% of the models used land cover and juxtaposition of habitats.

Table 3.2 Frequency of species by taxonomic group and variables included in the distribution models.

Taxonomic group	Land cover	Land cover and ecotone or riparian	Land cover and soils	Land cover and juxtaposition
Birds	135	30	0	21
Mammals	55	4	6	6
Amphibians	7	0	2	2
Reptiles	11	0	2	2

Species Richness

An early GAP hypothesis was that mapping of species-rich areas or "hotspots" offered an efficient and cost-effective way to conserve maximum biological diversity in a minimal area (Scott et al. 1987, 1993). Subsequent investigations have evaluated this concept and have changed our understanding of its utility (Jennings 2000). Some of the problems with the concept include: (1) species richness calculations are highly scale-dependent (Stoms 1992), (2) the lack of geographic correspondence between species richness of an indicator taxon and other components of biodiversity (Pendergast et al. 1993), and (3) the assumption that patterns in species richness are correlated in a predictable fashion with processes that are important to species, community, and ecosystem representation and persistence which are the goals of reserve identification, selection, and design (Flather et al. 1997). Although GAP continues to perform this useful pattern analysis, it is only one of many that may be performed with GAP data (Jennings 2000). Richness maps identify locations where the same number of elements, e.g., species, co-occur. Richest areas may or may not indicate the best conservation opportunities. These areas may provide a useful starting point to examine conservation opportunities in combination with other analyses or information. They do not provide consideration of unique assemblies of species or rare environments that are important for individual species. We calculated species richness both by land cover category and the 648-km^2 hexagon scale used to create species range maps.

By Land Cover Category

Species richness within land cover categories or alpha diversity (Whittaker 1960, Whittaker 1977) is the number of species predicted to occur across all pixels of a land cover category. This location- independent indicator of species richness is useful in identifying habitats with a large number of species but also is sensitive to the resolution or scale of the land cover legend. Calculation of species richness in each of the eight general land cover categories (Table 3.3) and the 39 finer-scale land cover categories (Table 3.4) reveal the scale dependence of species richness calculations. For example, at the level of eight general land cover categories, mammal and bird species richness calculations are greatest for the woodland category. However, Little Bluestem Prairie

and Needlegrass Prairie have mammal species richness comparable to or exceeding that of some woodland habitats when species richness is calculated using the more detailed land cover classification system. For birds, the Floodplain Woodland category had the highest species richness, and deciduous woodland categories had species richness greater than prairies and wetlands which presumably reflects the greater number of niches provided by the vertical structure of woodlands despite their small spatial extent in North Dakota. Species richness calculations for amphibians reveal the importance of wetland and prairie land cover categories.

Table 3.3 Vertebrate species richness by eight general land cover categories.

Land cover category	Bird species richness	Mammal species richness	Reptile species richness	Amphibian species richness
Woodland	134	57	8	7
Prairie	82	50	11	10
Shrubland	87	47	9	9
Planted Herbaceous Perennials	62	32	3	4
Sparse Vegetation	27	27	9	4
Cropland	37	22	2	1
Wetland	76	22	9	11
Urban	59	22	2	1

By 648 km^2 Hexagons

Species richness calculations at the hexagon scale are a reflection of landscape and regional diversity. Whittaker (1977) used the term "gamma diversity" to describe the number of species in a landscape containing more than one community type and "epsilon diversity" to describe geographic extents that incorporate more than one landscape. Species richness calculations at this scale are potentially useful to identify geographic locations that contain a large number of species, however, there are some potential problems with analysis at this scale. Hexagons lying on the edge of the state will tend to have fewer species because only a portion of these hexagons occurs within the state and thus they have a smaller physical area in which species may occur. Second, there is a tendency for analysis at this scale to emphasize areas where range boundaries overlap such as at the edge of ecoregions. Richness at the hexagon scale is depicted by taxonomic groups in Figures 3.1 - 3.4. Amphibian richness ranged from 4-10 species per hexagon with a mean of 7.33. Reptile richness was 5-11 species per hexagon with a mean of 7.49. Mammal richness was 31-57 species per hexagon with a mean of 47.45. Breeding bird richness was 87-166 species per hexagon with a mean of 133.1. At this scale, local patterns of habitat availability are suppressed, and the maps emphasize regional variation in species richness. For example, bird, mammal and amphibian species richness maps identify the eastern half of North Dakota as having relatively high species richness in spite of the small amount and fragmentation of natural habitats. The aggregation of wetland and prairie habitats at the hexagon scale accounts for the high bird

Table 3.4 Vertebrate species richness by 35 detailed land cover categories.

Land cover category	Bird species richness	Mammal species richness	Reptile species richness	Amphibian species richness
Cropland	37	22	2	1
Planted Herbaceous Perennials	62	32	3	4
Wet-Mesic Tallgrass Prairie	38	29	5	5
Mesic Tallgrass Prairie	37	33	3	4
Mesic Tall and Mixed grass Prairie	63	33	4	5
Bluestem-Needlegrass-Wheatgrass Prairie	31	26	3	3
Wheatgrass Prairie	61	39	7	5
Needlegrass Prairie	60	43	6	4
Little Bluestem Prairie	56	44	8	4
Fescue Prairie	52	25	4	4
Sand Prairie	50	30	8	3
Saline Prairie	39	16	6	9
Upland Deciduous Shrubland	62	34	6	3
Lowland Deciduous Shrubland	59	27	6	9
Sagebrush Shrubland	30	29	4	0
Ponderosa Pine Woodland	50	41	4	0
Limber Pine Woodland	49	33	5	0
Rocky Mountain Juniper Woodland	49	27	6	1
Mixed Conifer and Deciduous Woodland	89	35	6	4
Floodplain Woodland	101	37	6	7
Deciduous Woodland	76	36	6	2
Green Ash Woodland	84	43	6	2
Aspen Woodland	79	43	6	1
Bur Oak Woodland	77	41	6	2
Aspen-Bur Oak Woodland	79	43	6	2
Lacustrine Wetland	60	10	5	10
Riverine Wetland	53	8	4	10
Palustrine Temporary Wetland	35	18	6	10
Palustrine Seasonal Wetland	50	16	6	9
Palustrine Semi-permanent Wetland	59	14	7	9
Sparse Vegetation - Others	26	27	9	4
Sparse Vegetation - Badlands	26	27	9	4
Sparse Vegetation - Riverine	2	0	0	4
High Density Residential and Commercial	17	3	0	1
Low Density Residential and Recreation	59	22	2	1

species richness in the Drift Plain and Missouri Coteau physiographic regions. Species richness maps calculated by ecoregions, for example Omernik's level IV ecoregions (Bryce et al. 1998), may by a more effective means to reveal regional patterns of species richness than analysis at an arbitrary hexagon cell size.

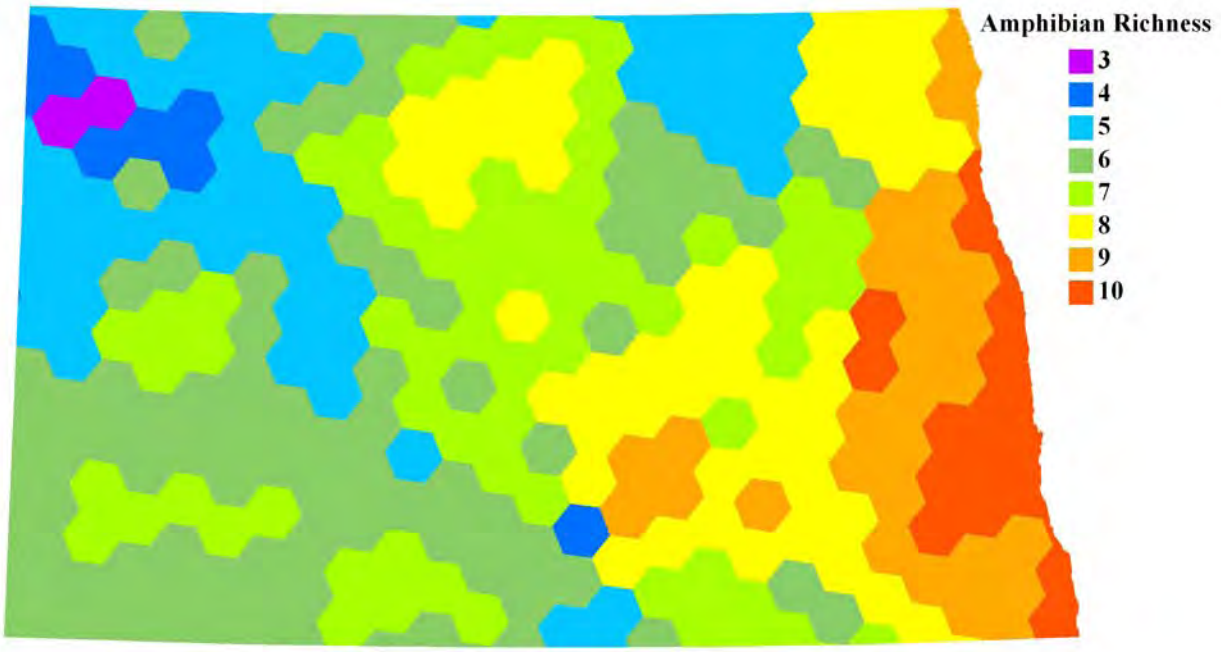


Fig 3.1. Amphibian species richness by 648 km^2 hexagons.

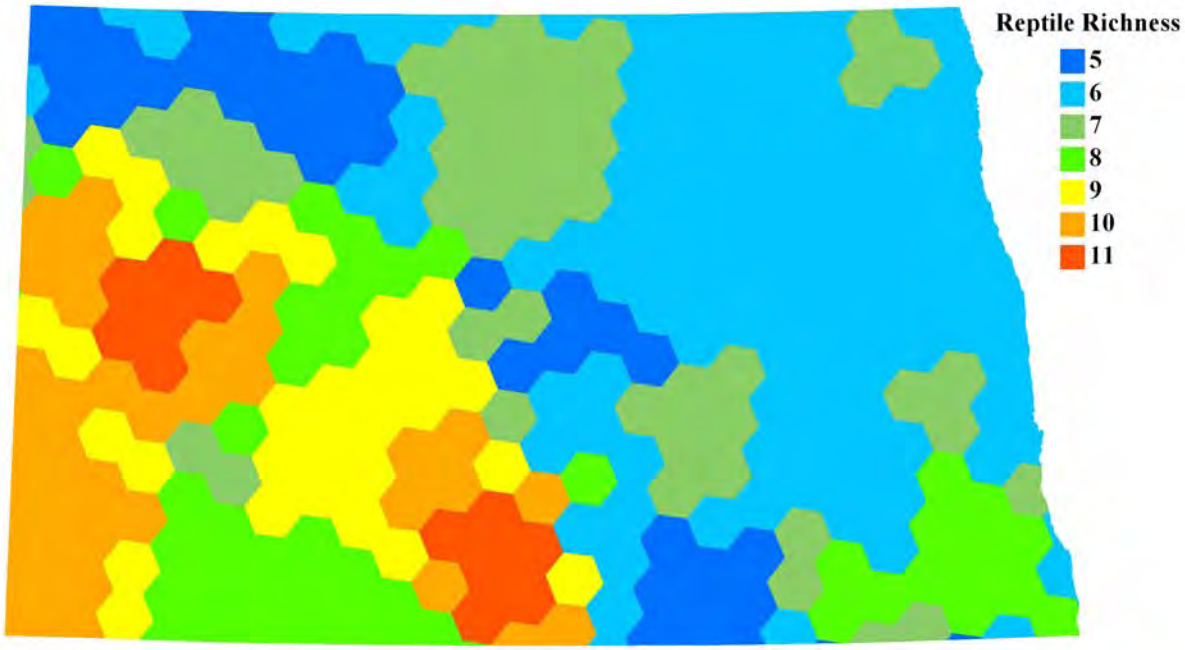


Fig 3.2. Reptile species richness by 648 km^2 hexagons.

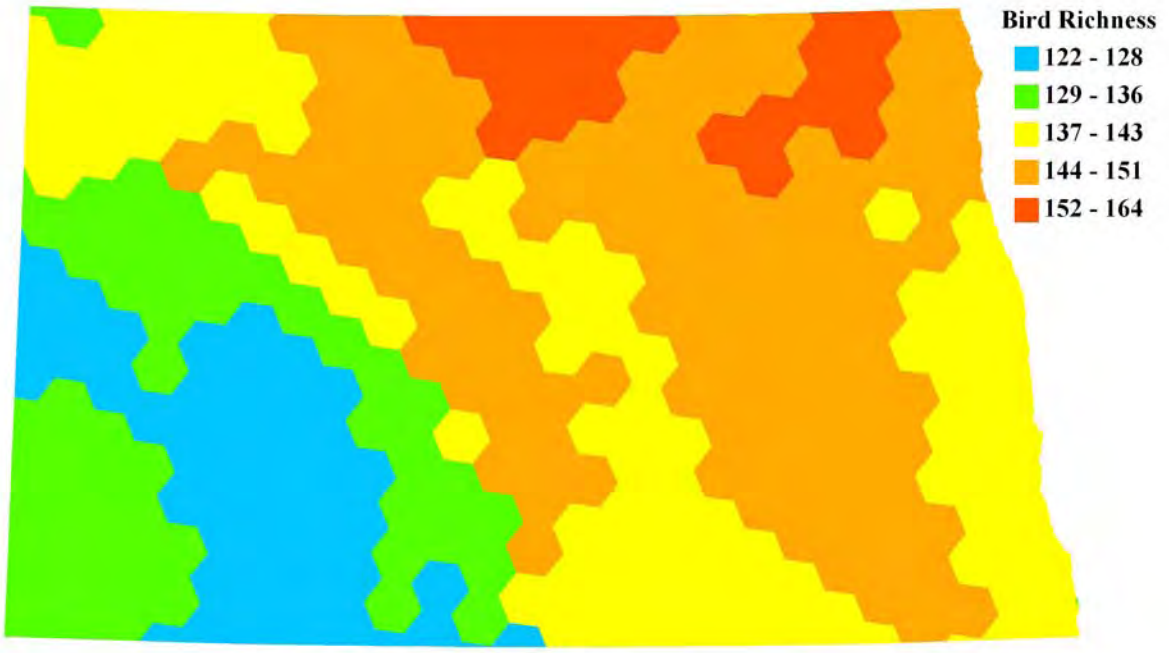


Fig 3.3. Bird species richness by 648 km^2 hexagons.

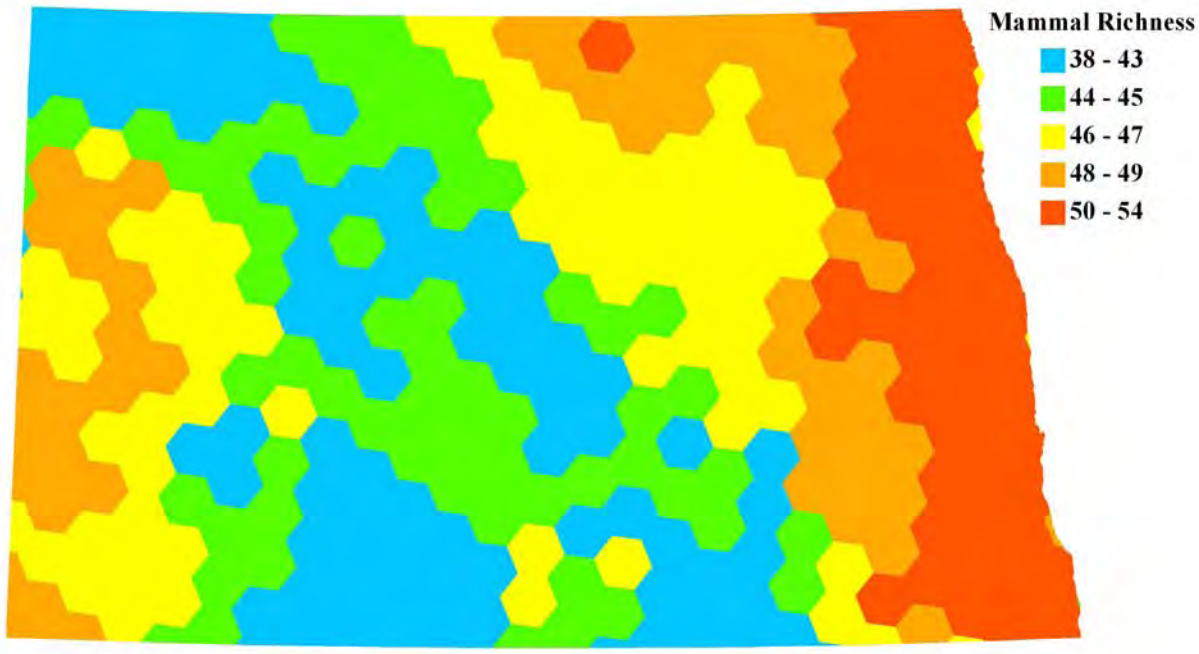


Fig 3.4. Mammal species richness by 648 km^2 hexagons.

Accuracy Assessment

Introduction

Assessing the accuracy of the predicted vertebrate distributions is subject to many of the same problems as assessing land cover maps, as well as a host of more serious challenges related to both the behavioral aspects of species and the logistics of detecting them (Boone and Krohn 1999, 2000; Edwards et al. 1996). These are described further in the Background section of the GAP Handbook on the national GAP web page. We do, however, feel it is important to provide users with a statement about the accuracy of GAP predicted vertebrate distributions within the limitations of available resources and practicalities of such an endeavor. We acknowledge that distribution maps are never finished products but are continually updated as new information is gathered. This reflects not only an improvement over the modeling process but also the opportunity to map changes in species distributions over time. However, we feel that assessing the accuracy of the current maps provides useful information about their reliability to potential users.

Our goal was to produce maps that predict distribution of terrestrial vertebrates and, from that, species richness and species composition with an accuracy of 80% or higher. Failure to achieve this level of accuracy indicates the need to refine the data sets and models used to predict distribution. There is a conscious effort in the GAP process, however, to err on the side of commission, (e.g., coding hexagons adjacent to hexagons with known location records as "probable" when creating species range maps; That is to attribute species as possibly present when they are not). There are two primary reasons for doing so: (1) few species have systematic, unbiased known ranges, and we believe science is best served by identifying a greater potential for sampling and investigation than using a conservative approach that may miss such opportunities; (2) in conducting the analysis of conservation representation (see the Analysis section), we believe it most appropriate to identify a species that may need additional conservation attention that is latter reclassified by further investigation rather than identifying a species as sufficiently protected that is latter reclassified as declining or extirpated.

Methods

Our approach to assessing the accuracy of the North Dakota GAP vertebrate distribution models was similar to that of other GAP projects (Edwards et al. 1996). We had difficulty identifying natural areas in North Dakota with long-term and accurate species lists. Systematic monitoring of vertebrate species is not a standard practice on many natural areas, and the general consensus was that most species lists were incomplete. Published lists also become outdated as species distributions change. We used published species checklists from four USFWS National Wildlife Refuges, The Nature Conservancy's Cross Ranch Nature Preserve, and Theodore Roosevelt National Park to examine the accuracy of the potential vertebrate distribution models (Table 3.5 and Fig. 3.5). The existing species lists were evaluated by expert reviewers and natural area biologists, and these revised species lists were compared with a species list assembled for

Table 3.5 Six natural areas used to assess the accuracy of North Dakota GAP vertebrate distribution models.

Natural area	Area (ha)	Birds	Mammals	Herptiles
Cross Ranch Nature Preserve	2382		x	
Tewaukon National Wildlife Refuge	3442	x	x	x
Arrowwood National Wildlife Refuge	6422	x		
Long Lake National Wildlife Refuge	8748	x		
Lostwood National Wildlife Refuge	11884	x	x	x
Theodore Roosevelt National Park	28467	x		x

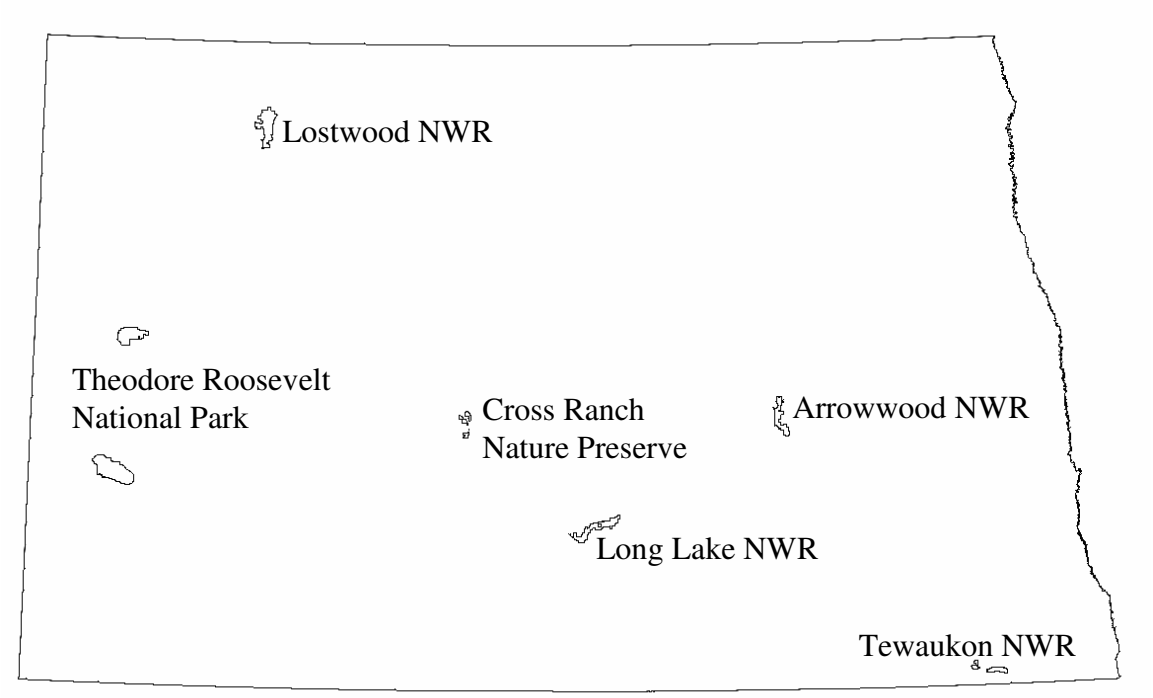


Fig 3.5 Location of six natural areas used to assess the accuracy of vertebrate distribution models.

the area using the predicted vertebrate distribution maps. The checklists were not used in the construction of species range maps. A North Dakota GAP species list for each area was created from the vertebrate distribution maps by extracting within the boundary lines of each natural area the results of the hypergrid analysis performed in conjunction within the investigation of species richness.

Results

Published bird species lists were available for four of the five areas, and published lists for mammal and herptile species were available for three of the five locations. The

complete accuracy assessment tables for each taxonomic group are in Appendices 3.4–3.7. Omission errors were smaller than commission errors for each taxonomic group at all locations (Table 3.6). Percent agreement for birds averaged 94% with a range of 84-98 %. Omission errors for birds averaged less than 1% with a range of 0-2%. Commission errors for birds averaged 5.4% with a range of 2-14%. One half of the commission errors in the birds of Theodore Roosevelt National Park are wetland birds including grebes and some species of waterfowl, which were predicted to occur because of the presence of riverine wetland habitat. Other congener species have been recorded as breeding in the park. Percent agreement for mammals averaged 89.6% with a range of 86-94%. Omission errors for mammals averaged 2% with a range of 0-3% whereas commission errors averaged 8.3% with a range of 3-14%. Percent agreement for herptiles averaged 92% with a range of 85-100%. Omission errors for herptiles averaged 2.6% with a range of 0-8% whereas commission errors averaged 5.3% with a range of 0-8%. Most of the commission errors are small mammals that have not been collected or well studied but are suspected to occur in the selected area and bird species seen but not yet recorded as breeding in the selected areas. Lists of the species identified as omission or commission errors at any of the six natural areas are presented in Tables 3.7–3.9 for birds, mammals, and herptiles, respectively. There was no relationship between percent agreement or omission and commission errors with natural-area size.

Table 3.6. Number of agreements and commission and omission errors from a comparison of vertebrate potential distribution maps with species checklists for six public natural areas.

Taxonomic Group	Arrowwood NWR	Long Lake NWR	Lostwood NWR	Tewaukon NWR	Theodore Roosevelt National Park	Cross Ranch Nature Preserve
			Birds			
Agreement	179(97%)	175(95%)	181(98%)	181(98%)	154(84%)	
Commission	5(3%)	9(5%)	3(2%)	3(2%)	27(14%)	
Omission	0	0	0	0	3(2%)	
			Mammals			
Agreement			67(94%)	61(86%)		63(89%)
Commission			2(3%)	10(14%)		6(8%)
Omission			2(3%)	0		2(3%)
			Reptiles			
Agreement			14(93%)	15(100%)	14(93%)	
Commission			1(7%)	0	0	
Omission			0	0	1(7%)	
			Amphibians			
Agreement			10(91%)	11(100%)	8(73%)	
Commission			1(9%)	0	2(18%)	
Omission			0	0	1(9%)	

Table 3.7. A list of bird species identified as omission (O) or commission (C) errors at one or more of five natural areas used to examine the accuracy of vertebrate distribution models. An A indicates agreement between species potential distribution maps and species checklists for the public natural area.

TNCcode	Common name	Scientific name	Arrow-wood NWR	Long Lake NWR	Lost-wood NWR	Tewaukon NWR	Theodore Roosevelt NP
ABNCA02010	Pied-Billed Grebe	Podilymbus podiceps	A	A	A	A	C
ABNCA03030	Eared Grebe	Podiceps nigricollis	A	A	A	A	C
ABNCA04010	Western Grebe	Aechmophorus occidentalis	A	A	A	A	C
ABNFD01020	Double-Crested Cormorant	Phalacrocorax auritus	A	A	A	A	C
ABNGA01020	American Bittern	Botaurus lentiginosus	A	A	A	A	C
ABNJB09010	Wood Duck	Aix sponsa	A	A	A	A	C
ABNJB10140	Cinnamon Teal	Anas cyanoptera	A	A	A	C	A
ABNJB10150	Northern Shoveler	Anas clypeata	A	A	A	A	C
ABNJB11030	Redhead	Aythya americana	A	A	A	A	C
ABNJB11070	Lesser Scaup	Aythya affinis	A	A	A	A	C
ABNJB18010	Common Goldeneye	Bucephala clangula	A	A	A	A	O
ABNJB22010	Ruddy Duck	Oxyura jamaicensis	A	A	A	A	C
ABNKC10010	Bald Eagle	Haliaeetus leucocephalus	A	C	A	A	A
ABNKC19050	Broad-Winged Hawk	Buteo platypterus	C	A	A	A	A
ABNKC22010	Golden Eagle	Aquila chrysaetos	A	C	C	A	A
ABNLC11010	Ruffed Grouse	Bonasa umbellus	A	A	A	A	C
ABNME05030	Virginia Rail	Rallus limicola	A	A	A	A	C
ABNME08020	Sora	Porzana carolina	A	A	A	A	A
ABNME14020	American Coot	Fulica americana	A	A	A	A	C
ABNND02010	American Avocet	Recurvirostra americana	A	A	A	A	C
ABNNF02010	Willet	Catoptrophorus semipalmatus	A	A	A	A	C
ABNNF04020	Spotted Sandpiper	Actitis macularia	A	A	A	A	C
ABNNF08040	Marbled Godwit	Limosa fedoa	A	A	A	A	C
ABNNF18010	Common Snipe	Gallinago gallinago	A	A	A	A	C
ABNNF20010	Wilson's Phalarope	Phalaropus tricolor	A	A	A	A	C
ABNSB10010	Burrowing Owl	Athene cunicularia	A	A	A	C	A
ABNUA03010	Chimney Swift	Chaetura pelagica	A	A	A	A	C
ABPAE43070	Great Crested Flycatcher	Myiarchus crinitus	A	C	A	A	A
ABPAT02010	Horned Lark	Eremophila alpestris	C	A	A	A	A
ABPAV02020	Blue Jay	Cyanocitta cristata	A	A	C	A	A
ABPBK03010	Northern Mockingbird	Mimus polyglottos	A	A	A	A	C
ABPBX24010	Yellow-Breasted Chat	Icteria virens	A	C	A	A	A
ABPBX45040	Scarlet Tanager	Piranga olivacea	A	C	A	A	A
ABPBX61030	Rose-Breasted Grosbeak	Pheucticus ludovicianus	C	A	A	A	O
ABPBX64020	Lazuli Bunting	Passerina amoena	A	C	A	A	A
ABPBX64030	Indigo Bunting	Passerina cyanea	A	C	A	A	A
ABPBX65010	Dickcissel	Spiza americana	C	A	A	A	C
ABPBX74080	Spotted Towhee	Pipilo maculatus	A	C	A	A	A
ABPBX94020	Chipping Sparrow	Spizella passerina	A	A	A	C	A
ABPBX94050	Field Sparrow	Spizella pusilla	A	C	C	A	A

Table 3.7 (continued). A list of bird species identified as omission or commission errors at one or more of five natural areas used to examine the accuracy of vertebrate distribution models.

TNCcode	Common name	Scientific name	Arrow-wood NWR	Long Lake NWR	Lost-wood NWR	Tewaukon NWR	Theodore Roosevelt NP
ABPBX95010	Vesper Sparrow	Pooecetes gramineus	C	A	A	A	A
ABPBXA0040	Le Conte's Sparrow	Ammodramus leconteii	A	A	A	A	C
ABPBXA6010	Mccown's Longspur	Calcarius mccownii	A	A	A	A	O
ABPBXB9190	Baltimore Oriole	Icterus galbula	A	A	A	A	C
ABPBXB9220	Bullock's Oriole	Icterus bullockii	A	A	A	A	C
ABPBY04040	House Finch	Carpodacus mexicanus	A	A	A	A	C
ABPBY05010	Red Crossbill	Loxia curvirostra	A	A	A	A	C

Table 3.8. A list of mammal species identified as omission or commission errors at one or more of three natural areas used to examine the accuracy of vertebrate distribution models.

TNC code	Common name	Scientific name	Lostwood NWR	Tewaukon NWR	Cross Ranch Nature Preserve
AMABA01190	Arctic Shrew	*Sorex arcticus*	A	C	A
AMABA03010	Northern Short-tailed Shrew	*Blarina brevicauda*	A	A	C
AMACC01060	Keen's Myotis	*Myotis keenii*	A	C	C
AMACC04010	Big Brown Bat	*Eptesicus fuscus*	A	C	A
AMAEB03010	Snowshoe Hare	*Lepus americanus*	A	A	C
AMAFB02230	Eastern Chipmunk	*Tamias striatus*	A	C	A
AMAFB06010	Black-tailed Prairie Dog	*Cynomys ludovicianus*	A	A	C
AMAFB07010	Gray Squirrel	*Sciurus carolinensis*	A	C	A
AMAFB09020	Northern Flying Squirrel	*Glaucomys sabrinus*	A	C	A
AMAFC01040	Northern Pocket Gopher	*Thomomys talpoides*	C	A	A
AMAFD01010	Olived-backed Pocket Mouse	*Perognathus fasciatus*	A	C	A
AMAFD01020	Plains Pocket Mouse	*Perognathus flavescens*	C	A	O
AMAFF02010	Plains Harvest Mouse	*Reithrodontomys montanus*	A	C	C
AMAFF08090	Bushy-tailed Woodrat	*Neotoma cinerea*	A	A	O
AMAFF11140	Prairie Vole	*Microtus ochrogaster*	A	C	A
AMAJF02010	Ermine	*Mustela erminea*	O	A	A
AMAJH03020	Bobcat	*Felis rufus*	A	C	A
AMALD01010	Pronghorn	*Antilocapridae americana*	O	A	A
AMALE04010	Bighorn Sheep	*Ovis canadensis*	A	A	C

Table 3.9. A list of herptile species identified as omission or commission errors at one or more of three natural areas used to examine the accuracy of vertebrate distribution models.

TNC code	Common name	Scientific name	Lostwood NWR	Tewaukon NWR	Theodore Roosevelt NP
AAABB01080	Canadian Toad	*Bufo hemiophrys*	C	A	C
AAABF01010	Plains Spadefoot Toad	*Scaphiopus bombifrons*	A	A	O
AAABH01200	Wood Frog	*Rana sylvatica*	A	A	C
ARAAB01012	Common Snapping Turtle	*Chelydra s. serpentina*	C	A	A
ARAAG01022	Midland Smooth Softshell Turtle	*Apalone m. mutica*	A	A	O

Limitations and Discussion

A database that encompasses the type and large amount of information that is incorporated into a Gap analysis is certain to have some errors and thus some uncertainty. The combined effect of errors in the land cover map, the species range representations, and the WHR models on species potential distribution maps are unknown.

The validity of the results of accuracy assessments of WHR models have been shown to be dependent on the size of the assessment sites, the duration of surveys, the biology and ecology of the fauna, as well as the quality of species predicted distribution models (Boone and Krohn 2000). Our analysis did not assess the accuracy of species habitat affinities but rather assessed presence or absence of a species in a geographic area. Because the accuracy assessment was not a probability-based sample, care must be taken with regards to inferences drawn from the results. Accuracy assessments are only applicable at the spatial and temporal scales at which they are conducted. For example, to infer from our results the accuracy of prediction for a 10-ha prairie surveyed one season would be inappropriate. Although the results from our accuracy assessment were encouraging, the vertebrate distribution maps have a number of limitations that users should consider.

Our simple WHR models do not account for community and ecosystem processes that may be important determinants of species occurrences. A species fundamental niche which corresponds to suitable or potential habitat, is often broader than its realized niche where it actually occurs. Biological and ecological factors, such as interactions with predators and competitors, influence the distribution of species. Thus, WHR models, which are based primarily upon affinities with land cover categories, in many cases will tend to over-estimate the actual distribution of a species and therefore species richness.

Model results depend on the scale and the generalization of the land cover map (Stoms 1992). From the well-known species-area relationship, we would expect fewer species to be found in a 1-ha patch than a 100-ha patch of the same habitat type. However, our simple WHR models do not incorporate the area or size of land cover patches into model predictions. For example, species distributions for woodland dependent species are likely overestimated as many small woodland patches depicted in the land cover map probably cannot sustain a breeding population. There is a tradeoff of predicting species presence

in patches too small to sustain a viable population (errors of commission) and not predicting species that inhabit small but critical habitat patches (errors of omission).

Over-prediction of the total area potentially occupied by the animals also can occur when a species affinity is with a subset of habitat characteristics of a broadly defined land cover category. A good example of this problem are the distribution maps for bats, cavity nesting birds, and other species requiring specific structural elements below the resolution of the land cover map.

WHR model predictions for colonial wetland birds overestimate the amount of occupied nesting habitat. Although nesting may not occur at many of the predicted habitat locations, adult or subadult birds can be present or even common during the breeding season. Many of these species have subpopulations of non-breeding adults or subadults, which wander throughout parts of North Dakota. For some species, such as the American White Pelican, nesting adults travel great distances from their colony to forage.

For accidental breeders, sporadic or irruptive breeders, or species nesting outside of their typical breeding range, the models exaggerate the species' distribution within the state. Even if suitable habitat is present, the species may not occur at a location in most years. Examples of accidental breeders include Least Bittern, American Black Duck, Cinnamon Teal, Merlin, Northern Mockingbird, Bell's Vireo, and Blue Grosbeak. Some of these species might be expanding their ranges into ND (e.g., Northern Mockingbird, Cattle Egret) or recolonizing portions of their former range (e.g., Merlin). Sporadic or irruptive breeders include Long-eared Owl, Ruby-throated Hummingbird, Pine Siskin, and Red Crossbill.

Finally, most species' distributions are not static but rather ebb and flow with changing climatic and biological conditions. For example, the potential distribution map for the Burrowing Owl includes a significant area of natural prairie that occurs east and north of the Missouri River. However, recent efforts to determine the status of the Burrowing Owl have concluded the species changed from common or uncommon to rare in the best potential habitat that remains and has disappeared from the eastern one-third of the state (Murphy et al. 2001).

LAND STEWARDSHIP

Introduction

To fulfill the analytical mission of GAP, it is necessary to compare the mapped distribution of elements of biodiversity with their representation in different categories of land stewardship and management. We use the term "stewardship" in place of "ownership" in recognition that legal ownership does not necessarily equate to the entity charged with management of the land, e.g., lands owned by the Army Corps of Engineers but managed by the North Dakota Game and Fish Department. We use management status to distinguish administrative units with different land management objectives and degrees of management for biodiversity. For example, a steward such as the U.S. Forest Service may manage administrative units with different management objectives within a National Grassland, e.g., Research Natural Areas, and Rangelands with Broad Resource Emphasis.

The purpose of comparing biotic distribution with stewardship is to provide a method by which land stewards can assess their relative amount of responsibility for the management of a species or plant community and identify other stewards sharing that responsibility. This information can reveal opportunities for cooperative management of that resource, which directly supports the primary mission of GAP to provide objective, scientific information to decision makers and managers to make informed decisions regarding biodiversity. It also is not unlikely that a steward that has previously borne the major responsibility for managing a species may, through such analyses, identify a more equitable distribution of that responsibility. We emphasize, however, that GAP only identifies private land as a homogeneous category and does not differentiate individual tracts or owners, unless the information was provided voluntarily to recognize a long-term commitment to biodiversity maintenance.

After comparison to stewardship, it is also necessary to compare biotic occurrence to categories of management status. The purpose of this comparison is to identify the need for change in management status for the distribution of individual elements or areas containing high degrees of diversity. Such changes can be accomplished in many ways that do not affect the stewardship status. While it will eventually be desirable to identify specific management practices for each tract, and whether they are beneficial or harmful to each element, GAP currently uses a scale of 1 to 4 to denote relative degree of maintenance of biodiversity for each tract. A status of "1" denotes the highest, most permanent level of maintenance, and "4" represents the lowest level of biodiversity management, or unknown status. This is a highly subjective area, and we recognize a variety of limitations in our approach, although we maintain certain principles in assigning the status level. Our first principle is that land ownership is not the primary determinant in assigning status. The second principle is that while data are imperfect, and all land is subject to changes in ownership and management, we can use the intent of a land steward as evidenced by legal and institutional factors to assign status. In other

words, if a land steward institutes a program backed by legal and institutional arrangements that are intended for permanent biodiversity maintenance, we use that as the guide for assigning status.

The characteristics used to determine status are as follows:

- Permanence of protection from conversion of natural land cover to unnatural (human-induced barren, exotic-dominated, arrested succession).
- Relative amount of the tract managed for natural land cover.
- Inclusiveness of the management, i.e., single feature or species versus all biota.
- Type of management and degree that it is mandated through legal and institutional arrangements.

The four status categories can generally be defined as follows (after Scott et al. 1993, Edwards et al. 1995, Crist et al. 1995):

Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, and intensity) are allowed to proceed without interference or are mimicked through management.

Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities.

Status 3: An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type or localized intense type. It also confers protection to federally listed endangered and threatened species throughout the area.

Status 4: Lack of irrevocable easement or mandate to prevent conversion of natural habitat types to anthropogenic habitat types. Allows for intensive use throughout the tract. Also includes those tracts for which the existence of such restrictions or sufficient information to establish a higher status is unknown.

Mapping Standards

When the NDGAP began to organize in 1998, very little digital boundary data existed for public lands in ND. The North Dakota Department of Transportation (NDDOT) was in the process of converting their mapping responsibilities for ND from a manual process to

a digital process. One of the NDDOT products is a state base map which contains boundaries for many of the federal and state public lands in ND. Organizations with stewardship responsibilities for public lands in North Dakota were contacted and queried about the availability of digital and analog maps, realty records, and management plans for their lands. Few organizations had digital boundary data for all their lands but many agencies had partial data sets and plans to create digital land ownership vectors for their lands. The scale of the boundary data being developed by the agencies ranged from 1:24,000 to 1:100,000. Based on this information, a decision was made that the NDGAP would acquire digital boundary data from public land managers in ND and would assemble the data for individual agencies into a single vector. If boundary data were not available from the agency that owned or managed the lands, the NDGAP would use the NDDOT digital state base map for those lands, and if not available in the NDDOT product the NDGAP would create the data. A useful starting point for addressing the inclusiveness of the stewardship vector for ND was a paper 1:500,000 scale land status map for North Dakota produced by the Bureau of Land Management in 1993.

Nearly all public land boundary data were acquired from the owner or manager of the land in digital format. Digital vectors of land ownership or stewardship boundaries in ND were acquired from 11 organizations (Table 4.1). Methods used to create the data included digitizing and GPS surveys. The cartographic scale of the source layers for the digitized data ranged from 1:12,000 to 1:100,000 with the majority of the data having a scale of 1:24,000. A U.S. Census Bureau TIGER vector developed from U.S. Geological Survey 1:100,000 digital line graphs was used for the ND state boundary.

The projection parameters and datum of the acquired vectors varied with the majority of the data in UTM 14, NAD 27 or NAD 83. All acquired vectors were reprojected to the NDGAP standard projection parameters of Albers Conical Equal Area, GRS 1980, NAD 83. Land boundary data for the two Military Bases and a ND National Guard Base were obtained from the NDDOT digital base map. Boundary data for lands managed by the ND Forest Service, ND Agricultural Experiment Stations, and the Audubon Society were created by the NDGAP by on-screen digitizing using 1:24,000 PLSS and DOQQ reference data. When a vector did not have metadata, we contacted the agency and obtained information on the methods used to create the data.

The vectors for American Indian Reservations do not depict land ownership in the same manner as vectors from other sources. The American Indian Reservation boundaries enclose lands under the jurisdiction of tribal governments recognized by the U.S. Government. Public lands within the Reservation boundaries are shown in the stewardship vector. The remaining lands within the reservation boundaries have a very complex ownership consisting of privately owned lands and tribal and individual Indian trusts managed by the USBIA. The management of individual Indian trust lands is the

Table 4.1. Organizations that provided digital land boundary data used to create the stewardship vector for the ND GAP. Data sources are listed in reserve of the order that they were used in the Arc-Info update function to create a single, all inclusive stewardship vector for ND. For example, the USFWS vector was used in the last iteration of the update function and its spatial topology and attributes superseded the previous vectors where overlap occurred.

Data Sources	Acronym
U.S. Fish and Wildlife Service	USFWS
ND Game and Fish Department	NDGF
U.S. Army Corps of Engineers	USACE
U.S. Forest Service	USFS
U.S. Bureau of Reclamation	USBR
U.S. National Park Service	USNPS
U.S. Bureau of Land Management	USBLM
U.S. Bureau of Indian Affairs	USBIA
The Nature Conservancy	TNC
ND Department of Transportation	NDDOT
ND State School Land	NDGS[a]

[a]The ND Geological Survey provided a vector of lands managed by the ND State Land Department.

subject of an on-going class action lawsuit, Cobell v. Norton, filed in 1996. All lands within reservation boundaries with the exception of public lands were assigned an owner and manager code of 2000.

We did not include water features in the stewardship vector unless they were present in the vectors obtained from the various agencies. Only water polygons belonging to large reservoirs were coded using the GAP water owner and manager numeric code (8000). The small number of water body polygons not belonging to a large reservoir (n =20) from all source vectors were coded with the owner and manager codes for the land unit that contained them. This was done for consistency since many lakes much larger than these were not included in the stewardship layer. Ownership, managing entities, and water rights are complex issues that will be addressed in the future by the aquatic component of GAP.

ND-GAP did not use a standard Minimum Mapping Unit (MMU). Instead, we followed the recommendation within the GAP handbook for mapping and categorizing land stewardship and maintained the resolution at which the digital data were acquired. About one quarter (24 percent) of the total number of ND GAP land units were less than 40 acres, with 60 percent of these land units owned by the USACE. Many of these USACE-owned land units were primarily small islands, or secondarily land bordered on one side

by water and the other by different landowners. Many of the remaining less than 40-acre land units were owned or managed by the USFWS, the USFS, or the NDGF.

Methods

Stewardship Mapping:

In most cases, the data received from an agency consisted of more than one vector. For example, the USFWS data set consisted of three data layers: fee title refuges, easement refuges, and waterfowl production areas, and the USFS and USACE data sets consisted of separate vectors for each management district. When the agency used the same procedure to create each vector, the individual vectors were united to create a single vector with all of the agency's lands in ND.

There were a small number of cases where internal administrative and management boundaries separating land units with different GAP status codes were not included in a vector acquired from an agency. When this occurred we created the internal management unit boundary after consultation with agency personnel.

Once a vector with the state-wide extent of an agency's land was created, the next step was the creation and population of a polygon attribute table with the GAP stewardship attributes. The attributes included owner, manager, and status for all polygons, and division, unit, date of establishment, and source of management information for lands assigned GAP status codes of 1 or 2 or for other lands if the information was available. Owner, manager and status were recorded using the numeric codes for the attributes found in the GAP Stewardship Handbook.

The next step in the development of the NDGAP stewardship vector was to combine the individual agency vectors into a single vector. Combining individual vectors from different sources and scales into a single vector is potentially difficult because of problems with coincident lines and the creation of spurious polygons when the boundaries of polygons on the source vectors are highly correlated (Burrough and McDonnell 1998: p 237). Large numbers of small spurious or sliver polygons can be created when what theoretically should be coincident lines in the source vectors are not. The greatest problem was the removal of the spurious polygons to avoid nonsense in the state stewardship vector. To minimize the spurious polygon problem, we constructed a hierarchy of data sets on the basis of the scale of the source data, the procedures used to create the vector, and the agency-imposed use constraints accompanying the data (Table 4.1). The hierarchy defined the order that data sets would be included in the Arc Info V7.2 update function. The update function combines vectors by overlaying the update vector over the input vector, with the spatial topology and attributes of the update vector superseding the input vector where overlaps occur. The importance of the hierarchy was to define the order that the different agency data sets were included in the repetitive use of the update function to construct a single, all-inclusive stewardship vector for ND. Agency data sets were introduced into the update function starting with the lowest level in the hierarchy, the boundary layer for ND, and continuing to the FWS Fee Title Refuge

vector which was assigned to the highest level the hierarchy. The update function minimized the amount of sliver and island edits that were required, while giving precedence to data sets of finer scale and accuracy.
At the conclusion of the iterative use of the update function, spurious sliver and island polygons were identified using an area to perimeter ratio and visually. Following the data set hierarchy, arcs and the sliver and island polygons were edited or eliminated as needed if determined to be trivial. Polygon attributes were checked and reattributed when necessary and excess data fields were deleted.

Land ownership and stewardship is dynamic. We terminated data collection for the NDGAP stewardship vector with the delivery of the USFWS vector in the spring 2003.

Management Status Categorization:

The NDGAP generally used the dichotomous key and the criteria in the GAP Stewardship Handbook to categorize the biodiversity management status of land units. A primary difficulty categorizing the status for some land units in ND using the GAP criteria was reconciling the requirement for natural land cover with legislation and management objectives. Many public lands in ND, in particular FWS Waterfowl Production Areas (WPA), have only fragments of natural land cover remaining but have wildlife or biodiversity conservation objectives. Strict conformance to the natural land cover requirement in the description of the four biodiversity status categories would require these lands being assigned a status 4 because natural land cover in has been replaced by planted grassland. In accordance with the GAP principles for assigning status categories (see introduction), lands that had a wildlife or biodiversity management objective were assigned a minimum status category of 3 even if natural land cover of the land unit had been replaced by a planted land cover.

Published management plans, such as the USFS Northern Great Plains Management Plan Revision, USFWS Comprehensive Conservation Plans, and the USACE Master Plan, greatly facilitated the categorization of the biodiversity management status of land units (Table 4.2). When management plans were not available, the categorization of biodiversity management status was more difficult and made on the basis of information provided by the land manager, legal mandates, and the management objective as implied by the land unit designation specified by the land owner. Because Comprehensive Conservation Plans required by the National Wildlife Refuge System Improvement Act of 1997 are not yet available for most FWS lands in ND, we requested information on the land cover composition, unique resources, and management objectives for WPAs from FWS personnel. WPAs with natural land cover greater than or equal to 95% were coded as status 2 and WPAs with natural land cover less than 95% or WPA without land cover composition information were coded as status 3. In a similar manner, we used knowledge of the land use history and the absence of natural land cover to assign a status code of 2 rather than 1 to the two Wilderness areas on FWS NWRs.

Table 4.2 Management Entity and area (sq. km) of status 1 and 2 lands in North Dakota

Managing Entity and Internal Management Division	Total Area sq. km	Information Sources used to Assign Management Status
U.S. Fish and Wildlife Service		
National Wildlife Refuge	856.98	1. Year 2000 North Dakota Briefing Book[1],
Waterfowl Production Area	133.13	2. Land Cover and Management Objective Spreadsheet[2],
Wilderness Area	39.43	3. personal communications
U.S. Forest Service		
Research Natural Area	81.44	1. Northern Great Plains Management Plan Revision[3],
General Forest Lands	484.90	2. Record of Decision for Dakota Prairie Grasslands[4]
National Park Service		
National Historic Site	6.90	1. Theodore Roosevelt National Park Zones Vector[5],
National Park	162.45	2. National Park Service website[6]
Wilderness Area	123.10	
Audubon Society Preserves	8.60	1. Personal communication, Donna Schneider, Audubon Society North Dakota
TNC Preserves	50.98	Personal communications: 1. Eric Rosenquist, TNC Preserve Manager, 2. Robert Self, TNC Preserve Manager, 3. Brian Winter, Regional Stewardship Director
University of North Dakota	1.29	Personal communication, Dr. Richard Crawford, UND
Totals	1949.2	

[1.] USFWS, Mountain-Prairie Region website, (http://mountain-prairie.fws.gov/reference/briefing_book_nd_2000.pdf).
[2.] Informational spreadsheet developed by ND-GAP and completed by USFWS Wetland Management District Personnel.
[3]. Northern Great Plains Management Plan Revision, CDs 1 and 2, Northern Great Plains Planning, USDA Forest Service, Chadron, NE.
[4]. Record of Decision for Dakota Prairie Grasslands, July 2002, Dakota Prairie Grasslands Office, Bismarck, ND.
[5.] Data supplied by the Theodore Roosevelt National Park GIS Lab.
[6.] National Park Service website, Theodore Roosevelt National Park, (http://www.nps.gov/thro/).

We also created two subcategories for status 4 lands owned by the ND State Land Department. The status subcategory 4a identifies land units where the natural land cover is intact and anthropogenic disturbance of the soils has been minimal. The land units do not warrant a higher status rating because they are not subject to an institutional management plan which would prevent conversion of natural land cover to anthropogenic land covers. Status subcategory 4b identifies land units owned by the ND State Land Department where the natural land cover has been destroyed by disturbances such as cropland tillage or mining. The status subcategories were created because status 4a lands owned by the ND State Land Department are pivotal to future prairie biodiversity conservation efforts on public lands in ND because of their area, geographical distribution, and diversity.

Reservoirs assigned GAP owner and manager codes of 8000 were assigned a status code of zero.

Results

Lands managed by public agencies comprise approximately 6.4% of ND lands with 4.3% under federal and 2% under state jurisdiction (Table 4.3, Map 4.1). Approximately 4.2% of the land in ND occurs within the boundaries of lands governed by five Native American Tribal Governments. Lands managed by non-profit conservation organizations account for less than half of one percent of the land in ND. Private land owners are responsible for the management of more than 89% of the land in ND (portions of Native American Reservations are privately owned).

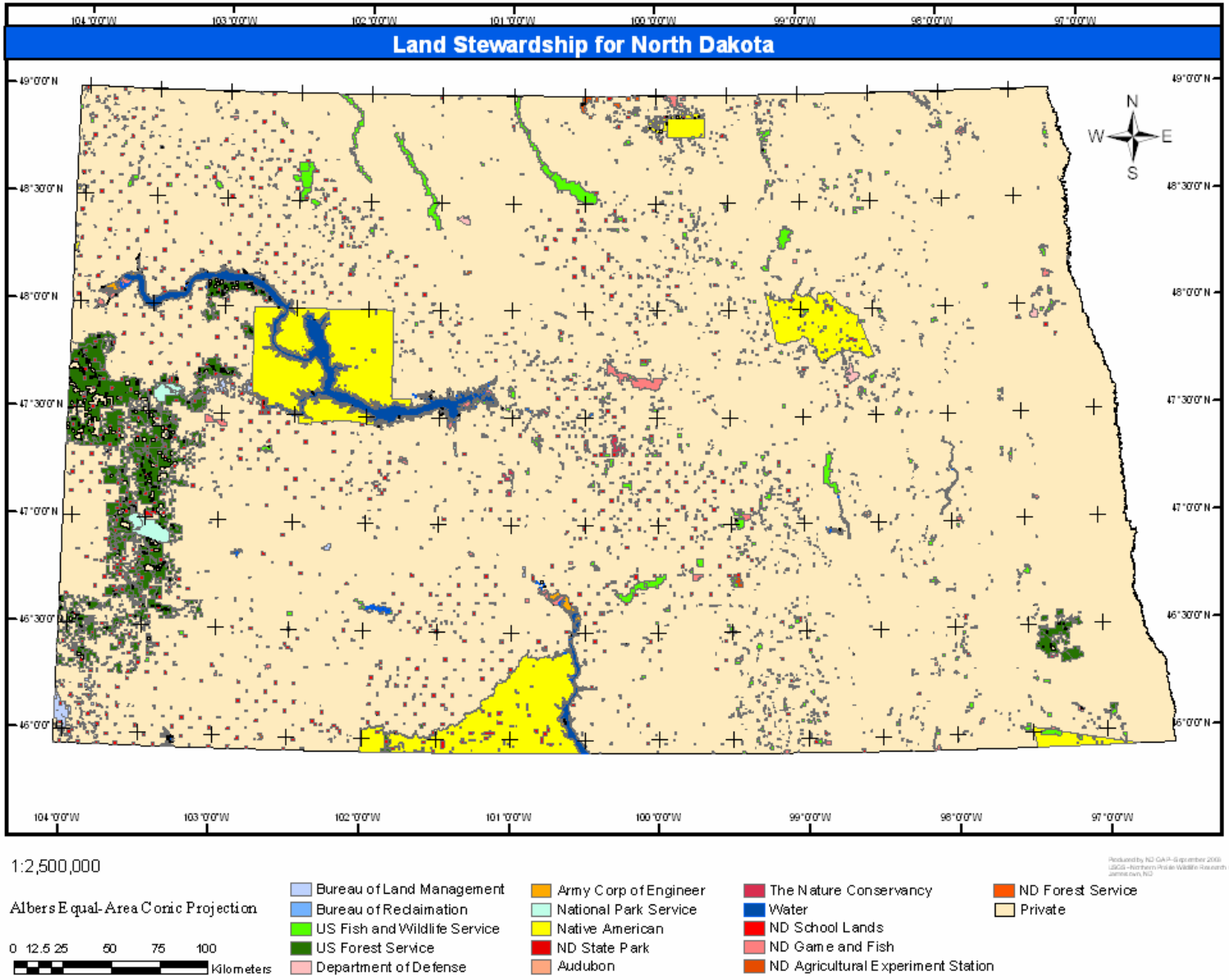
The USFS administers the largest amount of federal lands, 4467.34 sq. km, which is about double the amount of land managed by the USFWS, the second largest manager of federal lands in ND. USFS lands consist of the Little Missouri and Cedar River National Grasslands in western ND and the Sheyene National Grasslands in southeastern ND. The majority of USFWS lands are located east and north of the Missouri River in the Prairie Pothole Region of ND. More USFWS National Wildlife Refuges occur in ND than in any other state, although many of the 62 refuges are small and under easement from private land owners to provide resting and production areas for migratory birds (Bihrle 2003). The North Dakota State Land Department has management responsibility for the 2904.74 sq km of school lands which is 79% of lands under state jurisdiction.

Lands assigned to GAP status categories 1, 2, or 3 comprise less than 5% of land area of ND with only 1% in status categories 1 and 2 (Table 4.3, Map 4.2). Theodore Roosevelt National Park located in western ND accounts for 74% of the status 1 lands in ND. USFS Research Natural Areas, lands managed by the National Audubon Society, the Nature Conservancy, and the University of North Dakota account for the remainder of lands classified as status 1. The USFWS and the USFS has management responsibility for approximately 66 and 31%, respectively of the lands categorized as status 2 with the remainder under the management of the USNPS and private conservation organizations. Seven federal government agencies have responsibility for 5917.78 sq km or 87.8 % of the land classified as status 3 with the USFS, USFWS, USACE, and USBLM managing 65%, 21%, 8%, and 4% respectively, of these federal lands. Lands under state jurisdiction account for 11.6% of the lands classified as status 3 with the NDGF managing 654.4 sq. km or 83% of these lands. Status 4 lands are managed by private land owners (93.8%), Native American Tribal Governments (4.4%), and the ND State Land Department (1.7%).

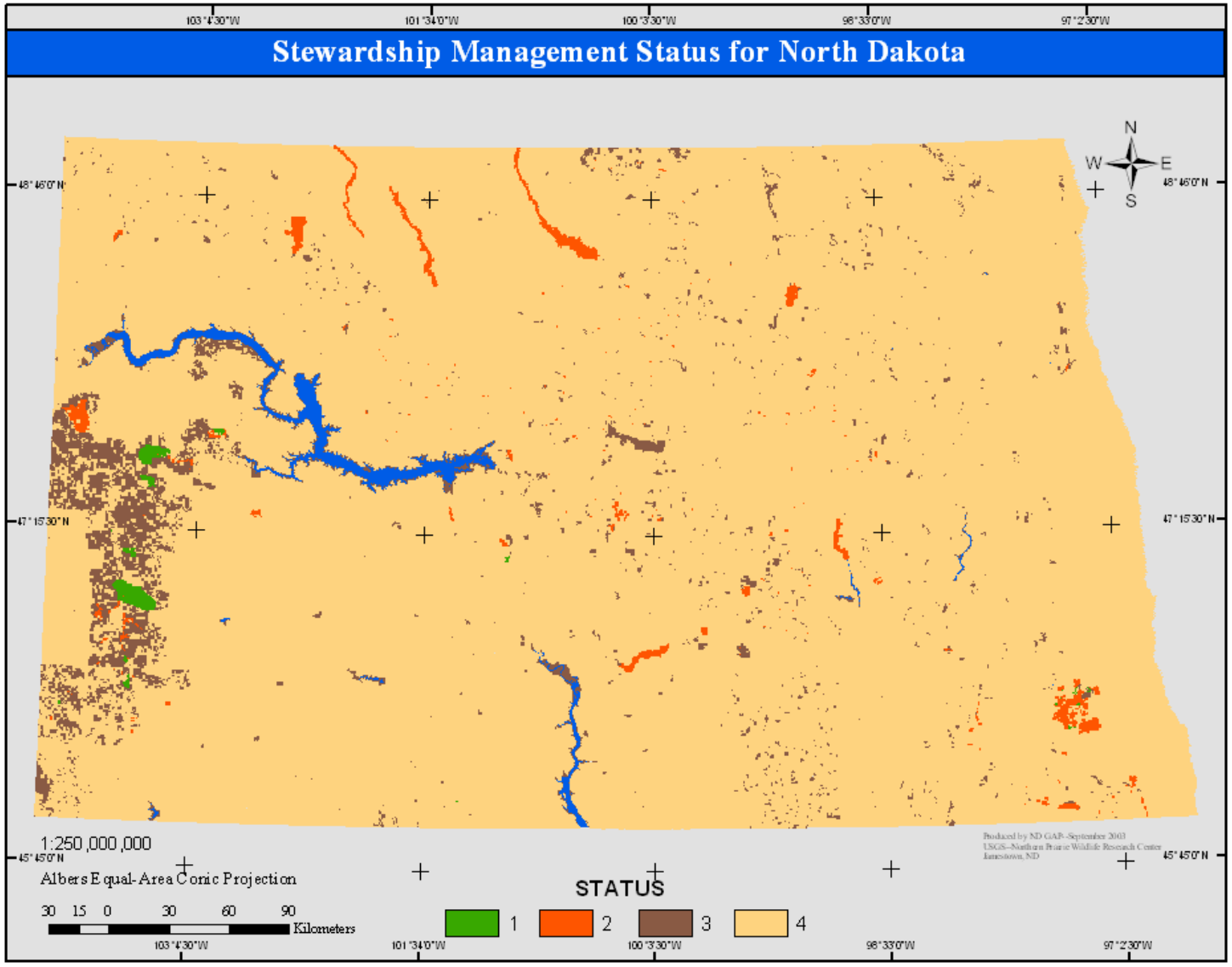
Eighty percent of the 2063 state school land units were given a status _sub category ranking of 4a because these land units have a high percentage of natural land cover and there has not been large scale anthropogenic disturbance of the soil. These land units do not warrant a higher status rating because they are not subject to an institutional management plan to prevent conversion of natural habitat types to anthropogenic habitat types.

Table 4.3 Area (sq. km) and percent of land by ND GAP stewardship and conservation status categories.

Manager/Steward	Land in Status 1		Land in Status 2		Land in Status 3		Land in Status 4		Total Area	Total Land Area
	sq. km	%	sq. km	%	sq.km	%	sq.km	%	sq.km	%
Federal	**371.16**	**97.16**	**1517.17**	**96.89**	**5917.78**	**87.78**	**73.49**	**0.04**	**7879.6**	**4.346**
U.S. Bureau of Reclamation					14.52	0.22			14.52	0.008
U.S. Bureau of Land Management					242.64	3.60			242.64	0.134
U.S. Fish and Wildlife Service			1029.54	65.75	1260.73	18.70	0.81	0.00	2291.08	1.264
U.S. National Park Service	284.08	74.37	8.38	0.54	1.56	0.02			294.02	0.162
U.S. Forest Service	87.08	22.80	479.25	30.61	3901.01	57.86			4467.34	2.464
U.S. Army Corps of Engineers					493.27	7.32			493.27	0.272
U.S. Department of Defense					4.05	0.06	72.68	0.04	76.73	0.042
Native American					**1.91**	**0.03**	**7572.37**	**4.39**	**7574.28**	**4.178**
Standing Rock Sioux							2677.31	1.55	2677.31	1.477
Three Affiliated Tribes					1.91	0.03	3158.31	1.83	3160.22	1.743
Turtle Mountain Chippewa							310.46	0.18	310.46	0.171
Spirit Lake Sioux							1177.82	0.68	1177.82	0.650
Sisseton-Wahpeton Sioux							248.47	0.14	248.47	0.137
State	**1.29**	**0.00**			**784.55**	**11.64**	**2914.69**	**1.69**	**3699.24**	**2.040**
University of North Dakota	1.29	0.00								
North Dakota State Parks					55.78	0.83			55.78	0.031
North Dakota Game and Fish					654.4	9.71			654.4	0.361
North Dakota School Lands							2904.74	1.68	2904.74	1.602
North Dakota Forest Service					55.31	0.82			55.31	0.031
North Dakota Agricultural Experiment Stations					19.06	0.28	9.95	0.01	29.01	0.016
Municipal					**19.6**	**0.29**			**19.6**	**0.011**
Non-Profit Conservation	**10.84**	**2.84**	**48.74**	**3.11**	**18.04**	**0.27**			**77.62**	**0.043**
National Audubon Society			8.6	0.55					8.6	0.005
The Nature Conservancy	10.84	2.84	40.14	2.56	18.04	0.27			69.02	0.038
Private							**162044.5**	**93.88**	**162044.5**	**89.382**
Open Water									1807.14	0.997
Total sq. kilometers of Land by Status Category	**383**		**1565.91**		**6741.88**		**172606.34**		**181297.13**	**100.000**
Total Status Land as a Pecentage of Total Land Area	0.21		0.86		3.72		95.21		100.00	
Total Area of North Dakota									183103.27	



Map 4.1. Land stewardship for North Dakota



Map 4.2. Gap stewardship management status for North Dakota

Limitations and Discussion

There are additional lands that could not be included in the stewardship vector but play an important role in biodiversity conservation in ND. In 2004, there are 3349 km^2 of wetlands and 620 km^2 of natural and semi-natural grassland protected by USFWS perpetual easements (Personnel Communication, Stu Wacker, USFWS). Conservation programs that are part of the National Farm Bill such as the Conservation Reserve Program (CRP) are also important to biodiversity conservation. Although lands enrolled in the CRP program have relatively short conservation contracts (typically 10 – 15 years) the program is beneficial in the short-term because of the large number of acres and the creation of an idle grassland land cover which is relatively scarce on other lands.

The stewardship vector is a compilation of ownership vectors provided by a variety of sources that are individually responsible for their accuracy. It was created solely for the purpose of conducting the analyses described in this report and is not suitable for locating boundaries on the ground or determining precise area measurements of individual tracts.

ANALYSIS BASED ON STEWARDSHIP AND MANAGEMENT STATUS

Introduction

As described in the Introduction of this report, a primary objective of GAP is to provide information on the distribution and status for two elements of biological diversity: natural land cover categories and terrestrial vertebrate species. This is accomplished by first producing maps of land cover (see Chapter 2), predicted distributions for selected animal species (see Chapter 3), and land stewardship and management status (see Chapter 4). Intersecting the land stewardship and management status map with the distribution of the elements allows the creation of tables that summarize the area and percent of total mapped distribution of each element in different land stewardship and management status categories. With these tables, a user can determine the representation of each element in the different stewardship and management status categories as appropriate to their needs. These comparisons do not measure viability, but are a start to assessing the likelihood of future threat to a biotic element through habitat conversion--the primary cause of biodiversity decline. These tables serve GAP's mission to provide land owners and managers with the information necessary to conduct informed policy development, planning, and management for biodiversity maintenance.

Although GAP "seeks to identify land cover types and species not adequately represented in the current network of biodiversity management areas" (GAP Handbook, Preface, Version 1, p. I), it is unrealistic to create a standard definition of "adequate representation" for either land cover types or individual species (Noss et al. 1995). A practical solution to this problem is to report both percentages and absolute area of each element in biodiversity management areas and allow the user to determine which types are adequately protected. There are many other factors that should be considered in such determinations such as (a) historic loss or gain in distribution, (b) nature of the spatial distribution, (c) immediate versus long-term risk, and (d) degree of local adaptation among populations of the biotic elements that are worthy of individual conservation consideration. Such analyses are beyond the scope of this project, but we encourage their application as well as field confirmation of the mapped distributions. As a coarse indicator of the status of the elements, gap analyses traditionally provide a breakdown along five levels of representation (<1%, 1–10%, 10–20%, 20–50%, >50%). The <1% level indicates those elements with essentially none of their distribution in a protected status while levels of 10%, 20%, and 50% have been recommended in the literature as necessary amounts of conservation (Noss and Cooperrider 1994; Noss 1991; Odum and Odum 1972; Specht et al. 1974; Ride 1975; Miller 1994).

The network of Conservation Data Centers (CDCs) and Natural Heritage Programs (NHPs) established cooperatively by The Nature Conservancy and various state agencies maintain detailed databases on the locations of rare elements of biodiversity. GAP cooperatively uses these data to develop predicted distributions of potentially suitable

habitat for these elements, which may be valuable for identifying research needs and preliminary considerations for restoration or reintroduction. Conservation of such elements, however, is best accomplished through the fine-filter approach of the above organizations as described in the introduction. It is not the role of GAP to duplicate or disseminate Heritage Program or CDC Element Occurrence Records. Users interested in more specific information about the location, status, and ecology of populations of such species are directed to the ND Natural Heritage Program.

Currently, land cover types and terrestrial vertebrates are the primary focus of GAP's mapping efforts; however, other components of biodiversity, such as aquatic organisms or selected groups of invertebrates may be incorporated into GAP distributional data sets. Where appropriate, GAP data also may be analyzed to identify the location of a set of areas in which most or all land cover types or species are predicted to be represented. The use of "complementarity" analysis, which additively identifies a selection of locations that may represent biodiversity, may prove most effective for guiding biodiversity maintenance efforts than "hot spots of species richness". Several quantitative techniques have been developed recently that facilitate this process (see Pressey et al. 1993, Williams et al. 1996, Csuti et al. 1997, for details). These areas become candidates for field validation and may be incorporated into a system of areas managed for the long-term maintenance of biological diversity.

Methods

The analysis of land cover by stewardship and management status was performed using the raster properties function in the vector attributes process of MicroImage's Map and Image Processing System software. The function computes a histogram of cell values from the land cover raster for each polygon in the stewardship vector and saves the results as an attribute table attached to the vector. The attribute table was exported to SAS and the relationship of land cover to steward and management status categories summarized.

The analysis of vertebrate distributions was performed only relative to the management status categories. The stewardship vector was converted to a raster where the cells corresponding to each polygon were assigned the management status category of the polygon. The proportion of each species potential distribution in each of the four status categories was calculated from the vertebrate distribution rasters and the raster representation of the management status categories using ArcGIS software and the sprich.aml provided by GAP.

Results

Land Cover Analysis by Steward

The area of land cover categories and the proportion of land cover categories within each stewardship category are presented in Tables 5.1 and 5.2, respectively. With more than 90% of the land area in ND under private ownership, it is not surprising that all of the

general land cover categories and 32 of the 39 detailed land cover categories are most abundant on private lands.

The USFS, NDSL, and USFWS manage 5.9%, 5.1%, and 1.7% of the prairie land cover category, respectively. Lands governed by the NASRS and NATAT accounted for 4.5% and 2.0% of the prairie land cover category. Nine stewards have less than 1% of the prairie land cover category on the lands they manage. Approximately 79% of the prairie land cover category occurred on private lands.

Private land owners are responsible for the stewardship of approximately 77% of the wetland land cover category. Ten percent of the wetland land cover category occurred within the open water category (i.e., large reservoirs) of the stewardship vector. The USFWS has responsibility for 5.9% of the wetland land cover category. Two percent of wetlands occur within lands governed by the NASLT and 1.5% of the wetland occurred on NDSL. Thirteen stewards individually have responsibility for less than 1 % and together 3.5% of the wetland land cover category.

Sixty-nine percent of the shrubland land cover category occurred on private lands. The USFS, NATAT, and the NDSL manage approximately 13.4%, 6.5%, and 3.5 %, respectively, of the shrubland land cover category. The BLM, FWS, NPS, ACE and NASLT each have about 1% of the shrubland land cover category on lands they manage. Stewardship responsibilities for shrublands may be distorted due to shrubland omissions related to the difficulty mapping shrublands for some portions of the state (see Chapter 2).

Seventy percent of the woodland land cover category occurs on private lands. This figure is probably an overestimate of the proportion of natural woodlands on private land since many of the woodlands in ND are planted. The USFS, NATAT, NATMC, NDGF, USFWS and ACE are stewards for 7.2%, 6.1%, 2.9%, 2.5%, 2.0% and 1.4%, respectively, of the woodland land cover category. The ACE, NDGF, and the USFWS are stewards for 4.4%, 4.2%, and 2.8 %, respectively, of the floodplain woodland land cover category.

The sparse vegetation land cover category includes the badlands topography in western ND. Approximately 28.5% of the land cover category is managed by the USFS. The NDSL, NPS, BLM and the NATAT are stewards for 3.9%, 3.7%, 3.1% and 2.5% percent of the sparsely vegetated land cover category, respectively. Fifty-one percent of the sparsely vegetated land cover category is privately managed.

Six of the 32 detailed natural and semi-natural land cover categories have more than 50% of their area occurring in stewardship categories other than private. Four of these six land cover categories (Rocky Mountain juniper, limber pine, mixed conifer/ deciduous woodlands, and sparsely vegetated badlands) have distributions restricted to western ND. The two remaining land cover categories with less than 50% of their area occurring on private lands are riverine sparse vegetation and lacustrine wetland which have their greatest abundance in the open water category of the stewardship vector.

Table 5.1. Area (sq. km) of land cover categories by land stewards.

Land Cover Category	Land Stewards[1]																		
	BLM	BOR	FWS	NPS	USDA	ACE	NASRS	NATAT	NASLT	NATMC	NASWT	NDGF	NDO	NDSL	TNC	AUD	PRIVATE	WATER	LCSUM
prairie total	**61.29**	**2.66**	**605.50**	**71.21**	**2103.38**	**145.48**	**1626.69**	**700.16**	**171.25**	**47.53**	**22.79**	**130.15**	**23.85**	**1820.06**	**31.16**	**1.68**	**28211.70**	**3.15**	**35779.70**
wet- mesic tall grass prairie		0.07	48.76		42.81	2.41	27.10		20.87	11.08	4.11	13.16	2.42	43.71	3.42		1216.15	0.03	1436.10
mesic tall grass prairie			2.13		36.74						3.30	0.62	0.20	0.93	0.28		111.87		156.06
mesic tall and mixed grass prairie	5.69	0.23	8.06	6.43	168.52	10.46	54.03	78.90		0.29		4.89	0.92	100.50	1.00		1610.18	0.60	2050.72
bluestem-needlegrass-wheatgrass prairie	0.52	0.22	213.85	0.11	44.02	26.94	65.75	4.88	65.30	9.66	9.78	22.60	4.24	231.69	6.28	1.36	5175.61	0.71	5883.51
wheatgrass prairie	19.57	0.81	72.65	15.14	485.48	29.16	586.59	132.74	18.68	6.52	3.80	19.29	6.50	472.25	7.73	0.19	6414.37	0.39	8291.86
needlegrass prairie	10.21	0.54	137.28	17.20	423.00	30.43	293.34	254.51	34.63	8.23		19.74	3.86	430.46	3.55	0.13	5725.61	0.43	7393.16
little bluestem prairie	13.71	0.30	21.16	19.27	483.24	20.19	340.01	103.44	5.66	3.34		11.68	2.17	217.60	2.42		3048.12	0.29	4292.61
fescue prairie	0.03		29.53		0.00					0.45		0.36	0.00	48.68			364.86		443.90
sand prairie	11.44	0.23	36.92	12.84	417.53	21.87	160.46	124.84	12.10	5.13	1.80	21.71	2.48	214.28	3.99		3215.36	0.47	4263.45
saline prairire	0.13	0.26	35.16	0.21	2.05	4.01	99.41	0.86	14.00	2.82		16.08	1.06	59.97	2.50		1329.58	0.23	1568.33
shrubland total	**62.84**	**0.87**	**68.13**	**69.17**	**706.37**	**68.62**	**9.04**	**344.04**	**53.47**	**2.54**	**0.03**	**34.07**	**8.04**	**184.24**	**2.76**	**1.01**	**3634.53**	**15.41**	**5265.17**
upland deciduous shrubland	13.25	0.84	66.08	47.45	414.54	50.33	8.56	309.07	50.94	1.93		27.73	5.99	139.55	2.71	1.01	3148.71	2.37	4291.07
sagebrush shrubland	48.22	0.03	0.11	21.71	291.43	10.47		34.30		0.19		1.94	1.24	43.07			443.67	0.65	897.04
lowland deciduous shrubland	1.37		1.94	0.01	0.39	7.82	0.48	0.67	2.53	0.42	0.03	4.40	0.81	1.62	0.05		42.15	12.39	77.06
woodland total	**20.79**	**0.49**	**85.05**	**44.23**	**309.86**	**59.44**	**33.51**	**261.87**	**77.20**	**125.84**	**6.39**	**107.42**	**56.07**	**78.64**	**5.25**	**0.19**	**2988.25**	**16.64**	**4277.13**
ponderosa pine woodland	0.22				2.98								0.00	0.29			6.10		9.60
limber pine woodland					0.15								0.00				0.10		0.25
rocky mountain juniper woodland	4.69	0.06	0.17	15.60	81.79	4.69		16.46		0.00		0.91	0.87	8.55			58.56	0.12	192.47
mixed conifer and deciduous woodland	8.21	0.12	0.16	12.15	116.70	10.12		95.01		0.02		2.94	2.76	16.11			183.90	0.14	448.34
floodplain woodland	1.92		19.35	9.57	10.28	30.34	8.49	2.68	1.82	0.21	0.89	28.53	3.77	3.94	4.54		542.38	15.95	684.65
deciduous woodland	2.07	0.08	41.00	1.38	35.25	8.28	17.09	49.55	21.55	6.29	5.51	30.19	6.95	18.37	0.64	0.18	1356.35	0.35	1601.09
green ash woodland	3.67	0.23	1.08	5.54	62.70	4.71	0.38	98.16	2.16	0.18		4.17	1.01	12.61	0.00	0.00	300.87	0.06	497.52
aspen woodland			10.86			0.18	2.55		8.73	37.74		19.35	7.18	6.19	0.04		197.67	0.00	290.49
bur oak woodland			5.93			0.97	1.75		35.10	20.23		9.38	6.64	3.66	0.01	0.00	151.80	0.01	235.49
aspen and bur oak woodland			6.50			0.16	3.25		7.85	61.17		11.96	26.88	8.93	0.01		190.53	0.01	317.24
wetlands total	**3.30**	**4.84**	**954.95**	**5.71**	**88.27**	**82.31**	**56.86**	**98.74**	**323.21**	**42.55**	**27.82**	**136.41**	**14.24**	**239.29**	**10.57**	**1.00**	**12327.77**	**1640.83**	**16058.68**
Lacustrine wetlands	0.22	3.54	371.95	0.01	0.07	45.03	1.35	9.49	198.65	8.87	0.55	49.81	3.36	29.42	1.86	0.31	1106.51	1614.64	3445.63
Riverine wetlands	0.90	0.03	6.77	5.01	13.72	1.65	8.80	0.87	1.07	0.10	0.59	2.36	0.70	7.81	0.30		383.82	3.18	437.68
Paustrine temporary wetland	1.14	0.05	66.38	0.23	41.34	3.57	16.87	39.10	25.98	0.98	6.30	15.86	0.51	49.11	1.78	0.13	2814.95	1.49	3085.78
Palustrine seasonal wetland	0.40	0.36	91.08	0.02	24.77	6.64	21.76	41.43	38.77	18.13	6.90	18.09	6.14	83.16	2.51	0.16	4799.49	1.67	5161.48
Palustrine semipermanent wetland	0.30	0.08	357.51	0.02	4.34	13.17	7.38	7.39	34.87	13.92	10.81	41.21	3.20	54.32	2.92	0.18	2238.80	2.35	2792.75
water	0.35	0.78	61.26	0.42	4.04	12.25	0.68	0.46	23.86	0.54	2.67	9.08	0.33	15.48	1.21	0.22	984.20	17.51	1135.35
sparse vegetation total	**58.60**	**0.18**	**1.59**	**68.42**	**532.98**	**27.14**	**24.05**	**46.19**	**0.00**	**0.37**	**0.00**	**11.94**	**2.51**	**72.19**	**0.34**	**0.00**	**946.31**	**80.01**	**1872.81**
sparse vegetation - others	0.25	0.14	1.49	0.09	0.06	2.47	5.08	0.87		0.15		2.68	0.15	3.21	0.34		290.46	1.03	308.47
sparse vegetation - badlands	58.35	0.04	0.10	68.33	532.90	16.76	18.96	44.56		0.21		3.32	2.33	68.97			653.53	1.29	1469.65
sparse vegetation - riverine	0.00			0.00	0.02	7.91		0.76				5.94	0.03	0.01			2.32	77.70	94.69
cropland	4.23	0.90	162.91	8.50	117.45	32.80	342.46	1339.82	360.62	35.48	150.24	74.56	12.24	128.17	1.62	1.88	85431.76	2.62	88208.26
planted perrenial herbaceous cover	23.31	3.25	391.53	24.84	574.42	89.67	584.93	360.49	191.45	44.93	41.13	143.90	21.75	368.07	16.65	2.83	27635.23	6.08	30524.47
high intensity residental			0.10	0.00	0.01	1.58	0.51	0.74	0.17	0.20		0.00	0.07	0.03			85.87	0.02	89.28
low intensity residental	0.00		0.63	0.08	0.47	4.52	1.14	2.54	1.05	1.10		0.05	0.80	0.10			266.70	0.23	279.39
commercial/industrial/transportation	0.00	0.32	10.84	1.12	3.37	9.33	0.92	3.54	2.10	9.36	0.15	1.62	0.58	2.10	0.28	0.01	429.40	0.37	475.41
urban grasslands		0.67	0.18		0.02	17.32	0.01	1.10	0.03			0.04	0.04	0.10			88.87	0.10	108.47
STEWARD SUM	234.37	14.17	2281.41	293.28	4436.60	538.21	2680.10	3159.24	1180.54	309.89	248.56	640.16	140.19	2893.00	68.64	8.60	162046.38	1765.46	182938.77

[1]BLM-Bureau of Land Management, BOR-Bureau of Reclamation, FWS-U.S. Fish and Wildlife Service, NPS-National Park Service, ACE-Army Corps of Engineers, NASRS-Native American Standing Rock Sioux, NATAT-Native American Three Affiliated Tribes, NASLT-Native American Spirit Lake Tribe, NATMC-Native American Turtle Mountain Chippewa, NASWT-Native American Sisseton-Wahpeton Sioux Tribe, NDGF-North Dakota Game and Fish, ND0-Other ND state government agencies, NDSL-North Dakota School Lands, TNC-The Nature Conservancy, AUD-The Audubon Society, PRIVATE-private land owners, WATER-large water bodies included in the stewardship vector, LCSUM-sum of the area of the land cover category across stewards.

Table 5.2. Percent of land cover categories by land stewards.

	Land Stewards[1]																	
Land Cover Category	BLM	BOR	FWS	NPS	USDA	ACE	NASRS	NATAT	NASLT	NATMC	NASWT	NDGF	NDO	NDSL	TNC	AUD	PRIVATE	WATER
prairie total	**0.2**	**0.0**	**1.7**	**0.2**	**5.9**	**0.4**	**4.5**	**2.0**	**0.5**	**0.1**	**0.1**	**0.4**	**0.1**	**5.1**	**0.1**	**0.0**	**78.8**	**0.0**
wet- mesic tall grass prairie		0.0	3.4		3.0	0.2	1.9		1.5	0.8	0.3	0.9	0.2	3.0	0.2		84.7	0.0
mesic tall grass prairie			1.4		23.5						2.1	0.4	0.1	0.6	0.2		71.7	
mesic tall and mixed grass prairie	0.3	0.0	0.4	0.3	8.2	0.5	2.6	3.8		0.0		0.2	0.0	4.9	0.0		78.5	0.0
bluestem-needlegrass-wheatgrass prairie	0.0	0.0	3.6	0.0	0.7	0.5	1.1	0.1	1.1	0.2	0.2	0.4	0.1	3.9	0.1	0.0	88.0	0.0
wheatgrass prairie	0.2	0.0	0.9	0.2	5.9	0.4	7.1	1.6	0.2	0.1	0.0	0.2	0.1	5.7	0.1	0.0	77.4	0.0
needlegrass prairie	0.1	0.0	1.9	0.2	5.7	0.4	4.0	3.4	0.5	0.1		0.3	0.1	5.8	0.0	0.0	77.4	0.0
little bluestem prairie	0.3	0.0	0.5	0.4	11.3	0.5	7.9	2.4	0.1	0.1		0.3	0.1	5.1	0.1		71.0	0.0
fescue prairie	0.0		6.7							0.1		0.1		11.0			82.2	
sand prairie	0.3	0.0	0.9	0.3	9.8	0.5	3.8	2.9	0.3	0.1	0.0	0.5	0.1	5.0	0.1		75.4	0.0
saline prairire	0.0	0.0	2.2	0.0	0.1	0.3	6.3	0.1	0.9	0.2		1.0	0.1	3.8	0.2		84.8	0.0
shrubland total	**1.2**	**0.0**	**1.3**	**1.3**	**13.4**	**1.3**	**0.2**	**6.5**	**1.0**	**0.0**	**0.0**	**0.6**	**0.2**	**3.5**	**0.1**	**0.0**	**69.0**	**0.3**
upland deciduous shrubland	0.3	0.0	1.5	1.1	9.7	1.2	0.2	7.2	1.2	0.0		0.6	0.1	3.3	0.1	0.0	73.4	0.1
sagebrush shrubland	5.4	0.0	0.0	2.4	32.5	1.2		3.8		0.0		0.2	0.1	4.8			49.5	0.1
lowland deciduous shrubland	1.8		2.5	0.0	0.5	10.1	0.6	0.9	3.3	0.5	0.0	5.7	1.0	2.1	0.1		54.7	16.1
woodland total	**0.5**	**0.0**	**2.0**	**1.0**	**7.2**	**1.4**	**0.8**	**6.1**	**1.8**	**2.9**	**0.1**	**2.5**	**1.3**	**1.8**	**0.1**	**0.0**	**69.9**	**0.4**
ponderosa pine woodland	2.3				31.1									3.0			63.5	
limber pine woodland					60.2												39.8	
rocky mountain juniper woodland	2.4	0.0	0.1	8.1	42.5	2.4		8.6		0.0		0.5	0.5	4.4			30.4	0.1
mixed conifer and deciduous woodland	1.8	0.0	0.0	2.7	26.0	2.3		21.2		0.0		0.7	0.6	3.6			41.0	0.0
floodplain woodland	0.3		2.8	1.4	1.5	4.4	1.2	0.4	0.3	0.0	0.1	4.2	0.6	0.6	0.7		79.2	2.3
deciduous woodland	0.1	0.0	2.6	0.1	2.2	0.5	1.1	3.1	1.3	0.4	0.3	1.9	0.4	1.1	0.0	0.0	84.7	0.0
green ash woodland	0.7	0.0	0.2	1.1	12.6	0.9	0.1	19.7	0.4	0.0		0.8	0.2	2.5	0.0	0.0	60.5	0.0
aspen woodland			3.7			0.1	0.9		3.0	13.0		6.7	2.5	2.1	0.0		68.0	0.0
bur oak woodland			2.5			0.4	0.7		14.9	8.6		4.0	2.8	1.6	0.0	0.0	64.5	0.0
aspen and bur oak woodland			2.0			0.0	1.0		2.5	19.3		3.8	8.5	2.8	0.0		60.1	0.0
wetlands total	**0.0**	**0.0**	**5.9**	**0.0**	**0.5**	**0.5**	**0.4**	**0.6**	**2.0**	**0.3**	**0.2**	**0.8**	**0.1**	**1.5**	**0.1**	**0.0**	**76.8**	**10.2**
Lacustrine wetlands	0.0	0.1	10.8	0.0	0.0	1.3	0.0	0.3	5.8	0.3	0.0	1.4	0.1	0.9	0.1	0.0	32.1	46.9
Riverine wetlands	0.2	0.0	1.5	1.1	3.1	0.4	2.0	0.2	0.2	0.0	0.1	0.5	0.2	1.8	0.1		87.7	0.7
Paustrine temporary wetland	0.0	0.0	2.2	0.0	1.3	0.1	0.5	1.3	0.8	0.0	0.2	0.5	0.0	1.6	0.1	0.0	91.2	0.0
Palustrine seasonal wetland	0.0	0.0	1.8	0.0	0.5	0.1	0.4	0.8	0.8	0.4	0.1	0.4	0.1	1.6	0.0	0.0	93.0	0.0
Palustrine semipermanent wetland	0.0	0.0	12.8	0.0	0.2	0.5	0.3	0.3	1.2	0.5	0.4	1.5	0.1	1.9	0.1	0.0	80.2	0.1
water	0.0	0.1	5.4	0.0	0.4	1.1	0.1	0.0	2.1	0.0	0.2	0.8	0.0	1.4	0.1	0.0	86.7	1.5
sparse vegetation total	**3.1**	**0.0**	**0.1**	**3.7**	**28.5**	**1.4**	**1.3**	**2.5**		**0.0**		**0.6**	**0.1**	**3.9**	**0.0**		**50.5**	**4.3**
sparse vegetation - others	0.1	0.0	0.5	0.0	0.0	0.8	1.6	0.3		0.1		0.9	0.0	1.0	0.1		94.2	0.3
sparse vegetation - badlands	4.0	0.0	0.0	4.6	36.3	1.1	1.3	3.0		0.0		0.2	0.2	4.7			44.5	0.1
sparse vegetation - riverine	0.0			0.0	0.0	8.4		0.8				6.3	0.0	0.0			2.5	82.1
cropland	0.0	0.0	0.2	0.0	0.1	0.0	0.4	1.5	0.4	0.0	0.2	0.1	0.0	0.1	0.0	0.0	96.9	0.0
planted perrenial herbaceous cover	0.1	0.0	1.3	0.1	1.9	0.3	1.9	1.2	0.6	0.1	0.1	0.5	0.1	1.2	0.1	0.0	90.5	0.0
high intensity residental			0.1	0.0	0.0	1.8	0.6	0.8	0.2	0.2		0.0	0.1	0.0			96.2	0.0
low intensity residental	0.0		0.2	0.0	0.2	1.6	0.4	0.9	0.4	0.4		0.0	0.3	0.0			95.5	0.1
commercial/industrial/transportation	0.0	0.1	2.3	0.2	0.7	2.0	0.2	0.7	0.4	2.0	0.0	0.3	0.1	0.4	0.1	0.0	90.3	0.1
urban grasslands		0.6	0.2		0.0	16.0	0.0	1.0	0.0			0.0	0.0	0.1			81.9	0.1

[1]See Table 5.1 for acronyms.

Careful inspection of the data in Tables 5.1 and 5.2 by an observer familiar with the vegetation of ND will reveal limitations of the land cover map (see Chapter 2). An example is the omission of aspen, bur oak and aspen-bur oak woodlands on lands managed by the BLM, USFS, NPS, and NATAT in western ND. As explained in the land cover chapter, these woodland land cover categories were not individually mapped for path 34 rows 26, 27 or 28 due to spectral confusion among the forest types and the small amount of training data available for these types. These woodland land cover categories are combined into a single generic deciduous woodland land cover category for that portion of the land cover map. We observed stands of aspen and bur oak woodlands on lands managed by the USFS and the NATAT during collection of data for the accuracy assessment of the land cover map and aspen woodlands have been mapped for Theodore Roosevelt National Park (Von Loh et al. 2002).

Land Cover Analysis by Management Status Categories

Five of the 32 detailed natural and semi-natural land cover categories have more than 10% of their total area on lands classified as status 1 or 2 (Table 5.3). Sixty percent of the limber pine woodlands in ND are managed as a special interest area by the USFS. Twenty-three percent of the area mapped as ponderosa pine woodland occurs on Research Natural Areas or Special Interest Areas managed by the USFS. Twenty-four percent of the area mapped as mesic tall grass prairie occurs on lands classified as status 1 or 2 with the USFS Sheyene National Grassland, the USFWS, and the TNC responsible for 95%, 4%, and 1% of these lands, respectively. Fourteen percent of the area mapped as Rocky Mountain juniper occurs on lands classified as status 1 or 2 with the NPS and USFS having responsibly for 60% and 39% of these lands, respectively. Twelve percent of lacustrine wetlands occur on lands classified as status 1 and 2 with the USFWS responsible for more than 99% of these wetlands.

Four natural vegetation land cover categories have more than 5% but less than 10% of their area on lands classified as status 1 or 2. These four land cover categories include fescue prairie, mixed conifer/deciduous woodland, palustrine semipermanent wetland, and sparse vegetation-badlands. Twenty natural vegetation land cover categories have more than 1% but less than 5% of their area on lands classified as status 1 or 2. Only one natural vegetation land cover category, saline prairie, has less than 1% of its area (0.9%) on lands classified as status 1 and 2. The table indicates small amounts of cropland, planted perennial herbaceous vegetation, and transportation land cover categories on lands classified as status 1 and 2. Most of these areas are errors in the land cover map. For example, areas mapped as cropland within Theodore Roosevelt National Park are actually prairie dog towns or sparsely vegetated badlands.

Table 5.3 Area (sq. km) and percent of land cover categories by four management status categories.

Land cover category	Status 1		Status 2		Percent in status 1 + 2	Status 3		Status 4		Total area km^2
	km^2	%	km^2	%		km^2	%	km^2	%	
prairie	**96.53**	**0.3**	**638.71**	**1.8**	**2.1**	**2419.21**	**6.8**	**32625.25**	**91.2**	**35779.70**
wet-mesic tall grass prairie	1.59	0.1	66.80	4.7	4.8	44.61	3.1	1323.11	92.1	1436.10
mesic tall grass prairie	0.75	0.5	36.76	23.6	24.0	2.46	1.6	116.09	74.4	156.06
mesic tall and mixed grass prairie	8.14	0.4	14.08	0.7	1.1	183.81	9.0	1844.69	90.0	2050.72
bluestem-needlegrass-wheatgrass prairie	1.74	0.0	144.79	2.5	2.5	157.09	2.7	5579.89	94.8	5883.51
wheatgrass prairie	20.73	0.3	83.72	1.0	1.3	551.46	6.7	7635.94	92.1	8291.86
needlegrass prairie	21.01	0.3	123.05	1.7	1.9	496.91	6.7	6752.18	91.3	7393.16
little bluestem prairie	23.20	0.5	40.95	1.0	1.5	510.21	11.9	3718.24	86.6	4292.61
fescue prairie		0.0	23.87	5.4	5.4	6.04	1.4	413.99	93.3	443.90
sand prairie	18.73	0.4	91.08	2.1	2.6	419.41	9.8	3734.23	87.6	4263.45
saline prairie	0.64	0.0	13.61	0.9	0.9	47.21	3.0	1506.88	96.1	1568.33
shrubland	**84.58**	**1.6**	**59.59**	**1.1**	**2.7**	**874.38**	**16.7**	**4246.62**	**80.7**	**5265.17**
upland deciduous shrubland	57.63	1.3	42.90	1.0	2.3	525.97	12.3	3664.56	85.4	4291.07
sagebrush shrubland	26.87	3.0	15.86	1.8	4.8	332.56	37.1	521.74	58.2	897.04
lowland deciduous shrubland	0.07	0.1	0.83	1.3	1.4	15.84	24.5	60.31	78.3	77.06
woodland	**63.81**	**1.5**	**94.89**	**2.2**	**3.7**	**529.20**	**12.4**	**3589.23**	**83.9**	**4277.13**
ponderosa pine woodland	2.17	22.6	0.01	0.1	22.7	1.03	10.7	6.39	66.6	9.60
limber pine woodland	0.15	60.2		0.0	60.2		0.0	0.10	39.8	0.25
rocky mountain juniper woodland	21.09	11.0	4.89	2.5	13.5	82.84	43.1	83.65	43.5	192.47
Mixed conifer and deciduous woodland	19.03	4.2	6.75	1.5	5.8	127.53	28.5	295.02	65.8	448.34
floodplain woodland	10.29	1.5	18.85	2.8	4.4	79.29	11.9	576.22	84.2	684.65
green ash woodland	7.35	1.5	3.65	0.7	2.2	72.12	14.5	414.69	83.3	497.81
deciduous woodland	3.63	0.2	44.55	2.8	3.0	77.08	4.8	1475.53	92.2	1600.80
aspen woodland	0.01	0.0	8.29	2.9	2.9	29.31	10.1	252.88	87.1	290.49
bur oak woodland	0.09	0.0	4.55	1.9	2.0	17.84	7.6	213.01	90.5	235.49
aspen and bur oak woodland		0.0	3.34	1.1	1.1	42.16	13.3	271.74	85.7	317.24
wetlands	**9.44**	**0.1**	**508.08**	**3.5**	**3.6**	**777.79**	**5.4**	**14763.37**	**91.9**	**16058.68**
lacustrine wetlands	0.01	0.0	217.64	11.9	11.9	257.14	14.0	2970.84	86.2	3445.63
riverine wetlands	4.86	1.1	5.96	1.4	2.5	20.61	4.7	406.24	92.8	437.68
palustrine temporary wetland	2.26	0.1	59.31	1.9	2.0	68.16	2.2	2956.05	95.8	3085.78
palustrine seasonal wetland	1.55	0.0	53.65	1.0	1.1	93.57	1.8	5012.71	97.1	5161.48
palustrine semipermanent wetland	0.05	0.0	147.19	5.3	5.3	273.77	9.8	2371.75	84.9	2792.75
water	0.71	0.1	24.33	2.2	2.2	64.54	5.8	1045.77	92.1	1135.35
sparse vegetation	**86.74**	**4.8**	**23.95**	**1.3**	**6.2**	**593.17**	**33.1**	**1168.95**	**62.4**	**1872.81**
sparse vegetation - others	0.00	0.0	0.31	0.1	0.1	7.36	2.4	300.80	97.5	308.47
sparse vegetation - badlands	86.74	5.9	23.64	1.6	7.5	571.87	38.9	787.41	53.6	1469.65
sparse vegetation - riverine		0.0		0.0	0.0	13.95	82.1	80.74	85.3	94.69
cropland	8.92	0.0	46.39	0.1	0.1	353.41	0.4	87799.54	99.5	88208.26
planted perrenial herbaceous cover	30.23	0.1	180.99	0.6	0.7	1072.63	3.5	29240.62	95.8	30524.47
high intensity residental	0.00	0.0	0.01	0.0	0.0	0.23	0.3	89.04	99.7	89.28
low intensity residental	0.08	0.0	0.07	0.0	0.1	3.17	1.1	276.07	98.8	279.39
commercial/industrial/transportati	0.89	0.2	7.66	1.6	1.8	11.04	2.3	455.83	95.9	475.41
urban grasslands		0.0	0.04	0.0	0.0	0.99	0.9	107.44	99.1	108.47
										182938.77

Vertebrate Distribution Analysis by Management Status Categories

A summary table is not provided due to the large number of species analyzed, but some generalizations and examples of species results by the various thresholds discussed in the chapter introduction are provided below. The complete vertebrate species distribution analysis table in Appendix 5.1 provides the area in hectares of the species' mapped distribution by status category, and the percent of the species' total distribution in each category. For example, the Burrowing Owl has 54,892 ha of potential habitat in lands that are ranked Status 1 or Status 2, which represents 1.7 % of that species' potential distribution.

Species with <1% of potential distribution in status 1 or 2 lands: 62 species total; 1 amphibian, 37 birds, 21 mammals, 3 reptiles. – Some of these are common species, e.g., sharp-tailed grouse, killdeer, white-tailed deer, coyote, red fox, and plains garter snake, which have large ranges and use a variety of habitats. The low percent of protected habitats is a reflection of the high percentage of ND that is privately owned. Other species such as McCown's longspur, Nashville warbler, purple finch, Ord's kangaroo rat, hispid pocket mouse, and eastern spotted skunk are near the edge of their range in ND. The false map turtle and midland smooth softshell turtle have distributions limited to the lower Missouri River in ND. None of their predicted habitat is protected in status 1 and 2 lands but 15–20% of their predicted distribution is in lands classified as status 3. These species may be negatively affected by unnatural stream flows since the creation of dams on the river. Five species, Franklin's gull, chestnut-collared longspur, grasshopper sparrow, Swainson's hawk, and lark bunting are members of a list of 25 species identified by the ND Game and Fish Department as having a high level of conservation priority.

Species with 1-5% of potential distribution in status 1 or 2 lands: 194 species total; 10 amphibians, 128 birds, 47 mammals, 9 reptiles. – This range of protection status includes 67% of the breeding terrestrial vertebrates in ND. Forty-three of these species were identified as having high (n=19) and moderate (n=24) levels of conservation concern by the ND Game and Fish Department. Particularly notable among these is the least tern, an endangered species, with 2.3% of its predicted habitat in status 1 or 2 lands.

Species with 5-10% of potential distribution in status 1 or 2 lands: 22 species total; 17 birds, 3 mammals, 2 reptiles. – Many of the bird species are associated with lacustrine and semi-permanent wetlands (e.g., American white pelican, pied-billed grebe, canvasback) or with woody borders of wetlands (e.g., northern waterthrush, belted kingfisher) that are well represented on National Wildlife Refuges. The long-eared myotis, Nutalls's cottontail, and bushy-tailed woodrat, and northern sagebrush lizard have distributions limited to western ND where the largest amount of public lands in status 1 and 2 occur. The common snapping turtle is associated with lacustrine and semi-permanent wetlands.

Species with l0%-20% of potential distribution in status 1 or 2 lands: 1 species total; 1 bird species. – The bufflehead is a small cavity-nesting duck associated with lacustrine

and semi-permanent wetlands that are well represented on National Wildlife Refuges within its limited breeding distribution in ND.

Species with 20% -<50% of potential distribution in status 1 or 2 lands: 2 species total; 1 bird, 1 reptile. – The red-breasted nuthatch is a rare and irregular species in ND associated with ponderosa pine woodlands a portion of which are managed as a Research Natural Area by the USFS. The northern prairie skink is associated with sandy areas in the eastern one-third of ND which includes Research Natural Areas in the Sheyene National Grasslands.

Species with at least 50% of potential distribution in status 1 and 2 lands: None

Species of Concern in ND

The US Fish and Wildlife Service have listed 23 vertebrate species that occur in ND as candidate, threatened or endangered species.

Birds
- Least Tern (*Sterna antillarum*)
- Bald Eagle (*Haliaeetus leucocephalus*)
- Whooping Crane (*Grus americana*)
- Peregrine Falcon (*Falco peregrinus anatum*)
- Piping Plover (*Charadrius melodus*)
- Western Burrowing Owl (*Athene cunicularia hypugea*)
- Black Tern (*Chlidonias niger*)
- Baird's Sparrow (*Ammodramus bairdii*)
- Northern Goshawk (*Accipiter gentilis*)
- Loggerhead Shrike (*Lanius ludovicianus*)
- Ferruginous Hawk (*Buteo regalis*)

Reptiles
- False Map Turtle (*Graptemys pseudogeographica pseudogeographica*)
- Eastern Short-Horned Lizard (*Phrynosoma douglassii brevirostra*)
- Northern Sagebrush Lizard (*Sceloporus graciosus graciosus*)

Mammals
- Black-Footed Ferret (*Mustela nigripes*) (currently extirpated)
- Gray Wolf (*Canis lupus*) (currently extirpated but transient)
- Swift Fox (*Vulpes velox*) (currently extirpated)
- Lynx (*Felis lynx*) (currently extirpated but transient)
- Wolverine (*Gulo gulo*) (currently extirpated)
- Pale Townsend's Big-Eared Bat (*Plecotus townsendii pallescens*)
- Long-Eared Myotis (*Myotis evotis*)
- Long-Legged Myotis (*Myotis volans*)
- Small-Footed Myotis (*Myotis ciliolabrum*)

The ND Game and Fish Department recently compiled a list of 100 species of concern (Dyke et al. 2004). Twenty-five terrestrial vertebrate species were listed as having a high level of conservation priority because of declining status either in ND or across their range, or because ND constituted the core of the species' breeding range and non-State Wildlife Grant funding is not readily available for them.

Birds

- Horned Grebe (*Podicips auritus*)
- American White Pelican (*Pelecanus erythrorhynchos*)
- American Bittern (*Botaurus lentiginosus*)
- Swainson's Hawk (*Buteo swainsoni*)
- Ferruginous Hawk (*Buteo regalis*)
- Yellow Rail (*Coturnicops noveboracensis*)
- Willet (*Catoptrophorus semipalmatus*)
- Upland Sandpiper (*Bartramia longicauda*)
- Long-Billed Curlew (*Numenius americanus*)
- Marbled Godwit (*Limosa fedoa*)
- Wilson's Phalarope (*Phalaropus tricolor*)
- Franklin's Gull (*Larus pipixcan*)
- Black Tern (*Chlidonias niger*)
- Black-Billed Cuckoo (*Coccyzus erythrophalmus*)
- Sprague's Pipit (*Anthus spragueii*)
- Grasshopper Sparrow (*Ammodramus savannarum*)
- Baird's Sparrow (*Ammodramus bairdii*)
- Nelson's Sharp-Tailed Sparrow (*Ammodramus nelsoni*)
- Lark Bunting (*Calamospiza melanocorys*)
- Chesnut-Collared Longspur (*Calcarius ornatus*)

Herptiles

- Canadian Toad (*Bufo hemiophrys*)
- Plains Spadefoot Toad (*Scaphiopus bombifrons*)
- Smooth Green Snake (*Opheodrys vernalis*)
- Western Hognose Snake (*Heterodon nasicus*)

Mammals

- Black-Tailed Prairie Dog (*Cynomys ludovicianus*)

Limitations and Discussion

A basic assumption of the analysis is that processes important to species, community, and ecosystem representation and persistence are correlated in a predictable way with status rankings. This assumption is untested. Some of the areas assigned to status 1 and 2 have small spatial extents and the full complement of ecosystem processes may not occur naturally in these areas. The analysis based on stewardship and management status did not consider the connectedness and juxtaposition of stewardship lands.

We were not able to include digital data for the distribution and spatial extent of private land easements in the stewardship vector. Thus, the analysis does not include the contribution of private land easements to the conservation of natural land cover categories and vertebrate species.

From a more technical perspective, it is critical that the following limitations are considered when using the results of our analyses: 1) the limitations described for each of the component parts (land cover mapping, animal species mapping, stewardship mapping) of the analyses, 2) the spatial accuracy and thematic accuracy of the components, and 3) the suitability of the results for the intended application (see Product Use and Availability Chapter). Refer to Chapters 2, 3, and 4 and the Limitations and Discussions sections of those Chapters for more information.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

On the 200th anniversary of the Lewis and Clark Expedition, there is no place in the Northern Great Plains where one can see the vast herbivore concentrations and associated carnivores described in the stories of Native Americans or the writing of Lewis and Clark and other early explorers. In ND, most of the natural prairie has been converted to cropland, tens of thousand of wetlands have been drained and farmed, and magnificent stands of floodplain forest along the Missouri and other rivers have been greatly reduced by water development projects and agriculture. Natural ecological processes have been greatly modified or eliminated by changes in the configuration of the landscape and the composition of the biota. The disruption of natural ecological processes is so great that temperate prairies may be North America's most endangered biome.

The conservation of biodiversity in the Northern Great Plains is a huge challenge both scientifically and socially (Johnson et al. 1994, Sieg et al. 1999). At a minimum, the challenge is to preserve and manage the small amount of remaining natural land cover and to sustain viable populations of the remaining endemic and native species while critical resources for their survival fluctuate in response to climatic, ecological, social, and economic forces. The evolution of prairie ecosystems took place under climates with periodic droughts, herbivory, and fire that resulted in spatial and temporal variability in the relative importance of limiting factors such as water, nutrients, and light. This dynamic environment forms the template for a complex web of biological interactions including competition, predation and mutualism. Ultimately the biodiversity of prairie ecosystems depends on the continued operation of these ecological processes at many temporal, spatial, and organizational scales (Huston 1994).

A strategy for conservation of biodiversity requires decisions of what is to be sustained, at what level, for how long, by whom, and for whom (Moir and Mowrer 1994). Before biodiversity conservation strategies can succeed, clear quantifiable objectives must be defined and evaluation methods developed (Johnson et al. 1994). The geospatial datasets for actual land cover, potential vertebrate species distributions, and land stewardship created by the ND-GAP provide an excellent starting point for land managers, planners, scientists, and policy makers to develop proactive habitat-based conservation plans. Conservation plans that take into consideration the overlapping habitat requirements of multiple species within functional communities and ecosystems (i.e., consideration of ecological and evolutionary processes) are a logical step towards the conservation of biodiversity given our incomplete knowledge of the subject (Noss et al. 1997). The geospatial framework should facilitate coordination of disparate habitat conservation efforts to affect unified, comprehensive conservation actions to reduce the impacts of the myriad of anthropogenic threats that fragment habitats.

Area requirements and habitat fragmentation effects are poorly understood for grassland bird species (Johnson 2001; Johnson and Igl 2001) and largely unknown for other less-studied animal and plant species in the Northern Great Plains (Sovada et al 2000). Wildlife investigations of lands enrolled in the Conservation Reserve Program have demonstrated the importance of matrix habitat quality, landscape composition, and landscape configuration for waterfowl and grassland birds (Johnson 2000, Reynolds et al. 2001). There are no simple answers to the design of landscape configurations for biodiversity conservation. Approaches that scale species attributes (e.g., area requirements, dispersal ability, resource acquisition strategies) to realistic landscape representations (e.g., multiple land cover categories with temporal and spatial variation in habitat quality) will be needed (Lambeck 1997, Vos et al. 2001, Jonzen et al. 2004, Wiegand et al. 2005).

Most of the remaining natural land cover in ND exists as relatively small, isolated patches. The State of North Dakota manages 1.29 km^2 of lands as research biological areas (protection status 1), 785 km^2 as wildlife management areas, state parks and forests (protection status 3) and 2905 km^2 of school lands (protection status 4). The Federal Government manages 1888 km^2 as wilderness areas, national parks, national wildlife refuges, waterfowl production areas, research natural areas, and tallgrass prairie restoration areas (protection status 1 or 2), and 5918 km^2 as multiple use lands (status 3). Non-Profit Conservation organizations manage 59.58 km^2 as nature preserves (protection status 1 or 2) and 18 km^2 (protection status 3).

With more than 90% of ND in private ownership, a major challenge facing biodiversity conservation is learning how to achieve desired goals compatible with and supported by local residents and private landowners (Clark 1996). Developing actions that foster a healthy environment and a healthy economy will be critical to success. A growing body of literature demonstrates there is not a trade-off of environmental amenities and economic development and in fact environmental amenities play a significant role in people's decision to move and establish businesses in an area. A lack of natural amenities that support recreation and eco-tourism corresponded to rapid loss of population from rural counties in the United States during 1970-2000 (McGanahan and Beale 2002, McGranahan 1999). Studies also have found that communities located near natural areas have healthier economies than communities that are not so located (Rudzitis and Johansen 1991, Rasker and Hackman 1996). Natural areas generate economic activity by attracting and retaining residents including business owners and retirees who want to be located near natural areas for recreation and attracting tourists and recreationists. In some high-amenity areas, growth has been so rapid that the challenge is not economic development but growth management (Theobald 2001).

Success in biodiversity conservation and restoration will depend upon the skilled presentation of conservation opportunities. Positive incentives, local leadership, and public participation are important characteristics for successful conservation programs (Anonymous 2001). The private sector can be drawn to habitat-based conservation planning by stream-lined regulations and providing a clear picture of future obligations

(Noss et al. 1997). By fulfilling the needs of many species at once, habitat-based conservation planning may keep some species off the endangered species list.

PRODUCT USE AND AVAILABILITY

How to Obtain the Products

It is the goal of the Gap Analysis Program and the USGS Biological Resources Division (BRD) to make the data and associated information as widely available as possible. Use of the data requires specialized software called geographic information systems (GIS) and substantial computing power. Additional information on how to use the data or obtain GIS services is provided below and on the GAP home page (URL below). While a CD-ROM of the data will be the most convenient way to obtain the data, it may also be downloaded via the Internet from the national GAP home page at:

http://www.gap.uidaho.edu/

The home page will also provide, over the long term, the status of our state's project, future updates, data availability, and contacts. Within a few months of this project's completion, CD-ROMs of the final report and data should be available at a nominal cost--the above home page will provide ordering information. To find information on the ND-GAP project's status and data, follow the links to "Current Projects" and then to the particular state of interest.

Disclaimer

Following is the official Biological Resources Division (BRD) disclaimer as of 29 January 1996, followed by additional disclaimers from GAP. Prior to using the data, you should consult the GAP home page (see How to Obtain the Products, above) for the current disclaimer.

Although these data have been processed successfully on a computer system at the BRD, no warranty expressed or implied is made regarding the accuracy or utility of the data on any other system or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data. It is strongly recommended that these data are directly acquired from a BRD server [see above for approved data providers] and not indirectly through other sources which may have changed the data in some way. It is also strongly recommended that careful attention be paid to the content of the metadata file associated with these data. The Biological Resources Division shall not be held liable for improper or incorrect use of the data described and/or contained herein.

These data were compiled with regard to the following standards. Please be aware of the limitations of the data. These data are meant to be used at a scale of 1:100,000 or smaller (such as 1:250,000 or 1:500,000) for the purpose of assessing the conservation status of animals and vegetation types over large geographic regions. The data may or may not have been assessed for statistical accuracy. Data evaluation and improvement may be ongoing. The Biological Resources Division makes no claim as to the data's suitability for other purposes. This is writable data which may have been altered from the original product if not obtained from a designated data distributor identified above.

Minimum GIS System Required for Data Use

The land cover and vertebrate species predicted habitats are in ArcGIS GRID format. All other GIS data are in ArcGIS vector format. These data may be successfully used with ESRI ArcGIS 8.x or other software that can import these formats.

Metadata

Proper documentation of information sources and processes used to assemble GAP data layers is central to the successful application of GAP data. Metadata documents the legacy of the data for new users. The Federal Geographic Data Committee (FGDC 1994, 1995) has published standards for metadata and NBII (<http://www.nbii.gov>) has updated those standards to include biological profiles. Executive Order 12906 requires that any spatial data sets generated with federal dollars will have FGDC-compliant metadata. Each spatial data layer provided is accompanied by its metadata.

Appropriate and Inappropriate Use of These Data

All information is created with a specific end use or uses in mind. This is especially true for GIS data, which is expensive to produce and must be directed to meet the immediate program needs. For GAP, minimum standards were set (see A Handbook for Gap Analysis, Scott et al. 1993) to meet program objectives. These standards include: scale or resolution (1:100,000 or 100 hectare minimum mapping unit), accuracy (80% accurate at 95% confidence), and format (ARC/INFO coverage tiled to the 30' x 60' USGS quadrangle).

Recognizing, however, that GAP would be the first, and for many years likely the only, source of statewide biological GIS maps, the data were created with the expectation that they would be used for other applications. Therefore, we list below both appropriate and inappropriate uses. This list is in no way exhaustive but should serve as a guide to assess whether a proposed use can or cannot be supported by GAP data. For most uses, it is unlikely that GAP will provide the only data needed, and for uses with a regulatory outcome, field surveys should verify the result. In the end, it will be the responsibility of each data user to determine if GAP data can answer the question being asked, and if they are the best tool to answer that question.

Scale: First we must address the issue of appropriate scale to which these data may be applied. The data were produced with an intended application at the ecoregion level, that

is, geographic areas from several hundred thousand to millions of hectares in size. The data provide a coarse-filter approach to analysis, meaning that not every occurrence of every plant community or animal species habitat is mapped, only larger, more generalized distributions. The data are also based on the USGS 1:100,000 scale of mapping in both detail and precision. When determining whether to apply GAP data to a particular use, there are two primary questions: do you want to use the data as a map for the particular geographic area, or do you wish to use the data to provide context for a particular area? The distinction can be made with the following example: You could use GAP land cover to determine the approximate amount of oak woodland occurring in a county, or you could map oak woodland with aerial photography to determine the exact amount. You then could use GAP data to determine the approximate percentage of all oak woodland in the region or state that occurs in the county, and thus gain a sense of how important the county's distribution is to maintaining that plant community.

Appropriate Uses: The above example illustrates two appropriate uses of the data: as a coarse map for a large area such as a county, and to provide context for finer-level maps. Specific case-study examples are provided in appendix 7.1, but following is a general list of applications:

- Statewide biodiversity planning
- Regional (Councils of Government) planning
- Regional habitat conservation planning
- County comprehensive planning
- Large-area resource management planning
- Coarse-filter evaluation of potential impacts or benefits of major projects or plan initiatives on biodiversity, such as utility or transportation corridors, wilderness proposals, regional open space and recreation proposals, etc.
- Determining relative amounts of management responsibility for specific biological resources among land stewards to facilitate cooperative management and planning.
- Basic research on regional distributions of plants and animals and to help target both specific species and geographic areas for needed research.
- Environmental impact assessment for large projects or military activities.
- Estimation of potential economic impacts from loss of biological resource-based activities.
- Education at all levels and for both students and citizens.

~~Inappropriate Uses:~~ It is far easier to identify appropriate uses than inappropriate ones, however, there is a "fuzzy line" that is eventually crossed when the differences in resolution of the data, size of geographic area being analyzed, and precision of the answer required for the question are no longer compatible. Examples include:

- Using the data to map small areas (less than thousands of hectares), typically requiring mapping resolution at 1:24,000 scale and using aerial photographs or ground surveys.
- Combining GAP data with other data finer than 1:100,000 scale to produce new hybrid maps or answer queries.
- Generating specific areal measurements from the data finer than the nearest thousand hectares (minimum mapping unit size and accuracy affect this precision).

- Establishing exact boundaries for regulation or acquisition.
- Establishing definite occurrence or non-occurrence of any feature for an exact geographic area (for land cover, the percent accuracy will provide a measure of probability).
- Determining abundance, health, or condition of any feature.
- Establishing a measure of accuracy of any other data by comparison with GAP data.
- Altering the data in any way and redistributing them as a GAP data product.
- Using the data without acquiring and reviewing the metadata and this report.

GLOSSARY OF ACRONYMS

ACE Army Corps of Engineers
AML ARC/INFO Macro Language
AUD The Audubon Society
BLM Bureau of Land Management
BOR Bureau of Reclamation
CDC Conservation Data Center
EPA Environmental Protection Agency
EROS National Center for Earth Resources Observation and Science
ESRI Environmental Systems Research Institute
FGDC Federal Geographic Data Committee
FTP file transfer protocol
GAP Gap Analysis Program
GIS Geographic Information System
GPS Global Positioning System
MIPS Map and Image Processing System
MOU Memorandum of Understanding
MMU Minimum mapping unit
NRCS Natural Resources Conservation Service
MRLC Multi-Resolution Land Characteristics Consortium
MSS Multi-Spectral Scanner
NALC North American Landscape Characterization (USEPA, USGS)
NASLT Native American Spirit Lake Tribe
NASRS Native American Standing Rock Sioux
NASWT Native American Sisseton-Wahpeton Sioux Tribe
NATAT Native American Three Affiliated Tribes
NATMC Native American Turtle Mountain Chippewa
NBII National Biological Information Infrastructure
NBS National Biological Service
NDGF North Dakota Game and Fish
NDSL North Dakota School Lands
NMD National Mapping Division
NPS National Park Service
NSDI National Spatial Data Infrastructure
NWI National Wetlands Inventory (USFWS)
OMB Office of Management and Budget (Administration)
SDTS Spatial Data Transfer Standard
RMSE Root mean square error
TIGER Topologically Integrated Geographic Encoding and Referencing system
TM Thematic Mapper
TNC The Nature Conservancy
UNESCO United Nations Educational, Scientific, and Cultural Organization
URL Universal Resource Locator

USDA United States Department of Agriculture
USFS US Forest Service
USFWS US Fish & Wildlife Service
UTM Universal Transverse Mercator
WHR Wildlife-habitat relationships

GLOSSARY OF TERMS

aerial videography - video images of the land surface taken from an airplane

algorithm - a procedure to solve a problem or model a solution (In GAP typically refers to a GIS procedure used to model animal distributions.)

alliance level - a land unit made up of an "alliance" of natural communities that have the same dominant or co-dominant plant species or, in the absence of vegetation, by the dominant land cover typically described according to the Anderson land cover classification (see "Natural Community Alliance" in Grossman et al. 1995)

alpha diversity - a single within-habitat measure of species diversity regardless of internal pattern, generally over an area of 0.1 to 1,000 hectares (see Whittaker 1960, 1977) -

Anderson Level II - the second hierarchical level in the Anderson land cover classification system (see Anderson et al. 1976)

anthropogenic - caused by man

assemblages - a group of ecologically interrelated plant and animal species

band, spectral - a segment of the electromagnetic spectrum defined by a range of wavelengths (e.g. blue, green, red, near infrared, far infrared) that comprise the Landsat TM imagery

beta diversity - the change in species diversity among different natural communities of a landscape; an index of between-habitat diversity (see Whittaker 1960, 1977)

biodiversity - generally, the variety of life and its interrelated processes

biogeographic - relating to the geographical distribution of plants and animals

biological diversity - see biodiversity

cartographic - pertaining to the art or technique of making maps or charts

classify - to assign objects, features, or areas on an image to spectral classes based upon their appearance as opposed to ‘classification’ referring to a scheme for describing the hierarchies of vegetation or animal species for an area

coarse filter - the general conservation activities that conserve the common elements of the landscape matrix, as opposed to the "fine filter" conservation activities that are aimed at special cases such as rare elements (see Jenkins 1985)

community - a group of interacting plants and animals

cover type - a non-technical higher-level floristic and structural description of vegetation cover

cross-walking - matching equivalent land cover categories between two or more classification systems

delineate - identifying the boundaries between more or less homogenous areas on remotely sensed images as visible from differences in tone and texture

delta diversity - the change in species diversity between landscapes along major climatic or physiographic gradients (see Whittaker 1977)

digitization - entering spatial data digitally into a Geographic Information System

ecoregion - a large region, usually spanning several million hectares, characterized by having similar biota, climate, and physiography (topography, hydrology, etc).

ecosystem - a biological community (ranging in scale from a single cave to millions of hectares), its physical environment, and the processes through which matter and energy are transferred among the components

edge-matching - the process of connecting polygons at the boundary between two independently created maps, either between TM scenes or between state GAP data sets

element - a plant community or animal species mapped by GAP. May also be referred to as "element of biodiversity".

error of commission - the occurrence of a species (or other map category) is erroneously predicted in an area where it is in fact absent

error of omission - when a model fails to predict the occurrence of a species that is actually present in an area

exact set coverage - a basic optimization problem to determine the best method for identifying general areas that, when selected sequentially, would have the greatest positive cumulative impact on attaining adequate representation of any or all biotic elements of interest

extinction - disappearance of a species throughout its entire range

extirpation - disappearance of a species from part of its range

fine filter - see "coarse filter"

floristic - pertaining to the plant species that make up the vegetation of a given area.

formation level - the level of land cover categorization between Group and Alliance describing the structural attributes of a land unit, for example, "Evergreen Coniferous Woodlands with Rounded Crowns" (see Jennings 1993b)

gamma diversity - the species diversity of a landscape, generally covering 1,000 to 1,000,000 hectares, made up of more than one kind of natural community (see Whittaker 1977)

gap analysis - a comparison of the distribution of elements of biodiversity with that of areas managed for their long-term viability to identify elements with inadequate representation

geographic information systems - computer hardware and software for storing, retrieving, manipulating, and analyzing spatial data

Global Positioning System (GPS) - an instrument that utilizes satellite signals to pinpoint its location on the earth's surface

greedy heuristic - an algorithm for exact set cover analysis (see Kiester et al., in press)

ground truthing - verifying maps by checking the actual occurrence of plant and animal species in the field at representative sample locations

habitat - the physical structure, vegetational composition, and physiognomy of an area, the characteristics of which determine its suitability for particular animal or plant species

hectare - a metric unit of area of 10,000 square meters and equal to 2.47 acres

hex/hexagon - typically refers to the EPA EMAP hexagonal grid of 635 square kilometer units

hyperclustering - a efficient, interactive method for accurately analyzing and classifying remotely-sensed data that reduces data size and computational requirements while retaining the integrity of the original data

lotic - flowing, e.g., water in a stream or river

metadata - information about data, e.g., their source, lineage, content, structure, and availability

minimum mapping unit - the smallest area that is depicted on a map

neotropics - the zoo-geographic region stretching southward from the tropic of Cancer and including southern Mexico, Central and South America, and the West Indies

phenology - the study of periodic biological phenomena, such as flowering, breeding, and migration, especially as related to climate

phenotype - the environmentally and genetically determined observable appearance of an organism, especially as considered with respect to all possible genetically influenced expressions of one specific character

physiognomic - based on physical features

physiographic province - a region having a pattern of relief features or land forms that differ significantly from that of adjacent regions

pixel - the smallest spatial unit in a raster data structure

polygon - an area enclosed by lines in a vector-based Geographic Information System data layer or a region of contiguous homogeneous pixels in a raster system

preprocessing - those operations that prepare data for subsequent analysis, usually by attempts to correct or compensate for systematic, radiometric, and geometric errors

pro-active - acting in anticipation of an event as opposed to reacting after the fact

range - the geographic limit of the species

range unit - a spatial, geographic unit to record and display species geographic range.

reach - a stream or river segment between inflowing tributaries

registration, spatial - matching different images to each other by finding points on the images that can be matched to known points on the ground

remote sensing - deriving information about the earth's surface from images acquired at a distance, usually relying on measurement of electromagnetic radiation reflected or emitted from the feature of interest

resolution - the ability of a remote sensing system to record and display fine detail in a distinguishable manner or: the smallest feature that can be distinguished or resolved on a map or image, such as a TM pixel

scale, map - the ratio of distance on a map to distance in the real word, expressed as a fraction; the smaller the denominator, the larger the scale, e.g. 1:24,000 is larger than 1:100,000

sensitivity analysis - the consideration of a number of factors involved in the mathematical modeling of an ecosystem and its components. These include feedback and

control, and the stability and sensitivity of the system as a whole to changes in some part of the system. Predictions can be made from the analysis.

simulated annealing - an algorithm used for set coverage analysis (see Kiester et al., in press)

species richness - the number of species of a particular interest group found in a given area

spectral cluster - a group of adjacent pixels that are uniform with respect to their brightness values

supervised classification - the process of classifying TM pixels of unknown identity by using samples of known identity (i.e., pixels already assigned to informational classes by ground truthing or registration with known land cover) as training data

synoptic - constituting a brief statement or outline of a subject; presenting a summary

tessellation - the division of a map into areas of equal and uniform shape such as the EPA- EMAP hexagon

Thematic Mapper - a sensor on LANDSAT 4 and 5 satellites that records information in seven spectral bands, has a spatial resolution of about 30 m x 30 m, and represents digital values in 256 levels of brightness per band

transect - a transversely cut line along which physical and biological observations are made

trophic structure - the various levels in a food chain, such as producers (plants), primary consumers (herbivores), and secondary consumers (carnivores)

Universal Transverse Mercator - one of several map projections or systems of transformations that enables locations on the spherical earth to be represented systematically on a flat map

Universal Transverse Mercator grid - a geographic reference system used as the basis for worldwide locational coding of information in a GIS or on a map

unsupervised classification - the definition, identification, labeling, and mapping of natural groups, or classes, of spectral values within a scene. These spectral classes are reasonably uniform in brightness in several spectral channels.

vector format - a data structure that uses polygons, arcs (lines), and points as fundamental units for analysis and manipulation in a Geographic Information System

virtual reality - a computer-generated simulation of reality with which users can interact using specialized peripherals such as data gloves and head-mounted computer graphic displays

wildlife habitat relationship model - a method of linking patterns of known habitat use by animal species with maps of existing vegetation, thereby identifying the spatial extent of important habitat features for use in conservation and management.

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Appendix 2.1 Provisional vegetation and land cover classification scheme developed early in the North Dakota Gap Analysis project showing the relationship of land cover categories to alliances in the North Dakota Subset of the National Vegetation Classification System.

Physiognomic Class
Physiognomic Subclass
Physiognomic Subgroup
ND GAP Land cover category
TNC/FGDC Alliances

FOREST - > 60 % tree canopy with crowns interlocking
Coniferous Forest
Planted/Cultivated
Coniferous Shelterbelts /Plantations
Deciduous Forest
Natural/Semi-Natural Upland
Green Ash -American Elm Forest
Fraxinus pennsylvanica - (*Ulmus americana*) Forest Alliance
Bur Oak Forest
Quercus macrocarpa Forest Alliance
Aspen Forest
Populus tremuloides Forest Alliance
Paper Birch Forest
Be*tula papyrifera* Forest Alliance
Natural/Semi-Natural Lowland
Green Ash-American Elm-Basswood Forest
Fraxinus pennsylvanica - Ulmus americana - Celtis (*occidentalis*, *laevigata*)
Temporarily Flooded Forest Alliance
Cottonwood Forest
Populus deltoides Temporarily Flooded Forest Alliance
Aspen Lowland Forest
Populus tremuloides Temporarily Flooded Forest Alliance

Planted/Cultivated

Deciduous Shelterbelts/Plantations

Mixed Conifer and Deciduous

Planted/Cultivated

Mixed Conifer and Deciduous Shelterbelts/Plantations

WOODLAND - Open stands of trees comprise 25 - 60 % cover

Coniferous Woodland

Natural/Semi-Natural

Rocky Mountain Juniper Woodland

Juniperus scopulorum Woodland Alliance

Limber Pine Woodland

Pinus flexilis Woodland Alliance

Ponderosa Pine Woodland

Pinus ponderosa Woodland Alliance

Deciduous Woodland

Natural/Semi-Natural Upland

Green Ash - American Elm Woodland

Fraxinus pennsylvanica - (*Ulmus americana*) Woodland Alliance

Bur Oak Woodland

Quercus macrocarpa Woodland Alliance

Aspen Woodland

Populus tremuloides Woodland Alliance

Paper Birch Woodland

Betula papyrifera Woodland Alliance

Natural/Semi-Natural Lowland

Cottonwood Woodland

Populus deltoides Temporarily Flooded Woodland Alliance

SHRUBLAND Shrubs > 25 % cover with < 25 % tree cover

Evergreen Shrubland

Natural/Semi-Natural

Silver Sagebrush Shrubland

Artemisia cana Shrubland Alliance

Big Sagebrush Shrubland

Artemisia tridentata ssp. *wyomingensis* Shrubland Alliance

Creeping Juniper Dwarf Shrubland

Juniperus horizontalis Dwarf-shrubland Alliance

Deciduous Shrubland

Natural/Semi-Natural

Upland Deciduous Shrubland

Amelanchier alnifolia Shrubland Alliance

Elaeagnus commutata Shrubland Alliance

Prunus virginiana Shrubland Alliance

Symphoricarpos occidentalis Shrubland Alliance

Shepherdia argentea Shrubland Alliance

Lowland Deciduous Shrubland

Salix exigua Temporarily Flooded Shrubland Alliance

Alnus incana Seasonally Flooded Shrubland Alliance

Cornus sericea - *Salix* spp. Seasonally Flooded Shrubland Alliance

Betula pumila - (*Salix* spp.) Saturated Shrubland Alliance

GRASSLAND

Tall Grass Prairie

Natural/Semi-Natural

Wet-Mesic Tall Grass Prairie -

Andropogon gerardii - (*Calamagrostis canadensis*, *Panicum virgatum*) Herbaceous Alliance

Mesic Tall Grass Prairie

Andropogon gerardii - (*Sorghastrum nutans*) Herbaceous Alliance

Mixed Grass Prairie

Natural/Semi-Natural

Mesic Mixed Grass Prairie

Pascopyrum smithii - *Stipa commata* Herbaceous Alliance

Pascopyrum smithii - Nasella viridula Herbaceous Alliance
Poa pratensis Herbaceous Alliance

Dry-Mesic Mixed Grass Prairie
Schizachyrium scoparium - Bouteloua species Herbaceous Alliance

Dry Mixed Grass Prairie
Stipa comata - Bouteloua gracilis Herbaceous Alliance

Fescue Prairie
Festuca scabrella Herbaceous Alliance

Inland Saltgrass Prairie
Distichlis spicata - (*Hordeum jubatum*) Temporarily Flooded Herbaceous Alliance
Hordeum jubatum Temporarily Flooded Herbaceous Alliance
Pascopyrum smithii Temporarily Flooded Herbaceous Alliance

Sand Prairie
Andropogon hallii Herbaceous Alliance
Calamovilfa longifolia Herbaceous Alliance

Planted/Cultivated

Exotic Grassland
Conservation Reserve Program
Agropyron cristatum
Bromus inermis

PERENNIAL FORB

Natural/Semi-natural

Exotic Forb
Euphorbia esula Herbaceous Alliance

Planted/Cultivated

Hayland
Alfalfa
Sweet Clover

WETLAND - National Wetlands Inventory data, contiguous wetlands dissolved to most permanent water regime

Temporary wetland
Carex lanuginosa Temporarily Flooded Herbaceous Alliance

Carex spp. - *Plantago eriopoda* Temporarily Flooded Herbaceous Alliance
Spartina pectinata Temporarily Flooded Herbaceous Alliance

Seasonal wetland

Carex (*rostrata*, *utriculata*) Seasonally Flooded Herbaceous Alliance
Carex aquatilis Seasonally Flooded Herbaceous Alliance
Carex atherodes Seasonally Flooded Herbaceous Alliance
Carex stricta Seasonally Flooded Herbaceous Alliance
Scolochloa festucacea Seasonally Flooded Herbaceous Alliance
Typha spp. - (*Scirpus* spp. - *Juncus* spp.) Seasonally Flooded Herbaceous Alliance

Semi-permanent wetland

Phragmites australis Semipermanently Flooded Herbaceous Alliance
Scirpus acutus - (*Scirpus tabernaemontani*) Semipermanently Flooded Herbaceous Alliance
Scirpus maritimus Semipermanently Flooded Herbaceous Alliance
Typha (*angustifolia*, *latifolia*) - (*Scirpus* spp.) Semipermanently Flooded Herbaceous Alliance

Permanent wetland

Potamogeton pectinatus Permanently Flooded Herbaceous Alliance
Potamogeton spp. - *Ceratophyllum* spp. - *Elodea* spp. Permanently Flooded Herbaceous Alliance
Ruppia maritima Permanently Flooded Herbaceous Alliance

Developed - areas where man-made structures cover large proportions of the land

Cropland - areas planted to annual grain or row crops

Sparse Vegetation/Barren Land Vegetation typically <10 %

Sarcobatus vermiculatus Shrubland Alliance
Atriplex confertifolia Shrubland Alliance
Artemisia tridentata Shrubland Alliance

Water

Appendix 2.2 Cell value in the land cover raster, land cover category name, and description of land cover category for 39 land cover categories at the lower level of the land cover classification system for the ND-GAP land cover map.

1 - Cropland. Lands tilled and planted to annual herbaceous small grain and row crops. Common small grain crops include wheat, barley, and oats. Examples of row crops include corn, sunflowers, soybeans, sugar beets, and potatoes. The land cover category includes both non-irrigated and irrigated crops. These lands have a bare soil phase during the growing season that generally occurs in early spring when most crops are planted. The bare soil phase is unique to croplands and is important for accurate discrimination of croplands from other land cover types using remotely sensed imagery.

2 - Planted Herbaceous Perennials. Lands planted to perennial herbaceous grasses, forbs, or grass-legume mixtures. Often the species planted are introduced species such as smooth brome, crested wheatgrass, alfalfa and sweet clover although some plantings are native grass species. Most lands are used to produce forage crops for harvest or for grazing by domestic livestock. This class includes lands enrolled in retired cropland conservation programs that are planted to grass and legume species. In addition to planted fields, smooth brome has invaded and established stands in many native grasslands and some of these are likely mapped as planted grasslands. Leafy spurge invasions in native grassland may also be mapped as this class.

10 - Wet-Mesic Tallgrass Prairie. Low lying lands of depressions and drainage ways with a high water table and high water availability. Characteristic native grasses include *Spartina pectina, Calamagrostis canadensis, Calamagrostis stricta, Carex lanuginosa, Andropogon gerardii and Panicum virgatum. Phalaris arundinacea* is a common non-native species in some stands. This map unit corresponds most closely with the concepts of the *Andropogon gerardii* - (*Calamagrostis canadensis, Panicum virgatum*) herbaceous alliance of the NVCS and the wet meadow and subirrigated range sites of the NRCS. Some stands of this category are mapped as palustrine temporary wetlands by the U.S FWS National Wetlands Inventory.

11 - Mesic Tallgrass Prairie. Nearly level lowlands, depressions and lower slopes in moderately rolling uplands than receive runoff from the adjacent landscape. Soils are deep, moderately well drained with variable texture and high available water capacity. Dominant grasses are *Andropogon gerardii, Sorghastrum natans, Panicum virgatum* and *Schizachyrium scoparium*. This map unit corresponds most closely with the concepts of the *Andropogon gerardii - Hesperostipa spartea* - Sporobolus heterolepis herbaceous vegetation association of the Andropogon gerardii - (*Sorghastrum nutans*) herbaceous alliance of the NVCS and the subirrigated range sites of the NRCS.

12 - Mesic Tall and Mixed Prairie. The species composition of this map unit is heavily influenced by grazing history and moisture availability. On the most mesic sites with light grazing, *Andropogon geradii* and other tall grasses can be abundant. As water availability decreases or herbivory increases, mid grasses such *as Pascopyrum smithii, Nassela viridula*, and *Bromus inermis* increase in importance. Under heavy continuous grazing *Poa pratensis* and *Bouteloua gracilis* can dominate the sites. Landscape positions include swales, depressions, and footslopes with increased water availability from runon from adjacent lands. This map unit corresponds to the concepts of the *Andropogon gerardii - Schizachyrium scoparium* Northern Plains Herbaceous Vegetation association, the *Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation association, and the *Poa pratensis* semi-natural herbaceous alliance of the NVCS and the overflow range site of the NRCS.

13 - Bluestem - Needlegrass-Wheatgrass Transition Prairie. A transition prairie between tallgrass prairie to the east and mixed prairie to the west generally occurring on soils derived from glacial materials (Clements 1920; Shantz 1923; Weaver and Fitzpatrick 1934; Weaver and Clements 1938; Kuchler 1964; Dix and Smeins 1967; Stewart 1975; Whitman and Barker 1994). Common species are *Schizachyrium scoparium, Hesperostipa spartea, Nassella viridula, Andropogon gerardii, Panicum virgatum, Pascopyrum smithii, Elymus trachycaulus, Hesperostipa comata, Bouteloua gracilis, Poa prantensis* and *Bromus inermis*. Dominance by a single species typically occurs only over small areas with most stands less than 0.1 ha in size. The complex distribution of species over short distances is believed to be largely determined by variability in plant available moisture and nutrients (Dix and Smeins 1967; Barnes et al. 1983). An outstanding feature of glacial till parent materials is their variability due to the diverse ways by which the debris was laid down, of differences in the chemical composition of the original materials and of fluctuation in the grinding action of the ice. Soils heterogeneity occurs over short distances with textures varying from sands, silts, sand, and clays. This map unit is most closely aligned with the concepts of the *Andropogon gerardii - Sporobolus heterolepis - Schizachyrium scoparium - Pascopyrum smithii* Herbaceous Vegetation association and the *Schizachyrium scoparium - Bouteloua curtipendula - Hesperostipa spartea* - (*Pascopyrum smithii*) Herbaceous Vegetation association of the NVCS and the thin upland range site of the NRCS.

14 - Wheatgrass Prairie. This vegetation occurs on nearly level to rolling landscapes with deep, well drained, medium to fine textured soils. Dominant graminoid species include *Pascopyrum smithii, Nassella viridula, Hesperostipa comata, and Bouteloua gracilis*. *Distichlis spicata* and *Opuntia fragilis* are often common and diagnostic species of sites with saline-alkali soils. *Artemisia tridentata spp. wyomingensis* and *Artemisia cana* can occur as scattered shrubs contributing little cover in some stands in the Missouri plateau physiographic region. This map unit corresponds to the concepts of the *Pascopyrum smithii* herbaceous alliance of the NVCS. The four associations within the alliance

include *Pascopyrum smithii - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation association, *Pascopyrum smithii - Hesperostipa comata* Central Mixedgrass Herbaceous Vegetation association, *Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation, and *Pascopyrum smithii* - (*Elymus trachycaulus*) Clay Pan Herbaceous Vegetation. This map unit corresponds to concepts of the NRCS silty, clay, and clay pan range sites.

15 - Needlegrass Prairie. Dominant grasses are *Hesperostipa comata*, *Bouteloua gracilis*, and upland *Carex spp*. *Pascopyrum smithii* and *Calamovilfa longifolia* are abundant locally. This vegetation occurs on nearly level to rolling landscapes with shallow to deep, moderately coarse textured soils, with moderate permeability and low to moderate available water capacity. This map unit corresponds to the concepts of the *Hesperostipa comata - Bouteloua gracilis* Alliance of the NVCS and the sandy and shallow-to-gravel rangesites of the NRCS.

16- Little Bluestem Bunch Grass Prairie. This map unit represents a heterogeneous plant community where *Schizachyrium scoparium* is a common and conspicuous species. Other common graminoid species include *Carex filifolia*, *Hesperostipa comata*, and *Calamovilfa longifolia*. In western ND some stands, particulary on north facing slopes, may have small thickets and scattered individuals of *Juniperus horizontalis, Rhus trilobatus*, *Shepardia argentea*, *Artemisia cana*, *Amelanchier alnifolia*, *Yucca glauca*, and occasionally individuals of *Juniperus scopulorum* or *Fraxinus pennsylvanica*. The community occurs primarily on steep to moderately steep slopes on the sides and crests of hills. Soils are shallow, of coarse to moderately fine texture, overlaying sandstone, shale or siltstone parent materials that restrict rooting depth. This map unit corresponds to the concepts of the *Schizachyrium scoparium - Bouteloua* (*curtipendula, gracilis*) - *Carex filifolia* Herbaceous Vegetation association, the *Schizachyrium scoparium - Muhlenbergia cuspidata* Herbaceous Vegetation association, and *the Juniperus horizontalis / Schizachyrium scoparium* Dwarf-shrubland assocation of the NVCS. Hansen et al. (1984) described a *Schizachyrium scoparium*/*Carex filifolia* habitat type and a *Juniperus horizontalis/Andropgon scoparius* habitat type in Thedore Roosevelt National Park. Whitman (1979) described an *Schizachyrium scoparium-Hesperostipa comata- Carex filfolia* and a *Hesperostipa comata-Muhlenbergia-Carex stenophylla* communites similar in concept to the map unit. Redmann (1975) in a study within the Fort Berthold Indian Reservation in western ND reported *Schizachyrium scoparium* was the dominant species of stands on coarse textured soils occurring on upper slope positions but also on sandy, rolling uplands west of the Missouri River. Although, generally associated with relatively coarse textured soils, Hegstad (1973) reported *Schizachyrium scoparium* was a common species on hill slopes of clay soils in northwestern ND. The map unit corresponds to the concepts of the NRCS shallow and very shallow range sites.

17 - Fescue Prairie. *Heterostipa curtiseta* and *Agropyron dasystachyum* are diagnostic grass species for this land cover type type. Cosby (1965) reported local areas dominated by *Festuca scabrella* in the northern 1/3 of North Dakota with the best examples of the community located on Lostwood National Wildlife Refuge in the north western ND on north facing slopes and on soils of medium texture. Hegstad (1973) reported *Festuca scabrella* was present on loamy soil on the Missouri Coteau in northwest ND and was the dominant plant in some areas where no heavy grazing had occurred. In a personnel communication in 1992 with Karen Smith, refuge manager for Lostwood National Wildlife Refuge, she reported areas dominated by *Festuca scabrella* were uncommon. Coupland (1992) reported that abundance of *Festuca scaberlla* can be greatly reduced under moderate and heavy grazing which he speculated was related to its erect growth habitat and the ease with which close grazing can remove a large proportion of the photosynthetic tissue. Coupland (1992) also reported that the rarity of flowering stalks of *Festuca scabrella* in some years results in the grass being confused with other species of mixed prairie, particularly *Stipa curtiseta* and as a consequence the grassland is often not recognized as being distinctive from the mixed prairie. This prairie land cover category was identified primarily on the basis of range condition inventories on State School lands in northwestern ND where *Heterostipa curtiseta* and *Agropyron dasystachyum* were identified as important components of the forage biomass on a number of the properties. The map unit corresponds to the concepts of the *Festuca altaica* herbaceous alliance and the *Festuca campestris* herbaceous alliance of the NVCS and the thin upland range site of the NVCS.

18 - Sand Prairie. Diagnostic grasses include *Calamovilfa longifolia*, *Andropogon hallii*, *Hesperostipa comata*, *and Bouteloua gracilis*. Stands of this map unit occur on poorly to moderately well-developed, well or excessively drained coarse textured sand, loamy sand, or sandy loam soils. Topography ranges from nearly level to hilly and choppy wind-worked sand dunes. There is little runoff or evaporation because of the high permeability of the soil. Soil near the surface is consequently dry throughout much of the year, but moisture is present further down, favoring deep-rooting species. The map unit corresponds to the concepts of the *Andropogon hallii* herbaceous alliance, *Calamovilfa longifolia* herbaceous alliance, and *Schizachyrium scoparium*-(*Sporobolus cryptandrus*) herbaceous alliance of the NVCS and the sand range site of the NRCS.

19 - Saline Prairie. Characteristic grasses include *Distichlis spicata*, *Hordeum jubatum*, *Puccinellia nuttalliana* and *Spartina gracilis*. This map unit occurs in shallow basins and lake plains, low terraces and bottomlands along streams that receive additional water from seepage and/or runon with deep, poorly drained, medium and fine textured saline and alkaline soils. The map unit corresponds to concepts of the *Pascopyrum smithii* temporarily flooded herbaceous alliance, *Distichlis spicata* - (*Hordeum jubatum*) temporarily flooded herbaceous alliance, and *Hordeum jubatum* temporaily flooded herbaceous alliance of the NVCS and the saline lowland range site of the NRCS. Some areas of this land cover category

may be included in the palustrine temporarily flooded wetland land cover category from U.S. FWS National Wetlands Inventory data.

20 - Upland Deciduous Shrubland. Upland areas dominated by shrubs typically occur on sites where available soil moisture is greater than sites with prairie land cover types and less than sites with woodland land cover types. Sites include well-drained depressions and riparian areas, north and east facing slopes, and woodland edges. Stands are typically small and vary greatly in shrub density and species composition. The following species are dominants in different stands. *Symphoricarpos occidentalis* occupies upland depressions, mesic swales, and flood plains. *Shepherdia argentea, Prunus virginiana, Amelanchier alnifolia, Crataegus chrysocarpa, Elaeagnus commutata, Prunus americana* often occur as small, dense thickets in mesic swales and aspects, and the outer edges of floodplains and woodlands. *Rhus glabara* occurs on the edges of Bur Oak woodlands in eastern ND. *Rhus trilobata* occupies ridges, hills, and slopes associated with scoria outcrops in south western ND. *Toxicodendron radicans* often obtains greatest abundance on sandy soils. This map unit corresponds to the concepts of the deciduous shrubland alliances of the NVCS for the species identified above.

21 - Lowland Deciduous Shrubland. Depression and riparian areas dominated by shrubs with a high water table and high water availability. This map unit includes lands mapped by the U.S. FWS National Wetland Inventory as Palustrine scrub-shrub. *Salix interior* and *Salix amygdaloides* are common shrub species in this map unit. *Corylus cornuta*, a common understory species of Aspen and Bur Oak woodlands, occurs as dense riparian shrublands in Pembina Hills. This map unit corresponds to the concepts of the *Salix (exugua*, interior) temporarily flooded shrubland alliance and *Cornus sericea-Salix spp*. seasonally flooded shrubland alliance of the NVCS.

22 - Sagebrush Shrubland. Evergreen shrublands dominated by *Artemisia cana* and *Artemisia tridentata wyomingensis*. *Artemisia cana* stands are best developed on flood plains and river terraces on soils derived from alluvial deposits (Hanson et. al. 1984., Wali et al. 1980). *Artemisia tridentata wyomingensis* often occurs as smaller stands on older, higher benches above the *Artemisia cana* on the floodplains. *Artemisia tridentata wyomingensis* stands are best developed in extreme south western ND on rolling to hilly topography. Both species of sagebrush occur with sparse to low canopy coverage on nearly level to rolling uplands in southwestern North Dakota. Both sagebrush species also occurs as small patches in the complex topography of the Little Missouri Badlands. *Artemisia tridentata wyomingensis* is most common on small terraces or narrow benches that parallel the contours of hills while *Artemisia cana* archives its greatest abundance in and along drainages. *Symporicarpos occidentalis* is a common shrub in *Artemisia cana* floodplains. Common native herbaceous species include *Pascopyrum smithii* and *Hesperostipa comata*. *Euphorbia esula* has invaded some silver sagebrush stands. This map unit corresponds to the concepts

of the *Artemisa cana* shrubland alliance, *Artemesia tridentata spp. wyomingensis* shrubland alliance, *Artemisia cana* temporarily flooded shrubland alliance, *Artemisia cana spp. cana* herbaceous alliance, and the *Artemisia tridentata spp. wyomingensis* shrub herbaceous alliance of the NVCS.

30 - Ponderosa Pine Woodland. Woodlands dominated by *Pinus ponderosa* in the Little Missouri Badlands in southwestern ND represent the northeastern-most extent of the species geographical range. Stands occur on coarse, stratified outcroppings of sandstone or scoria. Associated tree and tall shrub species include *Juniperus scopulorum*, *Fraxiunus pennsylvanica*, *Prunus virginiana* and *Shepherdia argentea*. The low shrub community includes *Rhus trilobata*, *Symphoricarpos occidentalis, Juniperus communis*, and *Juniperius horizontalis*. Herbaceceous species include *Schizachyrium scoparium*, *Bouteloua curtipendula*, *Muhlenbergia cuspidata, Carex filifolia, Pseudoroegneria spicata and Calamovilfa longifolia.* This map unit corresponds to the *Pinus ponderosa* woodland alliance of the NVCS.

31 - Limber Pine Woodland. A single small stand of *Pinus flexilis* in association with *Juniperus scopulorum* located in the Little Missouri Badlands in southwestern ND. No other stands of *Pinus flexilis* are known in ND with the nearest stands for the species located about 160 miles to the south in the Black Hills of South Dakota. The small stand of *Pinus flexilis* may have been seeded, either accidentally or purposely, by Indians camping in the area before settlement by European man. *Rhus trilobata* is the dominant shrub. The map unit corresponds to the *Pinus flexilis* woodland alliance of the NVCS.

32 - Rocky Mountain Juniper Woodland. These woodlands occur primarly on steep north, north-east or north-west facing slopes and draws in the Little Missouri Badlands in western ND. Associated shrub species include *Symphoricarpos occidentalis, Rhus trilobata, Prunus virginiana, Amelanchier alnifolia, Sheperdia argentea, Juniperus communis, Juniperus horizontalis*, and *Rosa woodsii*. Characteristic herbaceous species include *Oryzopsis micrantha* and *Achillea millefolium*. *Juniperus scopulorum* is also common in cottowood stands along the Little Missiouri river and as a component of *Pinus ponderosa* wooodlands. The map unit corresponds to the *Juniperus scopulorum* woodland alliance of the NVCS.

33 - Mixed Deciduous and Conifer Woodland. Woodlands dominated by a mixture of *Juniperus scopulorum* and *Fraxiunus pennsylvanica* and occasionally *Quercus macrocarpa*. These sites generally have soil moisture availability intermediate between *Fraxinus pennsylvanica* and *Juniperus scopulorum* woodlands.

34 - Floodplain Woodland. Woodlands occurring on the floodplains of the Red River and its tributaries, the Sheyene River, James River, Souris River, Mouse River, Missouri River and its tributaries, and Little Missouri River. Dominant tree

species include *Fraxinus pennsylvanica*, *Ulmus americana*, and *Populus deltoides*. Other associated tree species include *Tilia americana*, *Quercus macrocarpa, Populus tremuloides*, *Acer negundo*, *Celtis occidentalis*, and *Juniperus scopulorum*. This map unit includes wetlands mapped by the National Wetland Inventory as Palustrine forested. The variability and diversity of floodplain forests decreases from east to west. Structure and composition of the forest overstory are strongly related to stand age and horizontal and vertical position on the floodplain (Johnson et al. 1976). This map unit is corresponds to the concepts of several temporarily flooded forest and woodland alliances in the NVCS.

35 - Deciduous Woodland. Woodlands dominated by mixtures of deciduous species including the native tree species *Fraxinus pennsylvanica*, *Quercus macrocarpa, Populus tremulodies, Ulmus americana,* and *Populus deltoides* and a wide variety of introduced deciduous and conifer tree species planted in shelterbelts, windbreaks and tree rows.

36 - Green Ash Woodland. Fraxinus pennsylvanica - *Ulmus americana* woodlands are the most common type of woodland in North Dakota. Stands occur on the upland edge of floodplain woodlands, in the bottom and sides of draws and ravines, and mesic, typically north and north east facing, slopes. *Acer negundo* is a common tree species in these woodlands. This map unit corresponds to the concepts of the *Fraxinus pennsylvanica* forest and woodland alliances of the NVCS.

37 - Aspen Woodland. Woodlands dominated by *Populus tremuloides*. The largest aspen woodlands are located in the Turtle Mountains, Killdeer Mountains, and a deltaic sand area of western Pembina County. Smaller widely scattered stands are located Sheyene and Souris sandhills, Pembina Hills, Missouri River breaks and Little Missouri River Badlands, and in association with wetlands where they reach their greatest importance in northwestern North Dakota. Aspen are an early successional species and have a relatively short live span compared to other trees in ND. Aspen is often transitory, gradually giving way to more shade tolerant species. Associated tree species include *Quercus macrocarpa, Fraxinus pennsylvanica , Betula papyrifera, Populus balsamifera*, and *Acer negundo*. *Corylus cornuta, Prunus virginiana*, and *Amelanchier alnifolia* are common shrubs in aspen woodlands. This map unit corresponds to the concepts of the *Populus tremuloides* forest and woodland alliances of the NVCS.

38 - Bur Oak Woodland. Woodlands dominated by *Quercus macrocarpa* generally occur in the bottom and sides of draws and ravines, and well drained upland areas on a wide range of slope angles and aspects. *Populus tremulodies* and *Fraxinus pennsylvanica* are associated tree species in some stands. Associated shrub species include *Corylus cornuta, Prunus virginiana*, *Amelanchier alnifolia*, and *Symphoricarpos occidentalis*. *Carex pensylvanica* is a common herbaceous understory species in the more mesic stands. This map unit

corresponds to the concepts of the *Quercus macrocara* forest and woodland alliance of the NVCS.

39 - Aspen-Bur Oak Woodland. Woodlands dominated by a mixture of *Quercus macrocarpa and Populus tremuloides.*

40 - Lacustrine Wetland. Wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel, (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage.

41 - Riverine Wetland. Wetlands and deepwater habitats contained within a channel, with the following exception (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens. A channel is an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water. This map unit was created from U.S. Fish and Wildlife Service National Wetlands Inventory Data.

42 – Palustrine Temporary Wetland. Wetlands dominated by persistent emergents or aquatic beds where surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface. Plants that grow both in uplands and wetlands may be characteristic of this water regime. This map unit was created from U.S. Fish and Wildlife Service National Wetlands Inventory Data.

43 - Palustrine Seasonal Wetland. Wetlands dominated by persistent emergents or aquatic beds where surface water is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface. This map unit was created from U.S. Fish and Wildlife Service National Wetlands Inventory Data.

44 - Palustrine Semipermanent Wetland. Wetlands dominated by persistent emergents or aquatic beds where surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land's surface. This map unit was created from U.S. Fish and Wildlife Service National Wetlands Inventory Data.

45 - Water. Surface water identified from analysis of Landsat Thematic Mapper imagery that was not identified as wetlands in the U.S. Fish and Wildlife Service National Wetland Inventory Data. This land cover category can include an increase in the area of wetlands since the creation of the NWI data, edge effects related to resampling the NWI vectors to a raster format, and omission errors in NWI.

50 - Barren Land - lands characterized by rock, gravel, sand, or soil and the absence or low abundance of vegetation. Examples include mines, roads, oil pads and other anthropogenic or natural disturbances that result in the loss of vegetation.

51 - Sparse Vegetation - Badlands. Steep, primarily south and west facing slopes with less than < 20% vegetation cover in the Little Missouri Badlands and flats formed from mudstone, claystone, siltstone and scoria. Xeric shrubs species from *Artemisia, Chrysothamnus*, and *Atriplex* genera are often the principal vegetation.

52 - Sparse Vegetation - Riverine. Sparsely vegetated gravel and sand bars along the Missouri river.

60 - Developed - High Intensity Residential. Highly developed areas where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20% of the land cover. This map unit was created from the 1992 National Land Cover Data for North Dakota.

61 - Developed - Low Intensity Residential. Lands consisting of a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the land cover. Vegetation may account for 20-70 percent of the cover. These areas most commonly include single-family housing units. Population densities are lower than in high intensity residential areas. This map unit was created from the 1992 National Land Cover Data for North Dakota.

62 - Developed - Commercial/industrial/transportation. Infrastructure such as roads, railroads, airports and other highly developed areas not classified as high intensity residential. This map unit was created from the 1992 National Land Cover Data for North Dakota.

63 - Developed - Urban Grasslands. Lands planted to primarily grasses in developed settings for recreation, erosion control or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasslands, and industrial site grasslands. This map unit was created from the 1992 National Land Cover Data for North Dakota.

64 - Developed - Recently Developed. Areas that have been recently developed or were omissions in the developed land cover categories in the 1992 North Dakota National Land Cover data.

Appendix 2.3 Overall accuracy probabilities for North Dakota and physiographic regions.					
	N	Mean	Standard error	95% Confidence interval	
Overall accuracy	238	0.615894	0.009942	0.59630638	0.63548241

Overall accuracy by physiographic region					
Physiographic region	N	Mean	Standard error	95% Confidence interval	
Missouri Coteau	65	0.593040	0.017376	0.55832763	0.62775169
Missouri Plateau	71	0.616491	0.020920	0.57476836	0.65821452
Drift Prairie	64	0.613183	0.018138	0.57693588	0.64942925
Glacial Lake Agazzi	38	0.657682	0.022953	0.61117549	0.70418878

Appendix 2.4 Producer accuracy probabilities for 8 land cover categories at upper level of land cover classification system for North Dakota.					
Land cover[1]	N	Mean	Standard error	95% Confidence interval	
sparse vegetation	140	0.238175	0.038031	0.1629070	0.31344266
cropland	194	0.823604	0.011166	0.8015688	0.8456388
planted grassland	224	0.443401	0.017762	0.4083845	0.4784182
prairie	203	0.624273	0.018291	0.5881885	0.66035682
shrubland	151	0.122832	0.01742	0.0883804	0.15728313
urban	138	0.078455	0.045548	-0.0117112	0.16862126
wetland	221	0.560103	0.023956	0.5128719	0.60733484
woodland	218	0.479300	0.045208	0.3901603	0.5684396

[1] Planted grassland used as shorthand for planted herbaceous perennials.

Appendix 2.5 User accuracy probabilities for 8 land cover categories at upper level of land cover classification system for North Dakota.					
Land cover[1]	N	Mean	Standard error	95% Confidence interval	
sparse vegetation	85	0.278429	0.041538	0.19568	0.361178
cropland	235	0.772035	0.012463	0.747473	0.796597
planted grassland	238	0.511307	0.024242	0.463533	0.559081
prairie	235	0.543092	0.023657	0.496467	0.589717
shrubland	150	0.150347	0.01862	0.11352	0.187175
urban	36	0.145251	0.05183	0.037135	0.253368
wetland	232	0.560685	0.026751	0.507958	0.613412
woodland	213	0.620324	0.043012	0.535501	0.705147

[1] Planted grassland used as shorthand for planted herbaceous perennials.

Appendix 2.6 Producer accuracy probabilities for 8 land cover categories at upper level of land cover classification system by physiographic region.						
Physiographic region	Land cover[1]	N	Mean	Standard error	95% Confidence interval	
Missouri Coteau	sparse vegetation	43	0.00629	0.00436	-0.00252	0.01509
Missouri Coteau	cropland	50	0.78255	0.03162	0.719	0.84609
Missouri Coteau	planted grassland	63	0.45209	0.02892	0.39427	0.5099
Missouri Coteau	prairie	56	0.71274	0.02639	0.65986	0.76561
Missouri Coteau	shrubland	50	0.06428	0.02094	0.0222	0.10637
Missouri Coteau	urban	32	0	0	0	0
Missouri Coteau	wetland	65	0.60551	0.03212	0.54135	0.66968
Missouri Coteau	woodland	59	0.06592	0.0176	0.0307	0.10114
Missouri Plateau	sparse vegetation	50	0.31612	0.03978	0.23617	0.39607
Missouri Plateau	cropland	60	0.85878	0.024	0.81076	0.90679
Missouri Plateau	planted grassland	64	0.4601	0.03825	0.38366	0.53654
Missouri Plateau	prairie	67	0.58219	0.03007	0.52216	0.64222
Missouri Plateau	shrubland	47	0.19037	0.02583	0.13838	0.24236
Missouri Plateau	urban	42	0.01237	0.01117	-0.01019	0.03493
Missouri Plateau	wetland	60	0.40174	0.06898	0.2637	0.53977
Missouri Plateau	woodland	61	0.23606	0.03993	0.15619	0.31592
Drift Prairie	sparse vegetation	34	0	0	0	0
Drift Prairie	cropland	55	0.81774	0.02465	0.76833	0.86716
Drift Prairie	planted grassland	62	0.41349	0.03354	0.34643	0.48054
Drift Prairie	prairie	49	0.53155	0.06588	0.39909	0.66401
Drift Prairie	shrubland	31	0.15532	0.04789	0.05752	0.25311
Drift Prairie	urban	42	0.12967	0.10879	-0.09002	0.34937
Drift Prairie	wetland	64	0.54105	0.03757	0.46598	0.61612
Drift Prairie	woodland	61	0.58476	0.07148	0.44178	0.72773
Glacial Lake Agazzi	cropland	29	0.82452	0.02406	0.77524	0.8738
Glacial Lake Agazzi	planted grassland	35	0.44558	0.06164	0.32032	0.57085
Glacial Lake Agazzi	prairie	31	0.69252	0.03214	0.62688	0.75817
Glacial Lake Agazzi	shrubland	23	0.03976	0.02954	-0.02151	0.10102
Glacial Lake Agazzi	urban	22	0.11394	0.07043	-0.03252	0.2604
Glacial Lake Agazzi	wetland	32	0.56902	0.10235	0.36027	0.77776
Glacial Lake Agazzi	woodland	37	0.53984	0.05194	0.43451	0.64517

[1] Planted grassland used as shorthand for planted herbaceous perennials.

Appendix 2.7 User accuracy probabilities for 8 land cover categories at upper level of land cover category classification system by physiographic region.						
Strata	Land cover[1]	N	Mean	Standard error	95% Confidence Interval	
Missouri Coteau	sparse vegetation	19	0.01263	0.010723	-0.0099	0.03515
Missouri Coteau	cropland	65	0.71451	0.034207	0.64617	0.78284
Missouri Coteau	planted grassland	65	0.56194	0.036642	0.48874	0.63515
Missouri Coteau	prairie	65	0.48959	0.036951	0.41577	0.56341
Missouri Coteau	shrubland	43	0.14449	0.041552	0.06063	0.22834
Missouri Coteau	urban	9	0	0	0	0
Missouri Coteau	wetland	65	0.68606	0.037607	0.61093	0.76119
Missouri Coteau	woodland	51	0.21579	0.04587	0.12366	0.30792
Missouri Plateau	sparse vegetation	60	0.30446	0.043421	0.21757	0.39135
Missouri Plateau	cropland	71	0.78538	0.027484	0.73057	0.8402
Missouri Plateau	planted grassland	71	0.49302	0.050663	0.39198	0.59407
Missouri Plateau	prairie	69	0.61345	0.030704	0.55218	0.67472
Missouri Plateau	shrubland	62	0.17353	0.028232	0.11708	0.22998
Missouri Plateau	urban	7	0.04124	0.028348	-0.02813	0.1106
Missouri Plateau	wetland	65	0.38321	0.060853	0.26164	0.50478
Missouri Plateau	woodland	65	0.33841	0.034687	0.26912	0.40771
Drift prairie	sparse vegetation	6	0	0	0	0
Drift prairie	cropland	64	0.77034	0.02501	0.72036	0.82032
Drift prairie	planted grassland	64	0.46848	0.047726	0.3731	0.56385
Drift prairie	prairie	63	0.45204	0.066253	0.3196	0.58448
Drift prairie	shrubland	36	0.10937	0.032716	0.04295	0.17579
Drift prairie	urban	14	0.14832	0.086332	-0.03819	0.33483
Drift prairie	wetland	64	0.57124	0.039686	0.49193	0.65055
Drift prairie	woodland	62	0.72979	0.053629	0.62255	0.83702
Glacial Lake Agazzi	cropland	35	0.83301	0.028304	0.77549	0.89053
Glacial Lake Agazzi	planted grassland	38	0.5272	0.069212	0.38696	0.66744
Glacial Lake Agazzi	prairie	38	0.61946	0.077324	0.46279	0.77613
Glacial Lake Agazzi	shrubland	9	0.06633	0.028821	-0.00014	0.13279
Glacial Lake Agazzi	urban	6	0.30797	0.051674	0.17514	0.4408
Glacial Lake Agazzi	wetland	38	0.37841	0.08595	0.20426	0.55256
Glacial Lake Agazzi	woodland	35	0.6232	0.055926	0.50954	0.73685

[1] Planted grassland used as shorthand for planted herbaceous perennials.

Appendix 2.8 Producer accuracy probabilities for 8 land cover categories at upper level of land cover classification system for 4 anthropogenic land cover proportion strata by physiographic region.						
Strata[1]	Land cover[2]	N	Mean	Standard error	95% Confidence Interval	
Missouri Coteau_1	sparse vegetation	4	0.03797	0.03991	-0.08904	0.16499
Missouri Coteau_1	cropland	3	0.01188	0.00494	-0.00938	0.03313
Missouri Coteau_1	planted grassland	13	0.61599	0.03869	0.53168	0.70029
Missouri Coteau_1	prairie	11	0.81319	0.03503	0.73513	0.89125
Missouri Coteau_1	shrubland	12	0.0042	0.00324	-0.00293	0.01132
Missouri Coteau_1	urban	4	0	0	0	0
Missouri Coteau_1	wetland	14	0.66162	0.03429	0.58754	0.73571
Missouri Coteau_1	woodland	12	0.04773	0.03594	-0.03138	0.12684
Missouri Coteau_2	sparse vegetation	13	0.00509	0.0047	-0.00514	0.01532
Missouri Coteau_2	cropland	14	0.57436	0.05977	0.44525	0.70348
Missouri Coteau_2	planted grassland	17	0.48086	0.04144	0.393	0.56872
Missouri Coteau_2	prairie	15	0.70973	0.02619	0.65355	0.7659
Missouri Coteau_2	shrubland	14	0.07799	0.04132	-0.01128	0.16726
Missouri Coteau_2	urban	8	0	0	0	0
Missouri Coteau_2	wetland	17	0.6707	0.07444	0.5129	0.82849
Missouri Coteau_2	woodland	15	0.08869	0.0355	0.01255	0.16483
Missouri Coteau_3	sparse vegetation	18	0	0	0	0
Missouri Coteau_3	cropland	23	0.79241	0.03864	0.71228	0.87255
Missouri Coteau_3	planted grassland	23	0.31815	0.03811	0.23913	0.39718
Missouri Coteau_3	prairie	24	0.61093	0.04492	0.518	0.70386
Missouri Coteau_3	shrubland	21	0.09396	0.03025	0.03085	0.15707
Missouri Coteau_3	urban	16	0	0	0	0
Missouri Coteau_3	wetland	24	0.5126	0.03257	0.44523	0.57997
Missouri Coteau_3	woodland	23	0.07193	0.02567	0.0187	0.12516
Missouri Coteau_4	sparse vegetation	8	0	0	0	0
Missouri Coteau_4	cropland	10	0.90234	0.02297	0.85038	0.9543
Missouri Coteau_4	planted grassland	10	0.17653	0.04084	0.08415	0.2689
Missouri Coteau_4	prairie	6	0.73174	0.15476	0.33391	1.12957
Missouri Coteau_4	shrubland	3	0	0	0	0
Missouri Coteau_4	urban	4	0	0	0	0
Missouri Coteau_4	wetland	10	0.4251	0.05815	0.29356	0.55663
Missouri Coteau_4	woodland	9	0.01	0.00859	-0.0098	0.0298
Missouri Plateau_1	sparse vegetation	13	0.33956	0.04616	0.23898	0.44015
Missouri Plateau_1	cropland	7	0.52375	0.09768	0.28475	0.76276
Missouri Plateau_1	planted grassland	10	0.55242	0.11069	0.30202	0.80281
Missouri Plateau_1	prairie	16	0.58779	0.05197	0.47701	0.69857
Missouri Plateau_1	shrubland	13	0.21168	0.03094	0.14426	0.2791
Missouri Plateau_1	urban	10	0.03073	0.03012	-0.03742	0.09887
Missouri Plateau_1	wetland	11	0.3645	0.08025	0.1857	0.5433
Missouri Plateau_1	woodland	16	0.30993	0.04832	0.20693	0.41292
Missouri Plateau_2	sparse vegetation	17	0.31501	0.10331	0.096	0.53402
Missouri Plateau_2	cropland	19	0.76496	0.03114	0.69954	0.83038
Missouri Plateau_2	planted grassland	21	0.50998	0.04537	0.41533	0.60462
Missouri Plateau_2	prairie	20	0.62152	0.05278	0.51106	0.73199

Appendix 2.8 Producer accuracy probabilities for 8 land cover categories at upper level of land cover classification system for 4 anthropogenic land cover proportion strata by physiographic region (continued).						
Strata[1]	Land cover[2]	N	Mean	Standard error	95% Confidence Interval	
Missouri Plateau_2	shrubland	16	0.14629	0.05783	0.02304	0.26955
Missouri Plateau_2	urban	15	0.00444	0.00471	-0.00566	0.01455
Missouri Plateau_2	wetland	18	0.44123	0.15021	0.12433	0.75814
Missouri Plateau_2	woodland	19	0.16089	0.05407	0.0473	0.27448
Missouri Plateau_3	sparse vegetation	17	0.10632	0.05317	-0.00639	0.21904
Missouri Plateau_3	cropland	24	0.84798	0.04018	0.76486	0.9311
Missouri Plateau_3	planted grassland	23	0.39122	0.06657	0.25316	0.52929
Missouri Plateau_3	prairie	24	0.52019	0.03643	0.44483	0.59555
Missouri Plateau_3	shrubland	16	0.17443	0.02743	0.11598	0.23289
Missouri Plateau_3	urban	15	0	0	0	0
Missouri Plateau_3	wetland	23	0.35886	0.06689	0.22014	0.49758
Missouri Plateau_3	woodland	17	0.16762	0.0808	-0.00367	0.3389
Missouri Plateau_4	sparse vegetation	3	0	0	0	0
Missouri Plateau_4	cropland	10	0.95212	0.00959	0.93043	0.97382
Missouri Plateau_4	planted grassland	10	0.18825	0.02954	0.12143	0.25507
Missouri Plateau_4	prairie	7	0.06161	0.02309	0.0051	0.11812
Missouri Plateau_4	shrubland	2	0.01818	0.00661	-0.06578	0.10215
Missouri Plateau_4	urban	2	0	0	0	0
Missouri Plateau_4	wetland	8	0.50157	0.15037	0.146	0.85713
Missouri Plateau_4	woodland	9	0.08911	0.05689	-0.04207	0.22029
Drift Prairie_1	sparse vegetation	7	0	0	0	0
Drift Prairie_1	cropland	4	0.22706	0.15657	-0.27121	0.72533
Drift Prairie_1	planted grassland	9	0.55413	0.02131	0.50499	0.60327
Drift Prairie_1	prairie	9	0.7404	0.0844	0.54578	0.93502
Drift Prairie_1	shrubland	7	0.16745	0.10685	-0.09399	0.42889
Drift Prairie_1	urban	4	0	0	0	0
Drift Prairie_1	wetland	11	0.52003	0.0761	0.35046	0.6896
Drift Prairie_1	woodland	11	0.77223	0.07875	0.59676	0.94771
Drift Prairie_2	sparse vegetation	5	0	0	0	0
Drift Prairie_2	cropland	12	0.59861	0.08247	0.4171	0.78012
Drift Prairie_2	planted grassland	13	0.50431	0.05748	0.37907	0.62955
Drift Prairie_2	prairie	13	0.36809	0.06765	0.2207	0.51548
Drift Prairie_2	shrubland	7	0.17425	0.05157	0.04806	0.30044
Drift Prairie_2	urban	10	0.01966	0.01432	-0.01273	0.05205
Drift Prairie_2	wetland	13	0.64438	0.06495	0.50287	0.78589
Drift Prairie_2	woodland	12	0.56225	0.08184	0.38212	0.74238
Drift Prairie_3	sparse vegetation	19	0	0	0	0
Drift Prairie_3	cropland	29	0.79412	0.03119	0.73022	0.85802
Drift Prairie_3	planted grassland	30	0.35242	0.04694	0.25641	0.44843
Drift Prairie_3	prairie	22	0.46943	0.05515	0.35474	0.58412
Drift Prairie_3	shrubland	15	0.11221	0.06261	-0.02208	0.24649
Drift Prairie_3	urban	22	0.00357	0.00103	0.00143	0.0057
Drift Prairie_3	wetland	30	0.50902	0.05264	0.40136	0.61669
Drift Prairie_3	woodland	28	0.39155	0.09309	0.20054	0.58255
Drift Prairie_4	sparse vegetation	3	0	0	0	0
Drift Prairie_4	cropland	10	0.93437	0.00855	0.91502	0.95372

Appendix 2.8 Producer accuracy probabilities for 8 land cover categories at upper level of land cover classification system for 4 anthropogenic land cover proportion strata by physiographic region (continued).						
Strata[1]	Land cover[2]	N	Mean	Standard error	95% Confidence Interval	
Drift Prairie_4	planted grassland	10	0.09112	0.02405	0.03671	0.14552
Drift Prairie_4	prairie	5	0.05431	0.02693	-0.02046	0.12907
Drift Prairie_4	shrubland	2	0.15	0.015	-0.04059	0.34059
Drift Prairie_4	urban	6	0.53103	0.11001	0.24824	0.81383
Drift Prairie_4	wetland	10	0.34107	0.06792	0.18743	0.49471
Drift Prairie_4	woodland	10	0.10125	0.03596	0.01991	0.18259
Glacial Lake Agazzi_1	cropland	5	0.47841	0.15778	0.04033	0.91649
Glacial Lake Agazzi_1	planted grassland	8	0.60128	0.13847	0.27386	0.92871
Glacial Lake Agazzi_1	prairie	10	0.70631	0.04024	0.61528	0.79733
Glacial Lake Agazzi_1	shrubland	8	0.03747	0.03969	-0.05637	0.13131
Glacial Lake Agazzi_1	urban	5	0.03106	0.02393	-0.03538	0.09749
Glacial Lake Agazzi_1	wetland	9	0.36296	0.13728	0.04638	0.67954
Glacial Lake Agazzi_1	woodland	10	0.59521	0.12345	0.31594	0.87448
Glacial Lake Agazzi_2	cropland	5	0.59061	0.06812	0.40148	0.77974
Glacial Lake Agazzi_2	planted grassland	9	0.41805	0.07867	0.23663	0.59947
Glacial Lake Agazzi_2	prairie	9	0.73477	0.0501	0.61923	0.8503
Glacial Lake Agazzi_2	shrubland	6	0	0	0	0
Glacial Lake Agazzi_2	urban	7	0	0	0	0
Glacial Lake Agazzi_2	wetland	9	0.80136	0.06379	0.65426	0.94846
Glacial Lake Agazzi_2	woodland	9	0.48528	0.05109	0.36747	0.60309
Glacial Lake Agazzi_3	cropland	9	0.78187	0.03024	0.71213	0.85161
Glacial Lake Agazzi_3	planted grassland	9	0.35583	0.05001	0.24051	0.47116
Glacial Lake Agazzi_3	prairie	7	0.36643	0.07613	0.18015	0.55271
Glacial Lake Agazzi_3	shrubland	5	0.11494	0.12569	-0.23404	0.46392
Glacial Lake Agazzi_3	urban	7	0.26556	0.10651	0.00495	0.52617
Glacial Lake Agazzi_3	wetland	8	0.41513	0.08343	0.21785	0.6124
Glacial Lake Agazzi_3	woodland	9	0.60826	0.07451	0.43643	0.78009
Glacial Lake Agazzi_4	cropland	10	0.89367	0.02104	0.84607	0.94126
Glacial Lake Agazzi_4	planted grassland	9	0.14209	0.03242	0.06734	0.21684
Glacial Lake Agazzi_4	prairie	5	0.09474	0.03278	0.00373	0.18574
Glacial Lake Agazzi_4	shrubland	4	0	0	0	0
Glacial Lake Agazzi_4	urban	3	0.36364	0.18773	-0.4441	1.17137
Glacial Lake Agazzi_4	wetland	6	0.62733	0.09071	0.39414	0.86051
Glacial Lake Agazzi_4	woodland	9	0.19862	0.06428	0.0504	0.34685

[1]1-Anthropogenic land cover proportion strata 0-25%, 2- Anthropogenic land cover proportion strata 26-50%, 3- Anthropogenic land cover proportion strata 51-75%, 4-Anthropogenic land cover proportion strata 76-100%.

[2] Planted grassland used as shorthand for planted herbaceous perennials.

Appendix 2.9 User accuracy probabilities for 8 land cover categories at upper level of land cover classification system for 4 anthropogenic land cover proportion strata by physiographic region.						
Strata[1]	Land cover[2]	N	Mean	Standard error	95% Confidence interval	
Missouri Coteau_1	sparse vegetation	2	0.23077	0.14191	-1.57237	2.03391
Missouri Coteau_1	cropland	14	0.01753	0.01586	-0.01673	0.05178
Missouri Coteau_1	planted grassland	14	0.65482	0.04309	0.56173	0.74792
Missouri Coteau_1	prairie	14	0.54978	0.08465	0.3669	0.73266
Missouri Coteau_1	shrubland	7	0.02381	0.01275	-0.0074	0.05502
Missouri Coteau_1	urban	1	0	.	.	.
Missouri Coteau_1	wetland	14	0.84092	0.0383	0.75817	0.92366
Missouri Coteau_1	woodland	13	0.22222	0.11036	-0.01824	0.46268
Missouri Coteau_2	sparse vegetation	4	0.03333	0.03357	-0.07349	0.14015
Missouri Coteau_2	cropland	17	0.47649	0.08449	0.29737	0.65561
Missouri Coteau_2	planted grassland	17	0.60853	0.06974	0.4607	0.75636
Missouri Coteau_2	prairie	17	0.44907	0.051	0.34095	0.55718
Missouri Coteau_2	shrubland	13	0.16848	0.07697	0.00079	0.33618
Missouri Coteau_2	urban	5	0	0	0	0
Missouri Coteau_2	wetland	17	0.7611	0.06425	0.6249	0.89731
Missouri Coteau_2	woodland	12	0.2439	0.10778	0.00667	0.48113
Missouri Coteau_3	sparse vegetation	7	0	0	0	0
Missouri Coteau_3	cropland	24	0.69113	0.0427	0.6028	0.77947
Missouri Coteau_3	planted grassland	24	0.41985	0.06832	0.27852	0.56117
Missouri Coteau_3	prairie	24	0.47627	0.03502	0.40383	0.54871
Missouri Coteau_3	shrubland	20	0.15611	0.05711	0.03658	0.27564
Missouri Coteau_3	urban	1	0	.	.	.
Missouri Coteau_3	wetland	24	0.56081	0.04355	0.47072	0.65091
Missouri Coteau_3	woodland	22	0.22368	0.06003	0.09884	0.34853
Missouri Coteau_4	sparse vegetation	6	0	0	0	0
Missouri Coteau_4	cropland	10	0.87875	0.02624	0.81938	0.93811
Missouri Coteau_4	planted grassland	10	0.35557	0.10439	0.11943	0.59171
Missouri Coteau_4	prairie	10	0.32891	0.17931	-0.07671	0.73454
Missouri Coteau_4	shrubland	3	0	0	0	0
Missouri Coteau_4	urban	2	0	0	0	0
Missouri Coteau_4	wetland	10	0.33874	0.03533	0.25883	0.41866
Missouri Coteau_4	woodland	4	0.04	0.05117	-0.12284	0.20284
Missouri Plateau_1	sparse vegetation	14	0.38207	0.03453	0.30748	0.45666
Missouri Plateau_1	cropland	16	0.5022	0.12747	0.23052	0.77389
Missouri Plateau_1	planted grassland	16	0.39576	0.13851	0.10054	0.69099
Missouri Plateau_1	prairie	16	0.61964	0.04795	0.51745	0.72184
Missouri Plateau_1	shrubland	14	0.23555	0.041	0.14697	0.32413
Missouri Plateau_1	urban	2	0.10185	0.00566	0.02996	0.17374
Missouri Plateau_1	wetland	13	0.29563	0.09458	0.08955	0.50171
Missouri Plateau_1	woodland	16	0.38253	0.03941	0.29852	0.46653
Missouri Plateau_2	sparse vegetation	16	0.25773	0.12438	-0.00738	0.52284
Missouri Plateau_2	cropland	21	0.61891	0.06081	0.49205	0.74576
Missouri Plateau_2	planted grassland	21	0.58953	0.06891	0.44577	0.73328
Missouri Plateau_2	prairie	21	0.62024	0.05491	0.5057	0.73477
Missouri Plateau_2	shrubland	19	0.11298	0.04506	0.01832	0.20764

Appendix 2.9 User accuracy probabilities for 8 land cover categories at upper level of land cover classification system for 4 anthropogenic land cover proportion strata by physiographic region (continued).						
Strata[1]	Land cover[2]	N	Mean	Standard error	95% Confidence interval	
Missouri Plateau_2	urban	2	0.01695	0.00632	-0.06335	0.09724
Missouri Plateau_2	wetland	20	0.45551	0.12442	0.1951	0.71592
Missouri Plateau_2	woodland	20	0.25922	0.05866	0.13644	0.38201
Missouri Plateau_3	sparse vegetation	23	0.06208	0.03602	-0.01262	0.13679
Missouri Plateau_3	cropland	24	0.77674	0.04184	0.69019	0.86329
Missouri Plateau_3	planted grassland	24	0.44123	0.0833	0.26892	0.61355
Missouri Plateau_3	prairie	24	0.60988	0.05277	0.50071	0.71905
Missouri Plateau_3	shrubland	23	0.08397	0.03267	0.01623	0.15172
Missouri Plateau_3	urban	2	0	0	0	0
Missouri Plateau_3	wetland	23	0.39169	0.06496	0.25698	0.52641
Missouri Plateau_3	woodland	21	0.28144	0.09427	0.08478	0.47809
Missouri Plateau_4	sparse vegetation	7	0	0	0	0
Missouri Plateau_4	cropland	10	0.91896	0.01868	0.87671	0.9612
Missouri Plateau_4	planted grassland	10	0.36512	0.04908	0.25409	0.47614
Missouri Plateau_4	prairie	8	0.06147	0.03477	-0.02075	0.14368
Missouri Plateau_4	shrubland	6	0.01408	0.01211	-0.01705	0.04522
Missouri Plateau_4	urban	1	0	.	.	.
Missouri Plateau_4	wetland	9	0.24427	0.10569	0.00055	0.488
Missouri Plateau_4	woodland	8	0.34177	0.1684	-0.05643	0.73998
Drift prairie_1	cropland	11	0.18694	0.13806	-0.12067	0.49455
Drift prairie_1	planted grassland	11	0.59323	0.11268	0.34217	0.84429
Drift prairie_1	prairie	11	0.6524	0.10688	0.41426	0.89053
Drift prairie_1	shrubland	7	0.22153	0.04215	0.11839	0.32467
Drift prairie_1	urban	4	0	0	0	0
Drift prairie_1	wetland	11	0.592	0.07204	0.43148	0.75252
Drift prairie_1	woodland	11	0.80992	0.07097	0.65179	0.96804
Drift prairie_2	sparse vegetation	2	0	0	0	0
Drift prairie_2	cropland	13	0.53287	0.08626	0.34493	0.72082
Drift prairie_2	planted grassland	13	0.51964	0.07623	0.35356	0.68573
Drift prairie_2	prairie	13	0.38997	0.08329	0.2085	0.57143
Drift prairie_2	shrubland	9	0.08463	0.03443	0.00522	0.16403
Drift prairie_2	urban	3	0.17949	0.06218	-0.08807	0.44705
Drift prairie_2	wetland	13	0.62304	0.08938	0.42829	0.81779
Drift prairie_2	woodland	13	0.68801	0.08242	0.50842	0.86759
Drift prairie_3	sparse vegetation	4	0	0	0	0
Drift prairie_3	cropland	30	0.76927	0.02819	0.71161	0.82692
Drift prairie_3	planted grassland	30	0.39127	0.06878	0.25059	0.53194
Drift prairie_3	prairie	30	0.29033	0.05303	0.18188	0.39879
Drift prairie_3	shrubland	13	0.10168	0.05084	-0.00909	0.21244
Drift prairie_3	urban	5	0.00885	0.01057	-0.02049	0.03818
Drift prairie_3	wetland	30	0.57683	0.05406	0.46626	0.68739
Drift prairie_3	woodland	29	0.61712	0.06508	0.48381	0.75044
Drift prairie_4	cropland	10	0.84738	0.0475	0.73993	0.95483
Drift prairie_4	planted grassland	10	0.2465	0.06781	0.0931	0.39991
Drift prairie_4	prairie	9	0.09871	0.04203	0.00178	0.19564
Drift prairie_4	shrubland	7	0.00633	0.00628	-0.00905	0.02171

Appendix 2.9 User accuracy probabilities for 8 land cover categories at upper level of land cover classification system for 4 anthropogenic land cover proportion strata by physiographic region (continued).						
Strata[1]	Land cover[2]	N	Mean	Standard error	95% Confidence interval	
Drift prairie_4	urban	2	0.30616	0.02435	-0.00318	0.61551
Drift prairie_4	wetland	10	0.28664	0.06328	0.1435	0.42979
Drift prairie_4	woodland	9	0.36161	0.08124	0.17426	0.54895
Glacial Lake Agazzi_1	cropland	7	0.4776	0.21834	-0.05666	1.01186
Glacial Lake Agazzi_1	planted grassland	10	0.68468	0.10335	0.45089	0.91847
Glacial Lake Agazzi_1	prairie	10	0.66499	0.12811	0.37518	0.9548
Glacial Lake Agazzi_1	shrubland	3	0.08466	0.00567	0.06027	0.10904
Glacial Lake Agazzi_1	urban	3	0.10638	0.14502	-0.51757	0.73033
Glacial Lake Agazzi_1	wetland	10	0.25851	0.06944	0.10142	0.41561
Glacial Lake Agazzi_1	woodland	10	0.7001	0.126	0.41507	0.98514
Glacial Lake Agazzi_2	cropland	9	0.51153	0.16324	0.1351	0.88796
Glacial Lake Agazzi_2	planted grassland	9	0.54219	0.11481	0.27743	0.80695
Glacial Lake Agazzi_2	prairie	9	0.66079	0.08294	0.46954	0.85204
Glacial Lake Agazzi_2	shrubland	4	0	0	0	0
Glacial Lake Agazzi_2	urban	1	0	.	.	.
Glacial Lake Agazzi_2	wetland	9	0.5533	0.15998	0.1844	0.9222
Glacial Lake Agazzi_2	woodland	8	0.64244	0.07798	0.45803	0.82684
Glacial Lake Agazzi_3	cropland	9	0.79069	0.04121	0.69567	0.88571
Glacial Lake Agazzi_3	planted grassland	9	0.45528	0.09551	0.23504	0.67551
Glacial Lake Agazzi_3	prairie	9	0.19805	0.06677	0.04408	0.35201
Glacial Lake Agazzi_3	shrubland	1	0.22727	.	.	.
Glacial Lake Agazzi_3	urban	1	0.34783	.	.	.
Glacial Lake Agazzi_3	wetland	9	0.23343	0.0314	0.16103	0.30583
Glacial Lake Agazzi_3	woodland	8	0.64252	0.05949	0.50184	0.78321
Glacial Lake Agazzi_4	cropland	10	0.92394	0.01716	0.88511	0.96276
Glacial Lake Agazzi_4	planted grassland	10	0.12078	0.02946	0.05415	0.18742
Glacial Lake Agazzi_4	prairie	10	0.09677	0.04493	-0.00488	0.19842
Glacial Lake Agazzi_4	shrubland	1	0	.	.	.
Glacial Lake Agazzi_4	urban	1	0.37209	.	.	.
Glacial Lake Agazzi_4	wetland	10	0.36429	0.16448	-0.00779	0.73637
Glacial Lake Agazzi_4	woodland	9	0.1791	0.07254	0.01183	0.34638

[1] 1-Anthropogenic land cover proportion strata 0-25%, 2- Anthropogenic land cover proportion strata 26-50%, 3- Anthropogenic land cover proportion strata 51-75%, 4-Anthropogenic land cover proportion strata 76-100%.

[2] Planted grassland use as shorthand for planted herbaceous perennials.

Appendix 3.1 TNC code, common name, scientific name, and Taxonomic Serial Number for breeding birds, mammals, reptiles and amphibians included in the North Dakota Gap Analysis.

TNCCODE	Common name	Scientific name	TSN
AAAAA01140	Tiger Salamander	*Ambystoma tigrinum*	173592
AAAAE01040	Common Mudpuppy	*Necturus maculosus*	173630
AAABB01020	American Toad	*Bufo americanus*	173473
AAABB01050	Great Plains Toad	*Bufo cognatus*	173484
AAABB01080	Canadian Toad	*Bufo hemiophrys*	173487
AAABB01180	Woodhouse's Toad	*Bufo woodhousii*	173476
AAABC02050	Gray Treefrog/Cope's	*Hyla versicolor*	173503
AAABC05073	Boreal Chorus Frog	*Pseudacris triseriata maculata*	207312
AAABF01010	Plains Spadefoot Toad	*Scaphiopus bombifrons*	173428
AAABH01170	Northern Leopard Frog	*Rana pipiens*	173443
AAABH01200	Wood Frog	*Rana sylvatica*	173440
ABNBA01030	Common Loon	*Gavia immer*	174469
ABNCA02010	Pied-Billed Grebe	*Podilymbus podiceps*	174505
ABNCA03010	Horned Grebe	*Podiceps auritus*	174482
ABNCA03020	Red-Necked Grebe	*Podiceps grisegena*	174479
ABNCA03030	Eared Grebe	*Podiceps nigricollis*	174485
ABNCA04010	Western Grebe	*Aechmophorus occidentalis*	174503
ABNFC01010	American White Pelican	*Pelecanus erythrorhynchos*	174684
ABNFD01020	Double-Crested Cormorant	*Phalacrocorax auritus*	174717
ABNGA01020	American Bittern	*Botaurus lentiginosus*	174856
ABNGA02010	Least Bittern	*Ixobrychus exilis*	174846
ABNGA04010	Great Blue Heron	*Ardea herodias*	174773
ABNGA07010	Cattle Egret	*Bubulcus ibis*	174803
ABNGA08010	Green Heron	*Butorides virescens*	174793
ABNGA11010	Black-Crowned Night-Heron	*Nycticorax nycticorax*	174832
ABNJB05030	Canada Goose	*Branta canadensis*	174999
ABNJB09010	Wood Duck	*Aix sponsa*	175122
ABNJB10010	American Green-Winged Teal	*Anas crecca*	175081
ABNJB10040	American Black Duck	*Anas rubripes*	175068
ABNJB10060	Mallard	*Anas platyrhynchos*	175063
ABNJB10110	Northern Pintail	*Anas acuta*	175074
ABNJB10130	Blue-Winged Teal	*Anas discors*	175086
ABNJB10140	Cinnamon Teal	*Anas cyanoptera*	175089
ABNJB10150	Northern Shoveler	*Anas clypeata*	175096
ABNJB10160	Gadwall	*Anas strepera*	175073
ABNJB10180	American Wigeon	*Anas americana*	175094
ABNJB11020	Canvasback	*Aythya valisineria*	175129
ABNJB11030	Redhead	*Aythya americana*	175125
ABNJB11040	Ring-Necked Duck	*Aythya collaris*	175128
ABNJB11070	Lesser Scaup	*Aythya affinis*	175134
ABNJB18010	Common Goldeneye	*Bucephala clangula*	175141
ABNJB18030	Bufflehead	*Bucephala albeola*	175145
ABNJB20010	Hooded Merganser	*Lophodytes cucullatus*	175183

Appendix 3.1 (continued) TNC code, common name, scientific name, and Taxonomic Serial Number for breeding birds, mammals, reptiles and amphibians included in the North Dakota Gap Analysis.

TNCCODE	Common name	Scientific name	TSN
ABNJB22010	Ruddy Duck	*Oxyura jamaicensis*	175175
ABNKA02010	Turkey Vulture	*Cathartes aura*	175265
ABNKC10010	Bald Eagle	*Haliaeetus leucocephalus*	175420
ABNKC11010	Northern Harrier	*Circus cyaneus*	175430
ABNKC12020	Sharp-Shinned Hawk	*Accipiter striatus*	175304
ABNKC12040	Cooper's Hawk	*Accipiter cooperii*	175309
ABNKC19050	Broad-Winged Hawk	*Buteo platypterus*	175365
ABNKC19070	Swainson's Hawk	*Buteo swainsoni*	175367
ABNKC19110	Red-Tailed Hawk	*Buteo jamaicensis*	175350
ABNKC19120	Ferruginous Hawk	*Buteo regalis*	175377
ABNKC22010	Golden Eagle	*Aquila chrysaetos*	175407
ABNKD06020	American Kestrel	*Falco sparverius*	175622
ABNKD06030	Merlin	*Falco columbarius*	175613
ABNKD06090	Prairie Falcon	*Falco mexicanus*	175603
ABNLC11010	Ruffed Grouse	*Bonasa umbellus*	175790
ABNLC12010	Sage Grouse	*Centrocercus urophasianus*	175855
ABNLC13010	Greater Prairie-Chicken	*Tympanuchus cupido*	175834
ABNLC13030	Sharp-Tailed Grouse	*Tympanuchus phasianellus*	175841
ABNLC14010	Wild Turkey	*Meleagris gallopavo*	176136
ABNME01010	Yellow Rail	*Coturnicops noveboracensis*	176259
ABNME05030	Virginia Rail	*Rallus limicola*	176221
ABNME08020	Sora	*Porzana carolina*	176242
ABNME14020	American Coot	*Fulica americana*	176292
ABNNB03070	Piping Plover	*Charadrius melodus*	176507
ABNNB03090	Killdeer	*Charadrius vociferus*	176520
ABNND02010	American Avocet	*Recurvirostra americana*	176721
ABNNF02010	Willet	*Catoptrophorus semipalmatus*	176638
ABNNF04020	Spotted Sandpiper	*Actitis macularia*	176612
ABNNF06010	Upland Sandpiper	*Bartramia longicauda*	176610
ABNNF07070	Long-Billed Curlew	*Numenius americanus*	176593
ABNNF08040	Marbled Godwit	*Limosa fedoa*	176686
ABNNF18010	Common Snipe	*Gallinago gallinago*	176700
ABNNF20010	Wilson's Phalarope	*Phalaropus tricolor*	176736
ABNNM03020	Franklin's Gull	*Larus pipixcan*	176838
ABNNM03100	Ring-Billed Gull	*Larus delawarensis*	176830
ABNNM03110	California Gull	*Larus californicus*	176829
ABNNM08070	Common Tern	*Sterna hirundo*	176888
ABNNM08090	Forster's Tern	*Sterna forsteri*	176887
ABNNM08100	Least Tern	*Sterna antillarum*	176923
ABNNM10020	Black Tern	*Chlidonias niger*	176959
ABNPB04040	Mourning Dove	*Zenaida macroura*	177125
ABNRB02010	Black-Billed Cuckoo	*Coccyzus erythropthalmus*	177834
ABNSB01030	Eastern Screech-Owl	*Otus asio*	177856

Appendix 3.1 (continued) TNC code, common name, scientific name, and Taxonomic Serial Number for breeding birds, mammals, reptiles and amphibians included in the North Dakota Gap Analysis.

TNCCODE	Common name	Scientific name	TSN
ABNSB05010	Great Horned Owl	*Bubo virginianus*	177884
ABNSB10010	Burrowing Owl	*Athene cunicularia*	177946
ABNSB13010	Long-Eared Owl	*Asio otus*	177932
ABNSB13040	Short-Eared Owl	*Asio flammeus*	177935
ABNTA02020	Common Nighthawk	*Chordeiles minor*	177979
ABNTA04010	Common Poorwill	*Phalaenoptilus nuttallii*	177969
ABNUA03010	Chimney Swift	*Chaetura pelagica*	178001
ABNUC45010	Ruby-Throated Hummingbird	*Archilochus colubris*	178032
ABNXD01020	Belted Kingfisher	*Ceryle alcyon*	178119
ABNYF04040	Red-Headed Woodpecker	*Melanerpes erythrocephalus*	178186
ABNYF05010	Yellow-Bellied Sapsucker	*Sphyrapicus varius*	178202
ABNYF07030	Downy Woodpecker	*Picoides pubescens*	178259
ABNYF07040	Hairy Woodpecker	*Picoides villosus*	178262
ABNYF10020	Northern Flicker	*Colaptes auratus*	178154
ABNYF12020	Pileated Woodpecker	*Dryocopus pileatus*	178166
ABPAE32050	Western Wood-Pewee	*Contopus sordidulus*	178360
ABPAE32060	Eastern Wood-Pewee	*Contopus virens*	178359
ABPAE33030	Alder Flycatcher	*Empidonax alnorum*	178340
ABPAE33040	Willow Flycatcher	*Empidonax traillii*	178341
ABPAE33070	Least Flycatcher	*Empidonax minimus*	178344
ABPAE35020	Eastern Phoebe	*Sayornis phoebe*	178329
ABPAE35030	Say's Phoebe	*Sayornis saya*	178333
ABPAE43070	Great Crested Flycatcher	*Myiarchus crinitus*	178309
ABPAE52050	Western Kingbird	*Tyrannus verticalis*	178287
ABPAE52060	Eastern Kingbird	*Tyrannus tyrannus*	178279
ABPAT02010	Horned Lark	*Eremophila alpestris*	178402
ABPAU01010	Purple Martin	*Progne subis*	178464
ABPAU03010	Tree Swallow	*Tachycineta bicolor*	178431
ABPAU07010	Northern Rough-Winged Swallow	*Stelgidopteryx serripennis*	178443
ABPAU08010	Bank Swallow	*Riparia riparia*	178436
ABPAU09010	Cliff Swallow	*Petrochelidon pyrrhonota*	178455
ABPAU09030	Barn Swallow	*Hirundo rustica*	178448
ABPAV02020	Blue Jay	*Cyanocitta cristata*	179680
ABPAV09010	Black-Billed Magpie	*Pica pica*	179720
ABPAV10010	American Crow	*Corvus brachyrhynchos*	179731
ABPAW01010	Black-Capped Chickadee	*Poecile atricapillus*	554382
ABPAZ01010	Red-Breasted Nuthatch	*Sitta canadensis*	178784
ABPAZ01020	White-Breasted Nuthatch	*Sitta carolinensis*	178775
ABPBG03010	Rock Wren	*Salpinctes obsoletus*	178614
ABPBG09010	House Wren	*Troglodytes aedon*	178541
ABPBG10010	Sedge Wren	*Cistothorus platensis*	178605
ABPBG10020	Marsh Wren	*Cistothorus palustris*	178608
ABPBJ15010	Eastern Bluebird	*Sialia sialis*	179801

Appendix 3.1 (continued) TNC code, common name, scientific name and Taxonomic Serial Numbe for breeding birds, mammals, reptiles and amphibians included in the North Dakota Gap Analysis.

TNCCODE	Common name	Scientific name	TSN
ABPBJ15030	Mountain Bluebird	*Sialia currucoides*	179811
ABPBJ18080	Veery	*Catharus fuscescens*	179796
ABPBJ20170	American Robin	*Turdus migratorius*	179759
ABPBK01010	Gray Catbird	*Dumetella carolinensis*	178625
ABPBK03010	Northern Mockingbird	*Mimus polyglottos*	178620
ABPBK06010	Brown Thrasher	*Toxostoma rufum*	178627
ABPBM02060	Sprague's Pipit	*Anthus spragueii*	178499
ABPBN01020	Cedar Waxwing	*Bombycilla cedrorum*	178532
ABPBR01030	Loggerhead Shrike	*Lanius ludovicianus*	178515
ABPBW01110	Bell's Vireo	*Vireo bellii*	179003
ABPBW01170	Yellow-Throated Vireo	*Vireo flavifrons*	179009
ABPBW01210	Warbling Vireo	*Vireo gilvus*	179023
ABPBW01230	Philadelphia Vireo	*Vireo philadelphicus*	179022
ABPBW01240	Red-Eyed Vireo	*Vireo olivaceus*	179021
ABPBX01050	Orange-Crowned Warbler	*Vermivora celata*	178856
ABPBX01060	Nashville Warbler	*Vermivora ruficapilla*	178861
ABPBX03010	Yellow Warbler	*Dendroica petechia*	178878
ABPBX03020	Chestnut-Sided Warbler	*Dendroica pensylvanica*	178911
ABPBX05010	Black-And-White Warbler	*Mniotilta varia*	178844
ABPBX06010	American Redstart	*Setophaga ruticilla*	178979
ABPBX10010	Ovenbird	*Seiurus aurocapillus*	178927
ABPBX10020	Northern Waterthrush	*Seiurus noveboracensis*	178931
ABPBX11030	Mourning Warbler	*Oporornis philadelphia*	178939
ABPBX12010	Common Yellowthroat	*Geothlypis trichas*	178944
ABPBX24010	Yellow-Breasted Chat	*Icteria virens*	178964
ABPBX45040	Scarlet Tanager	*Piranga olivacea*	179883
ABPBX61030	Rose-Breasted Grosbeak	*Pheucticus ludovicianus*	179139
ABPBX61040	Black-Headed Grosbeak	*Pheucticus melanocephalus*	179140
ABPBX63010	Blue Grosbeak	*Guiraca caerulea*	179145
ABPBX64020	Lazuli Bunting	*Passerina amoena*	179151
ABPBX64030	Indigo Bunting	*Passerina cyanea*	179150
ABPBX65010	Dickcissel	*Spiza americana*	179165
ABPBX74030	Eastern Towhee	*Pipilo erythrophthalmus*	179276
ABPBX74080	Spotted Towhee	*Pipilo maculatus*	554380
ABPBX94020	Chipping Sparrow	*Spizella passerina*	179435
ABPBX94030	Clay-Colored Sparrow	*Spizella pallida*	179439
ABPBX94040	Brewer's Sparrow	*Spizella breweri*	179440
ABPBX94050	Field Sparrow	*Spizella pusilla*	179443
ABPBX95010	Vesper Sparrow	*Pooecetes gramineus*	179366
ABPBX96010	Lark Sparrow	*Chondestes grammacus*	179371
ABPBX98010	Lark Bunting	*Calamospiza melanocorys*	179312
ABPBX99010	Savannah Sparrow	*Passerculus sandwichensis*	179314
ABPBXA0010	Baird's Sparrow	*Ammodramus bairdii*	179339

Appendix 3.1 (continued) TNC code, common name, scientific name and Taxonomic Serial Number for breeding birds, mammals, reptiles and amphibians included in the North Dakota Gap Analysis.

TNCCODE	Common name	Scientific name	TSN
ABPBXA0020	Grasshopper Sparrow	*Ammodramus savannarum*	179333
ABPBXA0040	Le Conte's Sparrow	*Ammodramus leconteii*	179345
ABPBXA0070	Nelson's Sharp-Tailed Sparrow	*Ammodramus nelsoni*	554031
ABPBXA3010	Song Sparrow	*Melospiza melodia*	179492
ABPBXA3030	Swamp Sparrow	*Melospiza georgiana*	179488
ABPBXA4020	White-Throated Sparrow	*Zonotrichia albicollis*	179462
ABPBXA6010	Mccown's Longspur	*Calcarius mccownii*	179525
ABPBXA6040	Chestnut-Collared Longspur	*Calcarius ornatus*	179530
ABPBXA9010	Bobolink	*Dolichonyx oryzivorus*	179032
ABPBXB0010	Red-Winged Blackbird	*Agelaius phoeniceus*	179045
ABPBXB2030	Western Meadowlark	*Sturnella neglecta*	179039
ABPBXB3010	Yellow-Headed Blackbird	*Xanthocephalus xanthocephalus*	179043
ABPBXB5020	Brewer's Blackbird	*Euphagus cyanocephalus*	179094
ABPBXB6070	Common Grackle	*Quiscalus quiscula*	179104
ABPBXB7030	Brown-Headed Cowbird	*Molothrus ater*	179112
ABPBXB9070	Orchard Oriole	*Icterus spurius*	179064
ABPBXB9190	Baltimore Oriole	*Icterus galbula*	179083
ABPBXB9220	Bullock's Oriole	*Icterus bullockii*	554267
ABPBY04020	Purple Finch	*Carpodacus purpureus*	179186
ABPBY04040	House Finch	*Carpodacus mexicanus*	179191
ABPBY05010	Red Crossbill	*Loxia curvirostra*	179259
ABPBY06030	Pine Siskin	*Carduelis pinus*	179233
ABPBY06110	American Goldfinch	*Carduelis tristis*	179236
AMAAA01010	Virginia Opossum	*Didelphis virginiana*	179921
AMABA01190	Arctic Shrew	*Sorex arcticus*	179935
AMABA01250	Pigmy Shrew	*Microsorex hoyi*	179959
AMABA01280	Hayden's Shrew	*Sorex haydenii*	179945
AMABA03010	Northern Short-tailed Shrew	*Blarina brevicauda*	179967
AMACC01010	Little Brown Bat	*Myotis lucifugus*	179988
AMACC01060	Keen's Myotis	*Myotis keenii*	179989
AMACC01070	Long-eared Myotis	*Myotis evotis*	179995
AMACC01110	Long-legged Myotis	*Myotis volans*	179990
AMACC01140	Small-footed Myotis	*Myotis leibii*	179999
AMACC02010	Silver-haired Bat	*Lasionycteris noctivagans*	180014
AMACC04010	Big Brown Bat	*Eptesicus fuscus*	180008
AMACC05010	Eastern Red Bat	*Lasiurus borealis*	180016
AMACC05030	Hoary Bat	*Lasiurus cinereus*	180017
AMAEB01040	Eastern Cottontail	*Sylvilagus floridanus*	180124
AMAEB01060	Nuttall's Cottontail	*Sylvilagus nuttallii*	180126
AMAEB01070	Desert Cottontail	*Sylvilagus audubonii*	180122
AMAEB03010	Snowshoe Hare	*Lepus americanus*	180112
AMAEB03040	White-tailed Jackrabbit	*Lepus townsendii*	180118
AMAFB02020	Least Chipmunk	*Eutamius minimus*	180195

Appendix 3.1 (continued) TNC code, common name, scientific name and Taxonomic Serial Number for breeding birds, mammals, reptiles and amphibians included in the North Dakota Gap Analysis.

TNCCODE	Common name	Scientific name	TSN
AMAFB02230	Eastern Chipmunk	*Tamias striatus*	180207
AMAFB03010	Woodchuck	*Marmota monax*	180137
AMAFB05040	Richardson's Ground Squirrel	*Spermophilus richardsonii*	180157
AMAFB05090	Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*	180162
AMAFB05120	Franklin's Ground Squirrel	*Spermophilus franklinii*	180153
AMAFB06010	Black-tailed Prairie Dog	*Cynomys ludovicianus*	180186
AMAFB07010	Gray Squirrel	*Sciurus carolinensis*	180175
AMAFB07040	Eastern Fox Squirrel	*Sciurus niger*	180172
AMAFB08010	Red Squirrel	*Tamiasciurus hudsonicus*	180166
AMAFB09020	Northern Flying Squirrel	*Glaucomys sabrinus*	180169
AMAFC01040	Northern Pocket Gopher	*Thomomys talpoides*	180228
AMAFC02010	Plains Pocket Gopher	*Geomys bursarius*	180216
AMAFD01010	Olive-backed Pocket Mouse	*Perognathus fasciatus*	180260
AMAFD01020	Plains Pocket Mouse	*Perognathus flavescens*	180261
AMAFD03010	Ord's Kangaroo Rat	*Dipodomys ordii*	180244
AMAFD05050	Hispid Pocket Mouse	*Perognathus hispidus*	180264
AMAFE01010	American Beaver	*Castor canadensis*	180212
AMAFF02010	Plains Harvest Mouse	*Reithrodontomys montanus*	180344
AMAFF02030	Western Harvest Mouse	*Reithrodontomys megalotis*	180343
AMAFF03040	Deer Mouse	*Peromyscus maniculatus*	180276
AMAFF03070	White-footed Mouse	*Peromyscus leucopus*	180278
AMAFF06010	Northern Grasshopper Mouse	*Onychomys leucogaster*	180382
AMAFF08090	Bushy-tailed Woodrat	*Neotoma cinerea*	180371
AMAFF09020	Southern Red-backed Vole	*Clethrionomys gapperi*	180294
AMAFF11010	Meadow Vole	*Microtus pennsylvanicus*	180297
AMAFF11140	Prairie Vole	*Microtus ochrogaster*	180312
AMAFF13010	Sagebrush Vole	*Lagurus curtatus*	180355
AMAFF15010	Muskrat	*Ondatra zibethicus*	180318
AMAFH01010	Meadow Jumping Mouse	*Zapus hudsonius*	180386
AMAFH01020	Western Jumping Mouse	*Zapus princeps*	180387
AMAFJ01010	Common Porcupine	*Erethizon dorsatum*	180393
AMAJA01010	Coyote	*Canis latrans*	180599
AMAJA03010	Red Fox	*Vulpes vulpes*	180604
AMAJA04010	Common Gray Fox	*Urocyon cineroargenteus*	180609
AMAJE02010	Common Raccoon	*Procyon lotor*	180575
AMAJF01020	Fisher	*Martes pennanti*	180560
AMAJF02010	Ermine	*Mustela erminea*	180555
AMAJF02020	Least Weasel	*Mustela nivalis*	180554
AMAJF02030	Long-tailed Weasel	*Mustela frenata*	180556
AMAJF02050	Mink	*Mustela vison*	180553
AMAJF04010	American Badger	*Taxidea taxus*	180565
AMAJF05010	Eastern Spotted Skunk	*Spilogale putorius*	180570
AMAJF06010	Striped Skunk	*Mephitis mephitis*	180562

Appendix 3.1 (continued) TNC code, common name, scientific name and Taxonomic Serial Number for breeding birds, mammals, reptiles and amphibians included in the North Dakota Gap Analysis.

TNCCODE	Common name	Scientific name	TSN
AMAJF08010	River Otter	*Lutra canadensis*	180549
AMAJH03020	Bobcat	*Felis rufus*	203547
AMALC01010	Elk	*Cervus elaphus*	180695
AMALC02010	Mule Deer	*Odocoileus hemionus*	180698
AMALC02020	White-tailed Deer	*Odocoileus virginianus*	180699
AMALC03010	Moose	*Alces alces*	180703
AMALD01010	Pronghorn	*Antilocapridae americana*	180717
AMALE04010	Bighorn Sheep	*Ovis canadensis*	180711
ARAAB01012	Common Snapping Turtle	*Chelydra serpentina*	173752
ARAAD01011	Western Painted Turtle	*Chrysemys picta belli*	208620
ARAAD05082	False Map Turtle	*Graptemys pseudogeographica*	173800
ARAAG01022	Midland Smooth Softshell Turtle	*Apalone mutica*	208677
ARACF12032	Eastern Short Horned Lizard	*Phrynosoma douglassi brevirostre*	564567
ARACF14032	Northern Sagebrush Lizard	*Sceloporus graciosus graciosus*	208742
ARACH01102	Northern Prairie Skink	*Eumeces septentrionalis*	173969
ARADB07014	Eastern Yellowbelly Racer	*Coluber constrictor flaviventris*	209193
ARADB17010	Western Hognose Snake	*Heterodon nasicus*	174155
ARADB23020	Smooth Green Snake	*Opheodrys vernalis*	174173
ARADB2601A	Bullsnake	*Pituophis melanoleucus sayi*	209409
ARADB34032	Northern Red-bellied Snake	*Storeria occipitomaculata*	174131
ARADB36100	Plains Garter Snake	*Thamnophis radix*	174147
ARADB36130	Red-sided Garter Snake	*Thamnophis sirtalis parietalis*	209099
ARADE02128	Prairie Rattlesnake	*Crotalus viridis viridis*	209549

Appendix 3.2 Data sources for vertebrate species location records

Breeding Birds – Total Records 188,000+

Bird Banding Lab (24 April to 21 July banding data only)
Breeding Bird Survey, U. S. Geological Survey
Bureau of Reclamation
North Dakota Game and Fish Department, Sage Grouse Surveys
North Dakota Game and Fish Department, Sharp-tailed Grouse Surveys
North Dakota Game and Fish Department, Roadside Surveys
North Dakota Public Service Commission
University of Kansas Natural History Museum
North Dakota Natural Heritage Inventory
Smithsonian Natural History Museum
Museum of Texas Tech University
University of North Dakota
U.S. Fish and Wildlife Service
U.S. Geological Survey, Northern Prairie Wildlife Research Center
U.S. Army Corps of Engineers

Herptiles - Total Records 3,891

All extant locational data for North Dakota were compiled by Jeff Jundt, North American Reporting Center for Amphibian Malformations, as part of his MS thesis at North Dakota State University. Data came from North Dakota Game and Fish Department, University of North Dakota, North Dakota State University, Minot State University, U.S. Geological Survey, Northern Prairie Wildlife Research Center, North Dakota Natural Heritage Inventory, Wheeler and Wheeler (1963), and Woodworth Station.

Mammals – Total Records 8,600+

Bureau of Reclamation
North Dakota Public Service Commission
University of North Dakota
North Dakota State University
Bob Seabloom personal collection (University of North Dakota)
Smithsonian Natural History Museum
Museum of Texas Tech University
University of Kansas Natural History Museum
The Sam Noble Oklahoma Museum of Natural History, University of Oklahoma
North Dakota Game and Fish Department, Predator and other mammal surveys
North Dakota Game and Fish Department, Elk and Moose records
North Dakota Game and Fish Department, Hunting records for other game mammals
North Dakota Natural Heritage Inventory
U.S. Geological Survey, Northern Prairie Wildlife Research Center

Appendix 3.3 Names and affiliation of experts who reviewed vertebrate species range maps and species habitat affinities.

Name	Affliation	Reviewed
Ted Hoberg	Twining School, Grand Forks Air Base	reptiles, amphibians
Lawrence Igl	U.S. Geological Survey, NPWRC	birds
Bill Jensen	North Dakota Game and Fish Department	mammals
Jacqui Jerrads	North Dakota Game and Fish Department	mammals
Jeff Jundt	U.S. Geological Survey, NPWRC	reptiles, amphibians
Glennis Kaufman	Kansas State University	mammals
Ron Martin	North Dakota Birding Society	birds
Robert Seabloom	University of North Dakota (retired)	mammals
Marsha Sovada	U.S. Geological Survey, NPWRC	mammals
Dan Svingen	U.S. Forest Service	birds
Doug Backlund	South Dakota Department of Game, Fish and Parks	mammals, reptiles, amphibians
Eileen Dowd-Stukel	South Dakota Department of Game, Fish and Parks	mammals
Tate Fischer	United States Fish and Wildlife Service	amphibians
Bob Hodorff	United States Forest Service	mammals
Lynn Hetlet	United States Forest Service	mammals
Lenny McDaniel	United States Fish and Wildlife Service	mammals
Tim Mullican	Dakota Wesleyan University	mammals
David Naugle	University of Wisconsin, Stevens Point	birds
Jeff Palmer	Dakota State University	birds
George Rinker	University of South Dakota, retired	mammals
Dennis Skadsen	Natural History Investigations	mammals
Brian Smith	Black Hills State University	reptiles
Dan Tallman	Northern State University	birds
Steve Thompson	South Dakota Deptment of Game, Fish and Parks	reptiles, amphibians
Joel Tigner	Batworks	mammals
Paul Bartelt	Waldorf College	herptiles
Neil Bernstein	Mount Mercy College	herptiles
John Bowles	Central College (retired)	mammals
James Christiansen	Drake University	herptiles
Brent Danielson	Iowa State University	mammals
Jim Dinsmore	Iowa State University (retired)	birds
Curtis Eckerman	Iowa State Univeristy	herptiles
Bruce Ehresman	Iowa Department of Natural Resources	birds, mammals, herptiles
Eugenia Farrar	Iowa State University	herptiles
Jane Hey	Morningside College	herptiles
Daryl Howell	Iowa Department of Natural Resources	mammals
Rolf Koford	Iowa State University	birds
Richard Lampe	Buena Vista University	mammals
Jeff LeClere	Minnesota Department of Natural Resources	herptiles
Pat Schlarbaum	Iowa Department of Natural Resources	mammals
Jim Stroh	Morningside College	mammals
Howard Whidden	Augustana College	mammals

Appendix 3.4. Accuracy Assessment Tables for Bird Species.

Scientific_name	Arrowwood NWR	Long Lake NWR	Lostwood NWR	Tewaukon NWR	Theodore Roosevelt NP
Gavia immer	A	A	A	A	A
Podilymbus podiceps	A	A	A	A	C
Podiceps auritus	A	A	A	A	A
Podiceps grisegena	A	A	A	A	A
Podiceps nigricollis	A	A	A	A	C
Aechmophorus occidentalis	A	A	A	A	C
Pelecanus erythrorhynchos	A	A	A	A	A
Phalacrocorax auritus	A	A	A	A	C
Botaurus lentiginosus	A	A	A	A	C
Ixobrychus exilis	A	A	A	A	A
Ardea herodias	A	A	A	A	A
Bubulcus ibis	A	A	A	A	A
Butorides virescens	A	A	A	A	A
Nycticorax nycticorax	A	A	A	A	A
Branta canadensis	A	A	A	A	A
Aix sponsa	A	A	A	A	C
Anas crecca	A	A	A	A	A
Anas rubripes	A	A	A	A	A
Anas platyrhynchos	A	A	A	A	A
Anas acuta	A	A	A	A	A
Anas discors	A	A	A	A	A
Anas cyanoptera	A	A	A	C	A
Anas clypeata	A	A	A	A	C
Anas strepera	A	A	A	A	A
Anas americana	A	A	A	A	A
Aythya valisineria	A	A	A	A	A
Aythya americana	A	A	A	A	C
Aythya collaris	A	A	A	A	A
Aythya affinis	A	A	A	A	C
Bucephala clangula	A	A	A	A	O
Bucephala albeola	A	A	A	A	A
Lophodytes cucullatus	A	A	A	A	A
Oxyura jamaicensis	A	A	A	A	C
Cathartes aura	A	A	A	A	A
Haliaeetus leucocephalus	A	C	A	A	A
Circus cyaneus	A	C	A	A	A
Accipiter striatus	A	A	A	A	A
Accipiter cooperii	A	A	A	A	A
Buteo platypterus	C	A	A	A	A
Buteo swainsoni	A	A	A	A	A
Buteo jamaicensis	A	A	A	A	A
Buteo regalis	A	A	A	A	A
Aquila chrysaetos	A	C	C	A	A
Falco sparverius	A	A	A	A	A
Falco columbarius	A	A	A	A	A
Falco mexicanus	A	A	A	A	A
Bonasa umbellus	A	A	A	A	C

Appendix 3.4 (continued). Accuracy Assessment Tables for Bird Species.

Scientific_name	Arrowwood NWR	Long Lake NWR	Lostwood NWR	Tewaukon NWR	Theodore Roosevelt NP
Centrocercus urophasianus	A	A	A	A	A
Tympanuchus cupido	A	A	A	A	A
Tympanuchus phasianellus	A	A	A	A	A
Meleagris gallopavo	A	A	A	A	A
Coturnicops noveboracensis	A	A	A	A	A
Rallus limicola	A	A	A	A	C
Porzana carolina	A	A	A	A	A
Fulica americana	A	A	A	A	C
Charadrius melodus	A	A	A	A	A
Charadrius vociferus	A	A	A	A	A
Recurvirostra americana	A	A	A	A	C
Catoptrophorus semipalmatus	A	A	A	A	C
Actitis macularia	A	A	A	A	C
Bartramia longicauda	A	A	A	A	A
Numenius americanus	A	A	A	A	A
Limosa fedoa	A	A	A	A	C
Gallinago gallinago	A	A	A	A	C
Phalaropus tricolor	A	A	A	A	C
Larus pipixcan	A	A	A	A	A
Larus delawarensis	A	C	A	A	A
Larus californicus	A	A	A	A	A
Sterna hirundo	A	A	A	A	A
Sterna forsteri	A	A	A	A	A
Sterna antillarum	A	A	A	A	A
Chlidonias niger	A	A	A	A	A
Zenaida macroura	A	A	A	A	A
Coccyzus erythropthalmus	A	A	A	A	A
Otus asio	A	A	A	A	A
Bubo virginianus	A	A	A	A	A
Athene cunicularia	A	A	A	C	A
Asio otus	A	A	A	A	A
Asio flammeus	A	A	A	A	A
Chordeiles minor	A	A	A	A	A
Phalaenoptilus nuttallii	A	A	A	A	A
Chaetura pelagica	A	A	A	A	C
Archilochus colubris	A	O	A	A	A
Ceryle alcyon	A	A	A	A	A
Melanerpes erythrocephalus	A	A	A	A	A
Sphyrapicus varius	A	A	A	A	A
Picoides pubescens	A	A	A	A	A
Picoides villosus	A	A	A	A	A
Colaptes auratus	A	A	A	A	A
Dryocopus pileatus	A	A	A	A	A
Contopus sordidulus	A	A	A	A	A
Contopus virens	A	A	A	A	A
Empidonax alnorum	A	A	A	A	A
Empidonax traillii	A	A	A	A	A

Appendix 3.4 (continued). Accuracy Assessment Tables for Bird Species.

Scientific_name	Arrowwood NWR	Long Lake NWR	Lostwood NWR	Tewaukon NWR	Theodore Roosevelt NP
Empidonax minimus	A	A	A	A	A
Sayornis phoebe	A	A	A	A	A
Sayornis saya	A	A	A	A	A
Myiarchus crinitus	A	C	A	A	A
Tyrannus verticalis	A	A	A	A	A
Tyrannus tyrannus	A	A	A	A	A
Eremophila alpestris	C	A	A	A	A
Progne subis	A	O	A	A	A
Tachycineta bicolor	A	A	A	A	A
Stelgidopteryx serripennis	A	A	A	A	A
Riparia riparia	A	A	A	A	A
Petrochelidon pyrrhonota	A	A	A	A	A
Hirundo rustica	A	A	A	A	A
Cyanocitta cristata	A	A	C	A	A
Pica pica	A	A	A	A	A
Corvus brachyrhynchos	A	A	A	A	A
Poecile atricapillus	A	A	A	A	A
Sitta canadensis	A	A	A	A	A
Sitta carolinensis	A	A	A	A	A
Salpinctes obsoletus	A	A	A	A	A
Troglodytes aedon	A	A	A	A	A
Cistothorus platensis	A	A	A	A	A
Cistothorus palustris	A	A	A	A	A
Sialia sialis	A	A	A	A	A
Sialia currucoides	A	A	A	A	A
Catharus fuscescens	A	A	A	A	A
Turdus migratorius	A	A	A	A	A
Dumetella carolinensis	A	A	A	A	A
Mimus polyglottos	A	A	A	A	C
Toxostoma rufum	A	A	A	A	A
Anthus spragueii	A	A	A	A	A
Bombycilla cedrorum	A	A	A	A	A
Lanius ludovicianus	A	A	A	A	A
Vireo bellii	A	A	A	A	A
Vireo flavifrons	A	A	A	A	A
Vireo gilvus	A	A	A	A	A
Vireo philadelphicus	A	A	A	A	A
Vireo olivaceus	A	A	A	A	A
Vermivora celata	A	A	A	A	A
Vermivora ruficapilla	A	A	A	A	A
Dendroica petechia	A	A	A	A	A
Dendroica pensylvanica	A	A	A	A	A
Mniotilta varia	A	A	A	A	A
Setophaga ruticilla	A	A	A	A	A
Seiurus aurocapillus	A	A	A	A	A
Seiurus noveboracensis	A	A	A	A	A

Appendix 3.4 (continued). Accuracy Assessment Tables for Bird Species.

Scientific_name	Arrowwood NWR	Long Lake NWR	Lostwood NWR	Tewaukon NWR	Theodore Roosevelt NP
Oporornis philadelphia	A	A	A	A	A
Geothlypis trichas	A	A	A	A	A
Icteria virens	A	C	A	A	A
Piranga olivacea	A	C	A	A	A
Pheucticus ludovicianus	C	A	A	A	O
Pheucticus melanocephalus	A	A	A	A	A
Guiraca caerulea	A	A	A	A	A
Passerina amoena	A	C	A	A	A
Passerina cyanea	A	C	A	A	A
Spiza americana	C	A	A	A	C
Pipilo erythrophthalmus	A	A	A	A	A
Pipilo maculatus	A	C	A	A	A
Spizella passerina	A	A	A	C	A
Spizella pallida	A	A	A	A	A
Spizella breweri	A	A	A	A	A
Spizella pusilla	A	C	C	A	A
Pooecetes gramineus	C	A	A	A	A
Chondestes grammacus	A	A	A	A	A
Calamospiza melanocorys	A	A	A	A	A
Passerculus sandwichensis	A	A	A	A	A
Ammodramus bairdii	A	A	A	A	A
Ammodramus savannarum	A	A	A	A	A
Ammodramus leconteii	A	A	A	A	C
Ammodramus nelsoni	A	A	A	A	A
Melospiza melodia	A	A	A	A	A
Melospiza georgiana	A	A	A	A	A
Zonotrichia albicollis	A	A	A	A	A
Calcarius mccownii	A	A	A	A	O
Calcarius ornatus	A	A	A	A	A
Dolichonyx oryzivorus	A	A	A	A	A
Agelaius phoeniceus	A	A	A	A	A
Sturnella neglecta	A	A	A	A	A
Xanthocephalus xanthocephalus	A	A	A	A	A
Euphagus cyanocephalus	A	A	A	A	A
Quiscalus quiscula	A	A	A	A	A
Molothrus ater	A	A	A	A	A
Icterus spurius	A	A	A	A	A
Icterus galbula	A	A	A	A	C
Icterus bullockii	A	A	A	A	C
Carpodacus purpureus	A	A	A	A	A
Carpodacus mexicanus	A	A	A	A	C
Loxia curvirostra	A	A	A	A	C
Carduelis pinus	A	A	A	A	A
Carduelis tristis	A	A	A	A	A
Agreement	179	171	181	181	154
Commission	5	11	3	3	27
Omission	0	2	0	0	3

Appendix 3.5. Accuracy Assessment Table for Mammal Species

TNCcode	Common name	Scientific name	Lostwood NWR	Tewaukon NWR	Cross Ranch Nature Preserve
AMAAA01010	Virginia Opossum	*Didelphis virginiana*	A	A	A
AMABA01190	Arctic Shrew	*Sorex arcticus*	A	C	A
AMABA01250	Pigmy Shrew	*Microsorex hoyi*	A	A	A
AMABA01280	Hayden's Shrew	*Sorex haydenii*	A	A	A
AMABA03010	Northern Short-tailed Shrew	*Blarina brevicauda*	A	A	C
AMACC01010	Little Brown Bat	*Myotis lucifugus*	A	A	A
AMACC01060	Keen's Myotis	*Myotis keenii*	A	C	C
AMACC01070	Long-eared Myotis	*Myotis evotis*	A	A	A
AMACC01110	Long-legged Myotis	*Myotis volans*	A	A	A
AMACC01140	Small-footed Myotis	*Myotis leibii*	A	A	A
AMACC02010	Silver-haired Bat	*Lasionycteris noctivagans*	A	A	A
AMACC04010	Big Brown Bat	*Eptesicus fuscus*	A	C	A
AMACC05010	Eastern Red Bat	*Lasiurus borealis*	A	A	A
AMACC05030	Hoary Bat	*Lasiurus cinereus*	A	A	A
AMAEB01040	Eastern Cottontail	*Sylvilagus floridanus*	A	A	A
AMAEB01060	Nuttall's Cottontail	*Sylvilagus nuttallii*	A	A	A
AMAEB01070	Desert Cottontail	*Sylvilagus audubonii*	A	A	A
AMAEB03010	Snowshoe Hare	*Lepus americanus*	A	A	C
AMAEB03040	White-tailed Jack Rabbit	*Lepus townsendii*	A	A	A
AMAFB02020	Least Chipmunk	*Eutamius minimus*	A	A	A
AMAFB02230	Eastern Chipmunk	*Tamias striatus*	A	C	A
AMAFB03010	Woodchuck	*Marmota monax*	A	A	A
AMAFB05040	Richardson's Ground Squirrel	*Spermophilus richardsonii*	A	A	A
AMAFB05090	Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*	A	A	A
AMAFB05120	Franklin's Ground Squirrel	*Spermophilus franklinii*	A	A	A
AMAFB06010	Black-tailed Prairie Dog	*Cynomys ludovicianus*	A	A	C
AMAFB07010	Gray Squirrel	*Sciurus carolinensis*	A	C	A
AMAFB07040	Eastern Fox Squirrel	*Sciurus niger*	A	A	A
AMAFB08010	Red Squirrel	*Tamiasciurus hudsonicus*	A	A	A
AMAFB09020	Northern Flying Squirrel	*Glaucomys sabrinus*	A	C	A
AMAFC01040	Northern Pocket Gopher	*Thomomys talpoides*	C	A	A
AMAFC02010	Plains Pocket Gopher	*Geomy bursarius*	A	A	A
AMAFD01010	Olived-backed Pocket Mouse	*Perognathus fasciatus*	A	C	A
AMAFD01020	Plains Pocket Mouse	*Perognathus flavescens*	C	A	O
AMAFD03010	Ord's Kangaroo Rat	*Dipodomys ordii*	A	A	A
AMAFD05050	Hispid Pocket Mouse	*Perognathus hispidus*	A	A	A
AMAFE01010	American Beaver	*Castor Canadensis*	A	A	A
AMAFF02010	Plains Harvest Mouse	*Reithrodontomys montanus*	A	C	C
AMAFF02030	Western Harvest Mouse	*Reithrodontomys megalotis*	A	A	A
AMAFF03040	Deer Mouse	*Peromyscus maniculatus*	A	A	A
AMAFF03070	White-footed Mouse	*Peromyscus leucopus*	A	A	A
AMAFF06010	Northern Grasshopper Mouse	*Onychomys leucogaster*	A	A	A
AMAFF08090	Bushy-tailed Woodrat	*Neotoma cinerea*	A	A	O
AMAFF09020	Southern Red-backed Vole	*Clethrionomys gapperi*	A	A	A
AMAFF11010	Meadow Vole	*Microtus pennsylvanicus*	A	A	A

Appendix 3.5 (continued). Accuracy Assessment Table for Mammal Species

TNCcode	Common name	Scientific name	Lostwood NWR	Tewaukon NWR	Cross Ranch Nature Preserve
AMAFF11140	Prairie Vole	*Microtus ochrogaster*	A	C	A
AMAFF13010	Sagebrush Vole	*Lagurus curtatus*	A	A	A
AMAFF15010	Muskrat	*Ondatra zibethicus*	A	A	A
AMAFH01010	Meadow Jumping Mouse	*Zapus hudsonius*	A	A	A
AMAFH01020	Western Jumping Mouse	*Zapus princeps*	A	A	A
AMAFJ01010	Common Porcupine	*Erethizon dorsatum*	A	A	A
AMAJA01010	Coyote	*Canis Latrans*	A	A	A
AMAJA03010	Red Fox	*Vulpes vulpes*	A	A	A
AMAJA04010	Common Gray Fox	*Urocyon cineroargenteus*	A	A	A
AMAJE02010	Common Raccoon	*Procyon lotor*	A	A	A
AMAJF01020	Fisher	*Martes pennanti*	A	A	A
AMAJF02010	Ermine	*Mustela erminea*	O	A	A
AMAJF02020	Least Weasel	*Mustela nivalis*	A	A	A
AMAJF02030	Long-tailed Weasel	*Mustela frenata*	A	A	A
AMAJF02050	Mink	*Mustela vison*	A	A	A
AMAJF04010	American Badger	*Taxidea taxus*	A	A	A
AMAJF05010	Eastern Spotted Skunk	*Spilogale putorius*	A	A	A
AMAJF06010	Striped Skunk	*Mephitis mephitis*	A	A	A
AMAJF08010	River Otter	*Lutra canadensis*	A	A	A
AMAJH03020	Bobcat	*Felis rufus*	A	C	A
AMALC01010	Elk	*Cervus elaphus*	A	A	A
AMALC02010	Mule Deer	*Odocoileus hemionus*	A	A	A
AMALC02020	White-tailed Deer	*Odocoileus virginianus*	A	A	A
AMALC03010	Moose	*Alces Alces*	A	A	A
AMALD01010	Pronghorn	*Antilocapridae americana*	O	A	A
AMALE04010	Bighorn Sheep	*Ovis Canadensis*	A	A	C
Agreement			67	61	63
Commission			2	10	6
Ommission			2	0	2

Appendix 3.6. Accuracy Assessment Table for Amphibian Species

TNCcode	Common name	Scientific name	Lostwood NWR	Tewaukon NWR	Theodore Roosevelt NP
AAAAA01140	Tiger Salamander	*Ambystoma tigrinum*	A	A	A
AAAAE01040	Common Mudpuppy	*Necturus maculosus*	A	A	A
AAABB01020	American Toad	*Bufo americanus*	A	A	A
AAABB01050	Great Plains Toad	*Bufo cognatus*	A	A	A
AAABB01080	Canadian Toad	*Bufo hemiophrys*	C	A	C
AAABB01184	Woodhouse's Toad	*Bufo w. woodhousii*	A	A	A
AAABC02050	Gray Treefrog/Cope's	*Hyla versicolor/chrysoscelis*	A	A	A
AAABC05073	Boreal Chorus Frog	*Pseudacris triseriata maculata*	A	A	A
AAABF01010	Plains Spadefoot Toad	*Scaphiopus bombifrons*	A	A	O
AAABH01170	Northern Leopard Frog	*Rana pipiens*	A	A	A
AAABH01200	Wood Frog	*Rana sylvatica*	A	A	C
Agreement			10	11	8
Commission			1	0	2
Omission			0	0	1

Appendix 3.7. Accuracy Assessment Table for Reptile Species

TNCcode	Common name	Scientific name	Lostwood NWR	Tewaukon NWR	Theodore Roosevelt NP
ARAAB01012	Common Snapping Turtle	*Chelydra s. serpentina*	C	A	A
ARAAD01011	Western Painted Turtle	*Chrysemys picta belli*	A	A	A
ARAAD05082	False Map Turtle	*Graptemys p. pseudogeographica*	A	A	A
ARAAG01022	Midland Smooth Softshell Turtle	*Apalone m. mutica*	A	A	O
ARACF12032	Eastern Short Horned Lizard	*Phrynosoma douglassi brevirostre*	A	A	A
ARACF14032	Northern Sagebrush L	*Sceloporus g. graciosus*	A	A	A
ARACH01102	Northern Prairie Skink	*Eumeces septentrionalis*	A	A	A
ARADB07014	Eastern Yellowbelly Racer	*Coluber constrictor flaviventris*	A	A	A
ARADB17010	Western Hognose Snake	*Heterodon nasicus*	A	A	A
ARADB23020	Smooth Green Snake	*Opheodrys vernalis*	A	A	A
ARADB2601A	Bullsnake	*Pituophis melanoleucus sayi*	A	A	A
ARADB34032	Northern Redbelly Snake	*Storeria o. occipitomaculata*	A	A	A
ARADB36100	Plains Garter Snake	*Thamnophis radix*	A	A	A
ARADB36130	Red Sided Garter Snake	*Thamnophis sirtalis parietalis*	A	A	A
ARADE02128	Prairie Rattlesnake	*Crotalus v. viridis*	A	A	A
Agreement			14	15	14
Commission			1	0	0
Omission			0	0	1

Appendix 5.1 Area and percent of terrestrial vertebrate species distributions by four stewardship status categories.

Tnccode	Common name	Scientific name	status1		status2		status3		status4		total ha	% in status 1 and 2
			ha	%	ha	%	ha	%	ha	%		
AAAAA01140	Tiger Salamander	*Ambystoma tigrinum*	15460	0.7	59109	2.5	197920	8.3	2105600	88.5	2378089	3.1
AAAAE01040	Common Mudpuppy	*Necturus maculosus*	13	0.2	23	0.4	159	2.4	6358	97	6553	0.6
AAABB01020	American Toad	*Bufo americanus*	661	0.1	14895	1.2	20225	1.6	1205700	97.1	1241481	1.3
AAABB01050	Great Plains Toad	*Bufo cognatus*	29016	0.4	111210	1.5	509220	6.8	6849100	91.3	7498546	1.9
AAABB01080	Canadian Toad	*Bufo hemiophrys*	442	0.1	20234	2.5	30318	3.7	773190	93.8	824184	2.5
AAABB01180	Woodhouse's Toad	*Bufo woodhousii*	27960	0.4	94919	1.4	480040	7.1	6144700	91.1	6747619	1.8
AAABC02050	Gray Treefrog/Cope's	*Hyla versicolor*	467	0.2	7890	3.1	14097	5.5	232750	91.2	255204	3.3
AAABC05073	Boreal Chorus Frog	*Pseudacris triseriata maculata*	19515	0.4	79167	1.4	313750	5.7	5082000	92.5	5494432	1.8
AAABF01010	Plains Spadefoot Toad	*Scaphiopus bombifrons*	8	0	2389	1	5235	2.2	229750	96.8	237382	1
AAABH01170	Northern Leopard Frog	*Rana pipiens*	769	0	53744	2.9	102440	5.5	1721200	91.6	1878153	2.9
AAABH01200	Wood Frog	*Rana sylvatica*	6849	0.4	62700	3.4	107580	5.8	1674800	90.4	1851929	3.8
ABNBA01030	Common Loon	*Gavia immer*	0	0	4293	5.8	4693	6.3	65356	87.9	74342	5.8
ABNCA02010	Pied-Billed Grebe	*Podilymbus podiceps*	388	0	42203	5.1	68975	8.3	716630	86.5	828196	5.1
ABNCA03010	Horned Grebe	*Podiceps auritus*	191	0	44204	4.1	59779	5.5	986100	90.4	1090274	4.1
ABNCA03020	Red-Necked Grebe	*Podiceps grisegena*	0	0	37956	8.2	47243	10.3	375340	81.5	460539	8.2
ABNCA03030	Eared Grebe	*Podiceps nigricollis*	388	0	42203	5.1	68975	8.3	716630	86.5	828196	5.1
ABNCA04010	Western Grebe	*Aechmophorus occidentalis*	946	0.1	50899	3.2	80804	5	1477400	91.8	1610049	3.2
ABNFC01010	American White Pelican	*Pelecanus erythrorhynchos*	44	0	24273	7	26284	7.6	293870	85.3	344471	7.1
ABNFD01020	Double-Crested Cormorant	*Phalacrocorax auritus*	1760	0.1	46857	3.4	82077	6	1239600	90.5	1370294	3.6
ABNGA01020	American Bittern	*Botaurus lentiginosus*	20376	0.3	124080	1.6	444870	5.6	7340500	92.6	7929826	1.8
ABNGA02010	Least Bittern	*Ixobrychus exilis*	223	0	18230	2.8	35334	5.5	586020	91.6	639807	2.9
ABNGA04010	Great Blue Heron	*Ardea herodias*	1760	0.1	46857	3.4	82077	6	1239600	90.5	1370294	3.6
ABNGA07010	Cattle Egret	*Bubulcus ibis*	475	0	28178	1.9	49715	3.4	1385600	94.6	1463968	2
ABNGA08010	Green Heron	*Butorides virescens*	415	0.1	26806	3.4	37349	4.8	716540	91.7	781110	3.5
ABNGA11010	Black-Crowned Night-Heron	*Nycticorax nycticorax*	223	0	44249	4	61111	5.5	997040	90.4	1102623	4
ABNJB05030	Canada Goose	*Branta canadensis*	31769	0.4	143550	1.6	583240	6.5	8269000	91.6	9027559	1.9
ABNJB09010	Wood Duck	*Aix sponsa*	16500	0.7	61001	2.5	206070	8.4	2163200	88.4	2446771	3.2
ABNJB10010	American Green-Winged Teal	*Anas crecca*	31469	0.4	143510	1.6	576970	6.4	8227200	91.6	8979149	2
ABNJB10040	American Black Duck	*Anas rubripes*	1344	0	120400	2.2	159210	3	5103400	94.8	5384354	2.3
ABNJB10060	Mallard	*Anas platyrhynchos*	32355	0.2	148150	0.8	612880	3.4	17021000	95.5	17814385	1
ABNJB10110	Northern Pintail	*Anas acuta*	22431	0.1	139630	0.8	515420	3	16466000	96	17143481	1
ABNJB10130	Blue-Winged Teal	*Anas discors*	32347	0.2	148140	0.8	612490	3.4	16987000	95.5	17779977	1
ABNJB10140	Cinnamon Teal	*Anas cyanoptera*	1344	0	120400	2.2	159210	3	5103400	94.8	5384354	2.3
ABNJB10150	Northern Shoveler	*Anas clypeata*	29683	0.2	146540	0.8	580490	3.3	16936000	95.7	17692713	1
ABNJB10160	Gadwall	*Anas strepera*	32347	0.2	148140	0.8	612490	3.4	16987000	95.5	17779977	1
ABNJB10180	American Wigeon	*Anas americana*	31469	0.4	143510	1.6	576970	6.4	8227200	91.6	8979149	2

Appendix 5.1 (continued). Area and percent of terrestrial vertebrate species distributions by four stewardship status categories.

Tnccode	Common name	Scientific name	status1		status2		status3		status4		total ha	% in status 1 and 2
			ha	%	ha	%	ha	%	ha	%		
ABNJB11020	Canvasback	*Aythya valisineria*	76	0	38994	5.3	62188	8.4	640130	86.3	741388	5.3
ABNJB11030	Redhead	*Aythya americana*	753	0.1	45010	3.4	75260	5.7	1192900	90.8	1313923	3.5
ABNJB11040	Ring-Necked Duck	*Aythya collaris*	401	0	43988	3.8	60970	5.2	1063300	91	1168659	3.8
ABNJB11070	Lesser Scaup	*Aythya affinis*	29056	0.3	141850	1.6	548610	6.2	8177700	91.9	8897216	1.9
ABNJB18010	Common Goldeneye	*Bucephala clangula*	0	0	10705	4.6	17280	7.4	204090	87.9	232075	4.6
ABNJB18030	Bufflehead	*Bucephala albeola*	0	0	18762	16	10726	9.2	87727	74.8	117215	16
ABNJB20010	Hooded Merganser	*Lophodytes cucullatus*	400	0	41532	4.9	57450	6.8	743160	88.2	842542	5
ABNJB22010	Ruddy Duck	*Oxyura jamaicensis*	598	0.1	39640	5	65846	8.3	691800	86.7	797884	5
ABNKA02010	Turkey Vulture	*Cathartes aura*	22819	0.6	25395	0.6	337590	8.3	3663400	90.5	4049204	1.2
ABNKC10010	Bald Eagle	*Haliaeetus leucocephalus*	604	0.1	6889	1.2	43889	7.9	505560	90.8	556942	1.4
ABNKC11010	Northern Harrier	*Circus cyaneus*	10066	0.1	55665	0.4	242700	1.8	13135000	97.7	13443431	0.5
ABNKC12020	Sharp-Shinned Hawk	*Accipiter striatus*	3935	3	1492	1.1	29361	22.6	95397	73.3	130185	4.2
ABNKC12040	Cooper's Hawk	*Accipiter cooperii*	6419	1.5	9551	2.2	53555	12.5	358720	83.8	428245	3.7
ABNKC19050	Broad-Winged Hawk	*Buteo platypterus*	349	0.2	6556	3.2	13517	6.5	186800	90.1	207221	3.3
ABNKC19070	Swainson's Hawk	*Buteo swainsoni*	36572	0.2	92889	0.6	567970	3.5	15599000	95.7	16296431	0.8
ABNKC19110	Red-Tailed Hawk	*Buteo jamaicensis*	19874	0.1	95114	0.6	433550	2.8	15148000	96.5	15696538	0.7
ABNKC19120	Ferruginous Hawk	*Buteo regalis*	29468	0.4	78930	1.1	482610	6.9	6399800	91.5	6990808	1.6
ABNKC22010	Golden Eagle	*Aquila chrysaetos*	17631	0.7	23934	1	264730	11.1	2086400	87.2	2392695	1.7
ABNKD06020	American Kestrel	*Falco sparverius*	27115	0.2	95917	0.6	497490	3.1	15182000	96.1	15802522	0.8
ABNKD06030	Merlin	*Falco columbarius*	14105	1.4	24034	2.4	191790	19.2	771270	77	1001199	3.8
ABNKD06090	Prairie Falcon	*Falco mexicanus*	28973	0.7	33525	0.8	419670	10.1	3683800	88.4	4165968	1.5
ABNLC11010	Ruffed Grouse	*Bonasa umbellus*	1710	1.2	2136	1.5	20356	13.9	122230	83.5	146432	2.6
ABNLC12010	Sage Grouse	*Centrocercus urophasianus*	1502	0.3	5193	1	110810	21.1	406480	77.6	523985	1.3
ABNLC13010	Greater Prairie-Chicken	*Tympanuchus cupido*	566	0	17939	0.7	11840	0.5	2423800	98.8	2454145	0.8
ABNLC13030	Sharp-Tailed Grouse	*Tympanuchus phasianellus*	34623	0.2	95098	0.6	543600	3.4	15323000	95.8	15996321	0.8
ABNLC14010	Wild Turkey	*Meleagris gallopavo*	27449	0.4	94022	1.3	482880	6.6	6755600	91.8	7359951	1.7
ABNME01010	Yellow Rail	*Coturnicops noveboracensis*	414	0	53005	3.2	76495	4.6	1525200	92.2	1655114	3.2
ABNME05030	Virginia Rail	*Rallus limicola*	720	0.1	44966	3.5	73929	5.7	1182000	90.8	1301615	3.5
ABNME08020	Sora	*Porzana carolina*	15460	0.7	59109	2.5	197920	8.3	2105600	88.5	2378089	3.1
ABNME14020	American Coot	*Fulica americana*	720	0.1	44966	3.5	73929	5.7	1182000	90.8	1301615	3.5
ABNNB03070	Piping Plover	*Charadrius melodus*	226	0	22936	5	35277	7.6	403010	87.3	461449	5
ABNNB03090	Killdeer	*Charadrius vociferus*	17122	0.1	67995	0.5	386350	2.6	14632000	96.9	15103467	0.6
ABNND02010	American Avocet	*Recurvirostra americana*	9685	0.5	54693	2.8	143000	7.4	1733400	89.3	1940778	3.3
ABNNF02010	Willet	*Catoptrophorus semipalmatus*	19234	0.4	117460	2.2	379620	7.1	4835200	90.4	5351514	2.6
ABNNF04020	Spotted Sandpiper	*Actitis macularia*	561	0.1	24847	4.9	37000	7.3	443700	87.7	506108	5
ABNNF06010	Upland Sandpiper	*Bartramia longicauda*	21663	0.3	130120	1.7	490770	6.2	7215300	91.8	7857853	1.9
ABNNF07070	Long-Billed Curlew	*Numenius americanus*	22757	1.3	19306	1.1	330340	19.1	1361300	78.5	1733703	2.4

Appendix 5.1 (continued). Area and percent of terrestrial vertebrate species distributions by four stewardship status categories.

Tnccode	Common name	Scientific name	status1		status2		status3		status4		total ha	% in status 1 and 2
			ha	%	ha	%	ha	%	ha	%		
ABNNF08040	Marbled Godwit	*Limosa fedoa*	22013	0.3	125260	1.5	482570	5.9	7610200	92.4	8240043	1.8
ABNNF18010	Common Snipe	*Gallinago gallinago*	15460	0.7	59109	2.5	197920	8.3	2105600	88.5	2378089	3.1
ABNNF20010	Wilson's Phalarope	*Phalaropus tricolor*	22249	0.3	135630	1.6	487310	5.8	7754000	92.3	8399189	1.9
ABNNM03020	Franklin's Gull	*Larus pipixcan*	65	0	27754	0.4	44228	0.6	7446700	99	7518747	0.4
ABNNM03100	Ring-Billed Gull	*Larus delawarensis*	403	0	58749	0.6	113070	1.2	9594900	98.2	9767122	0.6
ABNNM03110	California Gull	*Larus californicus*	185	0	56314	0.7	122680	1.6	7416900	97.6	7596079	0.7
ABNNM08070	Common Tern	*Sterna hirundo*	6	0	36156	5.6	47928	7.4	566490	87.1	650580	5.6
ABNNM08090	Forster's Tern	*Sterna forsteri*	191	0	43700	4.2	57983	5.5	948270	90.3	1050144	4.2
ABNNM08100	Least Tern	*Sterna antillarum*	223	0.6	919	2.3	7808	19.4	31378	77.8	40328	2.8
ABNNM10020	Black Tern	*Chlidonias niger*	223	0	44249	4	61111	5.5	997040	90.4	1102623	4
ABNPB04040	Mourning Dove	*Zenaida macroura*	6428	1.4	9562	2.1	53945	11.7	392380	84.9	462315	3.5
ABNRB02010	Black-Billed Cuckoo	*Coccyzus erythropthalmus*	25729	1.3	27182	1.3	254200	12.6	1713300	84.8	2020411	2.6
ABNSB01030	Eastern Screech-Owl	*Otus asio*	12297	1.3	14751	1.5	110090	11.5	823610	85.7	960748	2.8
ABNSB05010	Great Horned Owl	*Bubo virginianus*	6419	1.5	9551	2.2	53555	12.5	358720	83.8	428245	3.7
ABNSB10010	Burrowing Owl	*Athene cunicularia*	11654	0.4	43238	1.4	258690	8.2	2860200	90.1	3173782	1.7
ABNSB13010	Long-Eared Owl	*Asio otus*	9219	1.5	11938	2	87635	14.3	503030	82.2	611822	3.5
ABNSB13040	Short-Eared Owl	*Asio flammeus*	12327	0.2	70565	1.1	339580	5.4	5876800	93.3	6299272	1.3
ABNTA02020	Common Nighthawk	*Chordeiles minor*	10542	0.1	68180	0.6	273910	2.2	11963000	97.1	12315632	0.6
ABNTA04010	Common Poorwill	*Phalaenoptilus nuttallii*	21713	3.1	6027	0.9	201400	28.7	473590	67.4	702730	4
ABNUA03010	Chimney Swift	*Chaetura pelagica*	2390	0.7	6740	1.9	28318	8	318190	89.5	355637	2.6
ABNUC45010	Ruby-Throated Hummingbird	*Archilochus colubris*	348	0.2	4918	2.5	10827	5.5	181190	91.8	197283	2.7
ABNXD01020	Belted Kingfisher	*Ceryle alcyon*	565	0.1	39595	5	64514	8.2	680850	86.7	785524	5.1
ABNYF04040	Red-Headed Woodpecker	*Melanerpes erythrocephalus*	4059	1.3	7426	2.3	36113	11.2	276040	85.3	323638	3.6
ABNYF05010	Yellow-Bellied Sapsucker	*Sphyrapicus varius*	349	0.1	7019	3	13543	5.8	214540	91.1	235450	3.1
ABNYF07030	Downy Woodpecker	*Picoides pubescens*	6428	1.4	9562	2.1	53945	11.7	392380	84.9	462315	3.5
ABNYF07040	Hairy Woodpecker	*Picoides villosus*	6428	1.4	9562	2.1	53945	11.7	392380	84.9	462315	3.5
ABNYF10020	Northern Flicker	*Colaptes auratus*	12203	1.4	13979	1.6	108870	12.1	764520	85	899572	2.9
ABNYF12020	Pileated Woodpecker	*Dryocopus pileatus*	349	0.3	1935	1.6	5566	4.7	111130	93.4	118979	1.9
ABPAE32050	Western Wood-Pewee	*Contopus sordidulus*	462	3.4	246	1.8	2199	16.3	10610	78.5	13517	5.2
ABPAE32060	Eastern Wood-Pewee	*Contopus virens*	365	0.1	7884	2.7	19043	6.5	267120	90.7	294412	2.8
ABPAE33030	Alder Flycatcher	*Empidonax alnorum*	51	0.1	354	0.4	8308	8.7	87102	90.9	95814	0.4
ABPAE33040	Willow Flycatcher	*Empidonax traillii*	21056	1.2	25939	1.5	214390	12.4	1464900	84.9	1726285	2.7
ABPAE33070	Least Flycatcher	*Empidonax minimus*	6775	1.3	10666	2	77961	14.7	434910	82	530312	3.3
ABPAE35020	Eastern Phoebe	*Sayornis phoebe*	399	0.1	22645	3.5	38040	5.8	590360	90.6	651444	3.5
ABPAE35030	Say's Phoebe	*Sayornis saya*	20467	0.6	52449	1.5	320050	9.2	3102400	88.8	3495366	2.1
ABPAE43070	Great Crested Flycatcher	*Myiarchus crinitus*	368	0.1	6339	2.2	18858	6.5	265510	91.2	291074	2.3
ABPAE52050	Western Kingbird	*Tyrannus verticalis*	35297	0.7	59397	1.2	447730	9	4416500	89.1	4958924	1.9

Appendix 5.1 (continued). Area and percent of terrestrial vertebrate species distributions by four stewardship status categories.

Tnccode	Common name	Scientific name	status1		status2		status3		status4		total ha	% in status 1 and 2
			ha	%	ha	%	ha	%	ha	%		
ABPAE52060	Eastern Kingbird	*Tyrannus tyrannus*	28781	0.5	60141	1.1	390730	7.3	4880200	91.1	5359852	1.7
ABPAT02010	Horned Lark	*Eremophila alpestris*	28558	0.2	73393	0.5	481020	3.1	14939000	96.2	15521971	0.7
ABPAU01010	Purple Martin	*Progne subis*	2	0	772	1	829	1	77975	98	79578	1
ABPAU03010	Tree Swallow	*Tachycineta bicolor*	3730	0.1	48384	1.2	154100	3.8	3863700	94.9	4069914	1.3
ABPAU07010	Northern Rough-Winged Swallow	*Stelgidopteryx serripennis*	8755	1.3	26684	4	92477	13.8	542020	80.9	669936	5.3
ABPAU08010	Bank Swallow	*Riparia riparia*	561	0.1	24847	4.9	37000	7.3	443700	87.7	506108	5
ABPAU09010	Cliff Swallow	*Petrochelidon pyrrhonota*	3906	0	22796	0.2	143360	1.2	11688000	98.6	11858062	0.2
ABPAU09030	Barn Swallow	*Hirundo rustica*	4479	0	62402	0.5	208270	1.6	12402000	97.8	12677151	0.5
ABPAV02020	Blue Jay	*Cyanocitta cristata*	6522	1.2	10334	2	55163	10.5	451480	86.2	523499	3.2
ABPAV09010	Black-Billed Magpie	*Pica pica*	31885	0.9	43774	1.2	378290	10.5	3139400	87.4	3593349	2.1
ABPAV10010	American Crow	*Corvus brachyrhynchos*	12281	1.3	14751	1.5	110090	11.5	823600	85.7	960722	2.8
ABPAW01010	Black-Capped Chickadee	*Poecile atricapillus*	6522	1.2	10334	2	55163	10.5	451480	86.2	523499	3.2
ABPAZ01010	Red-Breasted Nuthatch	*Sitta canadensis*	2135	19	411	3.7	3460	30.8	5222	46.5	11228	22.7
ABPAZ01020	White-Breasted Nuthatch	*Sitta carolinensis*	9126	1.7	11166	2	86417	15.7	443940	80.6	550649	3.7
ABPBG03010	Rock Wren	*Salpinctes obsoletus*	617	4.2	194	1.3	4465	30.6	9309	63.8	14585	5.6
ABPBG09010	House Wren	*Troglodytes aedon*	9852	1.1	13479	1.5	100410	11.4	755490	85.9	879231	2.7
ABPBG10010	Sedge Wren	*Cistothorus platensis*	759	0	77903	2.1	117880	3.2	3453600	94.6	3650142	2.2
ABPBG10020	Marsh Wren	*Cistothorus palustris*	198	0	46298	3.6	67194	5.2	1179400	91.2	1293090	3.6
ABPBJ15010	Eastern Bluebird	*Sialia sialis*	36233	0.5	99696	1.3	543630	7.1	6973700	91.1	7653259	1.8
ABPBJ15030	Mountain Bluebird	*Sialia currucoides*	30530	2.2	29811	2.1	322010	22.9	1025800	72.8	1408151	4.3
ABPBJ18080	Veery	*Catharus fuscescens*	2425	0.7	8147	2.4	34450	10	299410	86.9	344432	3.1
ABPBJ20170	American Robin	*Turdus migratorius*	6522	1.2	10334	2	55163	10.5	451480	86.2	523499	3.2
ABPBK01010	Gray Catbird	*Dumetella carolinensis*	24861	2	20084	1.6	226310	18	986320	78.4	1257575	3.6
ABPBK03010	Northern Mockingbird	*Mimus polyglottos*	9845	1.1	13395	1.5	98640	11.3	749450	86	871330	2.7
ABPBK06010	Brown Thrasher	*Toxostoma rufum*	23181	1.6	20433	1.4	214590	14.7	1206000	82.4	1464204	3
ABPBM02060	Sprague's Pipit	*Anthus spragueii*	17760	0.5	53286	1.4	297240	7.8	3435000	90.3	3803286	1.9
ABPBN01020	Cedar Waxwing	*Bombycilla cedrorum*	25721	1.3	27099	1.3	252430	12.5	1707200	84.8	2012450	2.6
ABPBR01030	Loggerhead Shrike	*Lanius ludovicianus*	34778	0.2	89995	0.6	552700	3.4	15375000	95.8	16052473	0.8
ABPBW01110	Bell's Vireo	*Vireo bellii*	155	0.1	438	0.1	9135	3	299040	96.8	308769	0.2
ABPBW01170	Yellow-Throated Vireo	*Vireo flavifrons*	356	0.1	7522	2	17739	4.8	345410	93.1	371026	2.1
ABPBW01210	Warbling Vireo	*Vireo gilvus*	4296	1	9063	2	45593	10.3	384000	86.7	442952	3
ABPBW01230	Philadelphia Vireo	*Vireo philadelphicus*	0	0	345	0.4	11395	13.7	71566	85.9	83306	0.4
ABPBW01240	Red-Eyed Vireo	*Vireo olivaceus*	9102	1.1	12650	1.6	91344	11.3	692870	86	805966	2.7
ABPBX01050	Orange-Crowned Warbler	*Vermivora celata*	0	0	345	0.4	11395	13.7	71566	85.9	83306	0.4
ABPBX01060	Nashville Warbler	*Vermivora ruficapilla*	0	0	344	0.4	11098	13.6	69928	85.9	81370	0.4
ABPBX03010	Yellow Warbler	*Dendroica petechia*	12550	1.3	15083	1.6	132890	13.7	807050	83.4	967573	2.9
ABPBX03020	Chestnut-Sided Warbler	*Dendroica pensylvanica*	0	0	345	0.4	11293	13.2	73802	86.4	85440	0.4

Appendix 5.1 (continued). Area and percent of terrestrial vertebrate species distributions by four stewardship status categories.

Tnccode	Common name	Scientific name	status1		status2		status3		status4		total ha	% in status 1 and 2
			ha	%	ha	%	ha	%	ha	%		
ABPBX05010	Black-And-White Warbler	*Mniotilta varia*	4069	1	9051	2.2	45136	11.1	350170	85.7	408426	3.2
ABPBX06010	American Redstart	*Setophaga ruticilla*	6419	1.5	9551	2.2	53555	12.5	358720	83.8	428245	3.7
ABPBX10010	Ovenbird	*Seiurus aurocapillus*	5380	1.5	7659	2.1	45407	12.6	301110	83.7	359556	3.6
ABPBX10020	Northern Waterthrush	*Seiurus noveboracensis*	0	0	14009	9.2	8804	5.8	129970	85.1	152783	9.2
ABPBX11030	Mourning Warbler	*Oporornis philadelphia*	0	0	344	0.4	11098	13.6	69928	85.9	81370	0.4
ABPBX12010	Common Yellowthroat	*Geothlypis trichas*	24262	0.1	103150	0.6	500120	3	15966000	96.2	16593532	0.8
ABPBX24010	Yellow-Breasted Chat	*Icteria virens*	35045	0.6	65270	1.2	486460	8.8	4946600	89.4	5533375	1.8
ABPBX45040	Scarlet Tanager	*Piranga olivacea*	365	0.1	6342	2.4	19202	7.3	238310	90.2	264219	2.5
ABPBX61030	Rose-Breasted Grosbeak	*Pheucticus ludovicianus*	368	0.1	7885	2.5	20426	6.5	287930	90.9	316609	2.6
ABPBX61040	Black-Headed Grosbeak	*Pheucticus melanocephalus*	3720	2.1	1326	0.8	31055	17.8	138560	79.3	174661	2.9
ABPBX63010	Blue Grosbeak	*Guiraca caerulea*	997	0.1	5456	0.6	47289	5.6	788880	93.6	842622	0.8
ABPBX64020	Lazuli Bunting	*Passerina amoena*	25015	1.6	20996	1.3	240230	14.9	1322900	82.2	1609141	2.9
ABPBX64030	Indigo Bunting	*Passerina cyanea*	25626	1.3	26399	1.4	252590	13.1	1620500	84.2	1925115	2.7
ABPBX65010	Dickcissel	*Spiza americana*	27897	0.2	92304	0.6	489900	3.1	15234000	96.1	15844101	0.8
ABPBX74030	Eastern Towhee	*Pipilo erythrophthalmus*	51	0	1532	1.4	12132	11.1	95931	87.5	109645	1.4
ABPBX74080	Spotted Towhee	*Pipilo maculatus*	25249	1.6	20714	1.3	239020	15.1	1301000	82	1585983	2.9
ABPBX94020	Chipping Sparrow	*Spizella passerina*	25721	1.3	27099	1.3	252430	12.5	1707200	84.8	2012450	2.6
ABPBX94030	Clay-Colored Sparrow	*Spizella pallida*	36115	0.5	98913	1.3	542020	7.2	6881000	91	7558048	1.8
ABPBX94040	Brewer's Sparrow	*Spizella breweri*	16693	3	4497	0.8	183250	32.7	356480	63.6	560920	3.8
ABPBX94050	Field Sparrow	*Spizella pusilla*	29631	1.3	42370	1.9	323400	14.2	1882700	82.6	2278101	3.2
ABPBX95010	Vesper Sparrow	*Pooecetes gramineus*	32576	0.2	80763	0.5	515410	3.3	15171000	96	15799749	0.7
ABPBX96010	Lark Sparrow	*Chondestes grammacus*	24118	0.2	74837	0.5	430180	2.8	14787000	96.5	15316135	0.7
ABPBX98010	Lark Bunting	*Calamospiza melanocorys*	30649	0.2	90859	0.6	529940	3.3	15615000	96	16266448	0.8
ABPBX99010	Savannah Sparrow	*Passerculus sandwichensis*	31612	0.2	146280	0.8	610380	3.4	16947000	95.6	17735272	1
ABPBXA0010	Baird's Sparrow	*Ammodramus bairdii*	12327	0.2	70565	1.1	339580	5.4	5876800	93.3	6299272	1.3
ABPBXA0020	Grasshopper Sparrow	*Ammodramus savannarum*	27802	0.2	87003	0.5	490840	3.1	15279000	96.2	15884645	0.7
ABPBXA0040	Le Conte's Sparrow	*Ammodramus leconteii*	18933	0.4	66571	1.3	291020	5.5	4939000	92.9	5315524	1.6
ABPBXA0070	Nelson's Sharp-Tailed Sparrow	*Ammodramus nelsoni*	726	0	56489	1.6	95634	2.8	3272600	95.5	3425449	1.7
ABPBXA3010	Song Sparrow	*Melospiza melodia*	30460	0.4	106310	1.3	519760	6.4	7518800	92	8175330	1.7
ABPBXA3030	Swamp Sparrow	*Melospiza georgiana*	292	0	19706	1.1	53448	3.1	1671400	95.8	1744846	1.2
ABPBXA4020	White-Throated Sparrow	*Zonotrichia albicollis*	0	0	1372	2.5	7236	13.2	46150	84.3	54758	2.5
ABPBXA6010	Mccown's Longspur	*Calcarius mccownii*	863	0.2	2804	0.6	63979	13.3	415090	86	482735	0.8
ABPBXA6040	Chestnut-Collared Longspur	*Calcarius ornatus*	10203	0.1	57029	0.5	267570	2.2	11727000	97.2	12061802	0.6
ABPBXA9010	Bobolink	*Dolichonyx oryzivorus*	25819	0.2	71733	0.5	446820	2.9	14843000	96.5	15387372	0.6
ABPBXB0010	Red-Winged Blackbird	*Agelaius phoeniceus*	19525	0.1	88592	0.6	345780	2.4	13926000	96.8	14379897	0.8
ABPBXB2030	Western Meadowlark	*Sturnella neglecta*	32613	0.2	95555	0.6	544250	3.4	15419000	95.8	16091418	0.8
ABPBXB3010	Yellow-Headed Blackbird	*Xanthocephalus xanthocephalus*	720	0.1	44966	3.5	73929	5.7	1182000	90.8	1301615	3.5

Appendix 5.1 (continued). Area and percent of terrestrial vertebrate species distributions by four stewardship status categories.

Tnccode	Common name	Scientific name	status1		status2		status3		status4		total ha	% in status 1 and 2
			ha	%	ha	%	ha	%	ha	%		
ABPBXB5020	Brewer's Blackbird	*Euphagus cyanocephalus*	22332	0.5	77851	1.8	369620	8.4	3909500	89.3	4379303	2.3
ABPBXB6070	Common Grackle	*Quiscalus quiscula*	1133	0	4641	0.1	36172	0.4	8803200	99.5	8845146	0.1
ABPBXB7030	Brown-Headed Cowbird	*Molothrus ater*	37123	0.2	104330	0.6	579310	3.5	15743000	95.6	16463763	0.9
ABPBXB9070	Orchard Oriole	*Icterus spurius*	15565	0.4	33249	0.8	240570	6	3725900	92.8	4015284	1.2
ABPBXB9190	Baltimore Oriole	*Icterus galbula*	4390	0.9	9835	2	46812	9.3	443090	87.9	504126	2.8
ABPBXB9220	Bullock's Oriole	*Icterus bullockii*	1223	1.8	376	0.6	9142	13.6	56659	84.1	67400	2.4
ABPBY04020	Purple Finch	*Carpodacus purpureus*	50	0	396	0.4	11527	10.4	99229	89.2	111202	0.4
ABPBY04040	House Finch	*Carpodacus mexicanus*	4170	0.9	9003	1.9	43751	9.2	417200	88	474124	2.8
ABPBY05010	Red Crossbill	*Loxia curvirostra*	3263	1	7160	2.1	37055	10.9	292740	86	340218	3.1
ABPBY06030	Pine Siskin	*Carduelis pinus*	6419	1.5	9551	2.2	53555	12.5	358720	83.8	428245	3.7
ABPBY06110	American Goldfinch	*Carduelis tristis*	20537	0.5	49694	1.1	323270	7.2	4126800	91.3	4520301	1.6
AMAAA01010	Virginia Opossum	*Didelphis virginiana*	153	0.2	1776	2	2963	3.4	82612	94.4	87504	2.2
AMABA01190	Arctic Shrew	*Sorex arcticus*	679	0.1	34926	3.6	35179	3.6	898850	92.7	969634	3.7
AMABA01250	Pigmy Shrew	*Microsorex hoyi*	937	0.1	42400	3.1	41854	3.1	1281300	93.8	1366491	3.2
AMABA01280	Hayden's Shrew	*Sorex haydenii*	8428	0.2	57743	1.2	239240	4.9	4545900	93.7	4851311	1.4
AMABA03010	Northern Short-tailed Shrew	*Blarina brevicauda*	2092	0	115720	1	189960	1.6	11692000	97.4	11999772	1
AMACC01010	Little Brown Bat	*Myotis lucifugus*	8988	0.2	99796	2.1	285970	6.1	4263800	91.5	4658554	2.3
AMACC01060	Keen's Myotis	*Myotis keenii*	749	0.2	8415	2.3	29159	8	326950	89.5	365272	2.5
AMACC01070	Long-eared Myotis	*Myotis evotis*	4442	4.5	2419	2.4	24319	24.6	67607	68.4	98786	6.9
AMACC01110	Long-legged Myotis	*Myotis volans*	20350	3.4	7393	1.2	164450	27.1	413590	68.3	605783	4.6
AMACC01140	Small-footed Myotis	*Myotis leibii*	16443	2.6	12547	2	213980	34	386100	61.4	629070	4.6
AMACC02010	Silver-haired Bat	*Lasionycteris noctivagans*	3120	1.3	6854	2.8	29941	12.2	205580	83.7	245495	4.1
AMACC04010	Big Brown Bat	*Eptesicus fuscus*	20489	0.7	41338	1.5	252890	9	2487500	88.8	2802217	2.2
AMACC05010	Eastern Red Bat	*Lasiurus borealis*	21496	0.9	59552	2.6	270680	11.9	1917800	84.5	2269528	3.6
AMACC05030	Hoary Bat	*Lasiurus cinereus*	6428	1.4	9562	2.1	53945	11.7	392380	84.9	462315	3.5
AMAEB01040	Eastern Cottontail	*Sylvilagus floridanus*	37116	0.2	104240	0.6	577540	3.5	15737000	95.6	16455896	0.9
AMAEB01060	Nuttall's Cottontail	*Sylvilagus nuttallii*	17902	3.8	7704	1.6	138650	29.7	303000	64.8	467256	5.5
AMAEB01070	Desert Cottontail	*Sylvilagus audubonii*	29399	1.6	18675	1	326990	17.4	1502700	80	1877764	2.6
AMAEB03010	Snowshoe Hare	*Lepus americanus*	9650	0.8	21659	1.8	146930	12.3	1013200	85	1191439	2.6
AMAEB03040	White-tailed Jackrabbit	*Lepus townsendii*	31072	0.5	73394	1.1	457990	6.9	6079000	91.5	6641456	1.6
AMAFB02020	Least Chipmunk	*Eutamius minimus*	18963	2.4	6751	0.9	219880	28	540120	68.7	785714	3.3
AMAFB02230	Eastern Chipmunk	*Tamias striatus*	347	0.2	2588	1.6	12582	7.7	148730	90.6	164246	1.8
AMAFB03010	Woodchuck	*Marmota monax*	623	0.1	11474	2.2	23801	4.5	488490	93.2	524388	2.3
AMAFB05040	Richardson's Ground Squirrel	*Spermophilus richardsonii*	731	0	63224	1.6	104970	2.7	3693500	95.6	3862425	1.7
AMAFB05090	Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*	30603	0.2	93919	0.6	522760	3.3	15319000	95.9	15966282	0.8
AMAFB05120	Franklin's Ground Squirrel	*Spermophilus franklinii*	895	0	65055	2.4	73577	2.7	2584900	94.9	2724427	2.4
AMAFB06010	Black-tailed Prairie Dog	*Cynomys ludovicianus*	17917	0.9	14331	0.7	256690	13.4	1624000	84.9	1912938	1.7

Appendix 5.1 (continued). Area and percent of terrestrial vertebrate species distributions by four stewardship status categories.

Tnccode	Common name	Scientific name	status1		status2		status3		status4		total ha	% in status 1 and 2
			ha	%	ha	%	ha	%	ha	%		
AMAFB07010	Gray Squirrel	*Sciurus carolinensis*	773	0	27423	0.3	78840	0.9	8294700	98.7	8401736	0.3
AMAFB07040	Eastern Fox Squirrel	*Sciurus niger*	6209	1.3	9561	2.1	53841	11.7	391740	84.9	461351	3.4
AMAFB08010	Red Squirrel	*Tamiasciurus hudsonicus*	143	0.1	1569	1.6	10582	10.5	88422	87.8	100716	1.7
AMAFB09020	Northern Flying Squirrel	*Glaucomys sabrinus*	155	0.3	1685	3.1	3503	6.4	49607	90.3	54949	3.4
AMAFC01040	Northern Pocket Gopher	*Thomomys talpoides*	5193	0	60120	0.5	229690	1.8	12266000	97.7	12561003	0.5
AMAFC02010	Plains Pocket Gopher	*Geomys bursarius*	531	0	14975	0.6	14397	0.5	2608200	98.9	2638103	0.6
AMAFD01010	Olived-backed Pocket Mouse	*Perognathus fasciatus*	797	0	21675	1.1	26701	1.4	1857700	97.4	1906873	1.2
AMAFD01020	Plains Pocket Mouse	*Perognathus flavescens*	542	0.1	16310	3.2	6836	1.3	488510	95.4	512198	3.3
AMAFD03010	Ord's Kangaroo Rat	*Dipodomys ordii*	0	0	0	0	3035	6.1	46629	93.9	49664	0
AMAFD05050	Hispid Pocket Mouse	*Perognathus hispidus*	12	0	0	0	1977	1	187300	98.9	189289	0
AMAFE01010	American Beaver	*Castor canadensis*	10395	0.8	37858	2.9	135240	10.2	1144300	86.2	1327793	3.6
AMAFF02010	Plains Harvest Mouse	*Reithrodontomys montanus*	0	0.0	0	0.0	3914	30.1	9085	69.9	12999	0.0
AMAFF02030	Western Harvest Mouse	*Reithrodontomys megalotis*	31826	0.3	67097	0.6	505490	4.7	10247000	94.4	10851413	0.9
AMAFF03040	Deer Mouse	*Peromyscus maniculatus*	27905	0.2	92315	0.6	490290	3.1	15267000	96.2	15877510	0.8
AMAFF03070	White-footed Mouse	*Peromyscus leucopus*	34258	0.5	87369	1.2	499580	7	6467400	91.2	7088607	1.7
AMAFF06010	Northern Grasshopper Mouse	*Onychomys leucogaster*	3874	0	76582	0.6	198670	1.4	13446000	98	13725126	0.6
AMAFF08090	Bushy-tailed Woodrat	*Neotoma cinerea*	17411	3.8	6588	1.5	138640	30.5	291220	64.2	453859	5.3
AMAFF09020	Southern Red-backed Vole	*Clethrionomys gapperi*	20848	1.2	24381	1.4	222290	12.4	1520000	85	1787519	2.5
AMAFF11010	Meadow Vole	*Microtus pennsylvanicus*	1204	0.1	48185	2.3	95999	4.6	1956200	93.1	2101588	2.4
AMAFF11140	Prairie Vole	*Microtus ochrogaster*	32164	0.4	87296	1.2	490600	6.8	6594900	91.5	7204960	1.7
AMAFF13010	Sagebrush Vole	*Lagurus curtatus*	18447	1.4	13343	1	244290	19.1	1005200	78.5	1281280	2.5
AMAFF15010	Muskrat	*Ondatra zibethicus*	6567	0.4	49945	3.3	126310	8.2	1348400	88.1	1531222	3.7
AMAFH01010	Meadow Jumping Mouse	*Zapus hudsonius*	32552	0.4	112880	1.4	534590	6.5	7497700	91.7	8177722	1.8
AMAFH01020	Western Jumping Mouse	*Zapus princeps*	573	0	61257	1.6	69746	1.8	3792700	96.6	3924276	1.6
AMAFJ01010	Common Porcupine	*Erethizon dorsatum*	6419	1.5	9551	2.2	53555	12.5	358720	83.8	428245	3.7
AMAJA01010	Coyote	*Canis latrans*	37474	0.2	116240	0.7	599810	3.4	16658000	95.7	17411524	0.9
AMAJA03010	Red Fox	*Vulpes vulpes*	37474	0.2	116240	0.7	599810	3.4	16658000	95.7	17411524	0.9
AMAJA04010	Common Gray Fox	*Urocyon cineroargenteus*	413	0	8667	0.2	30334	0.6	5435700	99.3	5475114	0.2
AMAJE02010	Common Raccoon	*Procyon lotor*	38134	0.2	156610	0.9	665550	3.6	17398000	95.3	18258294	1.1
AMAJF01020	Fisher	*Martes pennanti*										
AMAJF02010	Ermine	*Mustela erminea*	779	0	30378	1.6	62014	3.3	1788900	95	1882071	1.7
AMAJF02020	Least Weasel	*Mustela nivalis*	18926	0.1	103520	0.6	428670	2.7	15413000	96.5	15964116	0.8
AMAJF02030	Long-tailed Weasel	*Mustela frenata*	36575	0.4	111600	1.3	563750	6.6	7855600	91.7	8567525	1.7
AMAJF02050	Mink	*Mustela vison*	16659	0.6	67688	2.6	210560	8.1	2295400	88.6	2590307	3.3
AMAJF04010	American Badger	*Taxidea taxus*	33624	0.2	101070	0.6	559320	3.4	15577000	95.7	16271014	0.8
AMAJF05010	Eastern Spotted Skunk	*Spilogale putorius*	607	0	10922	1.3	4784	0.6	823740	98	840053	1.4
AMAJF06010	Striped Skunk	*Mephitis mephitis*	37474	0.2	116240	0.7	599810	3.4	16658000	95.7	17411524	0.9

Appendix 5.1 (continued). Area and percent of terrestrial vertebrate species distributions by four stewardship status categories.

Tnccode	Common name	Scientific name	status1		status2		status3		status4		total ha	% in status 1 and 2
			ha	%	ha	%	ha	%	ha	%		
AMAJF08010	River Otter	*Lutra canadensis*	64	0.4	342	1.9	1010	5.7	16180	92	17596	2.3
AMAJH03020	Bobcat	*Felis rufus*	27919	0.7	61631	1.6	367440	9.6	3387900	88.1	3844890	2.3
AMALC01010	Elk	*Cervus elaphus*	15207	0.7	37708	1.8	192400	9.4	1809900	88.1	2055215	2.6
AMALC02010	Mule Deer	*Odocoileus hemionus*	35045	0.6	25887	0.4	460930	7.8	5387800	91.2	5909662	1.0
AMALC02020	White-tailed Deer	*Odocoileus virginianus*	37474	0.2	116240	0.7	599810	3.4	16658000	95.7	17411524	0.9
AMALC03010	Moose	*Alces alces*	391	0	7359	0.2	24153	0.6	4252500	99.3	4284403	0.2
AMALD01010	Pronghorn	*Antilocapridae americana*	16214	0.9	12817	0.7	221400	12.4	1529700	85.9	1780131	1.6
AMALE04010	Bighorn Sheep	*Ovis canadensis*	15423	3.5	10609	2.4	155580	34.8	265380	59.4	446992	5.8
ARAAB01012	Common Snapping Turtle	*Chelydra serpentina*	565	0.1	39595	5	64514	8.2	680850	86.7	785524	5.1
ARAAD01011	Western Painted Turtle	*Chrysemys picta belli*	16500	0.7	61001	2.5	206070	8.4	2163200	88.4	2446771	3.2
ARAAD05082	False Map Turtle	*Graptemys pseudogeographica*	0	0	0	0	8391	19.6	34440	80.4	42831	0
ARAAG01022	Midland Smooth Softshell Turtle	*Apalone mutica*	0	0	0	0	1195	15.5	6536	84.5	7732	0
ARACF12032	Eastern Short Horned Lizard	*Phrynosoma douglassi brevirostre*	23765	2.6	15164	1.7	258080	28.5	609300	67.2	906309	4.3
ARACF14032	Northern Sagebrush Lizard	*Sceloporus graciosus graciosus*	15620	6.3	5182	2.1	102660	41.4	124390	50.2	247852	8.4
ARACH01102	Northern Prairie Skink	*Eumeces septentrionalis*	190	1.5	5217	40.3	835	6.4	6713	51.8	12955	41.7
ARADB07014	Eastern Yellowbelly Racer	*Coluber constrictor flaviventris*	29946	1.2	19356	0.8	350060	14.2	2058900	83.8	2458262	2
ARADB17010	Western Hognose Snake	*Heterodon nasicus*	508	0.1	13575	2.4	13506	2.4	537980	95.1	565569	2.5
ARADB23020	Smooth Green Snake	*Opheodrys vernalis*	7301	0.4	37620	2.3	107760	6.5	1500700	90.8	1653381	2.7
ARADB2601A	Bullsnake	*Pituophis melanoleucus sayi*	6899	0.2	15759	0.5	150470	5	2813800	94.2	2986928	0.8
ARADB34032	Northern Red-bellied Snake	*Storeria occipitomaculata*	1053	0.1	49337	3.4	59952	4.1	1360300	92.5	1470642	3.4
ARADB36100	Plains Garter Snake	*Thamnophis radix*	37479	0.2	130990	0.7	627330	3.5	16895000	95.5	17690799	1
ARADB36130	Red-sided Garter Snake	*Thamnophis sirtalis parietalis*	37480	0.2	152790	0.8	655320	3.6	17194000	95.3	18039590	1.1
ARADE02128	Prairie Rattlesnake	*Crotalus viridis viridis*	20329	1	16369	0.8	286610	14.3	1676100	83.8	1999408	1.8

Appendix 7.1 List of Example GAP Applications

Businesses and Non-government Organizations:
The following are some examples of applications of GAP data by the private sector:

- The Wyoming Natural Heritage Program (a private non-government organization) transformed the endangered and sensitive species database into a spatially referenced digital geographic information system using the GAP digital base map and other GAP spatial data.
- Hughes Corp. is experimenting with the Utah and Nevada GAP digital base maps, simulating images to aid the development of new space-based remote sensing devices.
- The Nature Conservancy used the Wyoming GAP data to develop a map of ecoregions of Wyoming.
- Weyerhaeuser Corp. is using the Arkansas GAP data in managing their lands in Arkansas.
- IBM Corp. is funding a project at the University of California-Santa Barbara that, in part, uses GAP data in the development of visualization software.
- NM-GAP vegetation data is being used for an environmental assessment of a proposed spaceport, a state/private venture.

County and City Planning:
Some other examples of the use of GAP by local governments are:

- CA-GAP biological data were combined with the Southern California Association of Governments (SCAG) land ownership data to show which ownerships and jurisdictions were needed for joint conservation planning and management of a particular natural community or species, maximizing efficiency and minimizing the potential for yet another conservation crisis.
- In California, county and city planners of several jurisdictions, wildlife agencies, developers of the 4S Ranch property, and the state Natural Communities Conservation Planning program used the GAP regional data, as well as more detailed information, to conserve 1,640 acres of habitat within a 2,900-acre planned development.
- Day-to-day county planning operations in Piute, Grande, and Washington counties, Utah.
- County planners in Piute County, Utah, used GAP data to optimize the siting of a proposed sawmill for aspen with respect to the distribution of aspen stands.
- Missoula County, Montana, used the GAP land cover map of the area as a base map for its comprehensive long-range plan.
- Snohomish County, Washington, used the GAP land cover map in meeting state requirements for a growth management plan.
- The City of Bainbridge Island, Washington, used GAP data to assist them in development of a watershed planning project.

State Uses:
The following are some examples of uses of GAP data by state agencies.

- The GAP database of species habitats was used by the Tennessee Wildlife Resources Agency (TWRA) to update its book "Species in Need of Management."
- Images of land cover derived from GAP TM data are used by TWRA for locating particular habitat types. Information on the locations of these habitat types is provided by TWRA to the public for a wide variety of public service functions, from education to cooperative resource management.
- Early GAP data developed by TWRA were used to help identify an extremely important area of the state with high biodiversity that was subsequently purchased by the state for conservation.
- Preliminary findings from GAP were used by TWRA to develop three resource management initiatives.
- The Tennessee GAP project, which is being carried out primarily by TWRA, is the foundation of a multi-agency, long-term biodiversity program for Tennessee.
- GAP data have been used by the Tennessee Forestry Stewardship Program to help develop a district program for nine conservation planning districts, outlining Best Management Practices (BMPs) for biological conservation on private lands.
- GAP data are being used extensively by TWRA in the preparation of project proposals to the North American Waterfowl Conservation Program. These proposals require that biodiversity issues are addressed in specific detail. The use of GAP data on occurrence of land cover types and terrestrial vertebrates has made this possible.
- The Wyoming Department of Fish and Game used GAP data to assist them in transforming the Wildlife Observation System database into a spatially referenced geographic information system.
- The Utah Division of Wildlife Resources and the Bear River Water Conservancy District used the Utah GAP land cover map in a resource management assessment for mitigating conflicts between a proposed groundwater withdrawal project and the maintenance of an elk calving area in the Uinta Mountains.
- The Utah Division of Wildlife Resources, the Rocky Mountain Elk Foundation, and Sheik Safari International used the Utah GAP land cover map to identify critical elk habitat. The environmental profile of these areas was then used to identify other similar areas for elk habitat enhancement.
- The Utah Division of Wildlife Resources used the Utah GAP land cover map for a rapid ecological assessment of the Echo Henefer Wildlife Management Area.
- The Washington Department of Fish and Wildlife used GAP data to develop a breeding bird atlas and an atlas of mammals of Washington State.
- The Washington Department of Fish and Wildlife uses GAP data to operate an integrated landscape management program.
- The Washington Department of Fish and Wildlife uses GAP data from Eastern Washington to assist with an innovative program that brings the forest products industry, state agency biologists, non-government organizations, and tribal biologists together in the field to jointly determine the appropriate management practices for any particular site of concern (Timber, Fish & Wildlife Program).
- The Idaho Department of Fish and Game used GAP data to evaluate the impact from expanded military training activities on public lands in Southern Idaho.

- The Idaho Department of Fish and Game uses GAP data for regional planning efforts on a regular basis.

Statewide Planning:
Biodiversity planning programs or projects are now under way in Arizona, California, Colorado, Maine, Missouri, Nevada, Oregon, and Tennessee. It is likely that similar efforts will develop in other states. These activities were the subject of the State Biodiversity Programs meeting discussed on page _ in this report. In some cases, these efforts grew out of the state GAP project, however, in most cases, the GAP data are being used to meet a previously defined need. In all cases, GAP data are central to their development and operations. The goals of each of these programs or projects are presented briefly below.

Federal Agency Applications:
Some examples of applications of GAP data by federal agencies follow:
- GAP data are being supplied to all military installations in the Great Basin ecoregion for integrated management of the natural resources. These installations constitute a very large amount of land area. Much of it is of high value for native species.
- The Ouachita National Forest used the Arkansas GAP data to help them develop an ecosystem management plan.
- The Wyoming GAP data were used by NASA to calibrate a model that predicts vegetation types based on climate and soil variables.
- The potential contributions to biodiversity conservation of four different options proposed for new wilderness designation in Idaho were quantified by the Idaho Cooperative Fish and Wildlife Research Unit in cooperation with the Park Studies Unit.
- The potential contributions to biodiversity conservation of four different options proposed for new national park designation in Idaho were quantified by the Idaho Cooperative Park Studies Unit.
- The U.S. Forest Service in Booneville, Arkansas, used the Arkansas GAP data land cover maps in a 3-dimensional presentation to provide the public with a visual representation of the region and to enhance the public's involvement with the National Forest planning process.
- The U.S. Fish and Wildlife Service regularly uses the GAP data for Southern California for habitat evaluation and management.
- The U.S. Forest Service, Bureau of Land Management, and National Park Service are using the GAP data for a wide variety of natural resource management operations in Utah. For example, the entire Utah GAP database is directly linked with existing National Park Service databases for use by National Parks.
- The Bureau of Land Management uses the Wyoming GAP data for managing the Buffalo Resource Area.
- The U.S. Forest Service used the Utah GAP data to help assist them in evaluating human-induced impacts to forested lands surrounding ski resorts in central Utah.
- The U.S. Fish and Wildlife Service in Delaware used GAP data to help identify potential habitat for the federally endangered Delmarva fox squirrel. These maps

were displayed and served as a catalyst for bringing together people with a stake in the issue.

- The U.S. Fish and Wildlife Service used the Indiana GAP data as part of a biological assessment for the base closure of the Jefferson Proving Grounds and its conversion to a National Wildlife Refuge. This 58,000-acre installation has restricted human access due to unexploded ordinance and contains some of the highest-quality natural habitat in Indiana.
- The U.S. Fish and Wildlife Service in Louisiana used GAP data to avoid conflict over the designation of critical habitat of the federally endangered Louisiana black bear.
- The NOAA Coastal Marine Sanctuary in Washington State uses GAP data for an educational display.
- In Washington and New Mexico, digital land cover maps have been distributed to all National Forests.
- The U.S. Natural Resources Conservation Service (NRCS) in New Mexico is using a GAP clustered imagery as a base for their land cover mapping activities.
- The Department of Defense is funding the development of an electronic environmental information system for the Mojave ecoregion, which would use GAP data as a foundation or base layer of information. The system will link 29 DoD installations to a common source of environmental information.

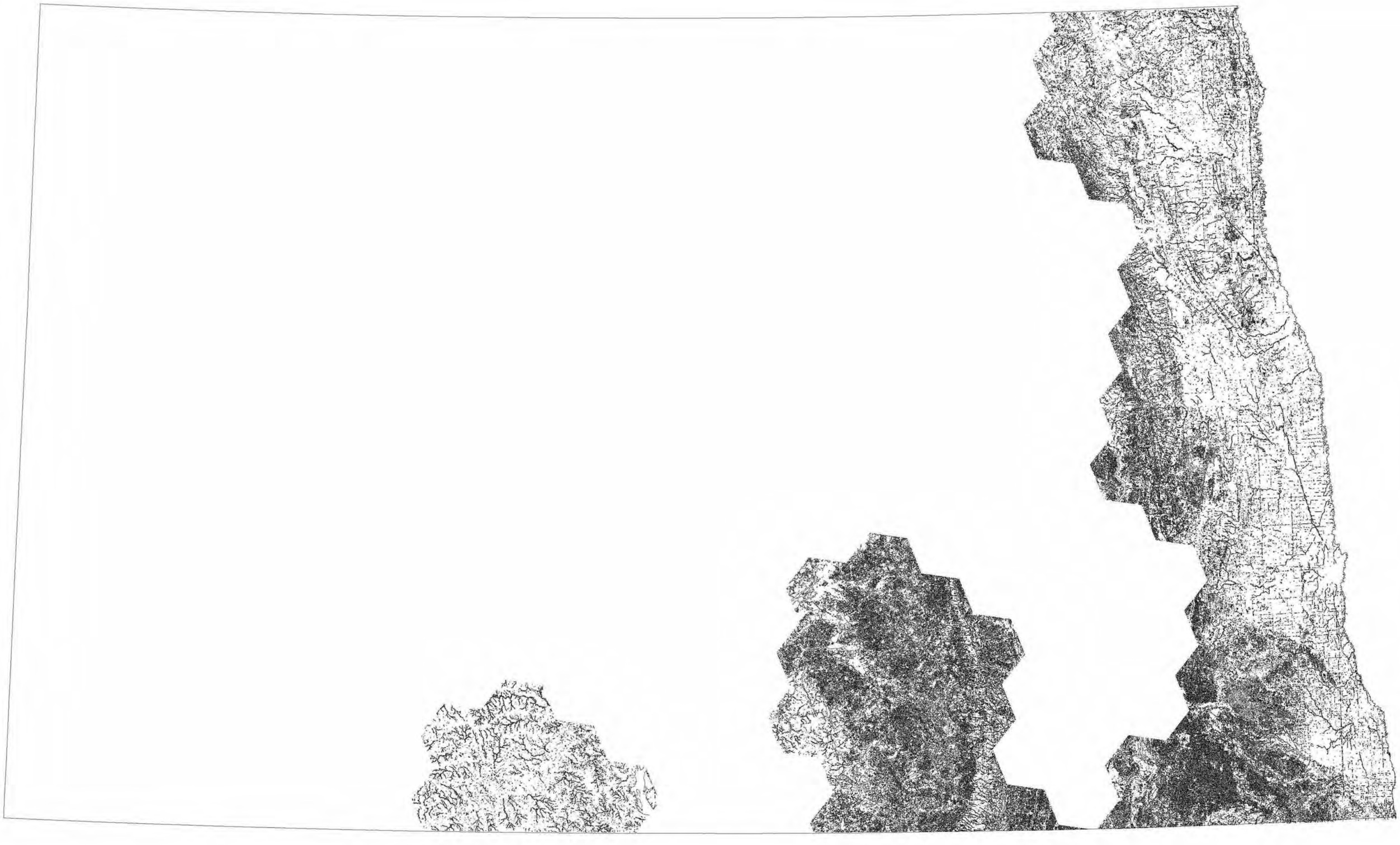
North Dakota Applications

- The ND-GAP land cover data is used by USFWS Private Land biologists to evaluate the land cover composition of watersheds for proposed wetland creations.
- The ND-GAP land cover data was used by USGS wildlife biologists in the design of a survey for Richardson's ground squirrels.
- The ND-GAP land cover data is used by North Dakota Game and Fish Department biologists to evaluate land cover composition for a variety of planning purposes including ND's Comprehensive Wildlife Conservation Strategy.
- The ND-GAP land cover data is used by the ND Natural Resources Conservation Service for watershed planning purposes.
- The ND-GAP land cover data is used by the U.S. Forest Service Fire Sciences Laboratory in a national fire regime and vegetation mapping project.
- The ND-GAP vertebrate data was used by EPA region 7 and the Missouri Resource Assessment Partnership as one input to Cplan, a reserve design algorithm, as part of the EPAs Critical Ecosystems program.
- The ND-GAP vertebrate data was used by University of Illinois researchers investigating deer ticks and Lyme disease for the Center of Disease Control.
- The ND-GAP vertebrate data was used by biologists preparing a book on the mammals of ND.
- The ND-GAP stewardship data was used by South Dakota State University in the Upper Missouri River Aquatic Gap Project.

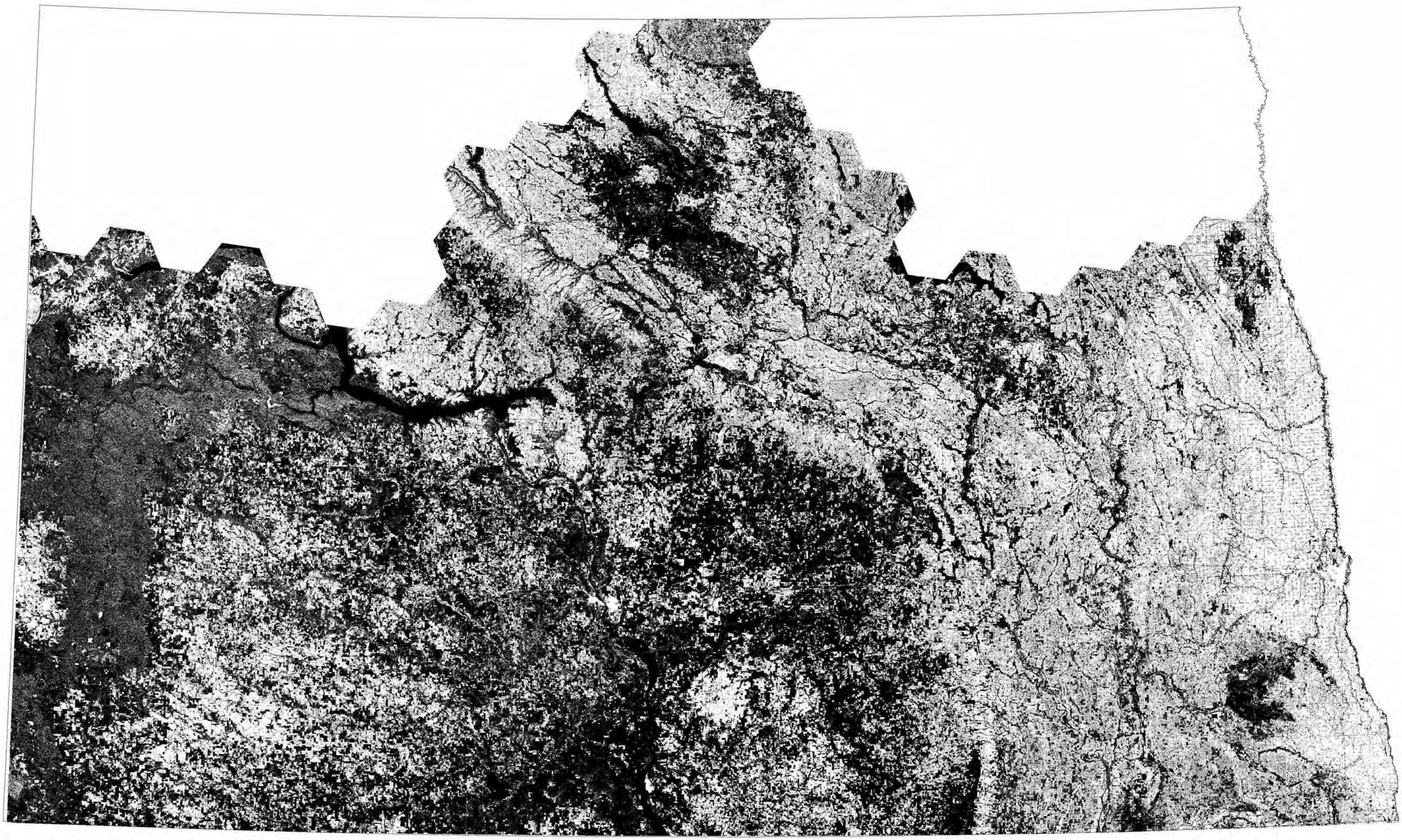
Tiger Salamander(Ambystoma tigrinum

Common Mudpuppy(Necturus maculosus)

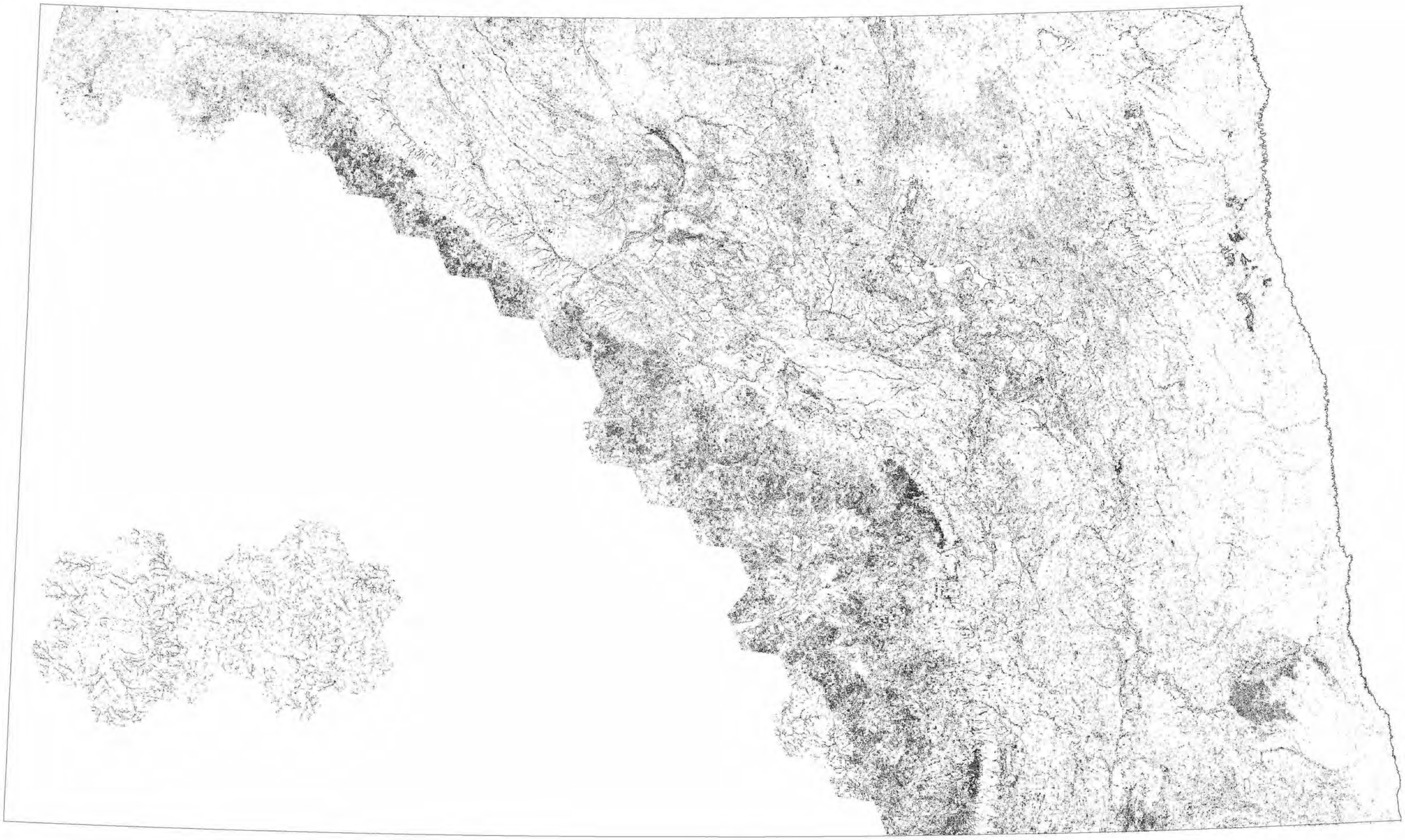
American Toad(Bufo americanus)



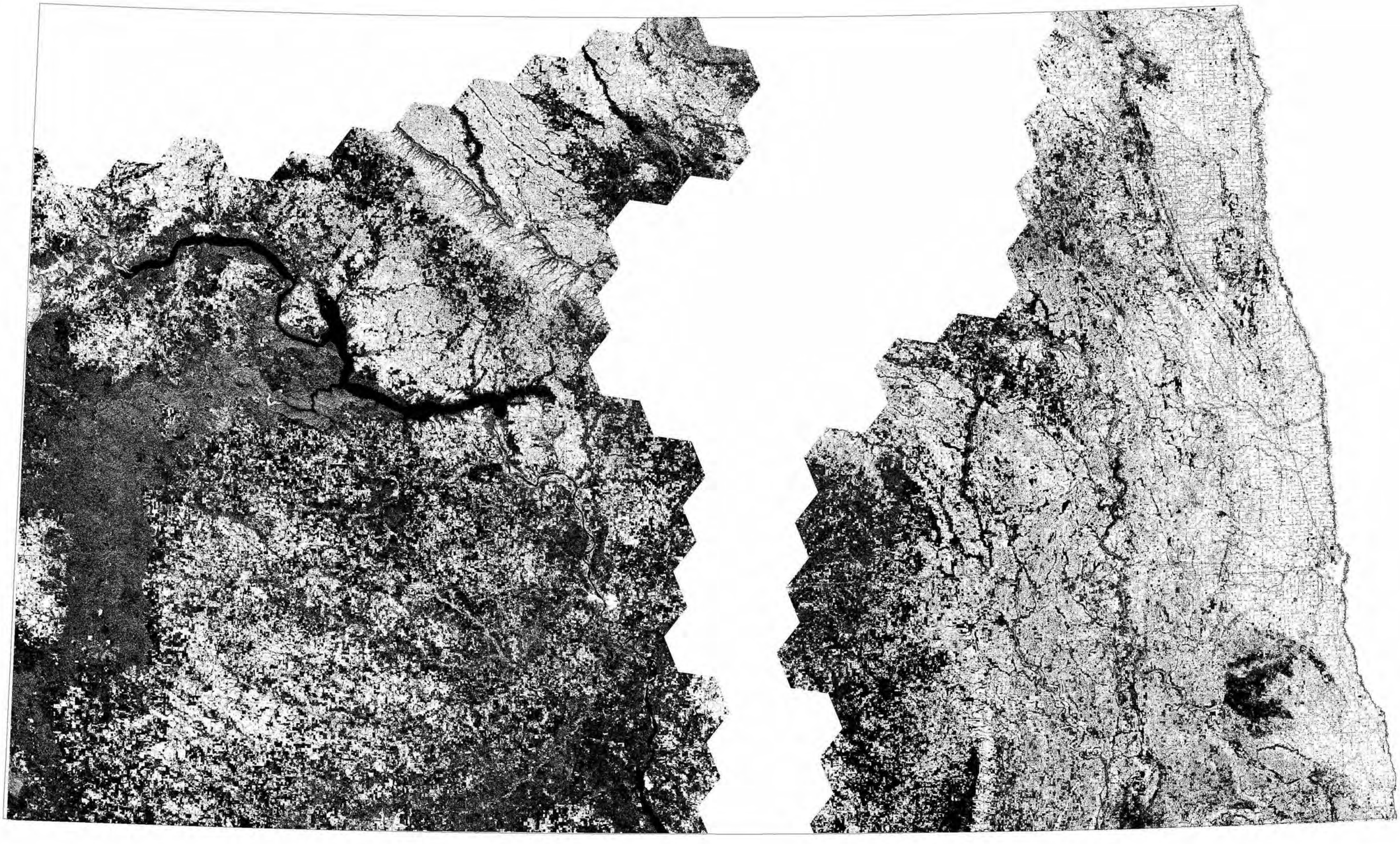
Great Plains Toad(Bufo cognatus)



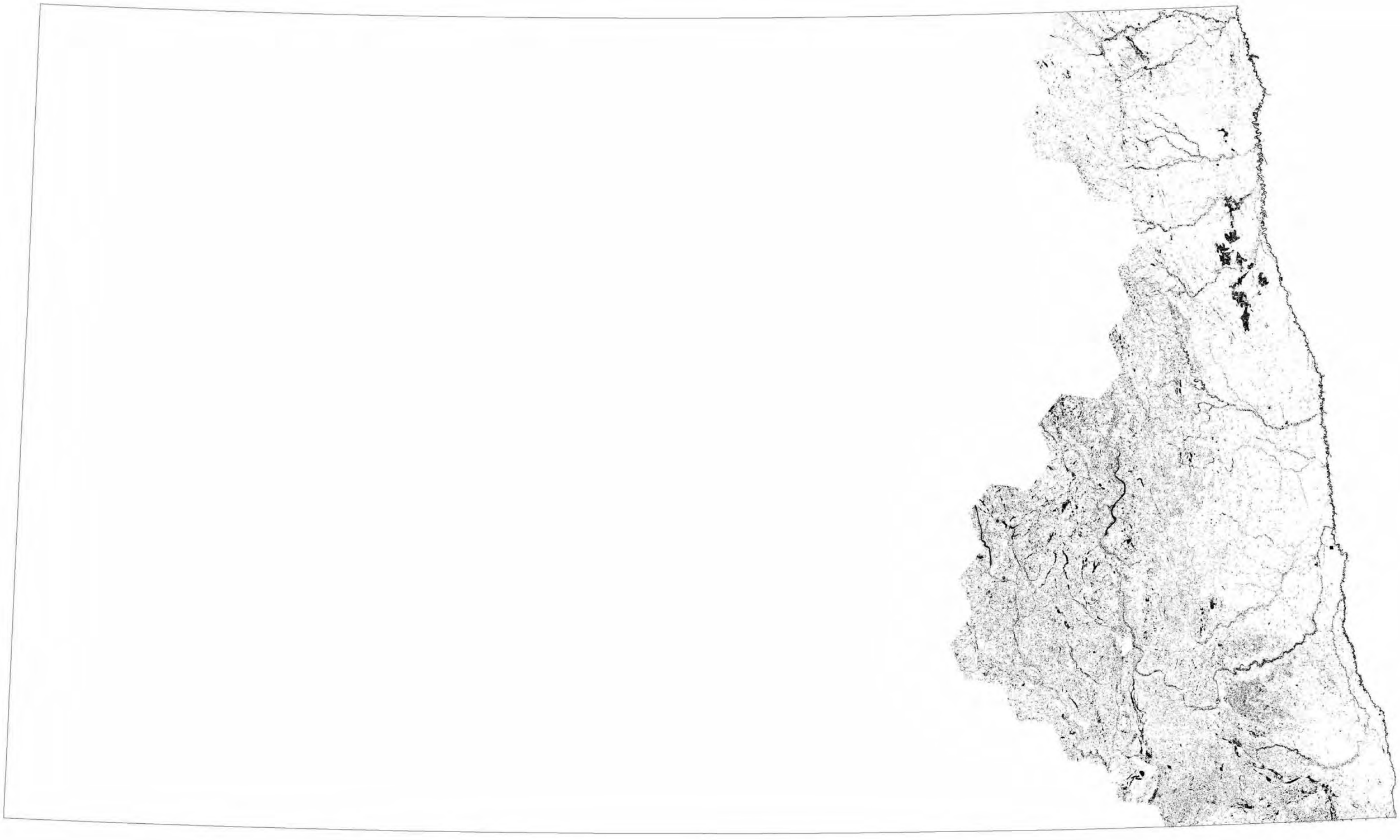
Canadian Toad(Bufo hemiophrys)



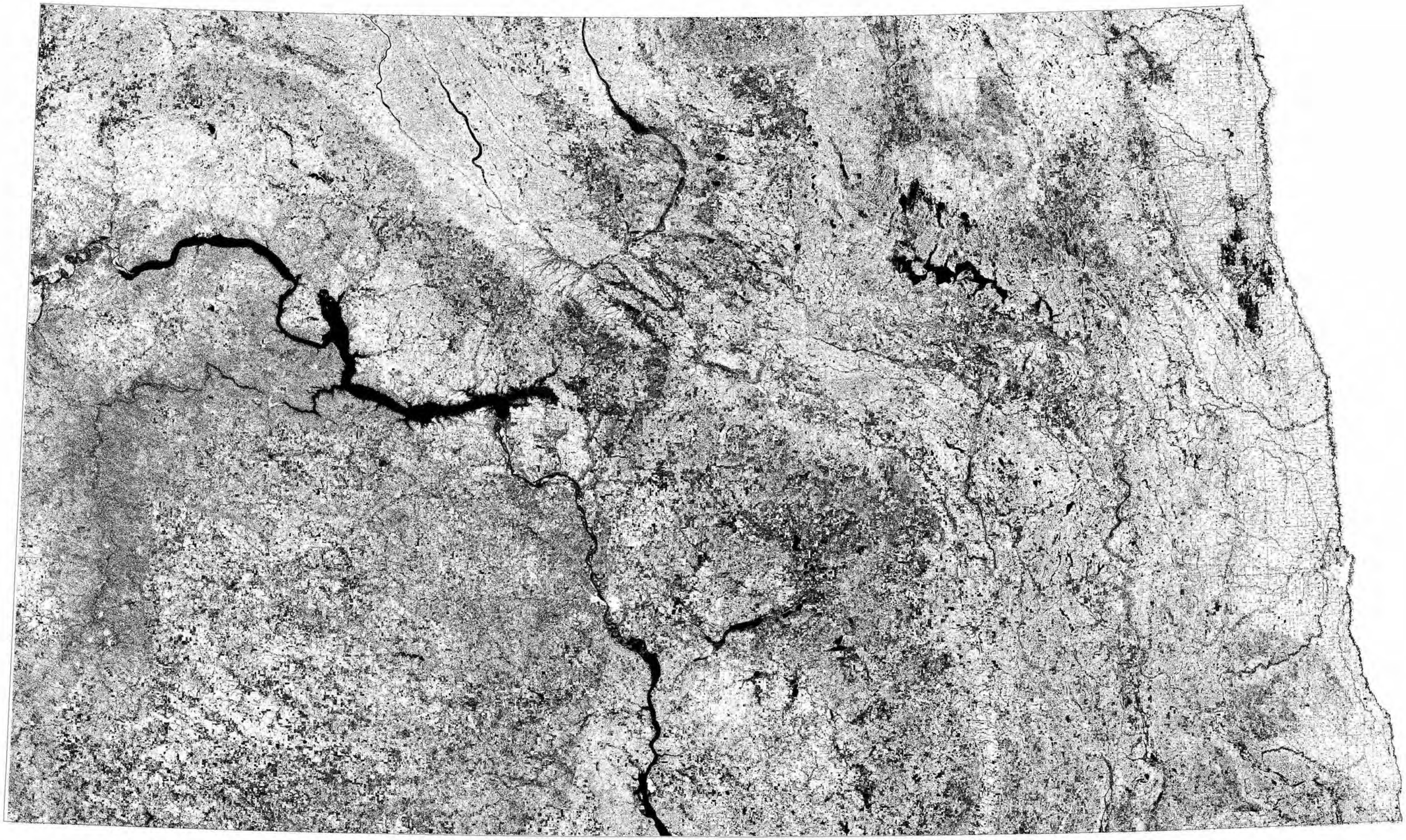
Woodhouse's Toad(Bufo w. woodhousii)



Gray Treefrog/Cope's(Hyla versicolor/chrysoscelis)

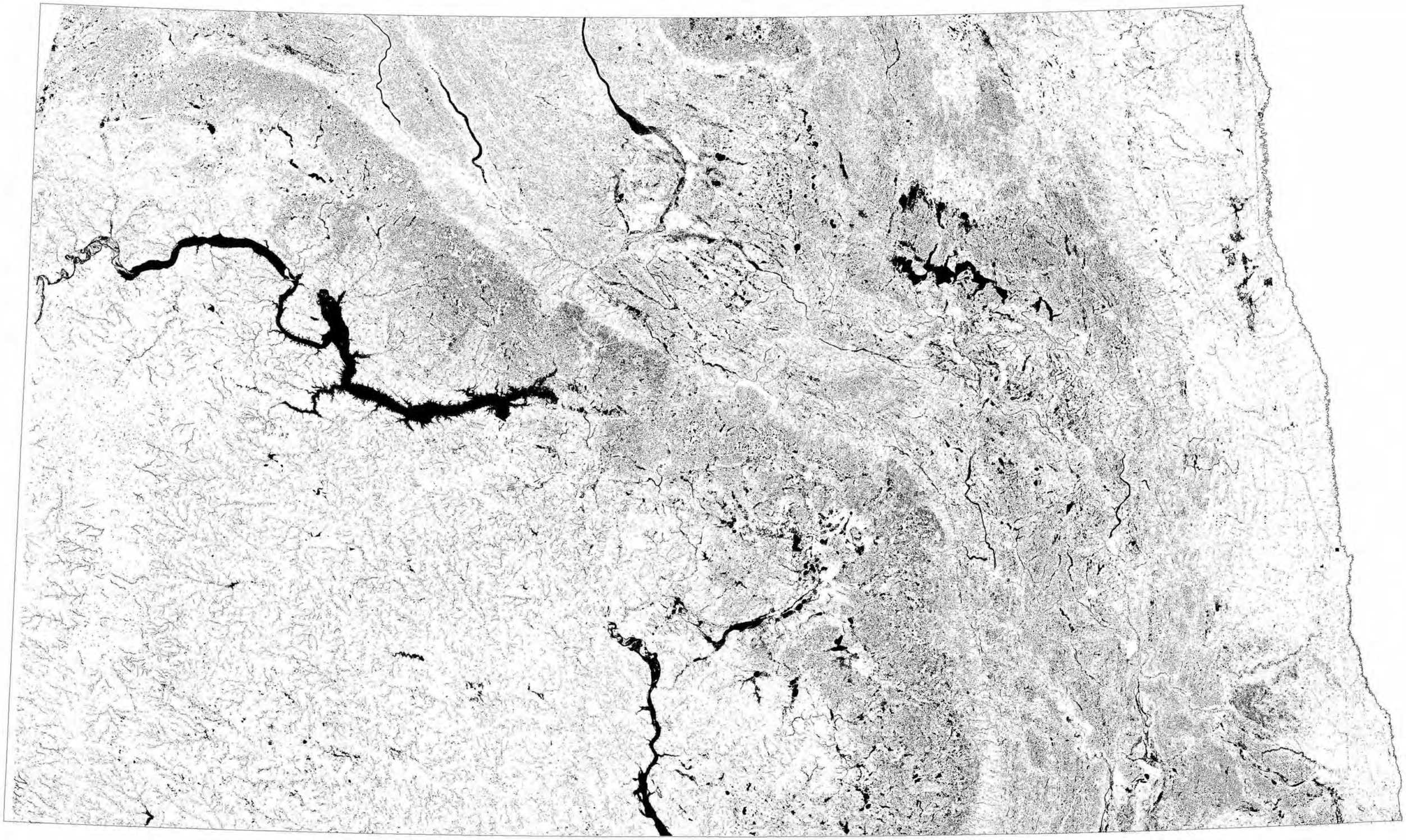


Boreal Chorus Frog(Pseudacris triseriata maculata)

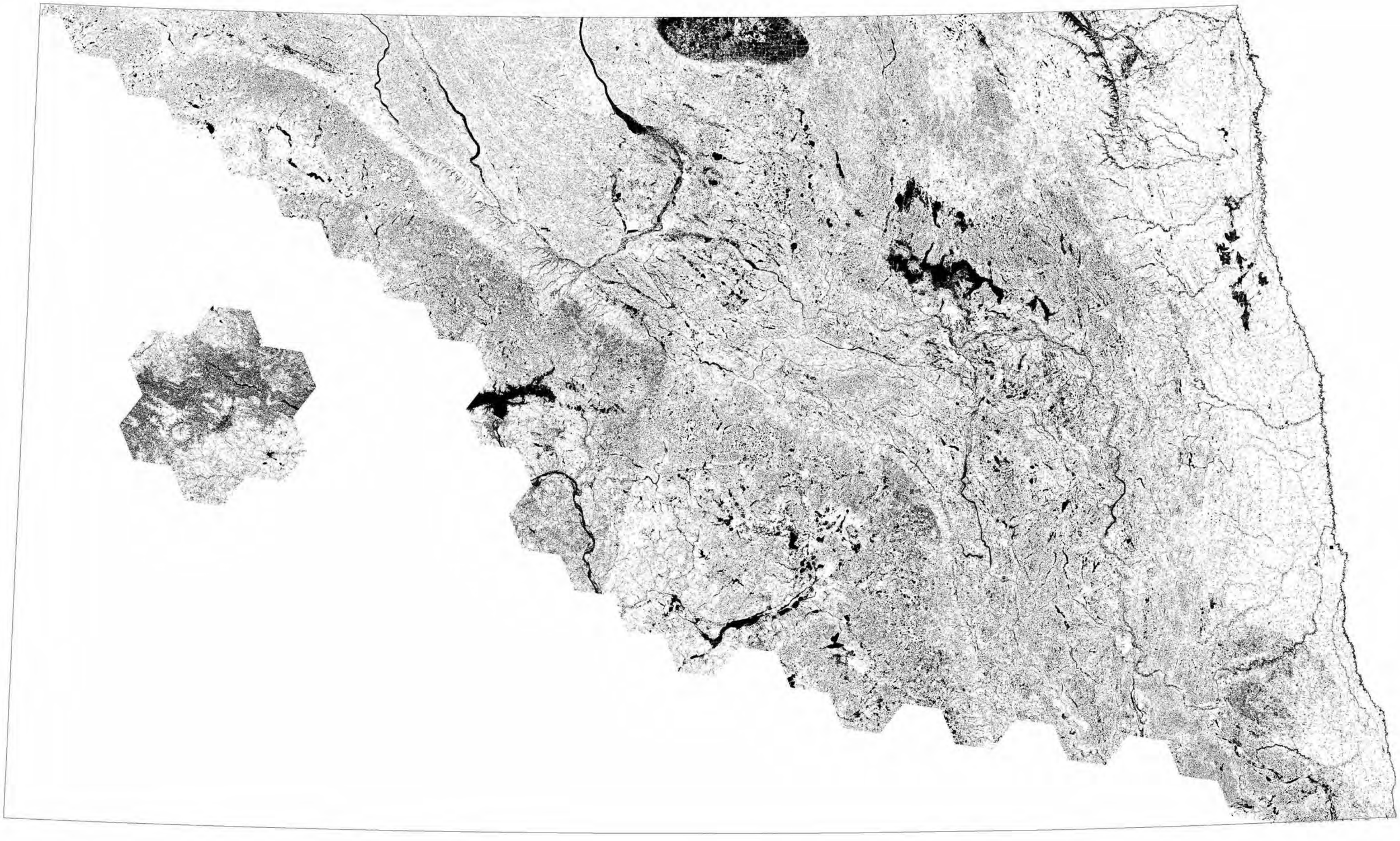


Plains Spadefoot Toad(Scaphiopus bombifrons)

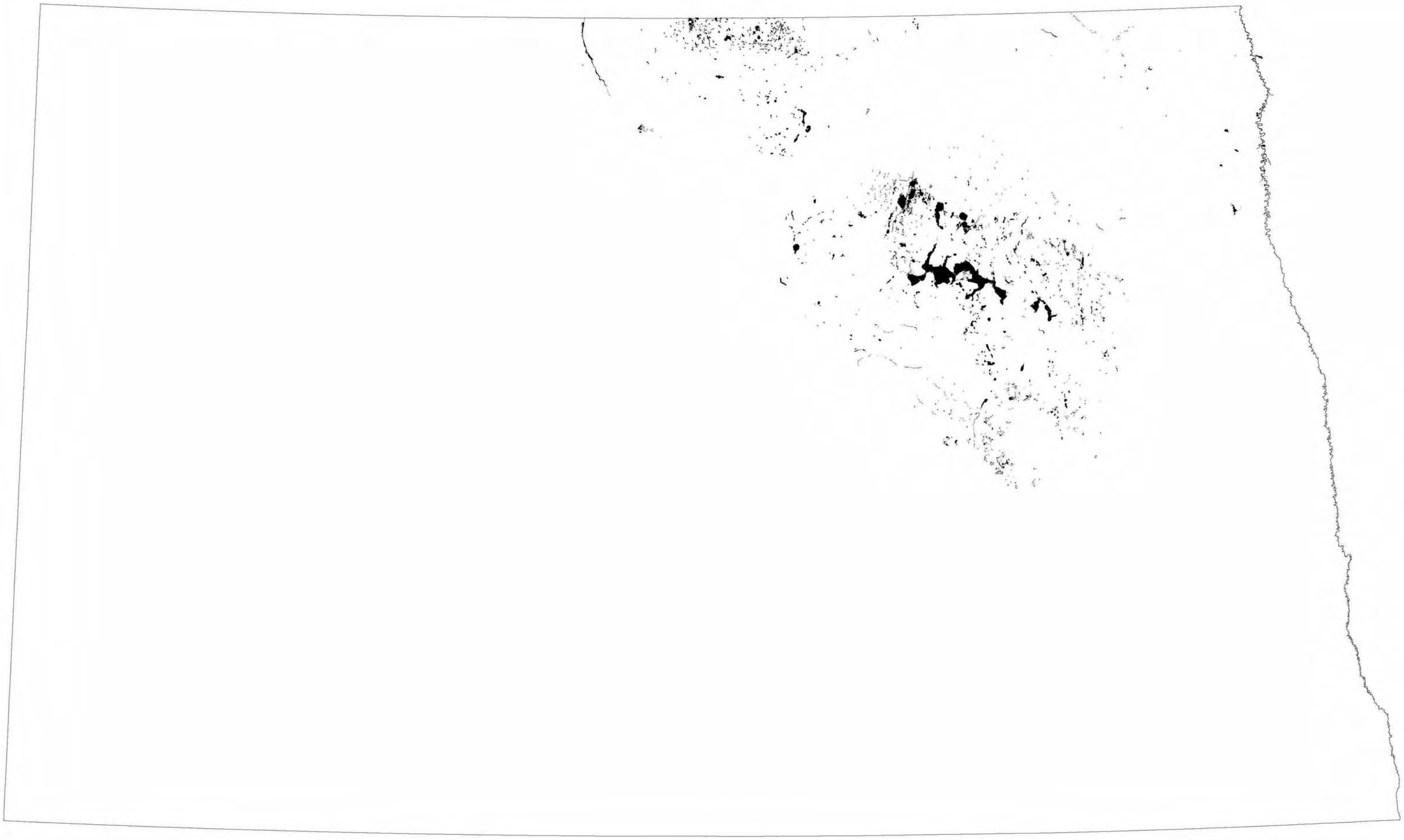
Northern Leopard Frog(Rana pipiens)



Wood Frog(Rana sylvatica)

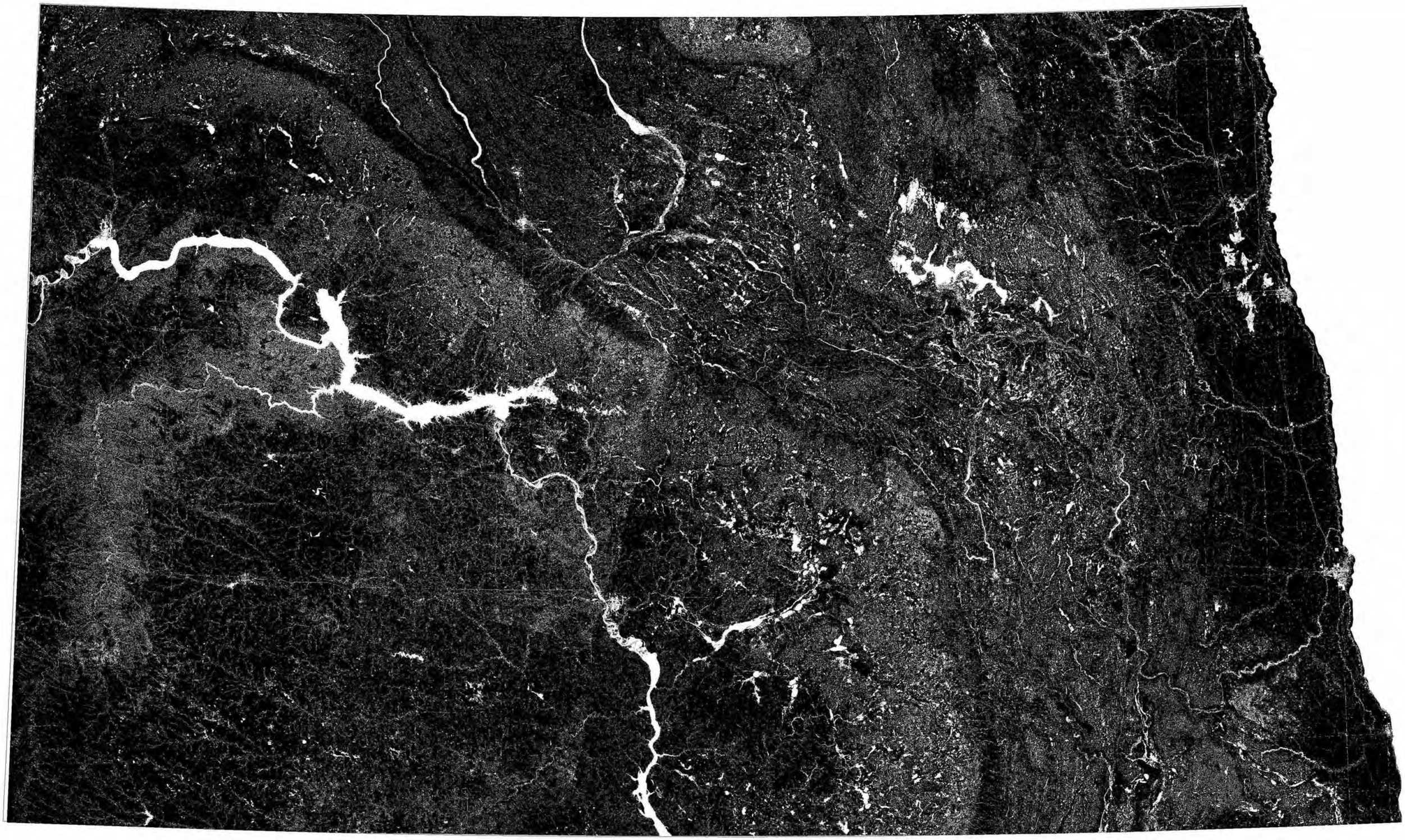


COMMON LOON(Gavia immer)

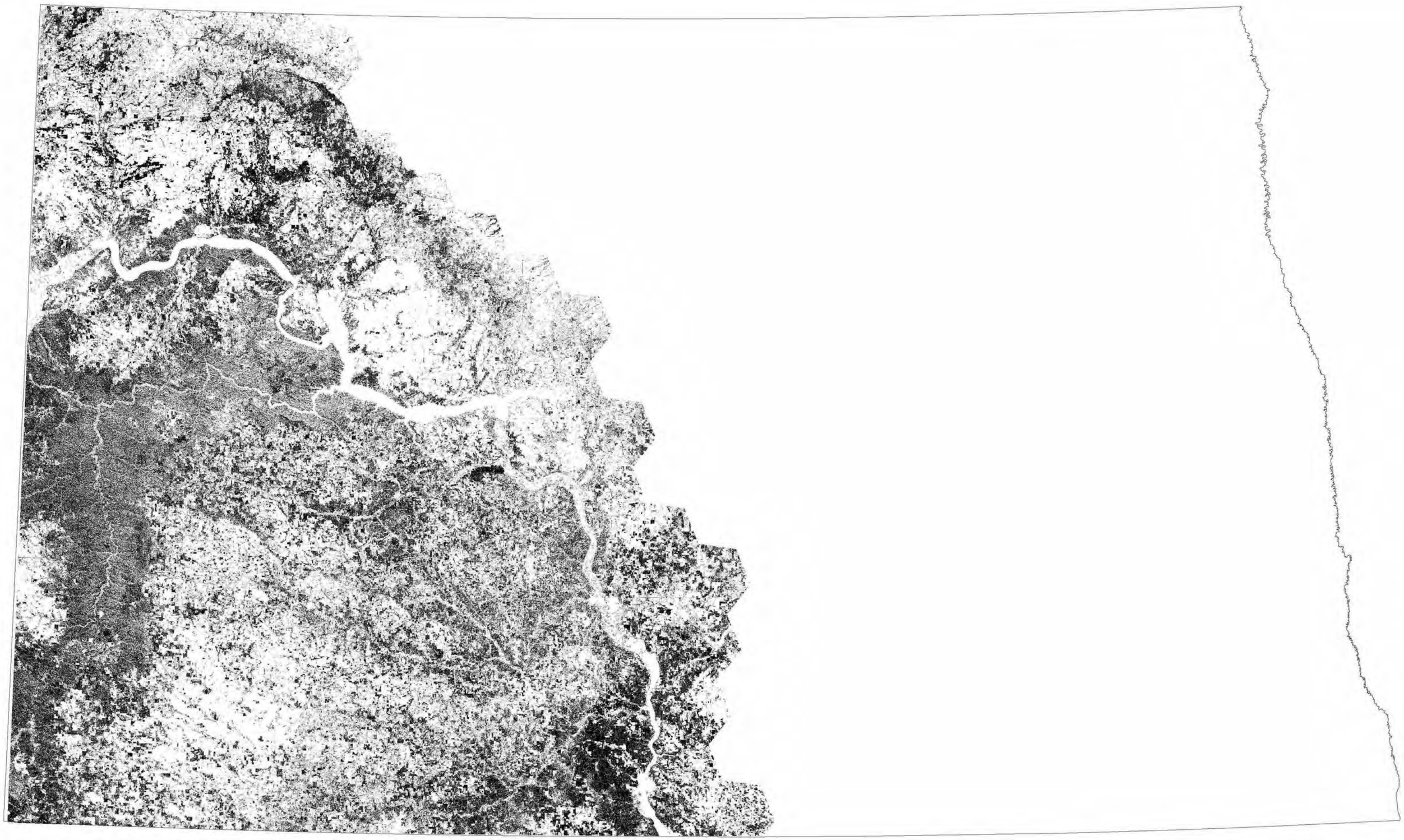


MERLIN(Falco columbarius)

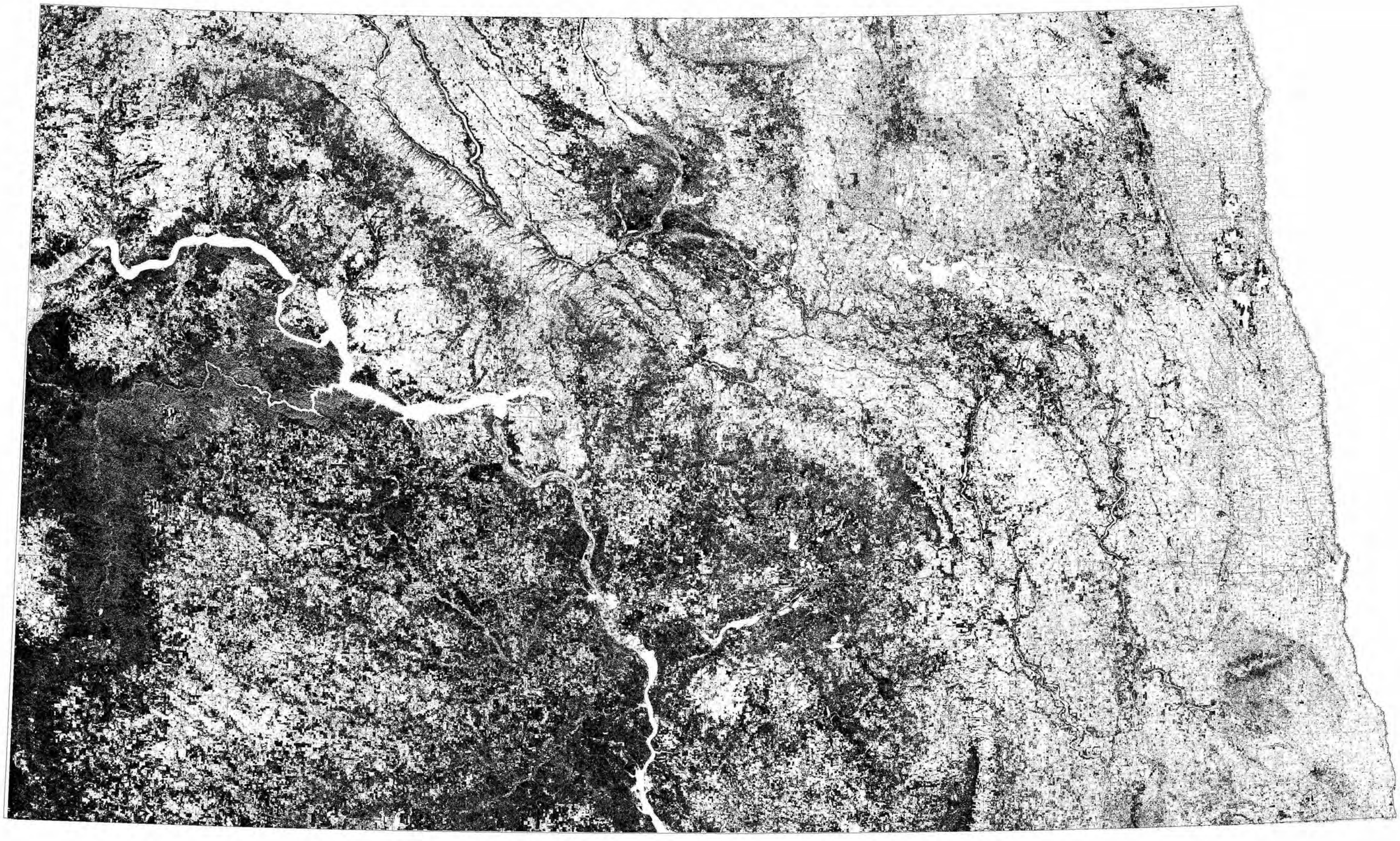
AMERICAN KESTREL(Falco sparverius)



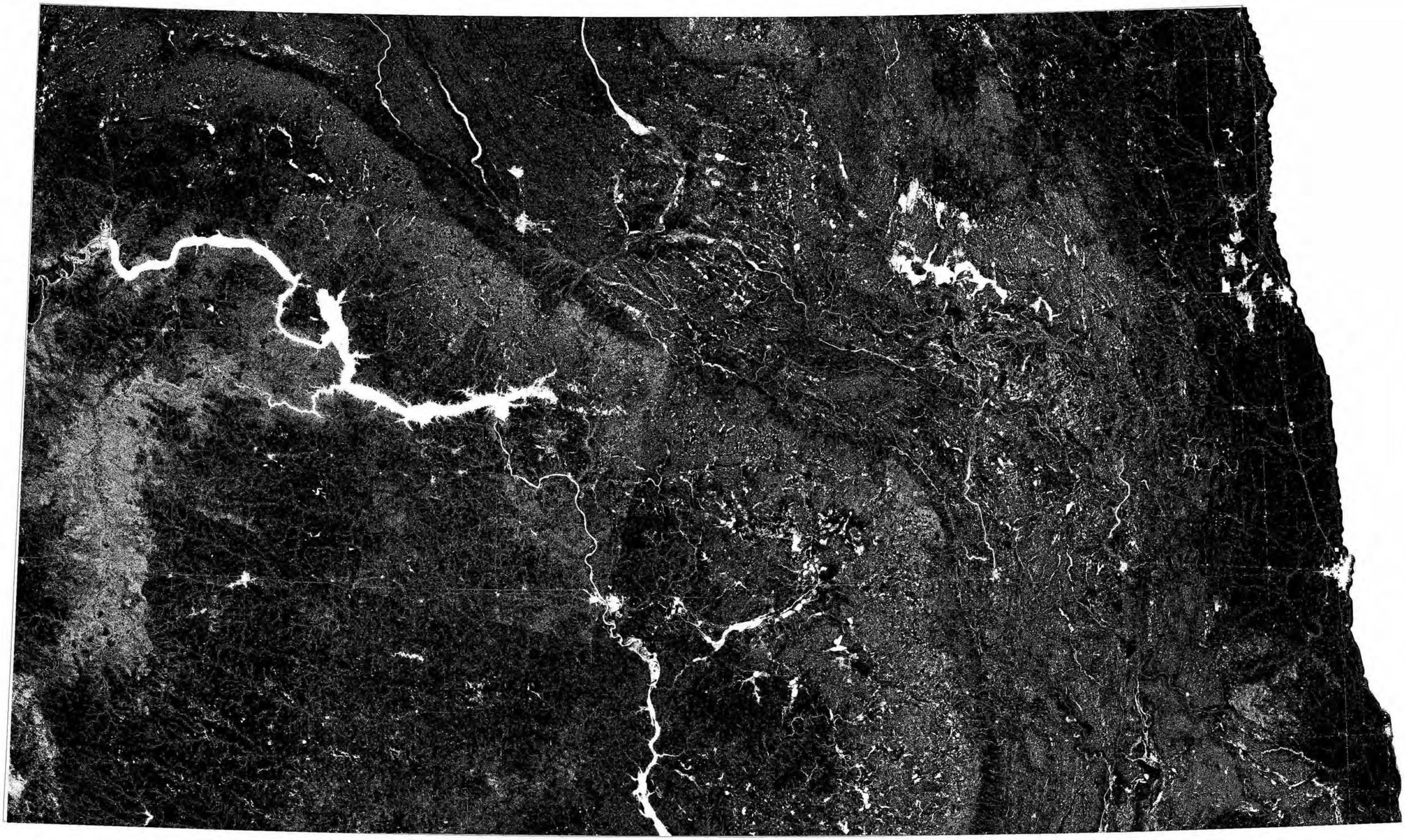
GOLDEN EAGLE(Aquila chrysaetos)



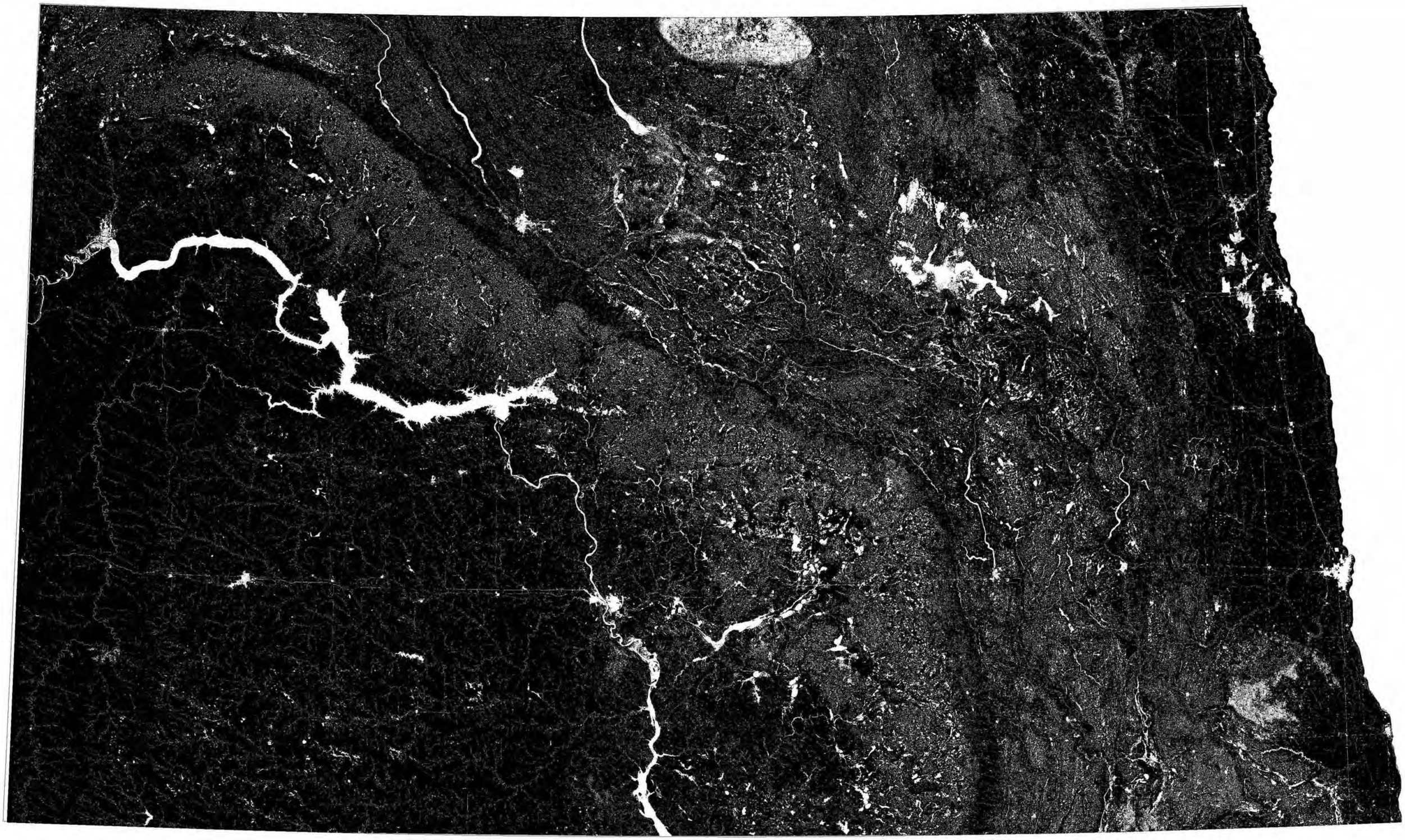
FERRUGINOUS HAWK(Buteo regalis)



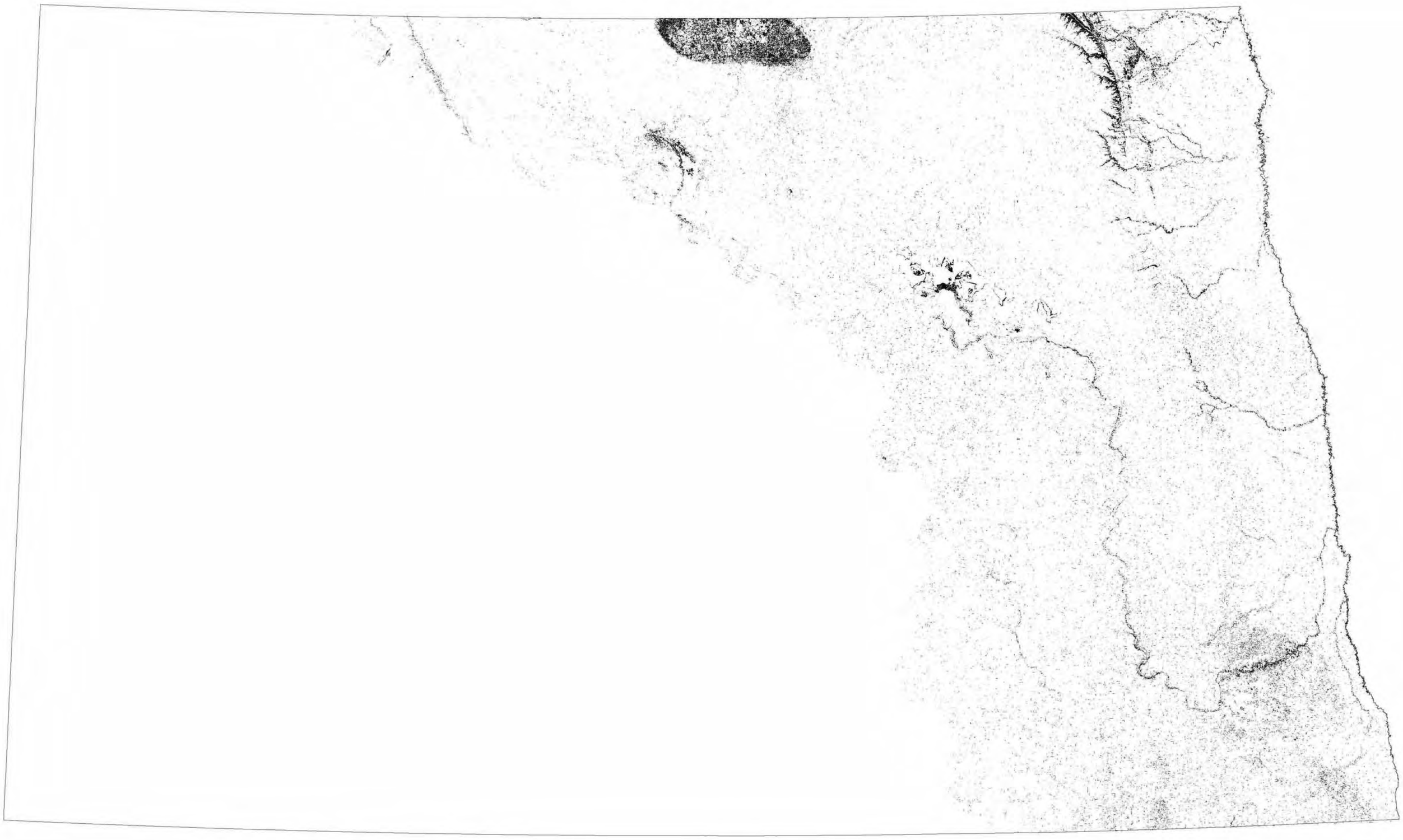
RED-TAILED HAWK(Buteo jamaicensis)



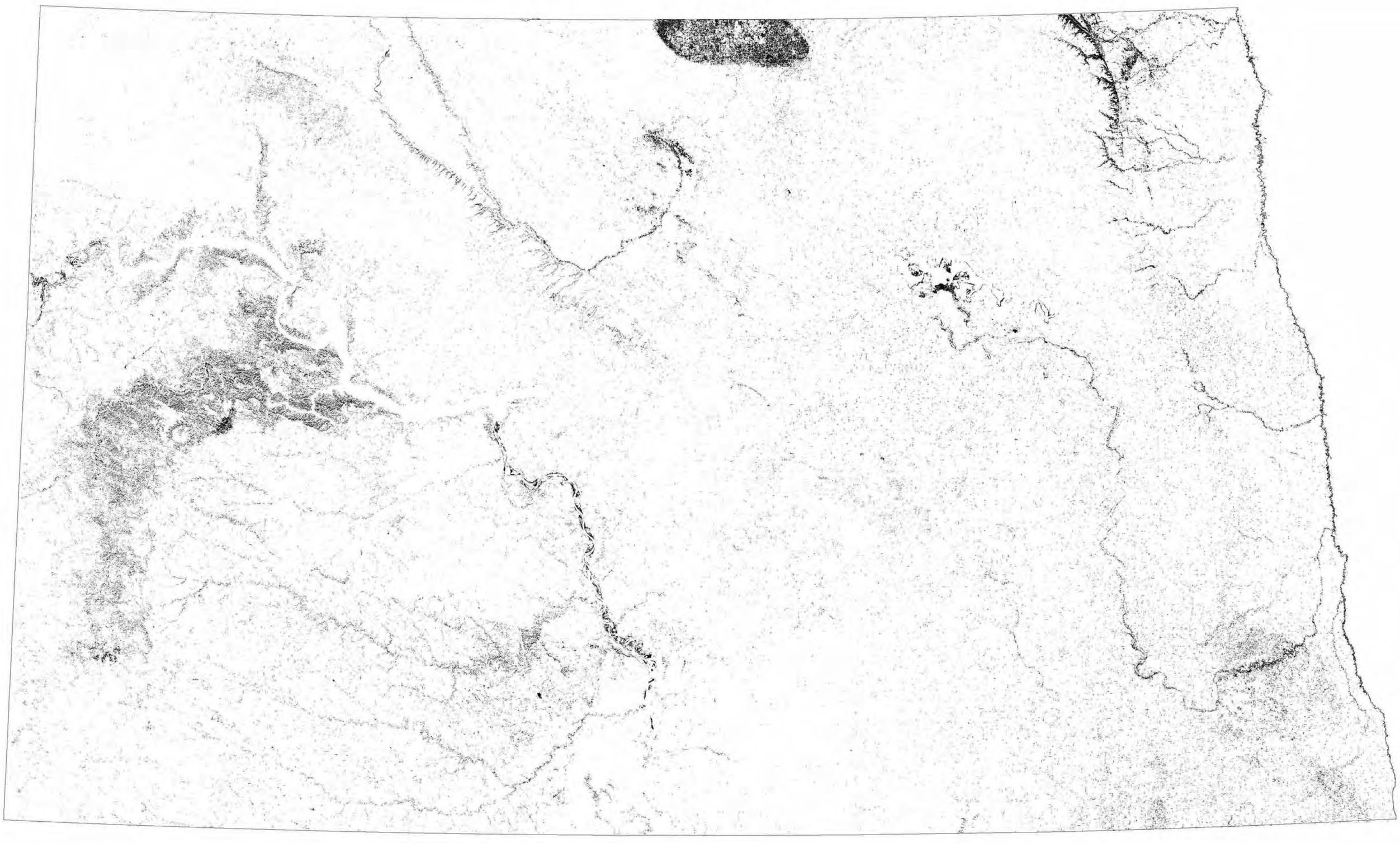
SWAINSON'S HAWK(Buteo swainsoni)



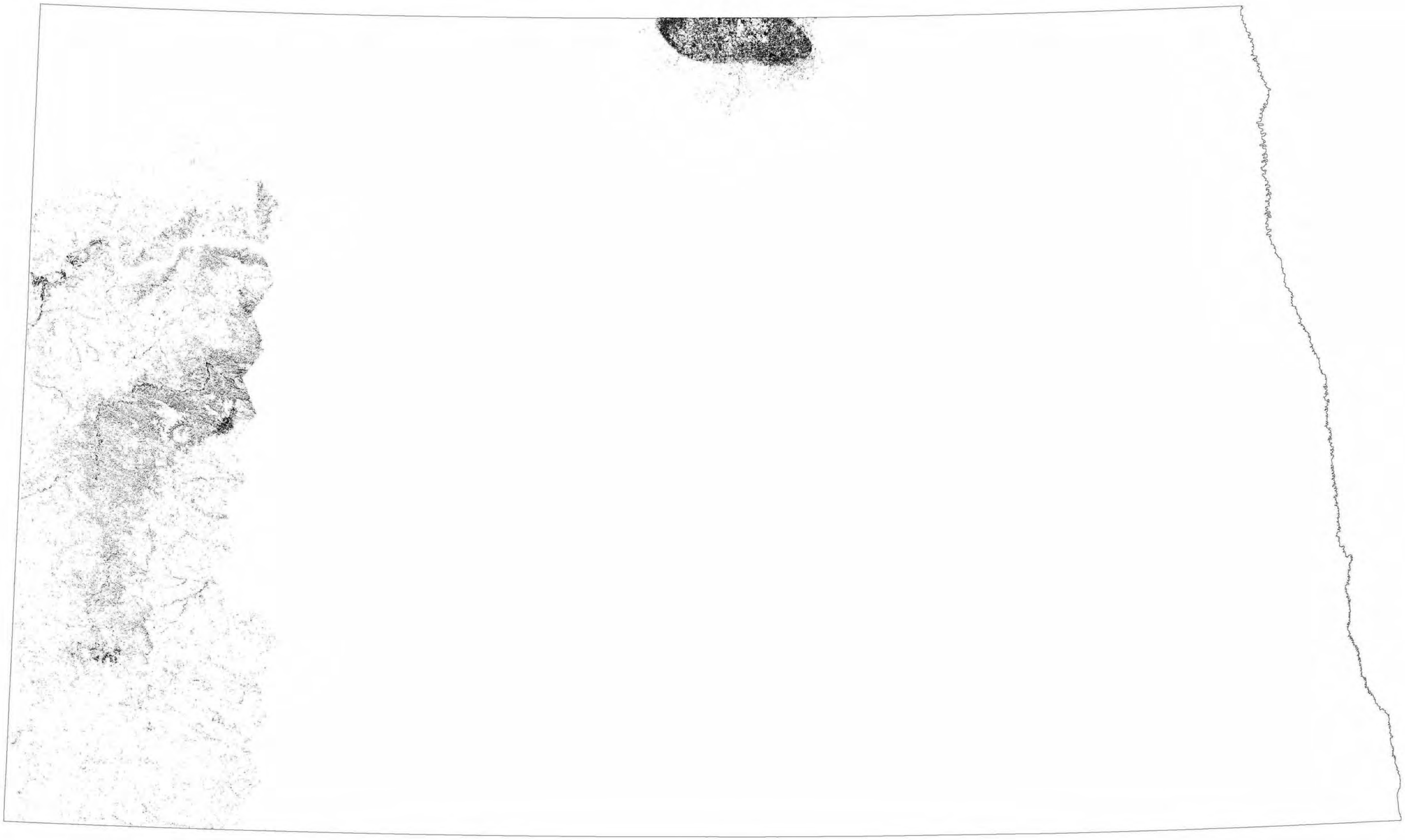
BROAD-WINGED HAWK(Buteo platypterus)



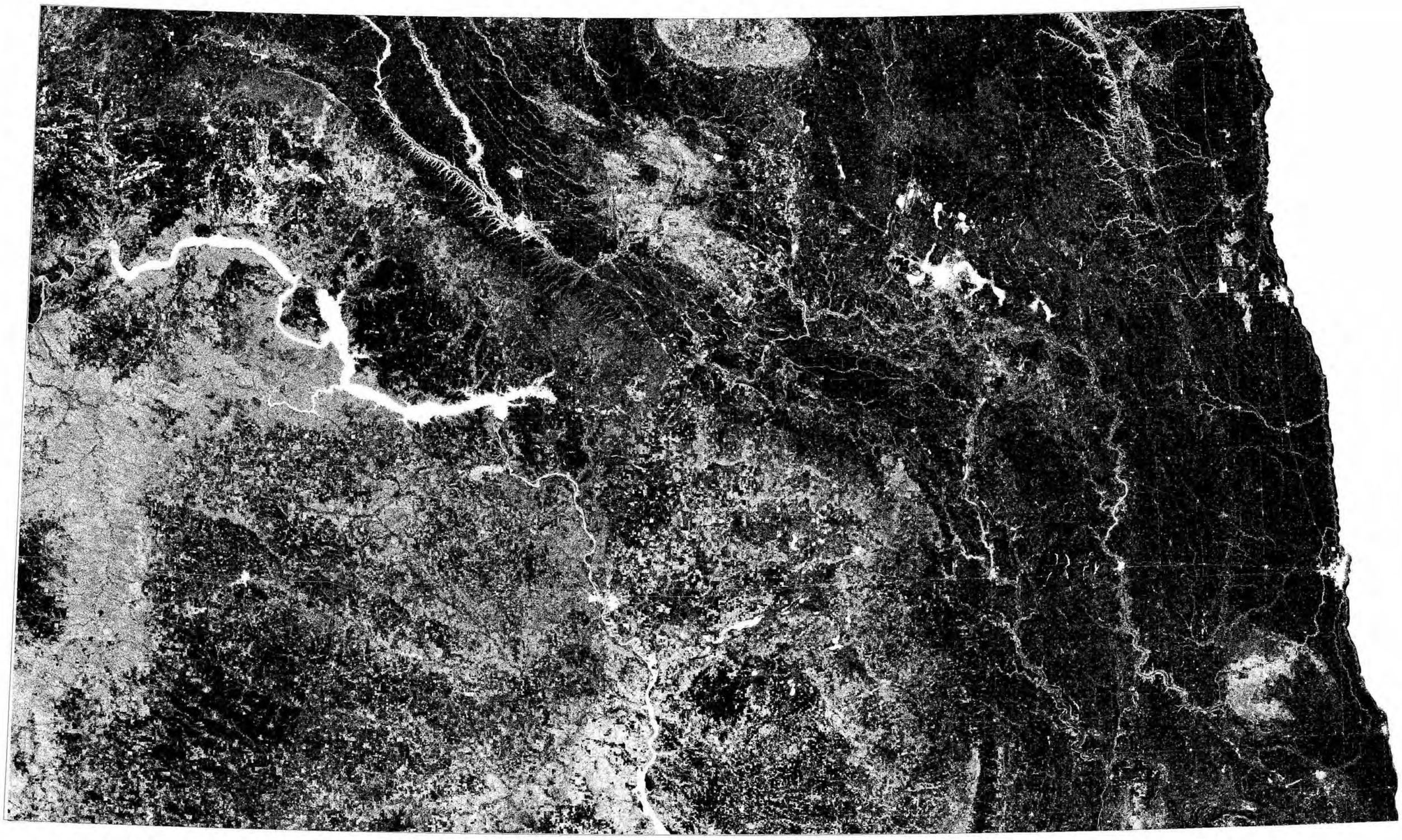
COOPER'S HAWK(Accipiter cooperii)



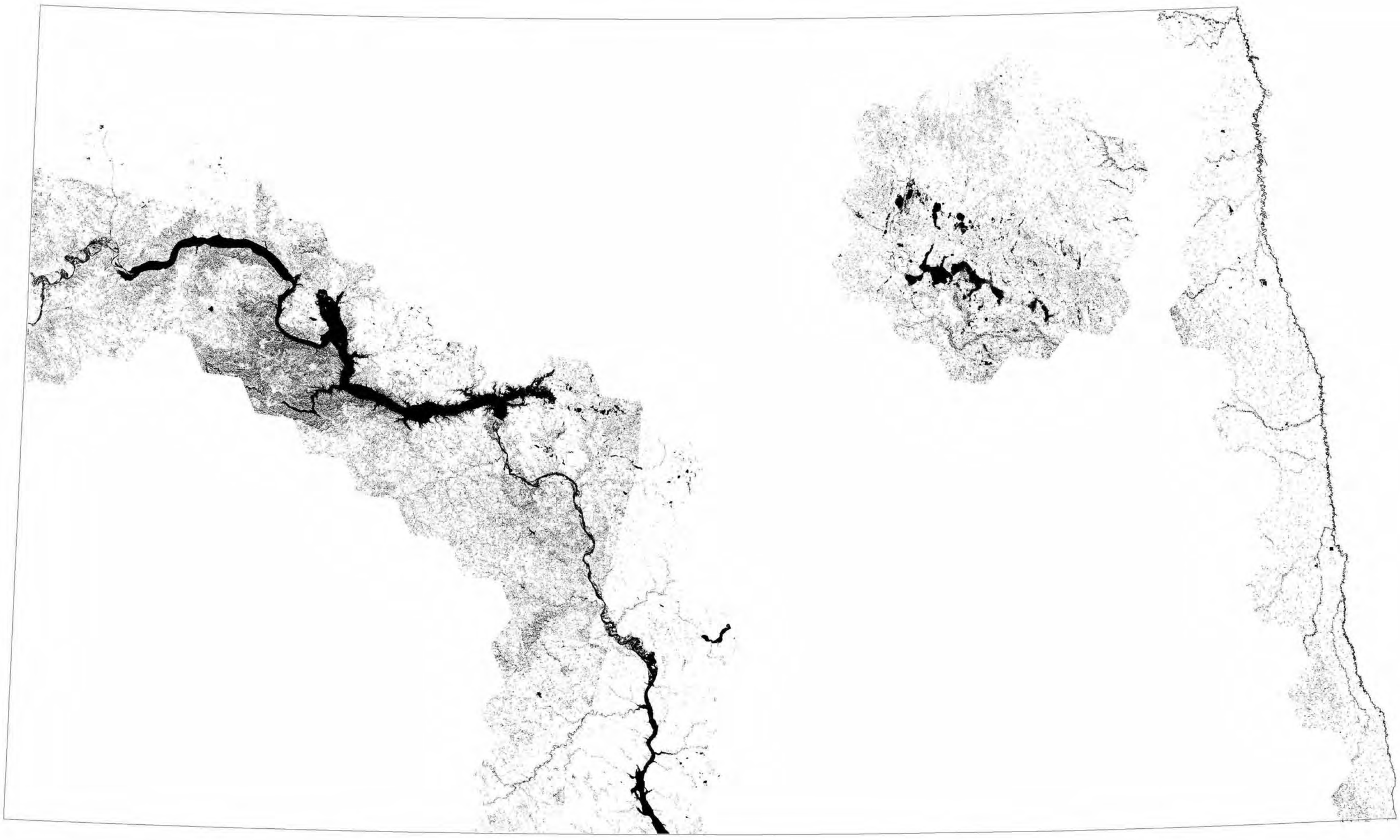
SHARP-SHINNED HAWK(Accipiter striatus)



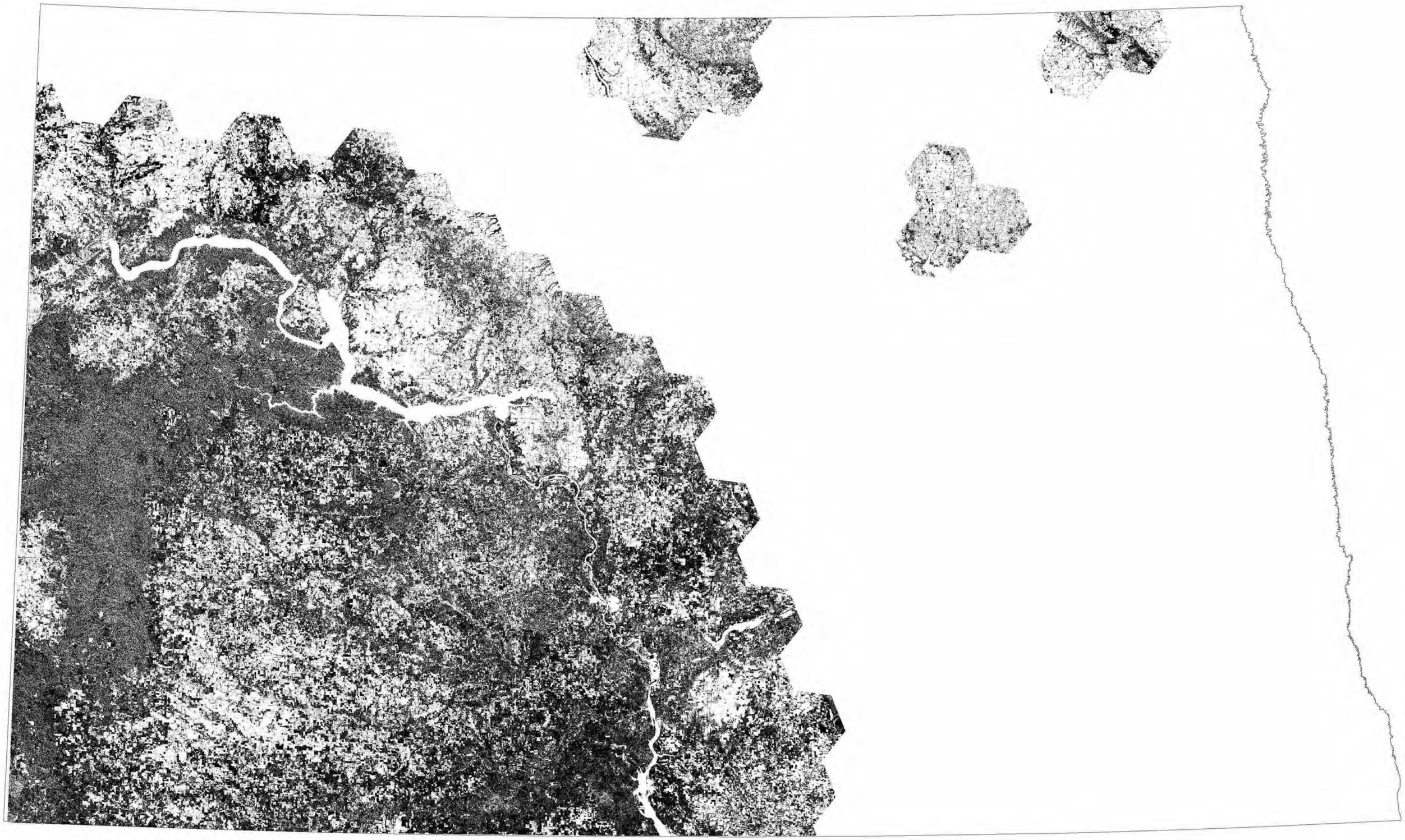
NORTHERN HARRIER(Circus cyaneus)



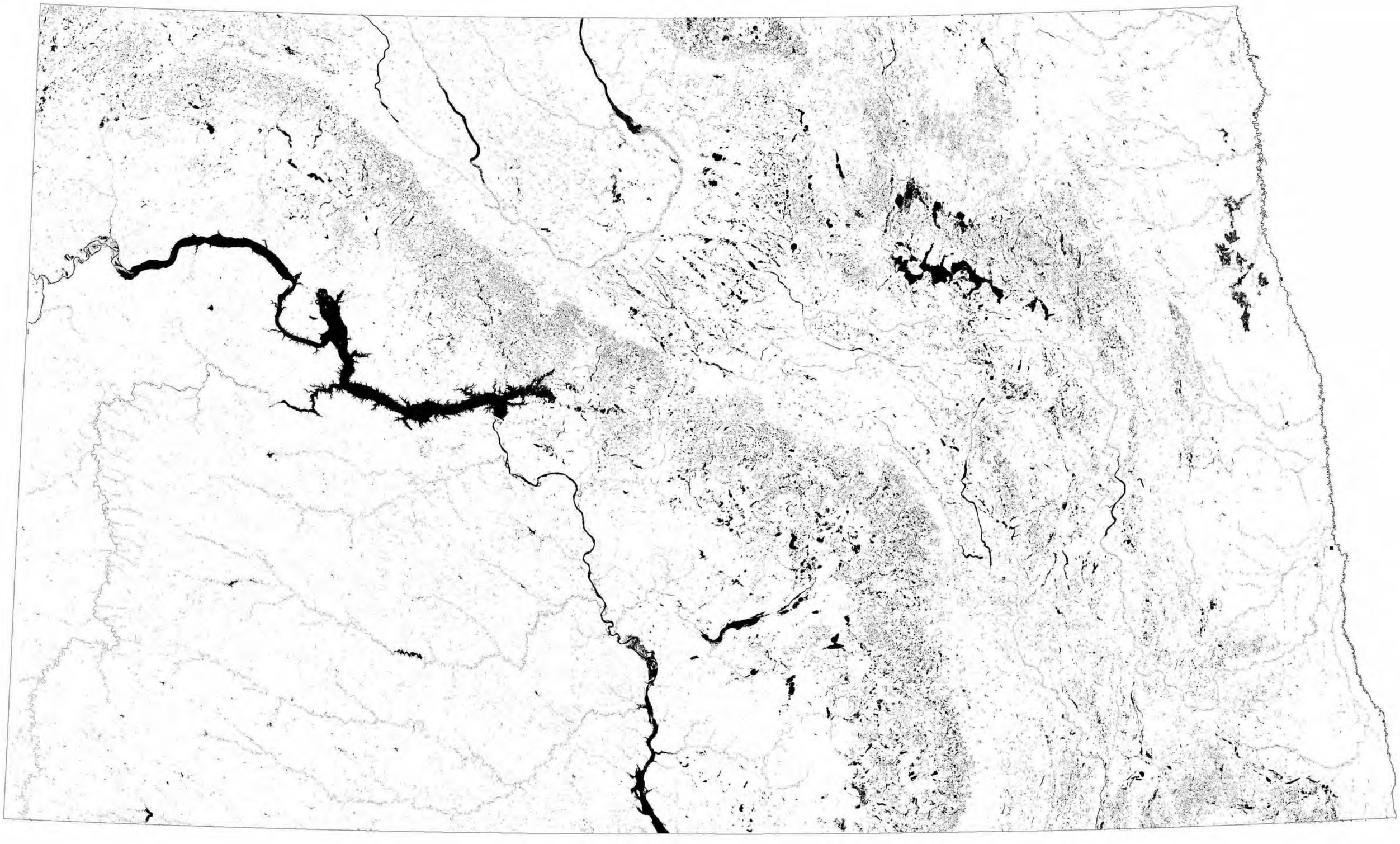
BALD EAGLE(Haliaeetus leucocephalus)



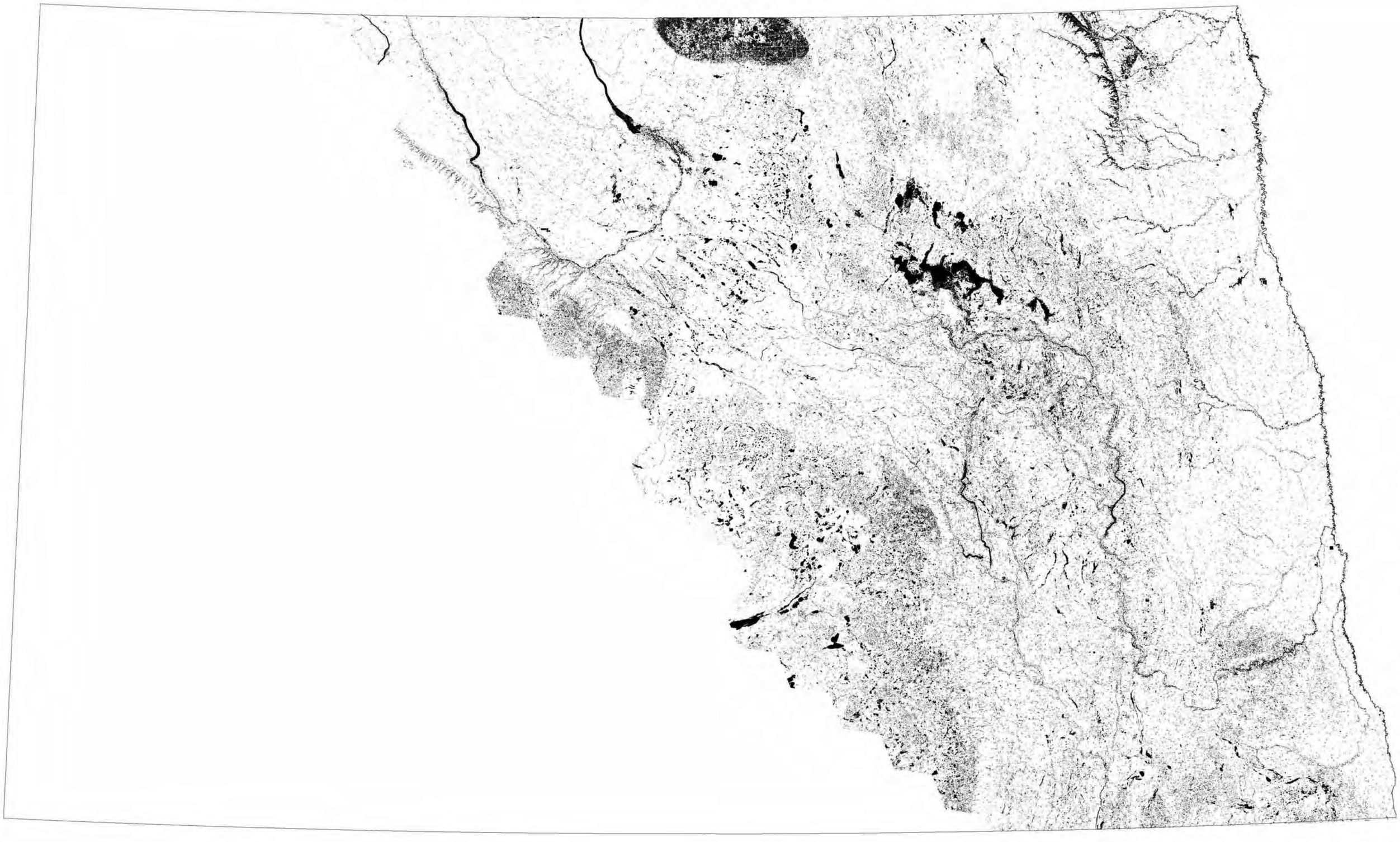
TURKEY VULTURE(Cathartes aura)



RUDDY DUCK(Oxyura jamaicensis)

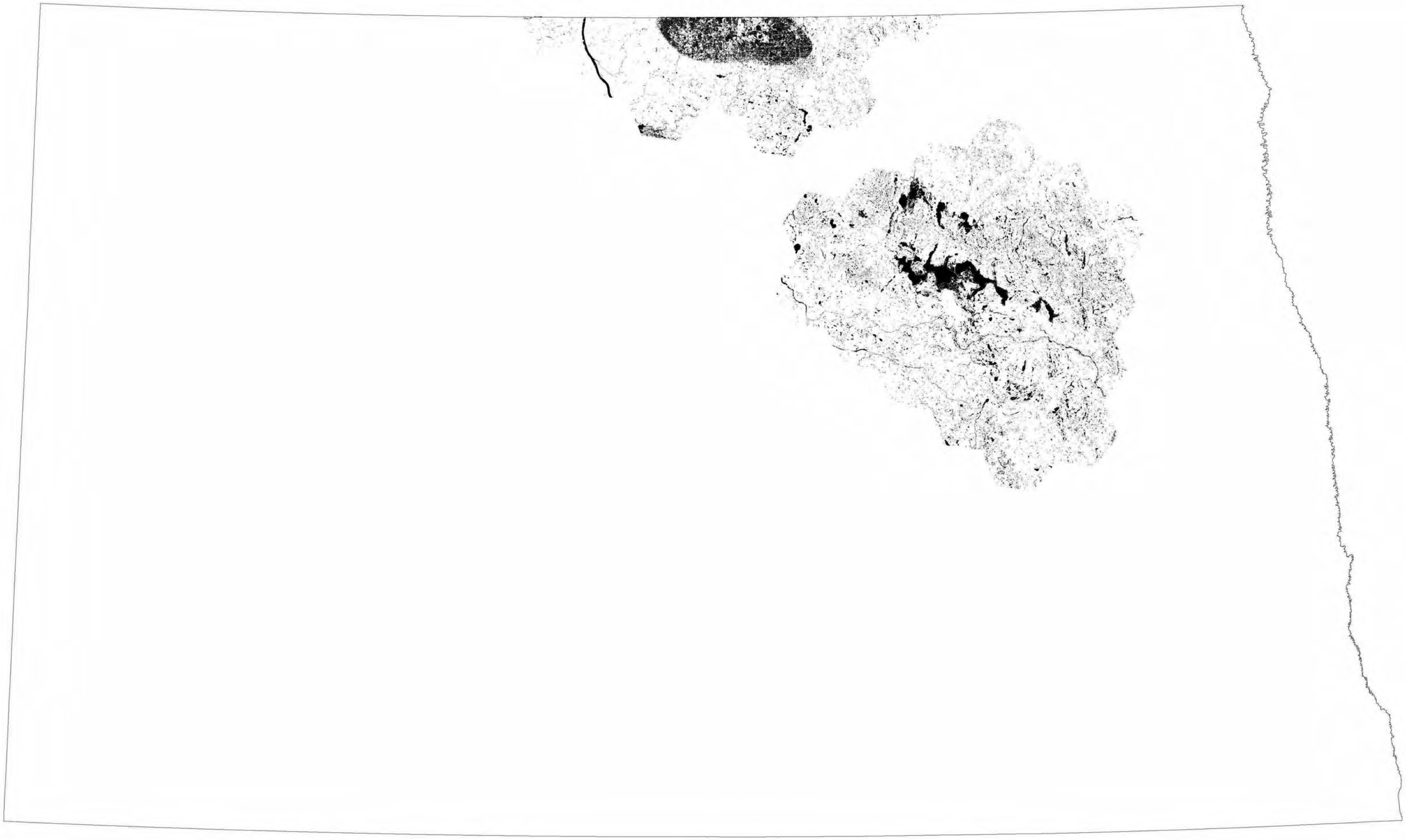


NORTHERN SHOVELER(Anas clypeata)

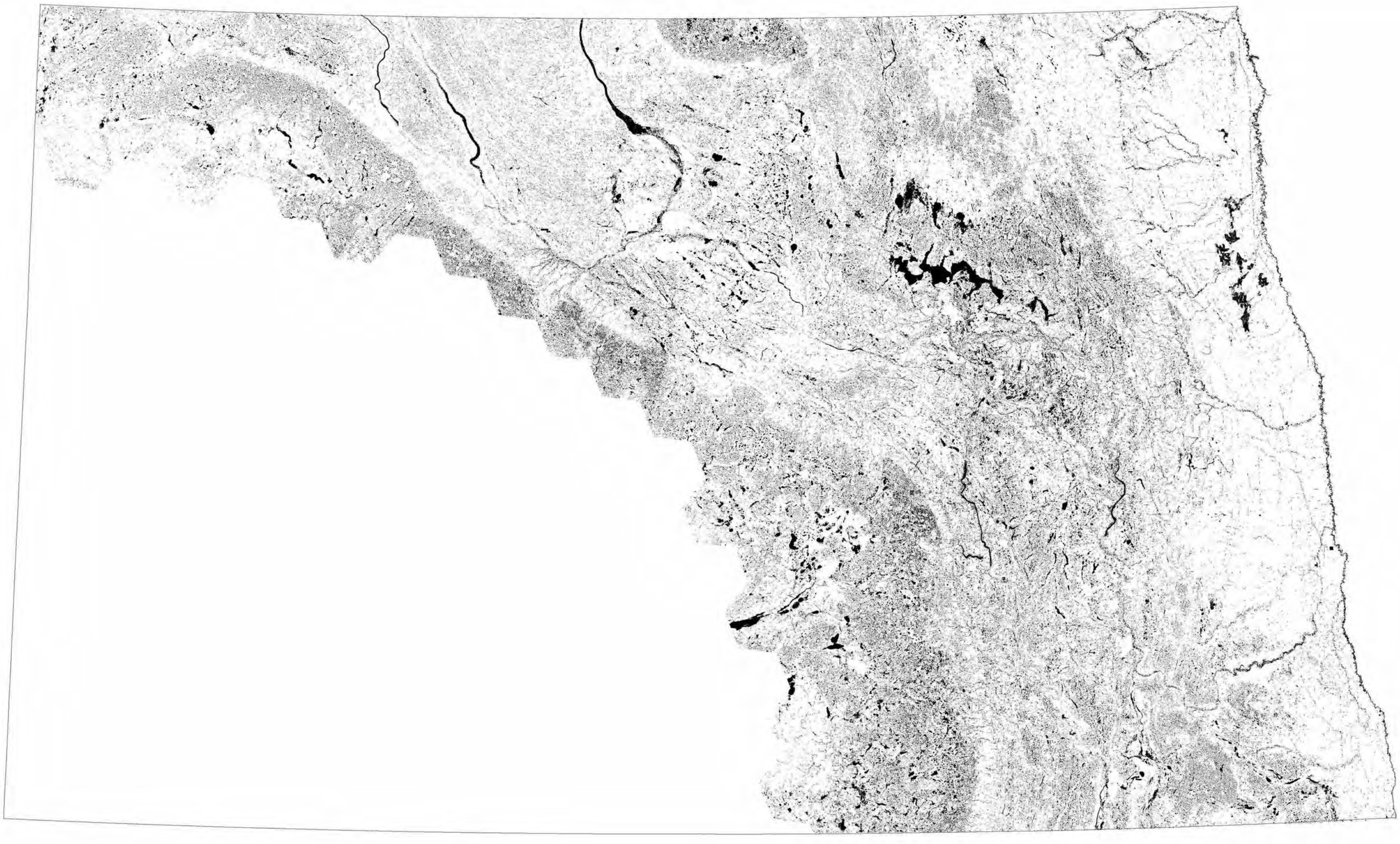


BUFFLEHEAD(Bucephala albeola)

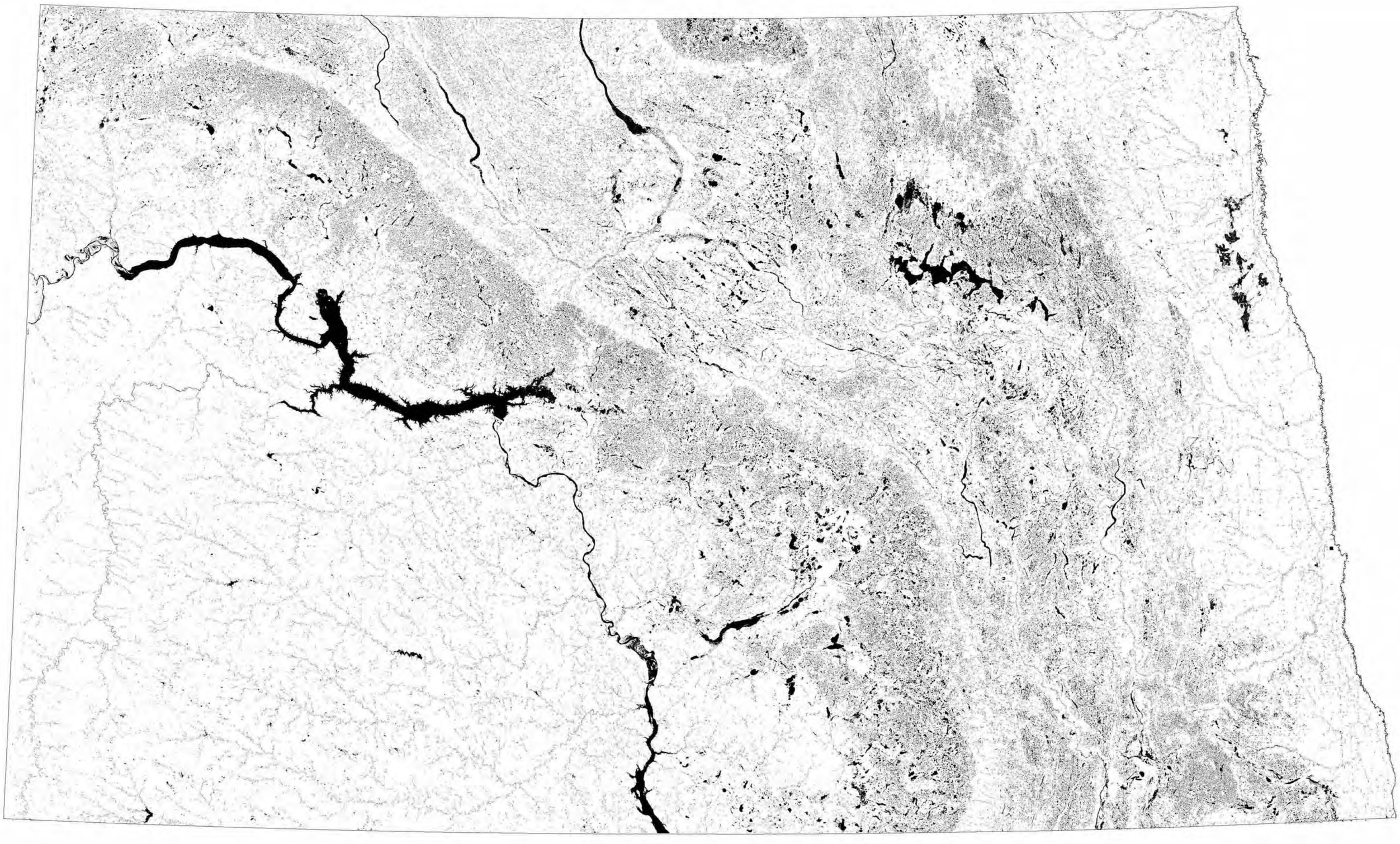
COMMON GOLDENEYE(Bucephala clangula)



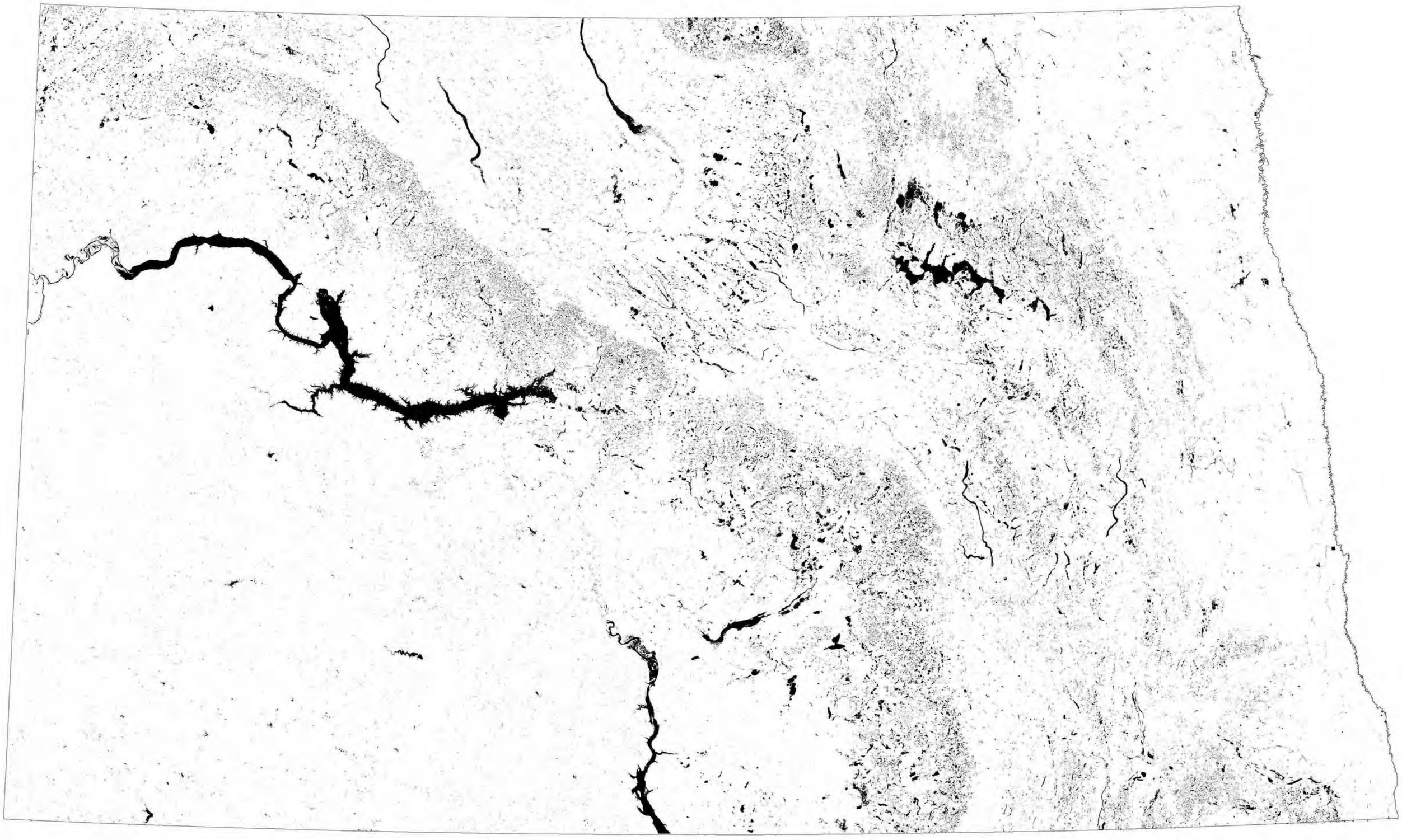
RING-NECKED DUCK(Aythya collaris)



REDHEAD(Aythya americana)

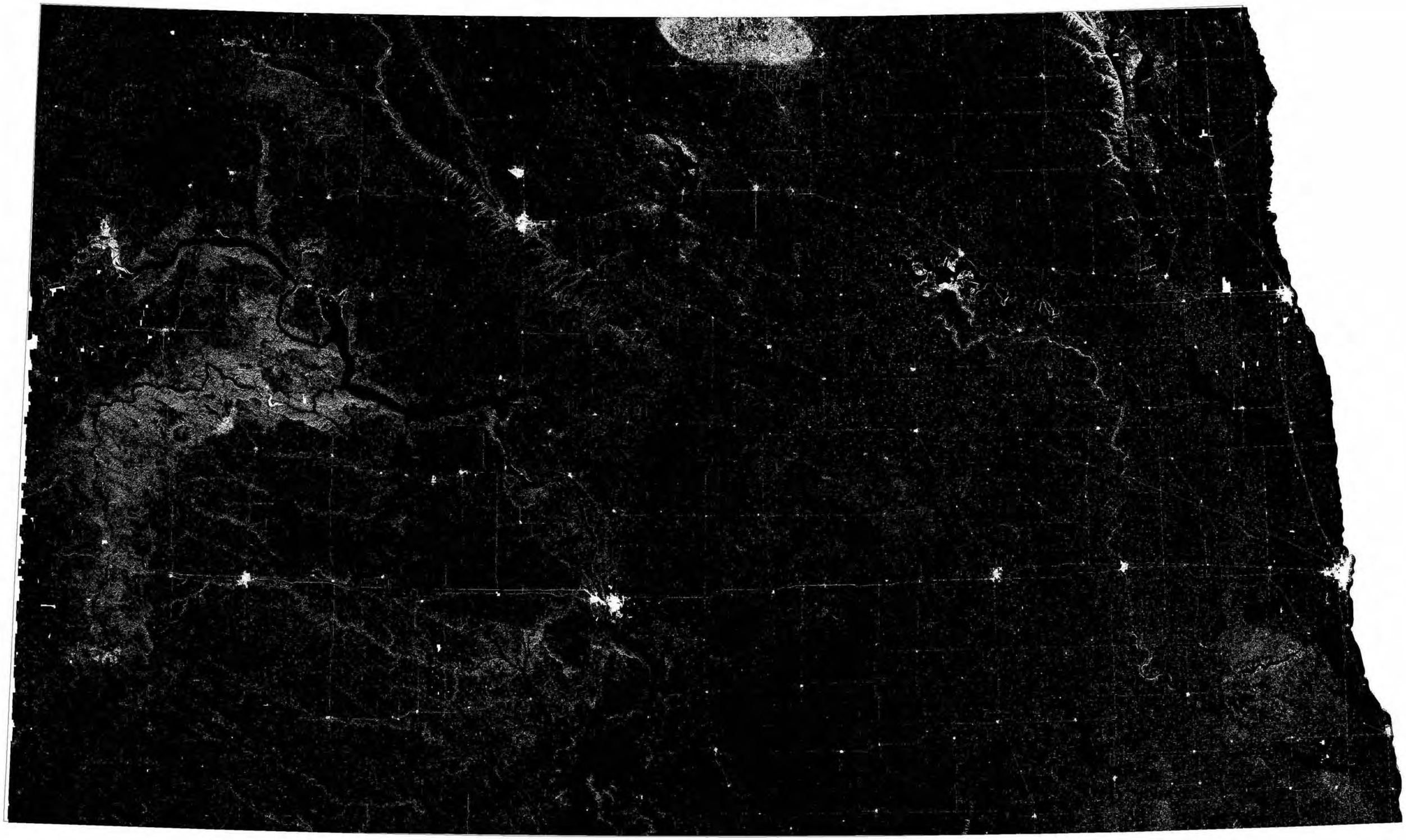


CANVASBACK(Aythya valisineria)

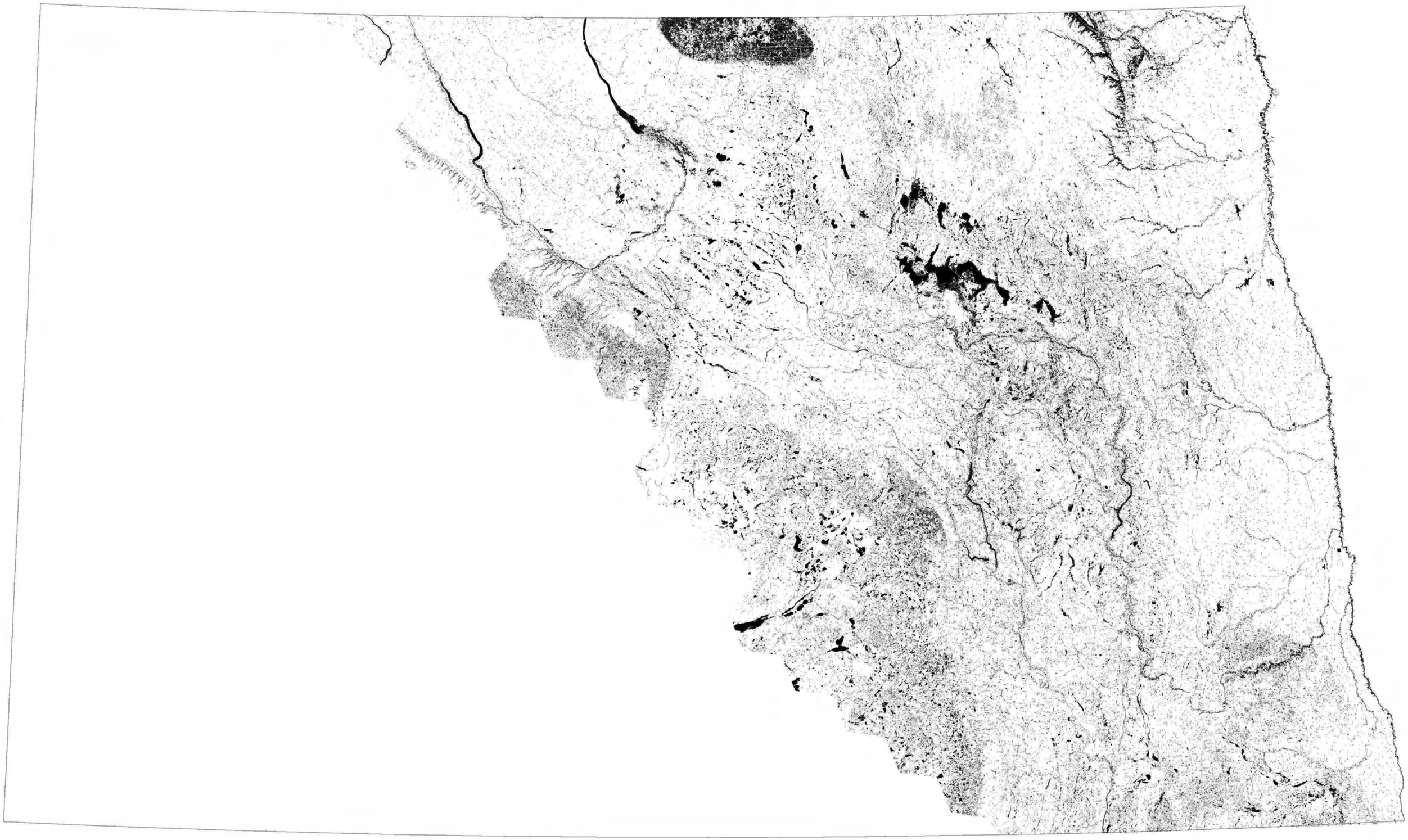


AMERICAN WIGEON(Anas americana)

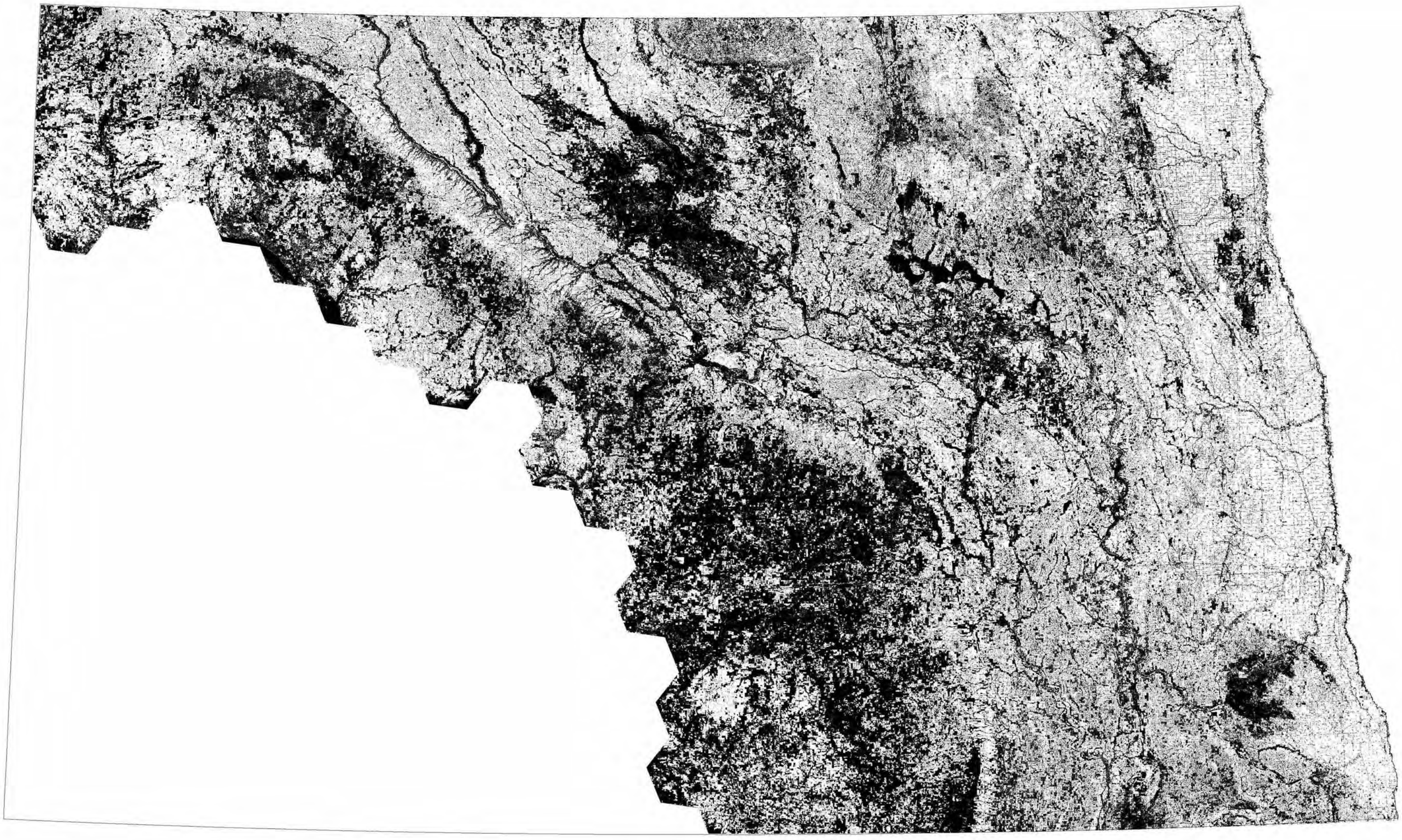
GADWALL(Anas strepera)



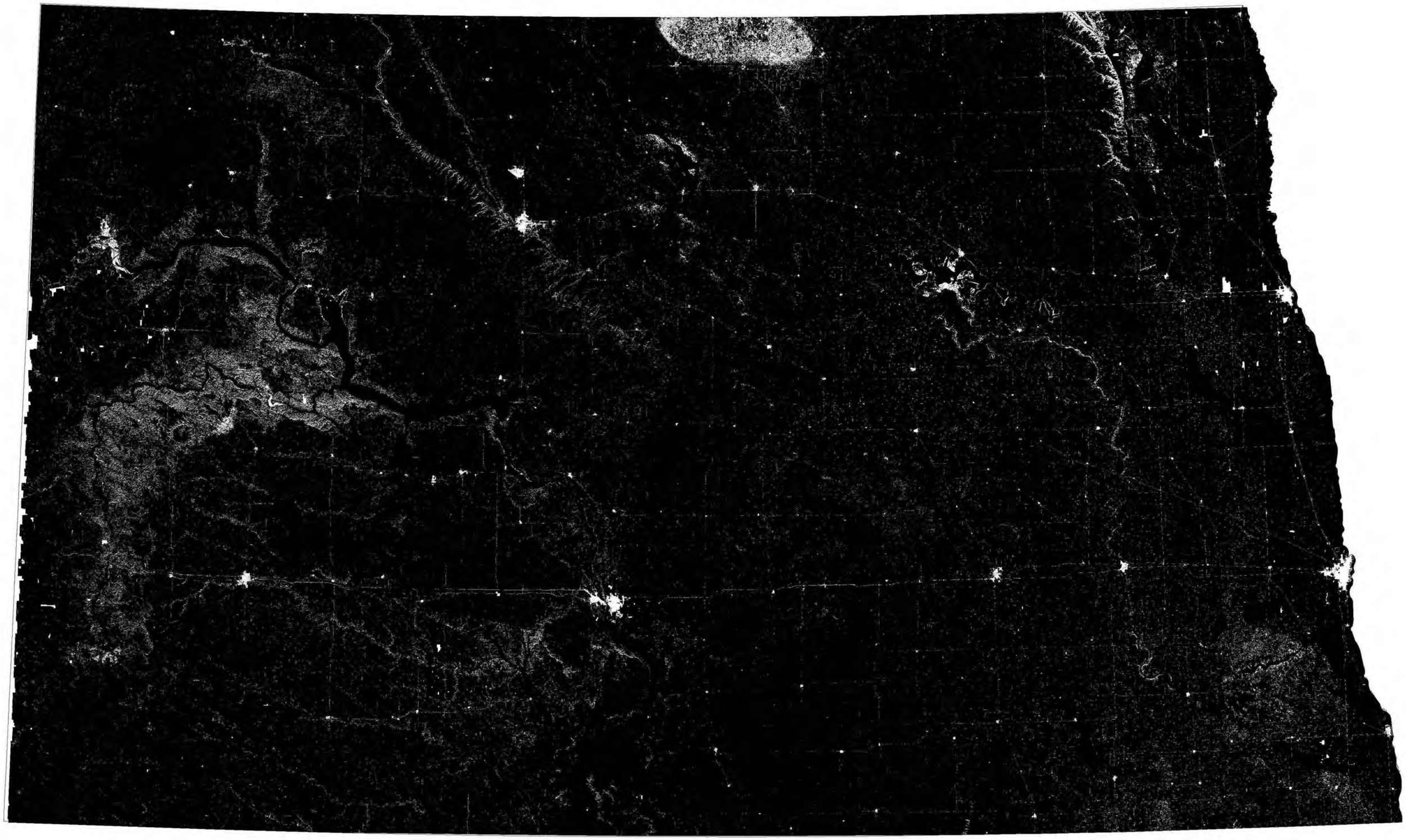
Northern Shoveler (Anas clypeata)



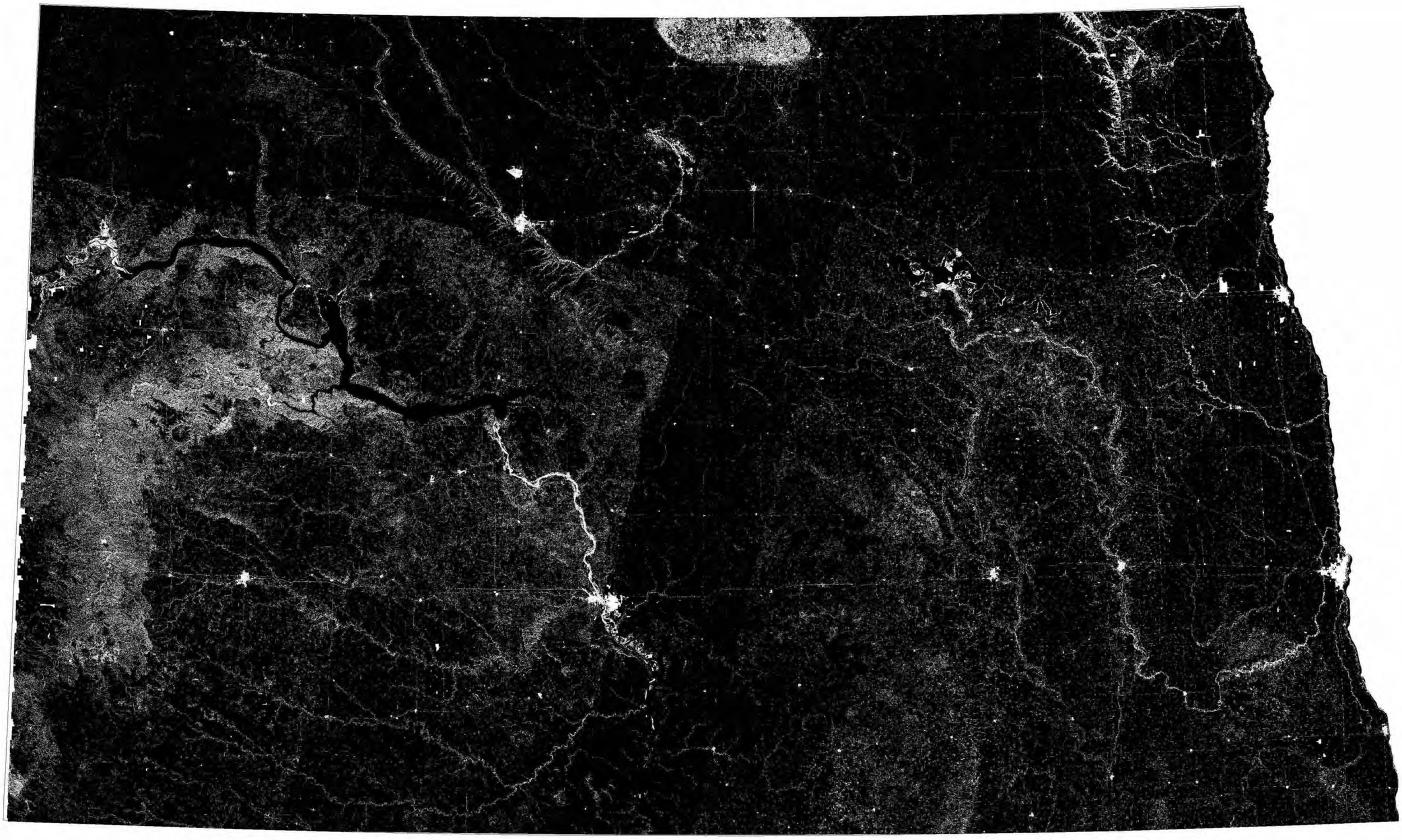
CINNAMON TEAL(Anas cyanoptera)



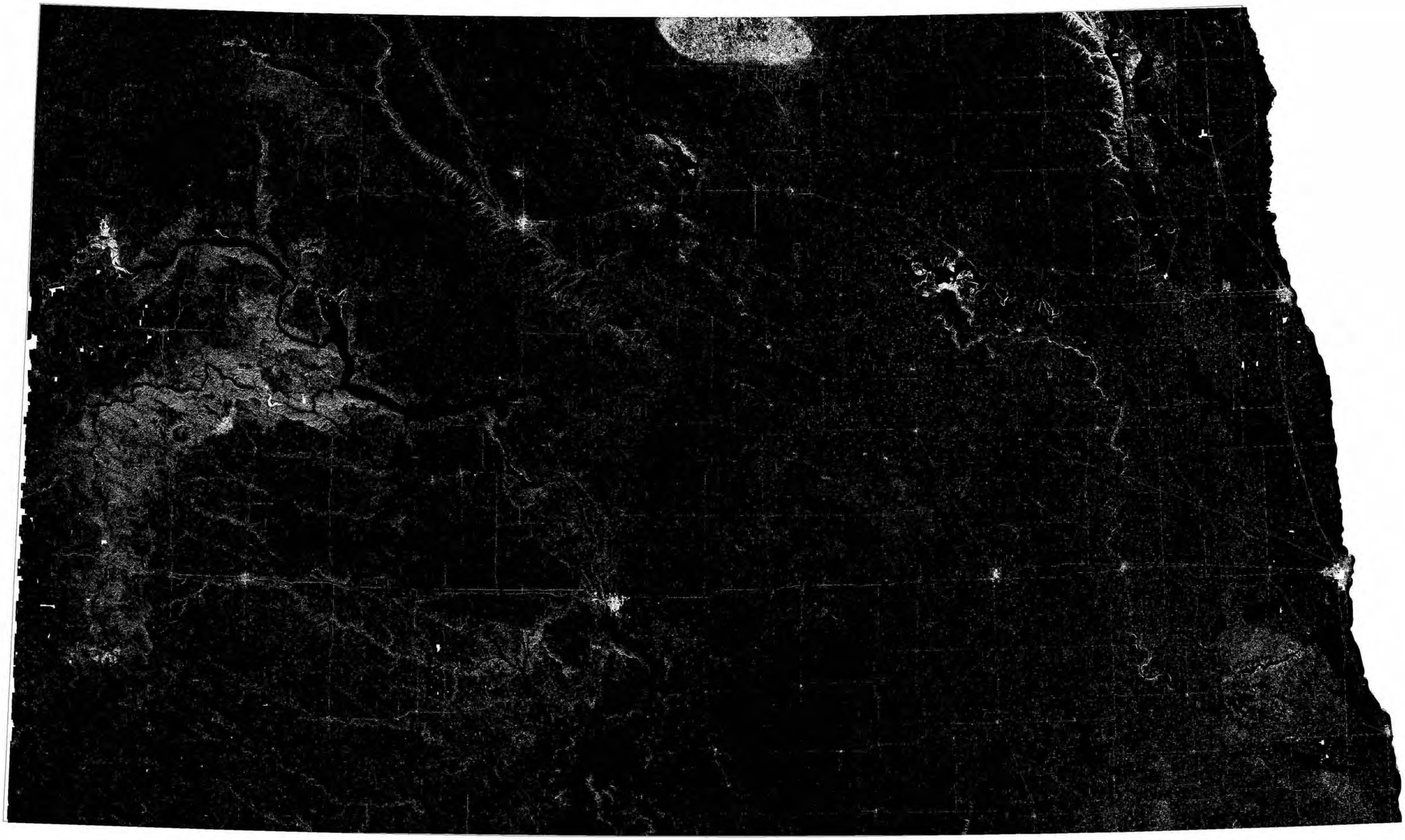
BLUE-WINGED TEAL(Anas discors)



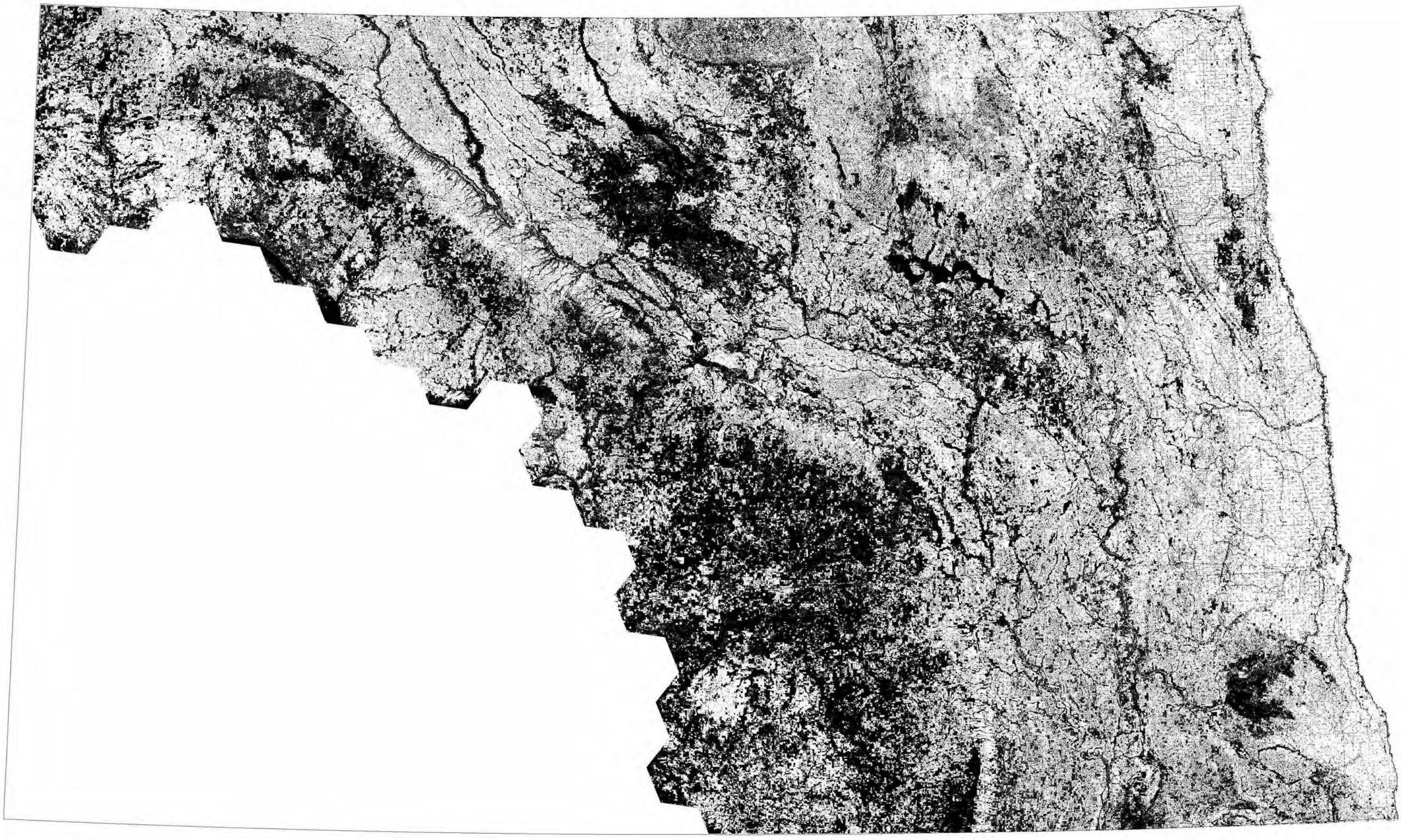
NORTHERN PINTAIL(Anas acuta)



MALLARD(Anas platyrhynchos)

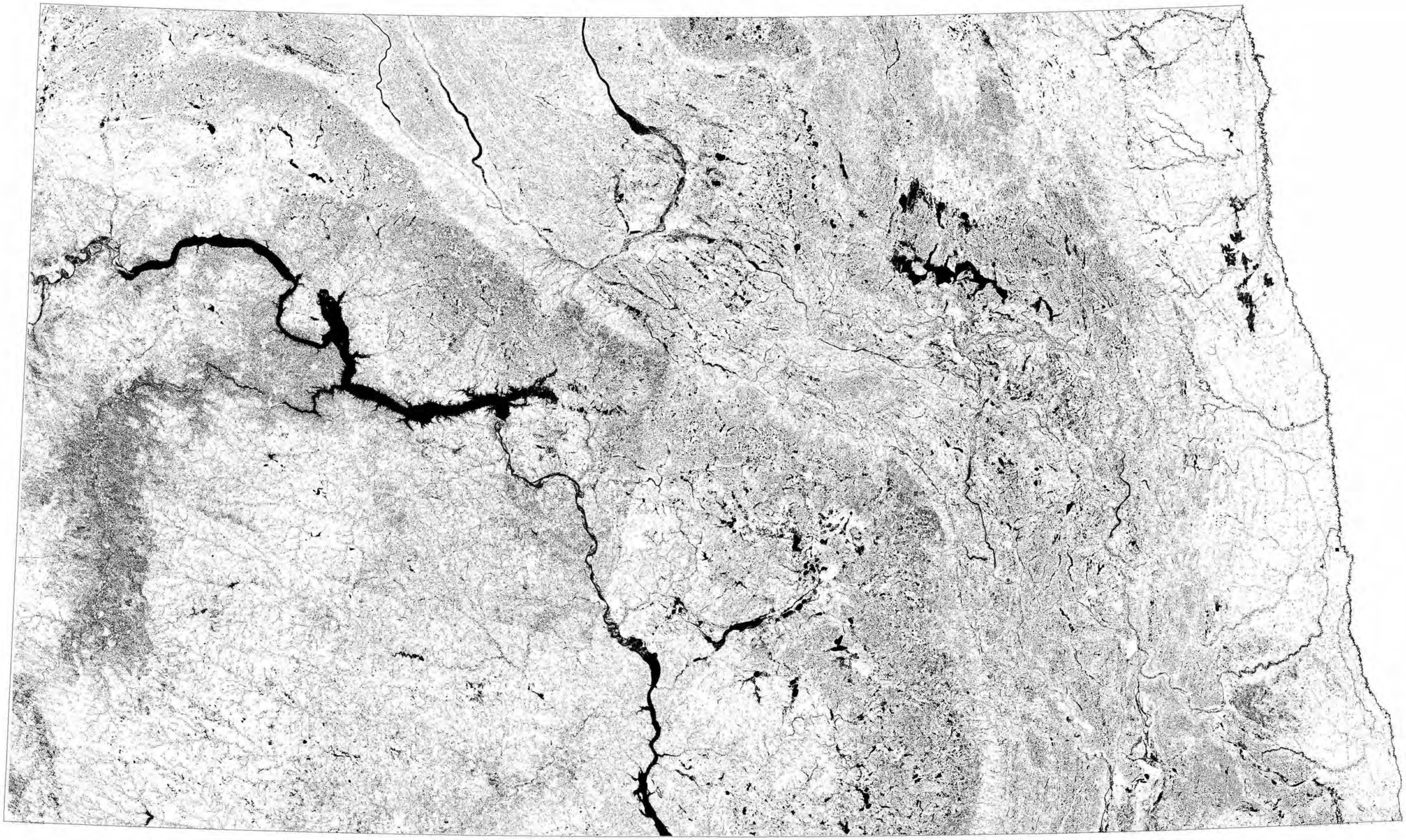


AMERICAN BLACK DUCK(Anas rubripes)



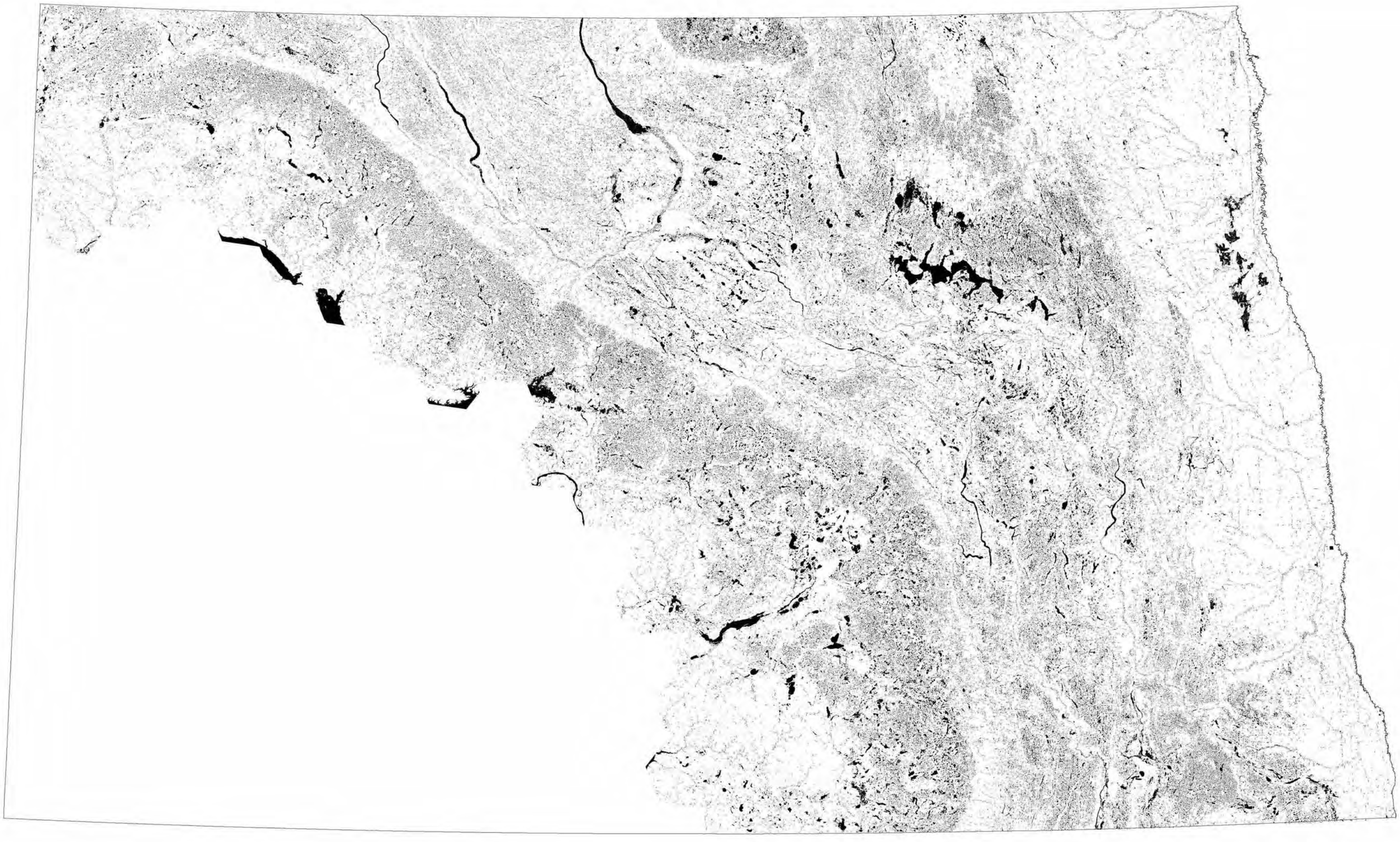
AMERICAN GREEN-WINGED TEAL(Anas crecca)

WOOD DUCK(Aix sponsa)

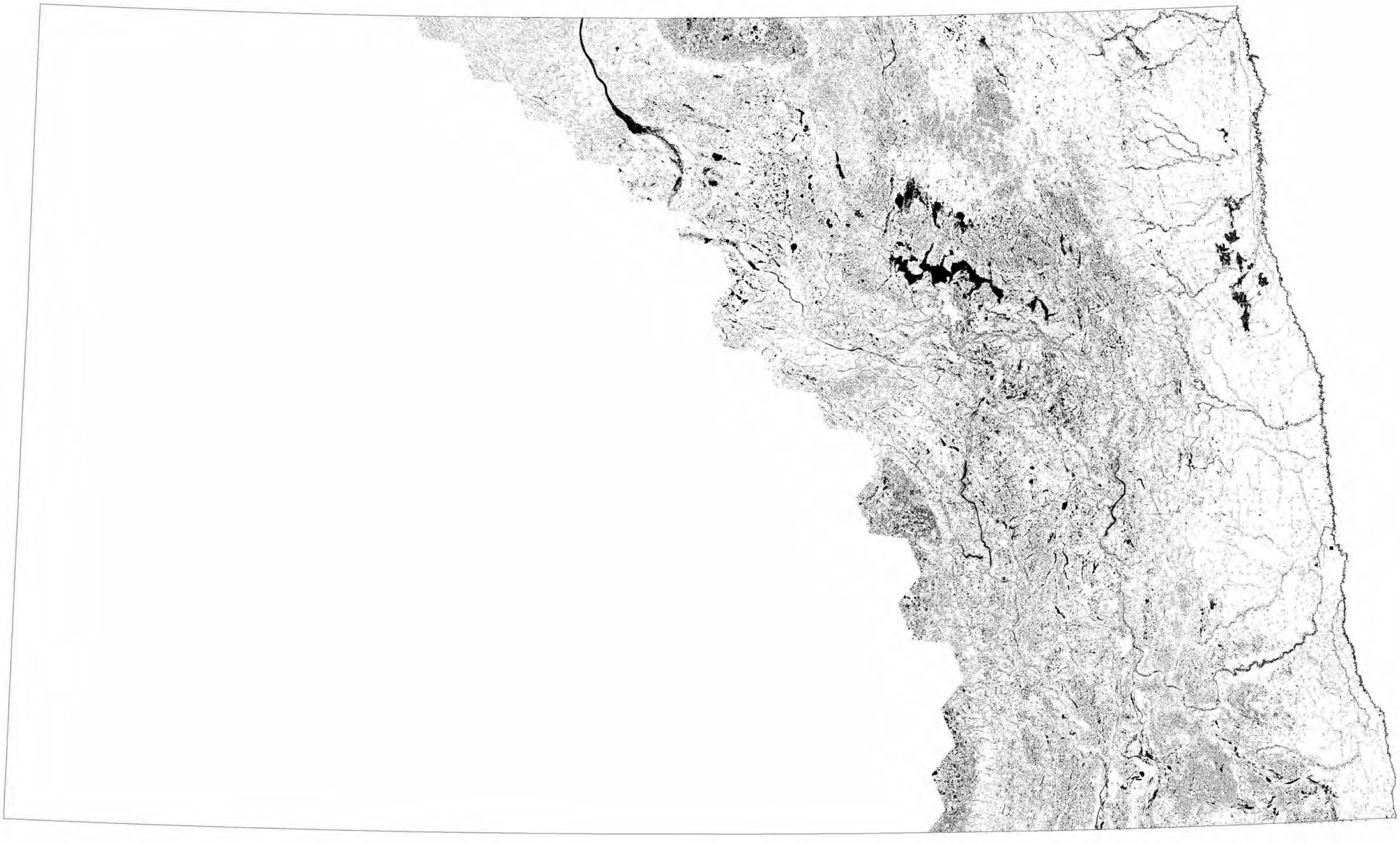


CANADA GOOSE(Branta canadensis)

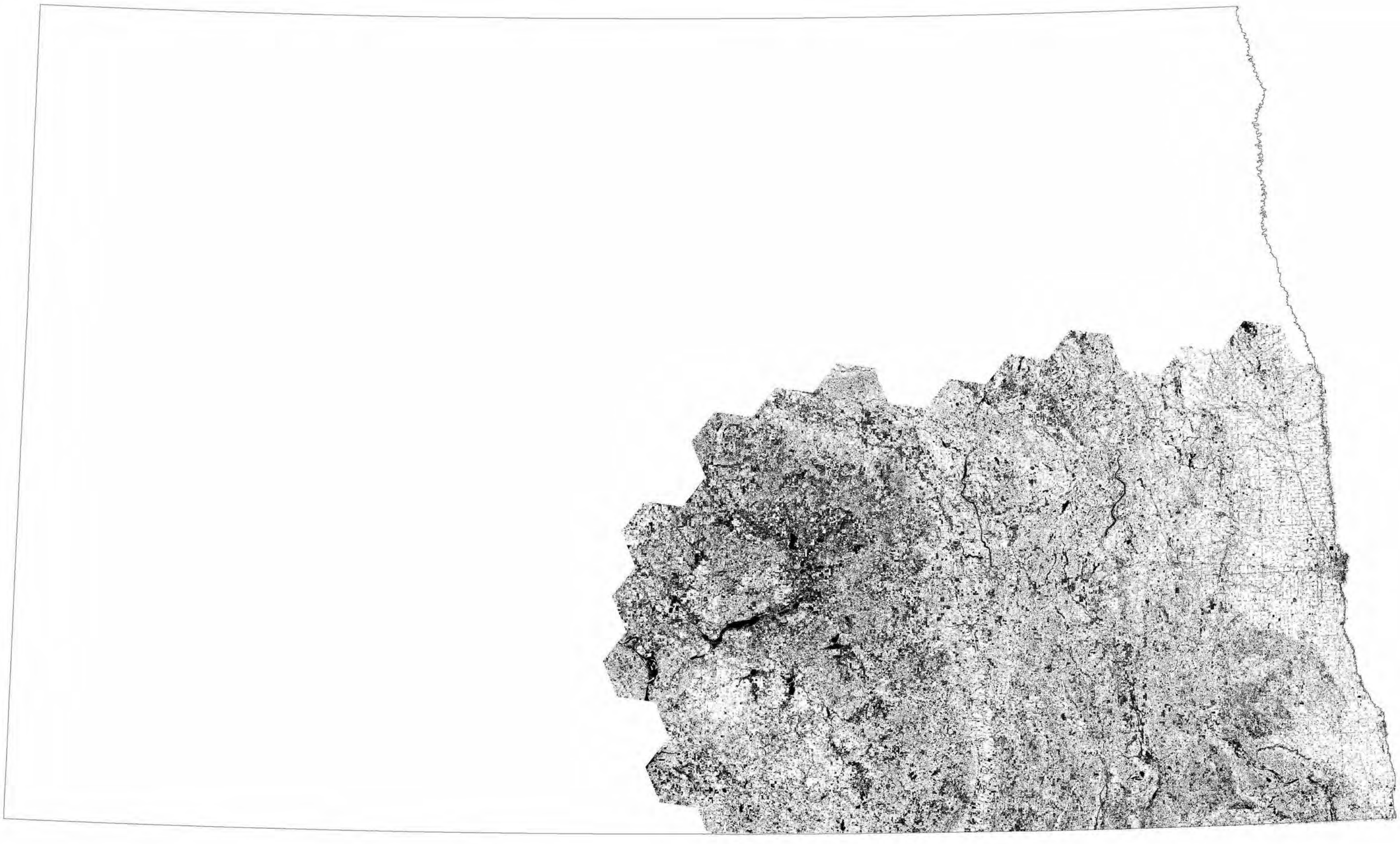
BLACK-CROWNED NIGHT-HERON(Nycticorax nycticorax)



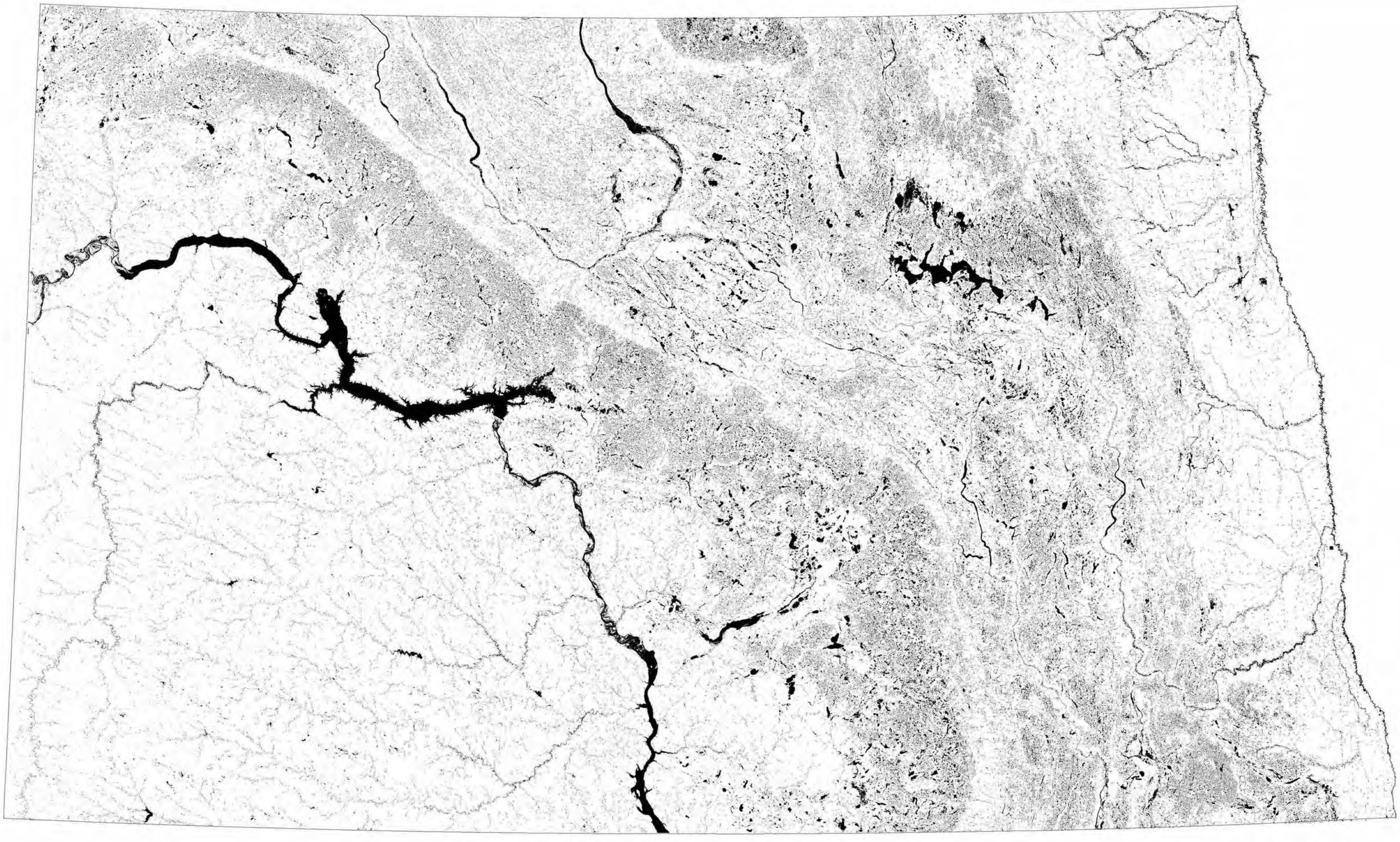
GREEN HERON(Butorides virescens)



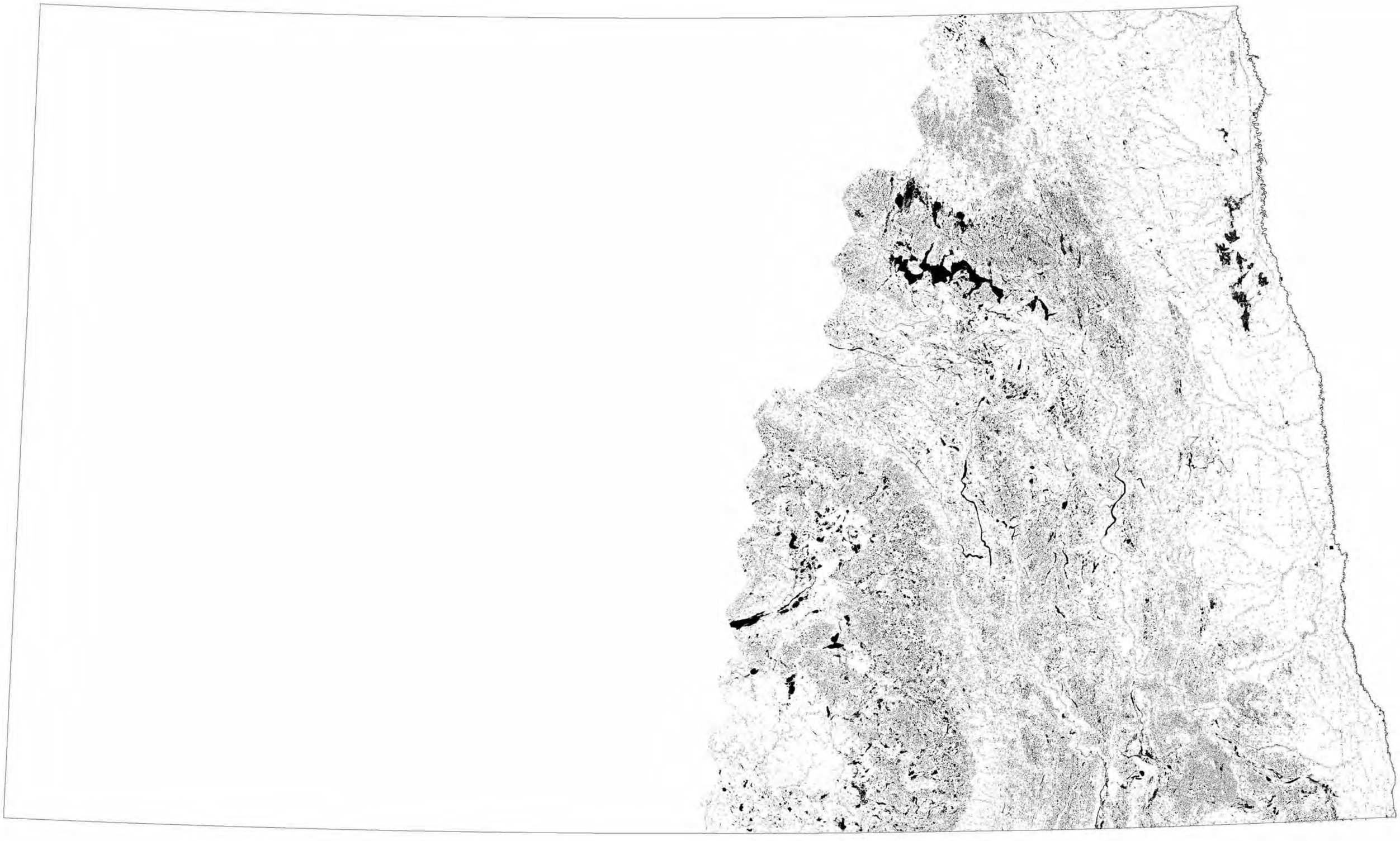
CATTLE EGRET(Bubulcus ibis)



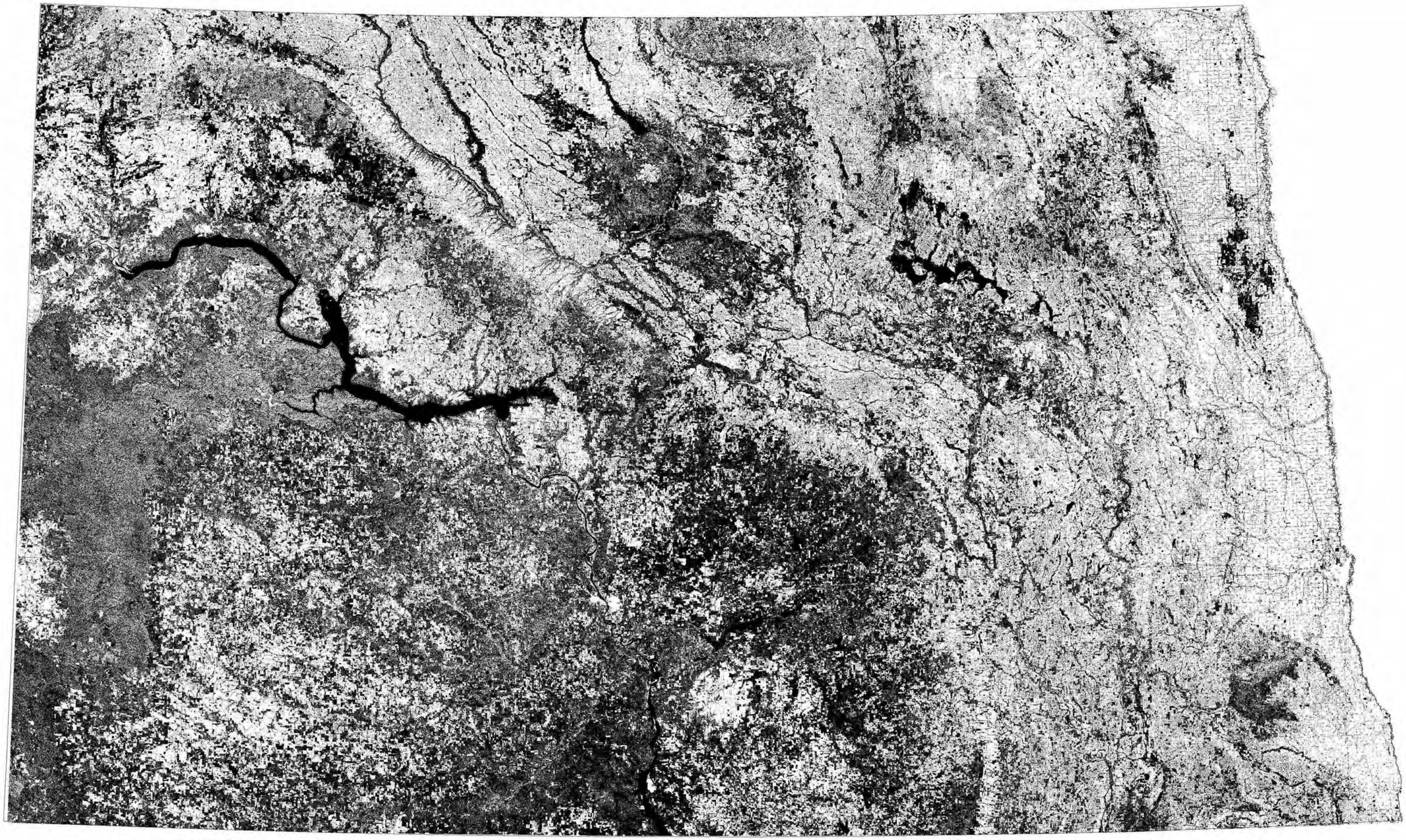
GREAT BLUE HERON(Ardea herodias)



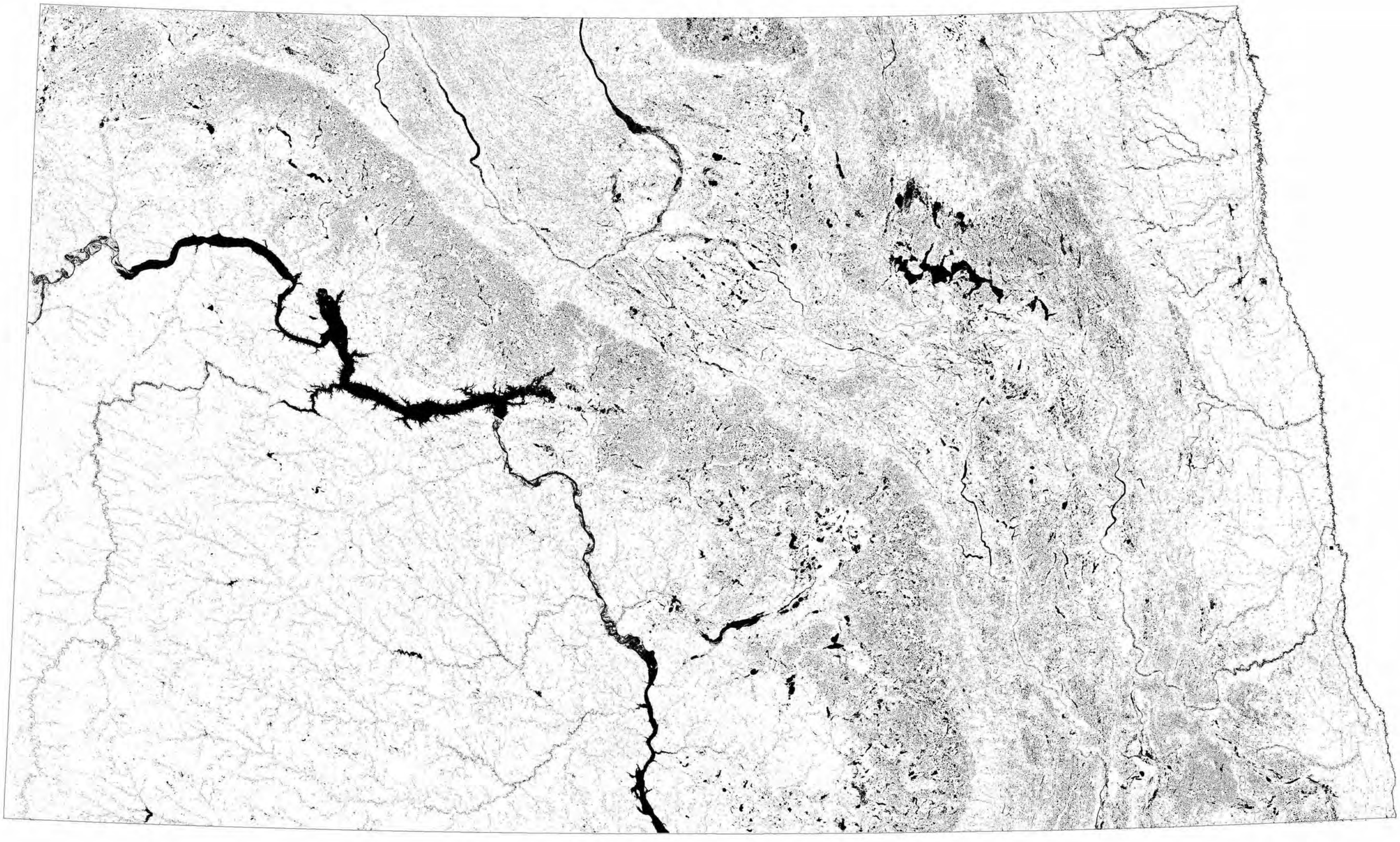
LEAST BITTERN(Ixobrychus exilis)



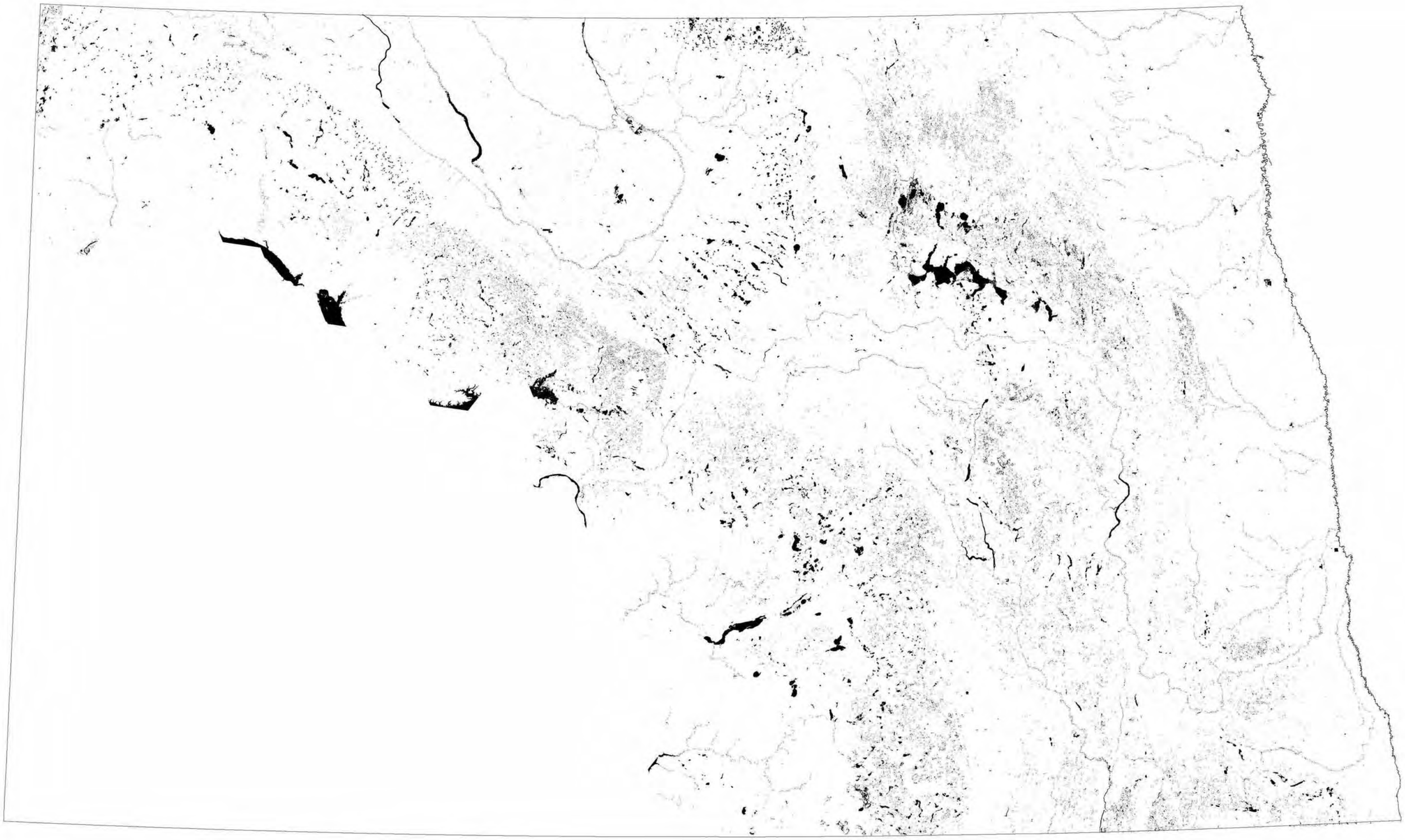
AMERICAN BITTERN(Botaurus lentiginosus)



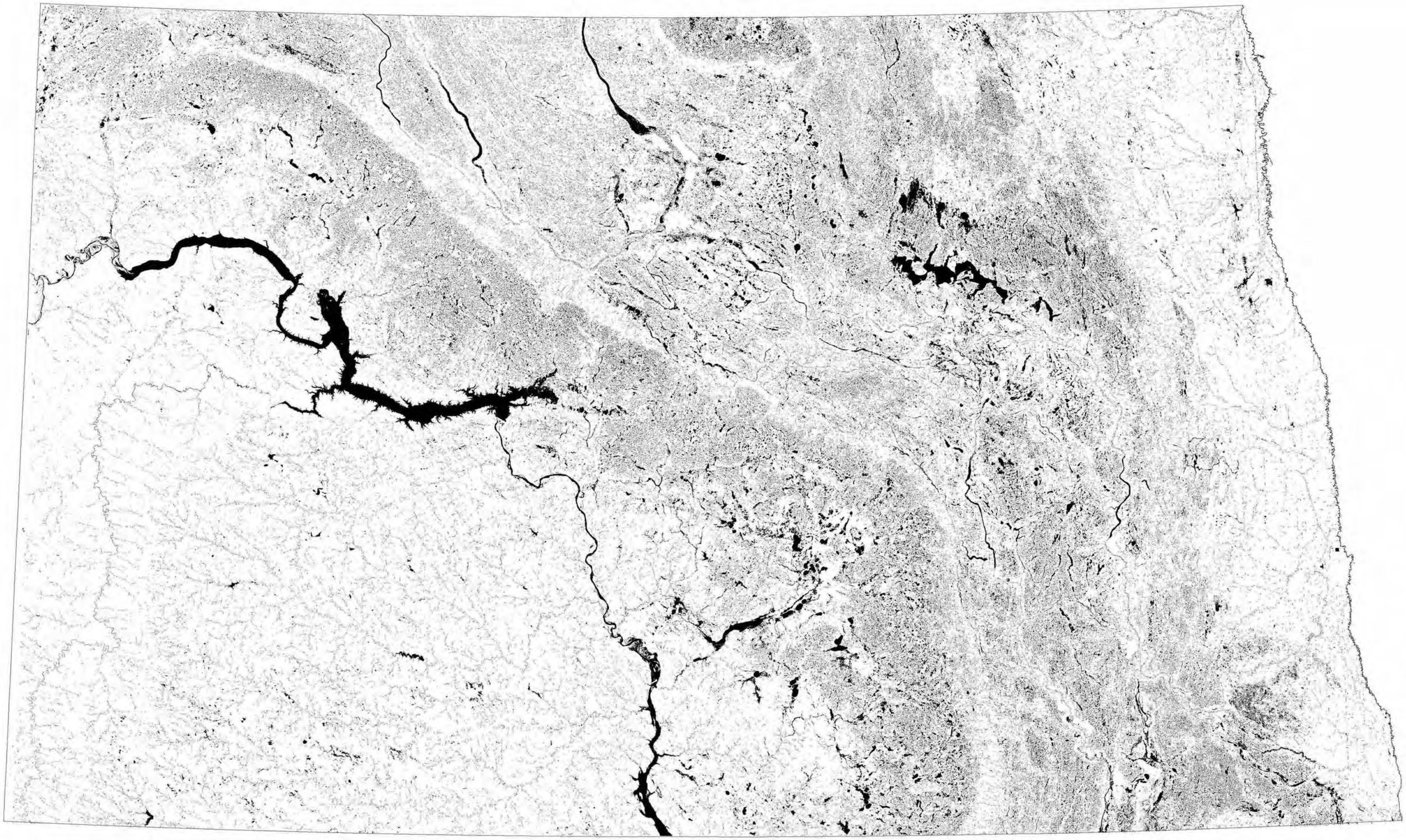
DOUBLE-CRESTED CORMORANT(Phalacrocorax auritus)



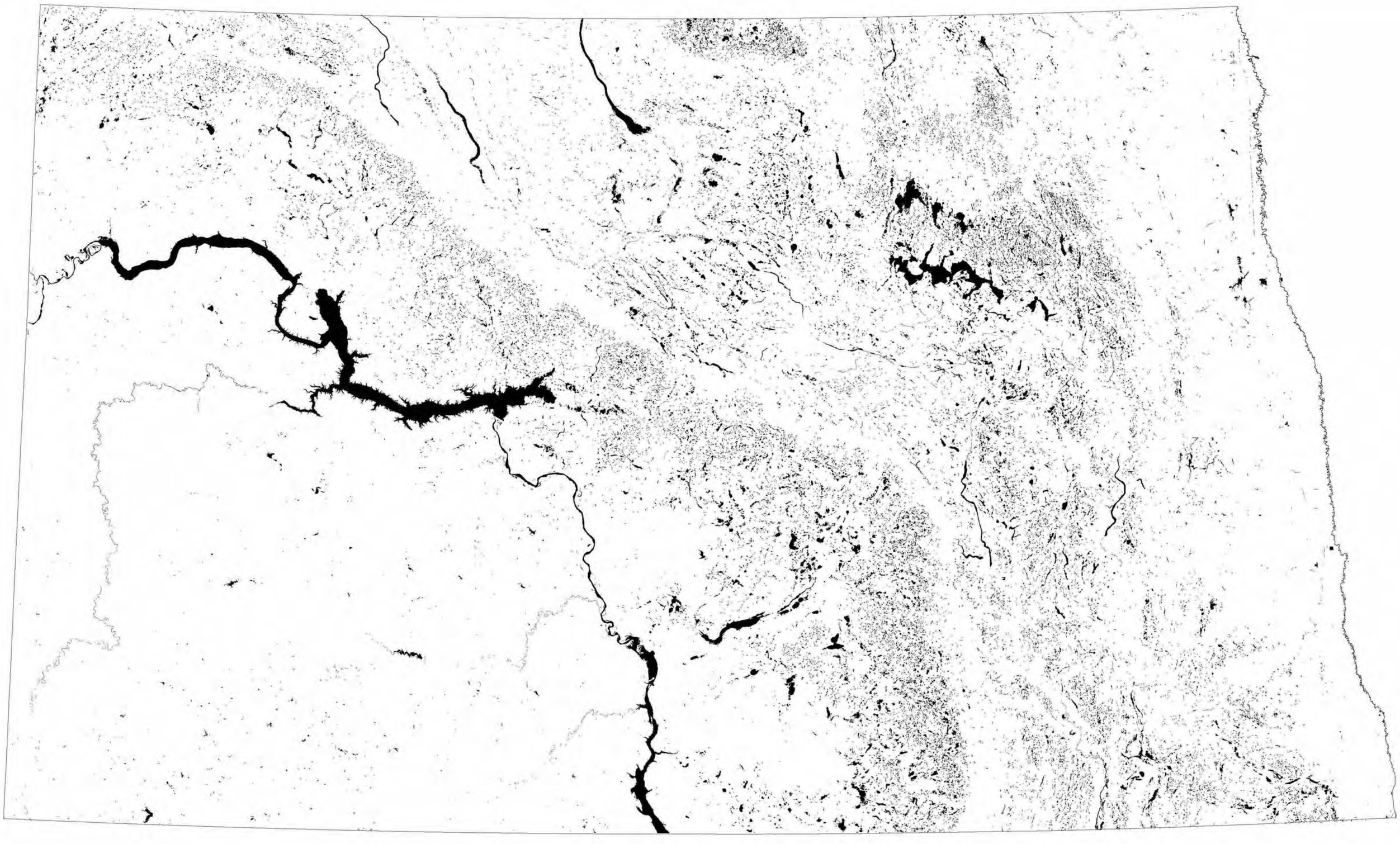
AMERICAN WHITE PELICAN(Pelecanus erythrorhynchos)



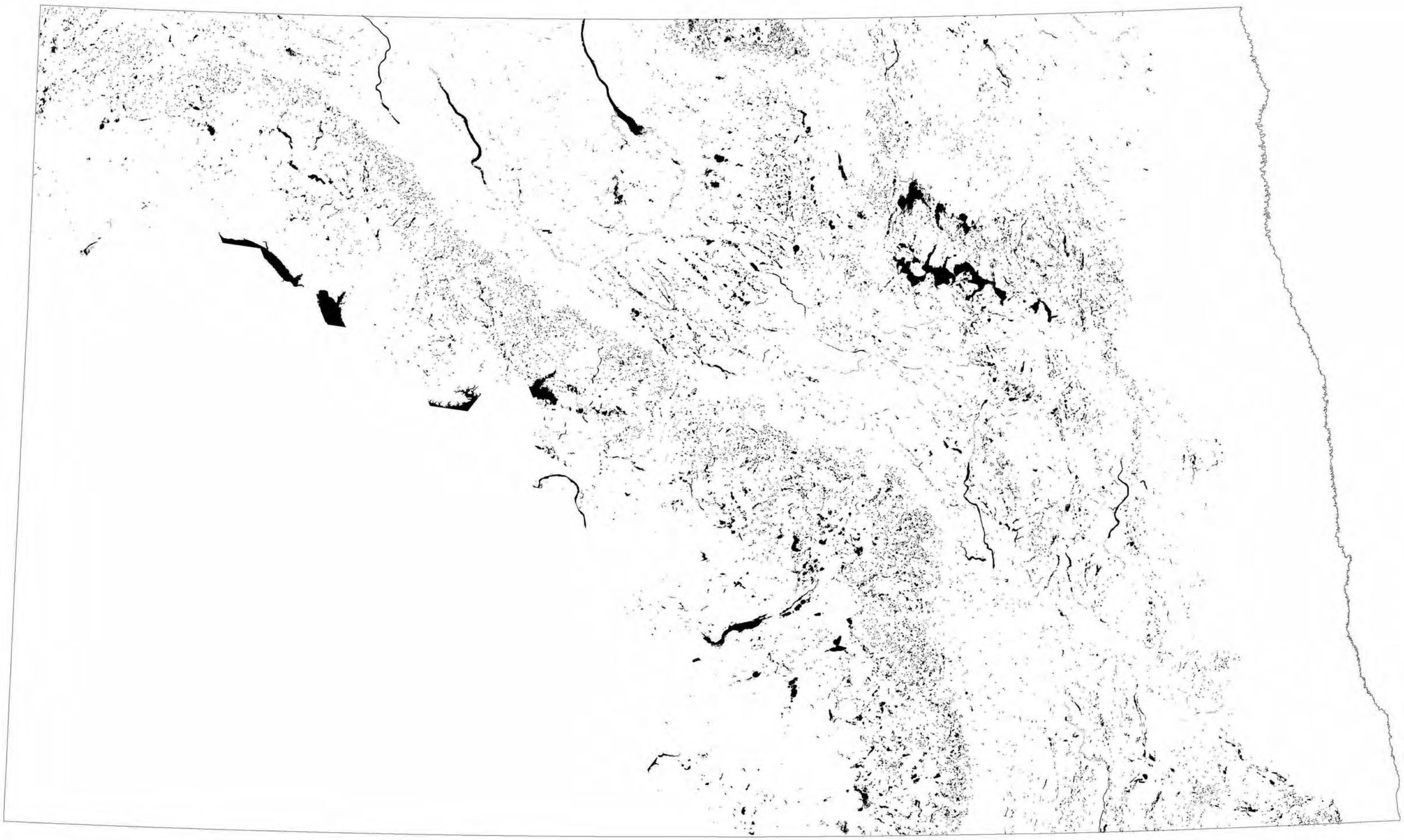
WESTERN GREBE(Aechmophorus occidentalis)



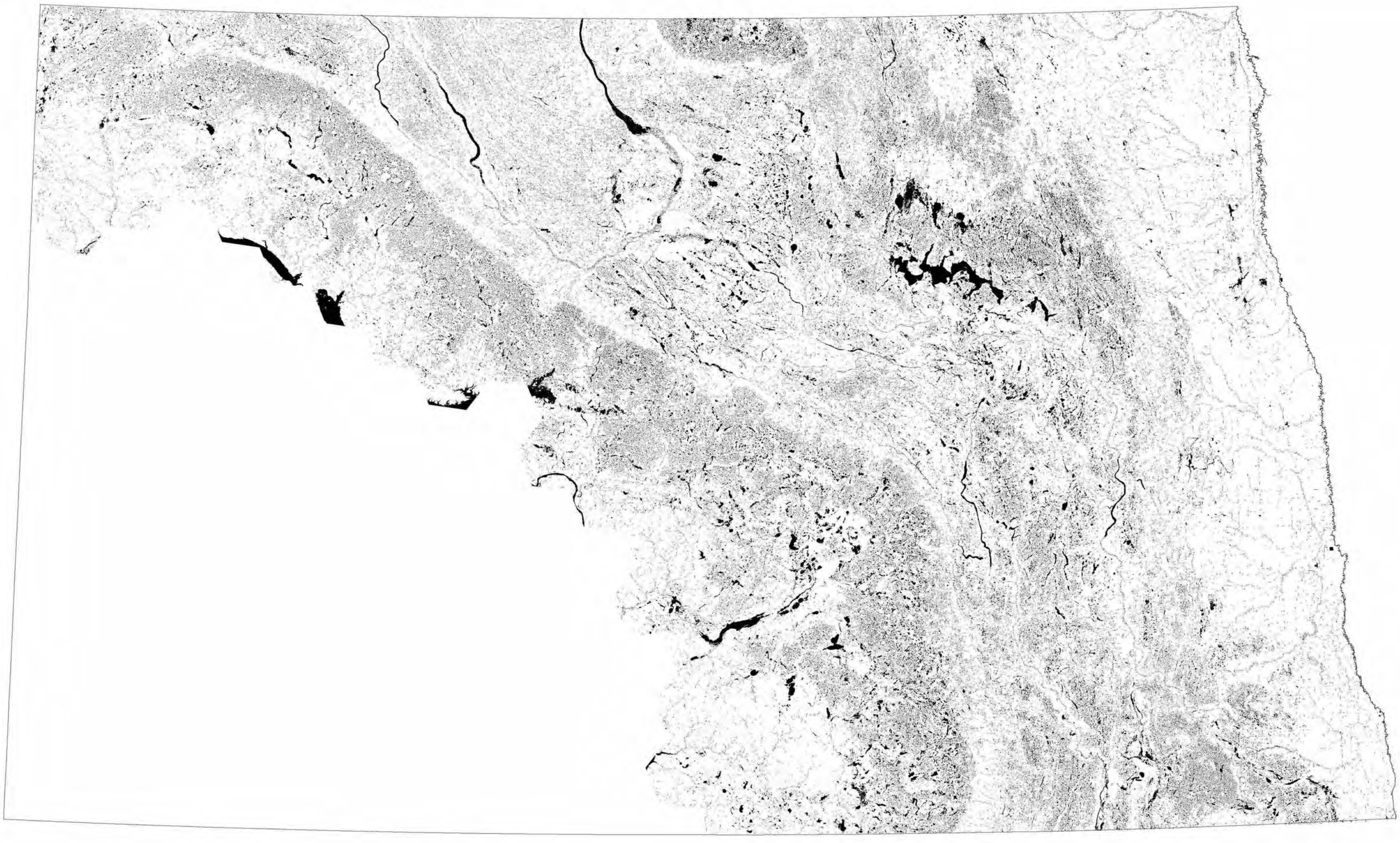
EARED GREBE(Podiceps nigricollis)



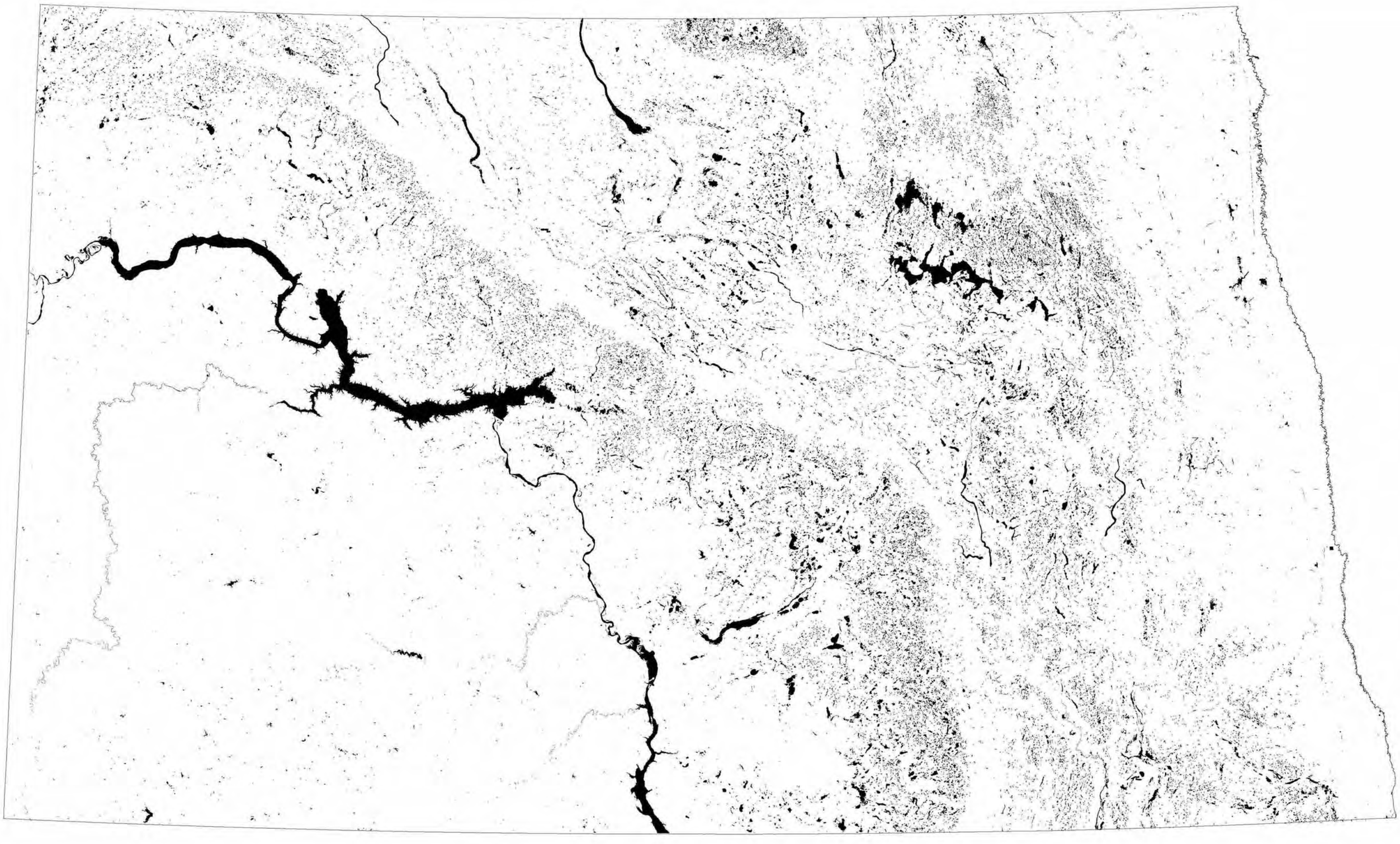
RED-NECKED GREBE(Podiceps grisegena)



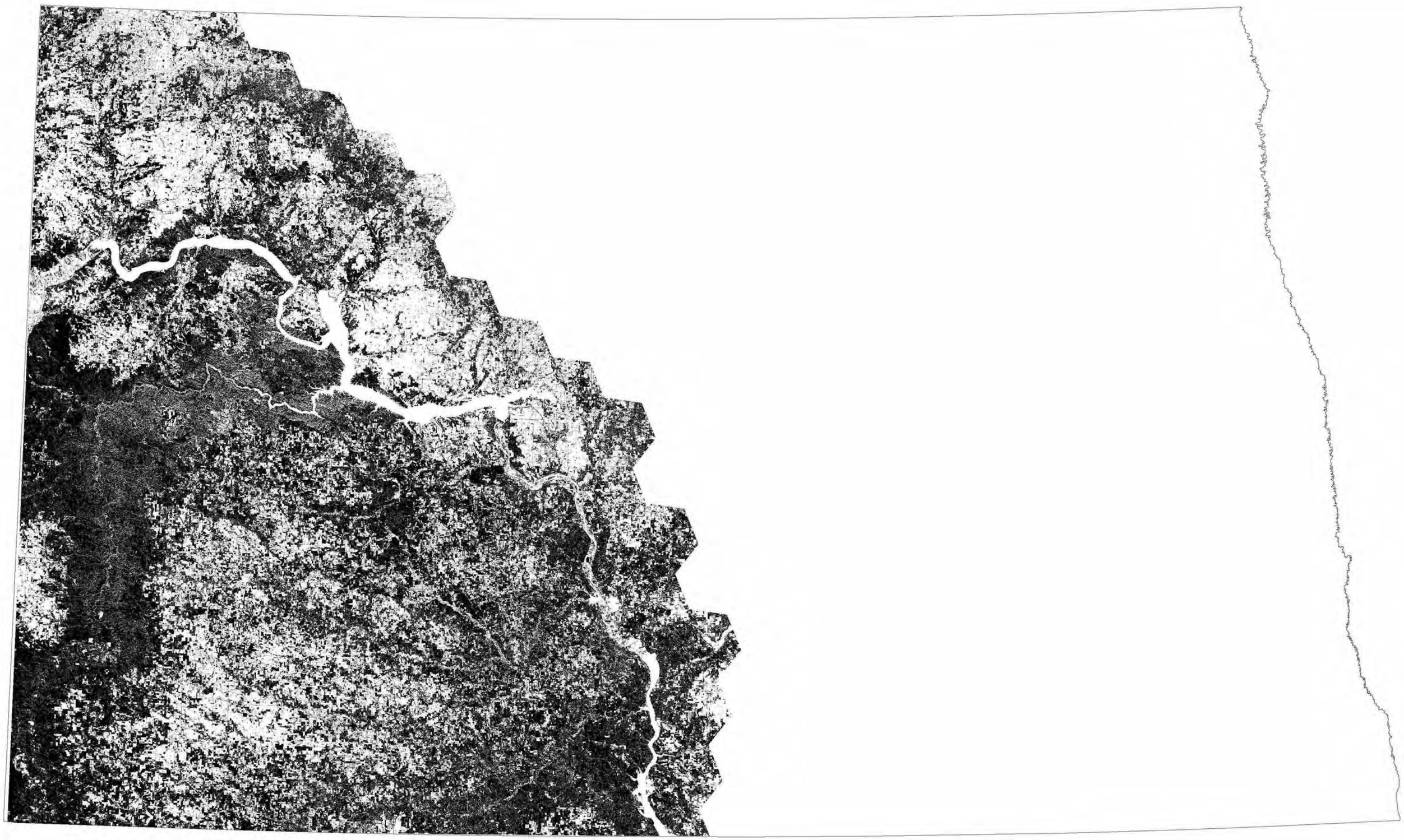
HORNED GREBE(Podiceps auritus))



PIED-BILLED GREBE(Podilymbus podiceps)



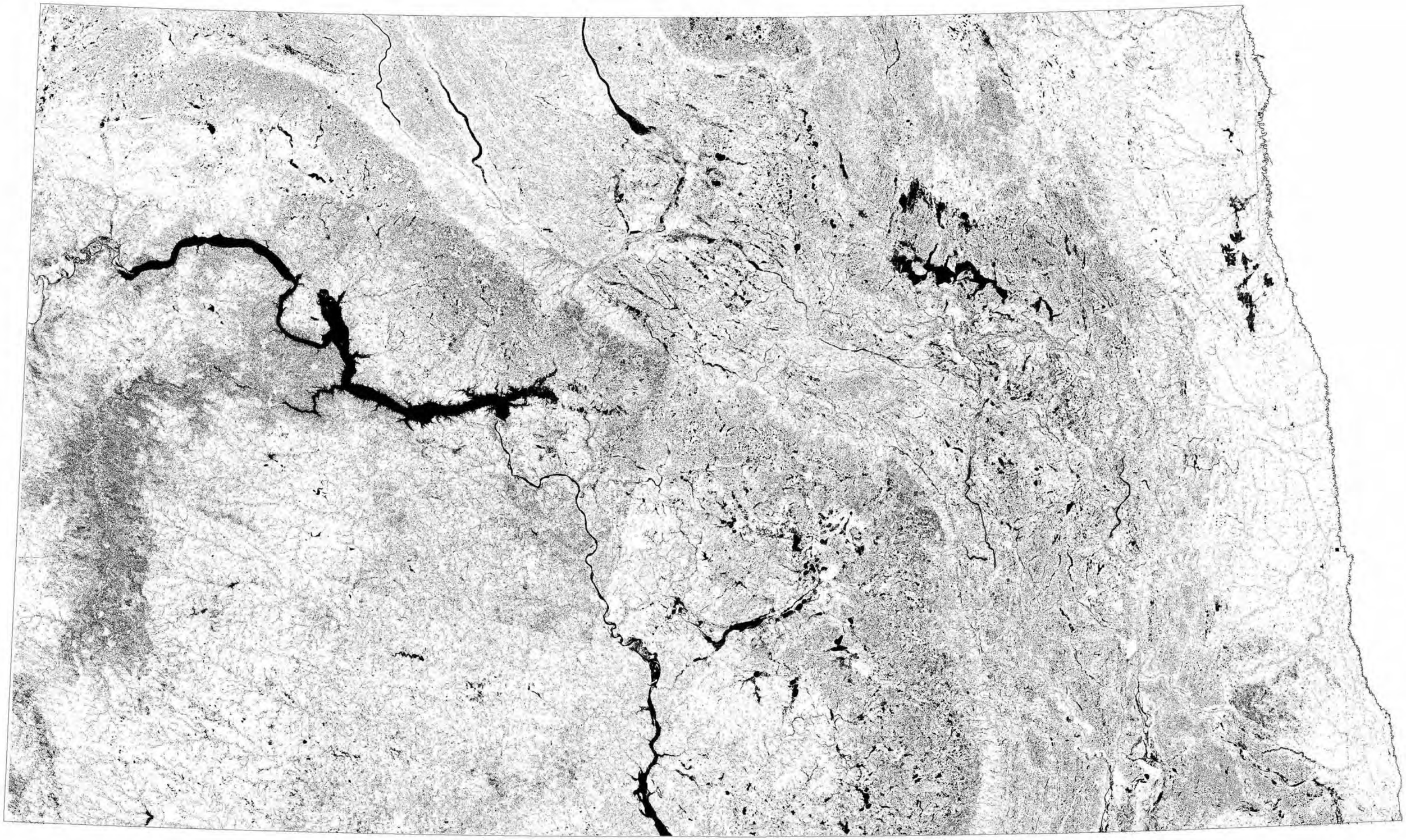
PRAIRIE FALCON(Falco mexicanus)



RUFFED GROUSE(Bonasa umbellus)

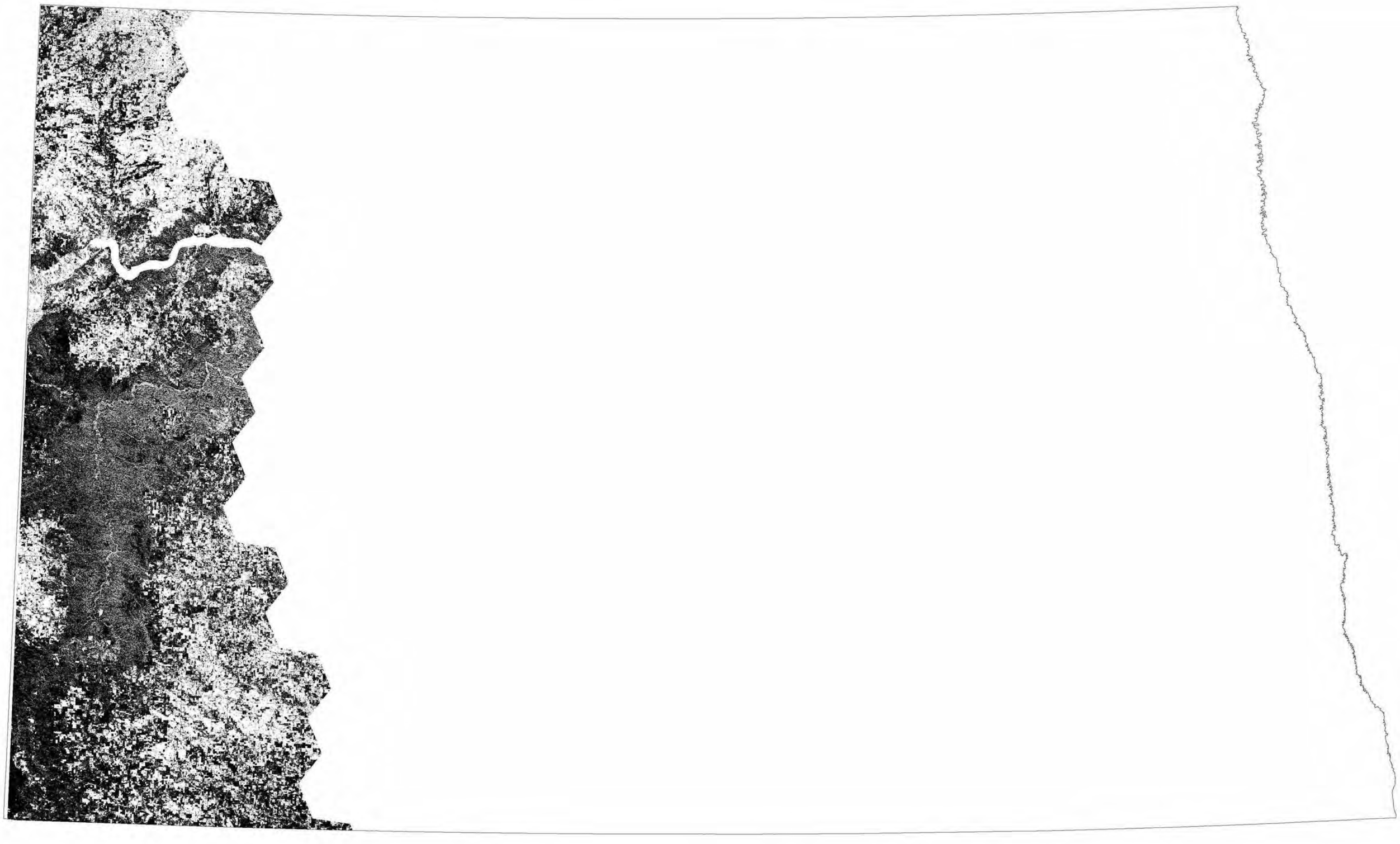
WILSON'S PHALAROPE(Phalaropus tricolor)

COMMON SNIPE(Gallinago gallinago)



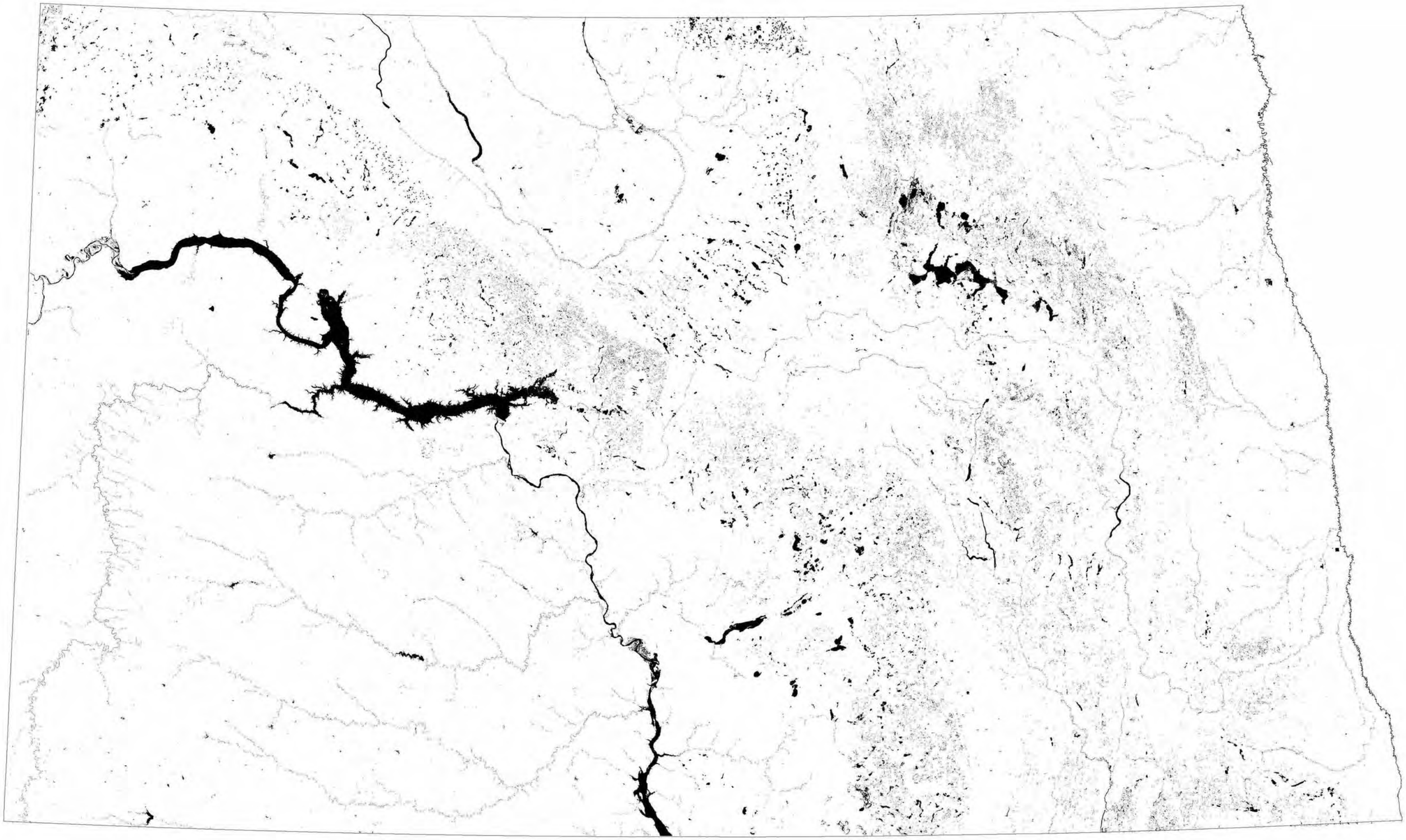
MARBLED GODWIT(Limosa fedoa)

LONG-BILLED CURLEW(Numenius americanus)



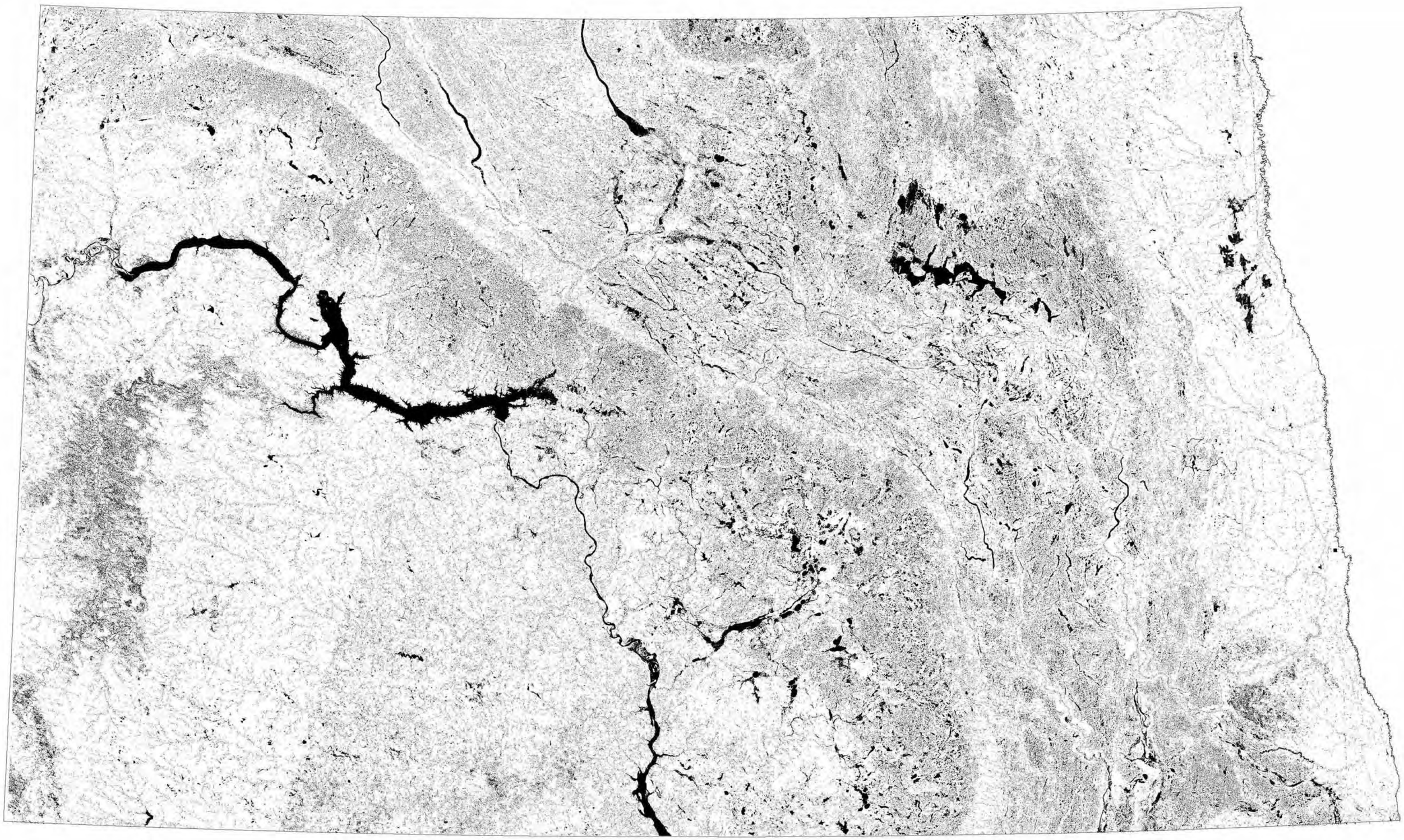
UPLAND SANDPIPER(Bartramia longicauda)

SPOTTED SANDPIPER(Actitis macularia)

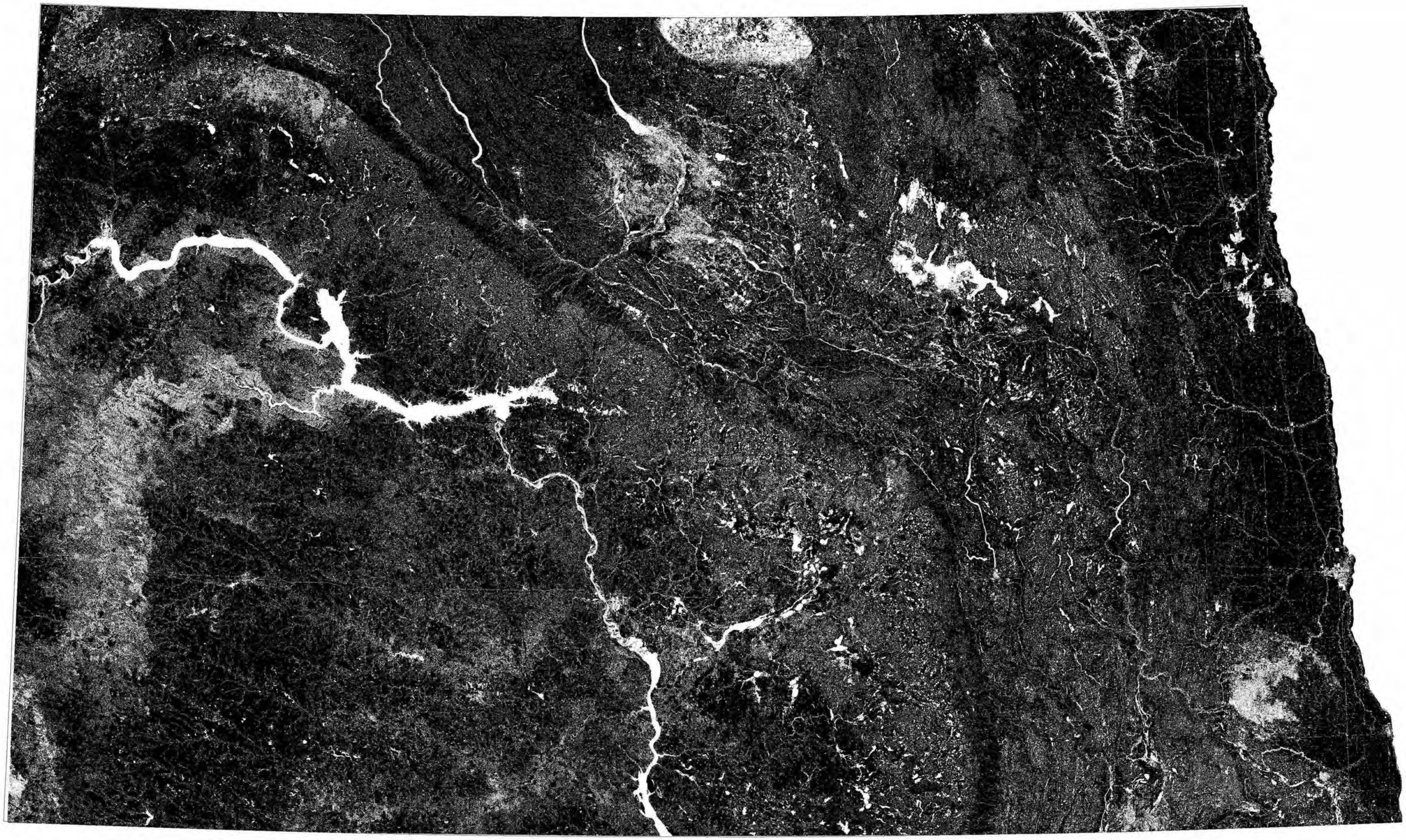


WILLET(Catoptrophorus semipalmatus)

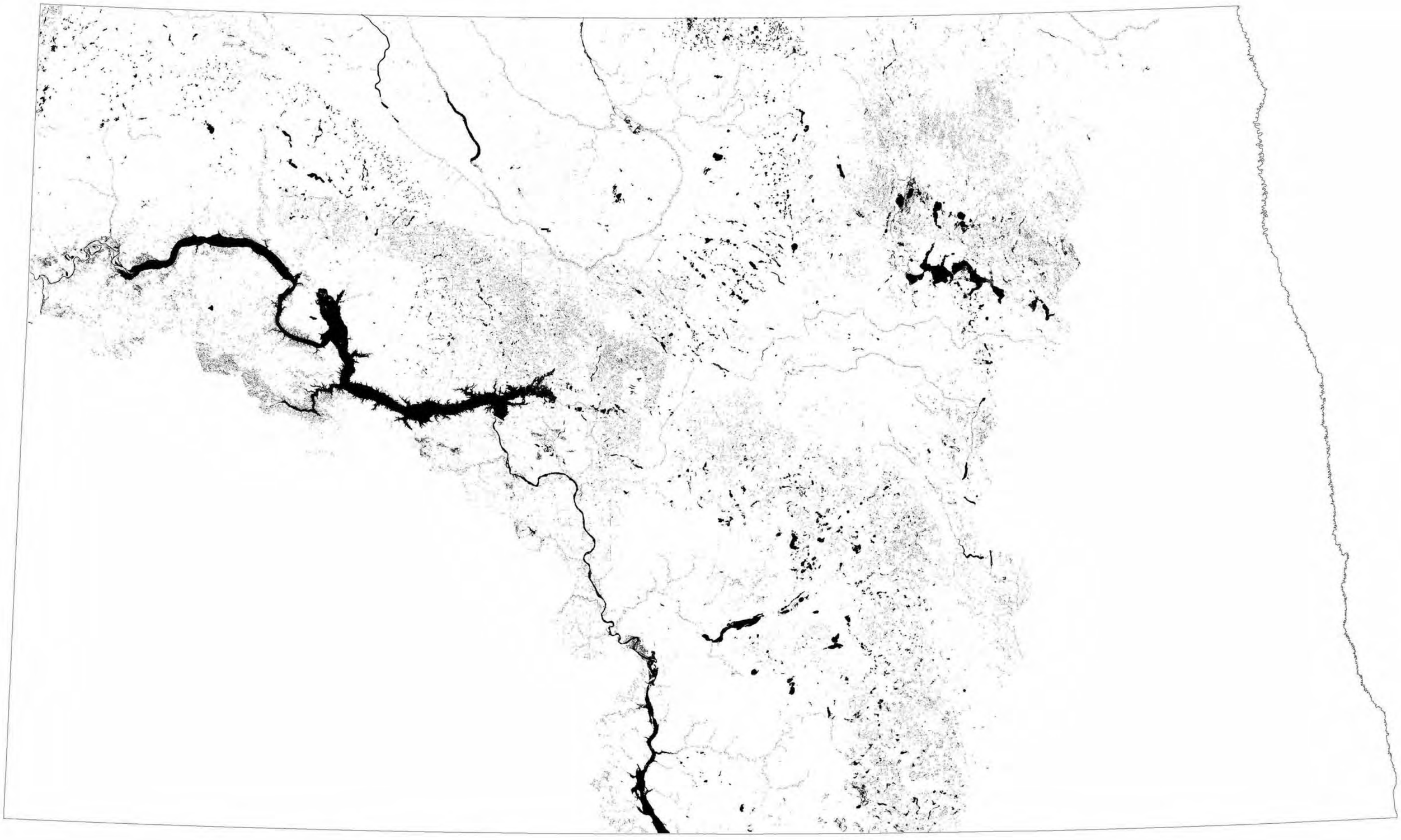
AMERICAN AVOCET(Recurvirostra americana)



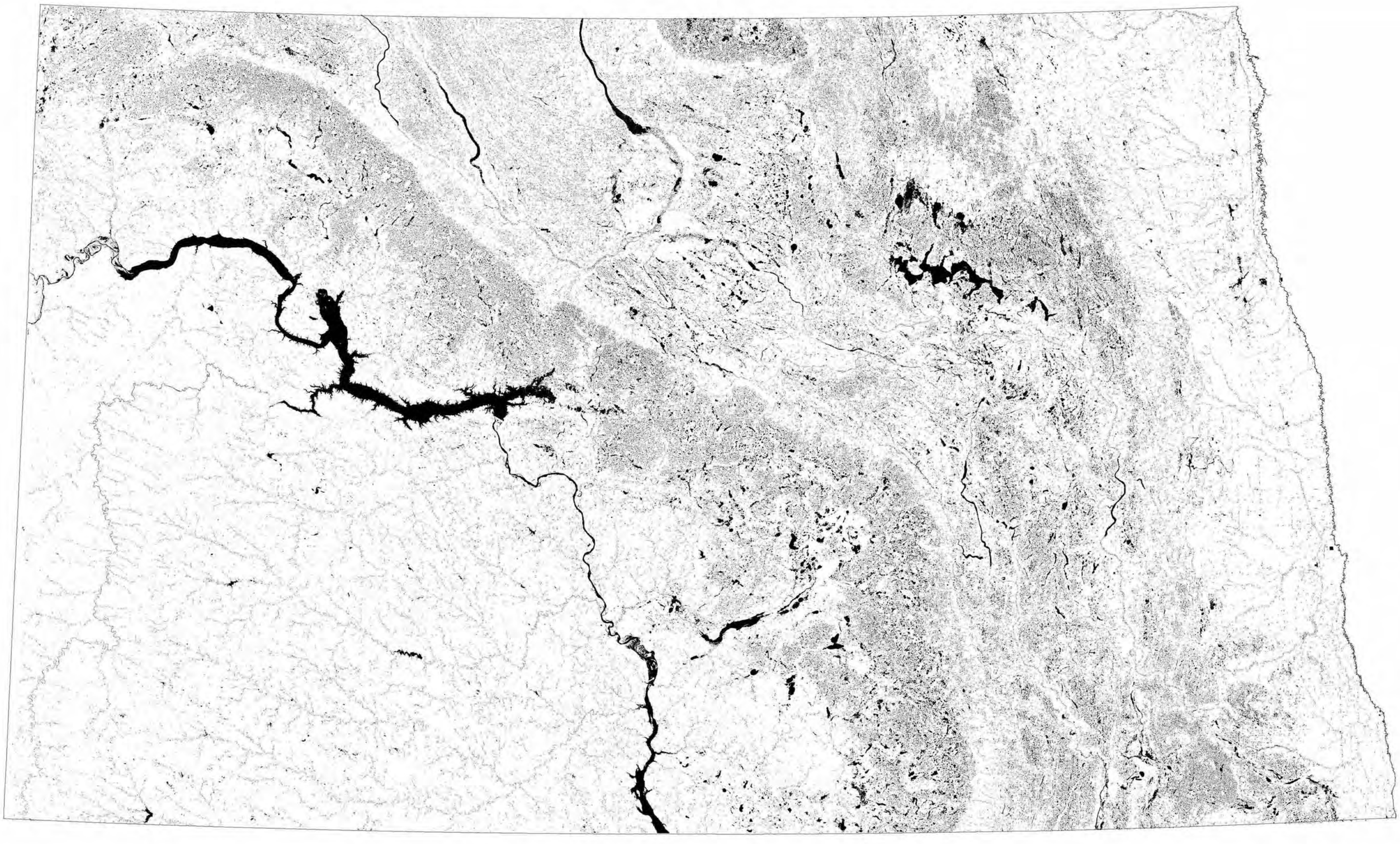
KILLDEER(Charadrius vociferus)



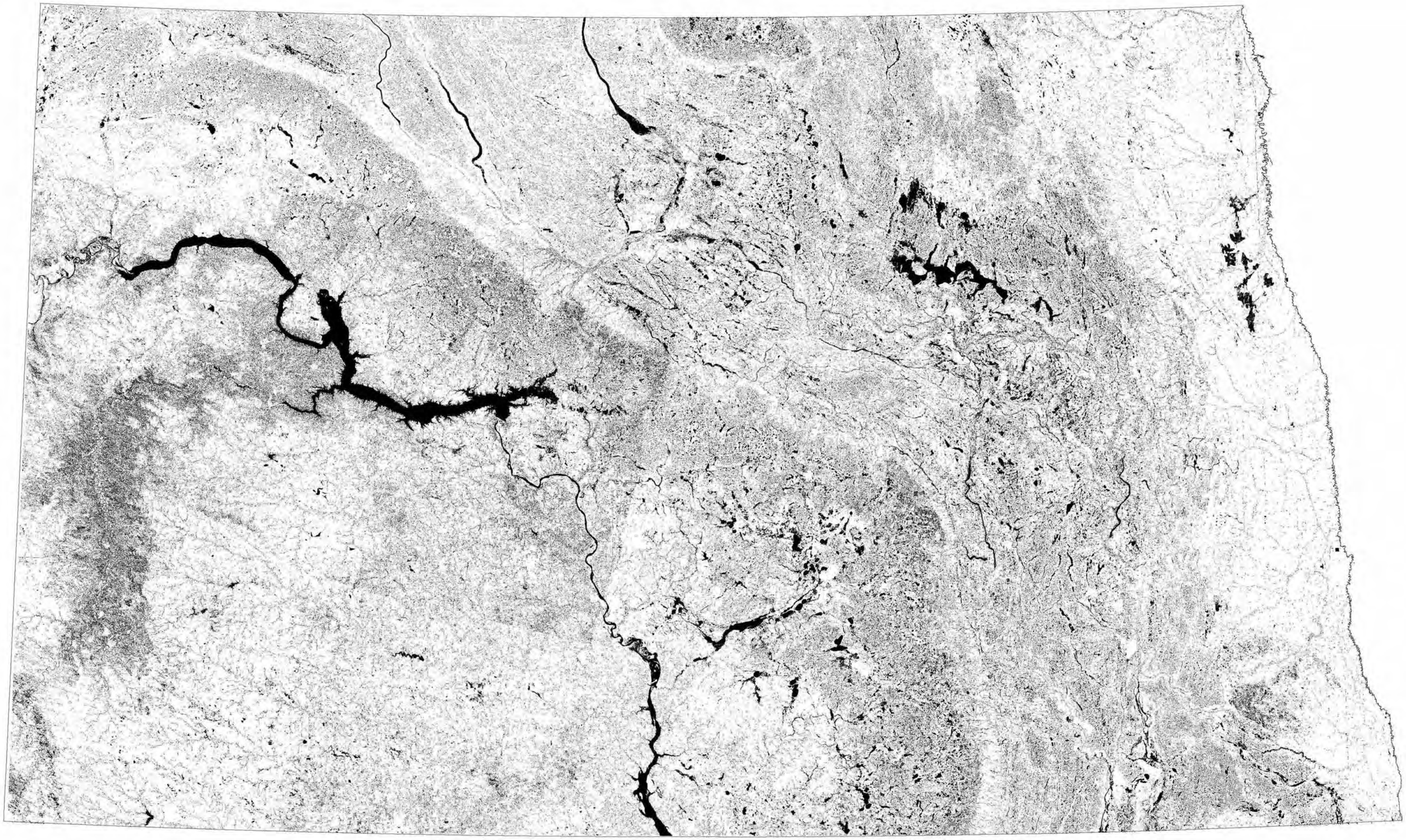
PIPING PLOVER(Charadrius melodus)



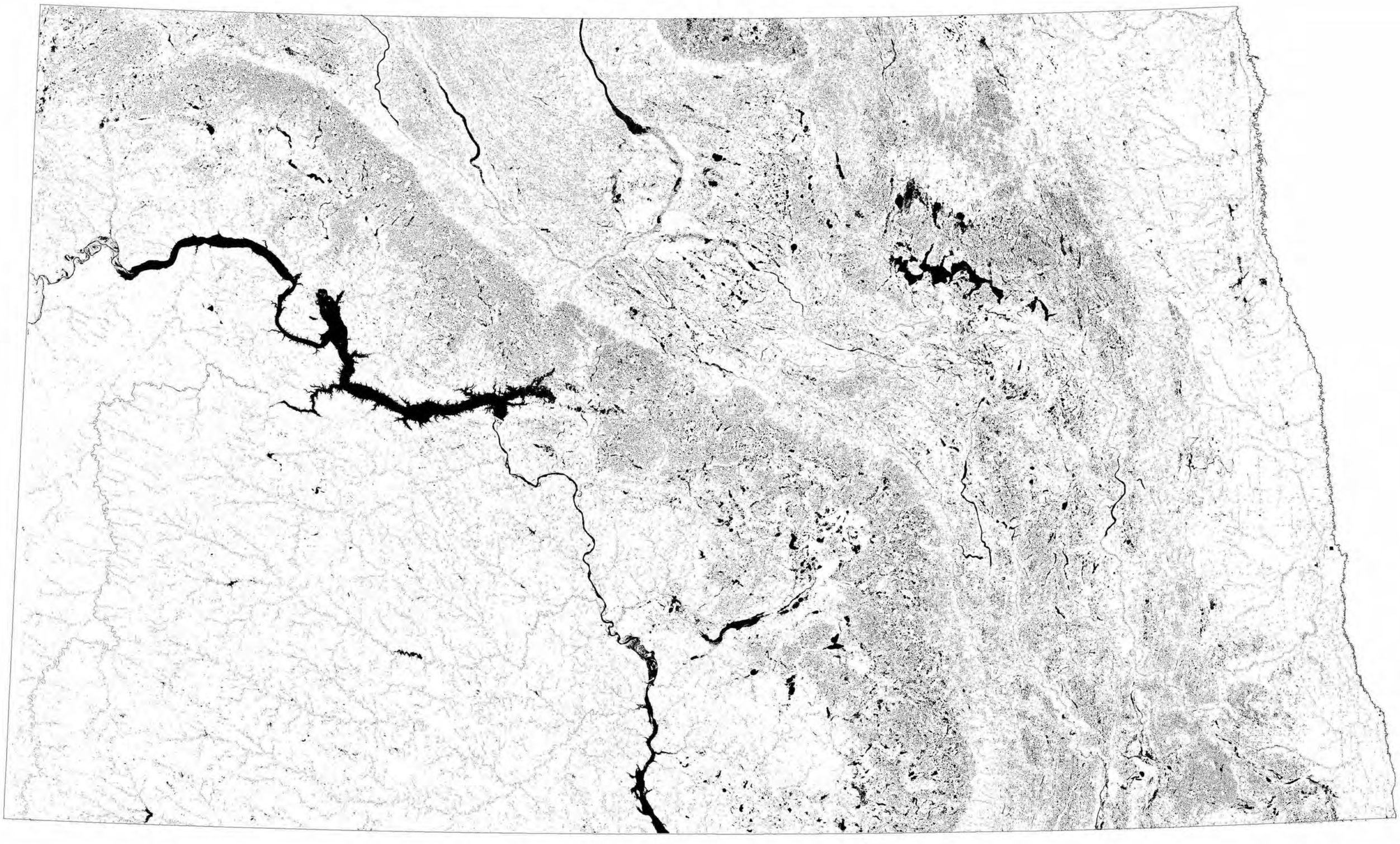
AMERICAN COOT(Fulica americana)



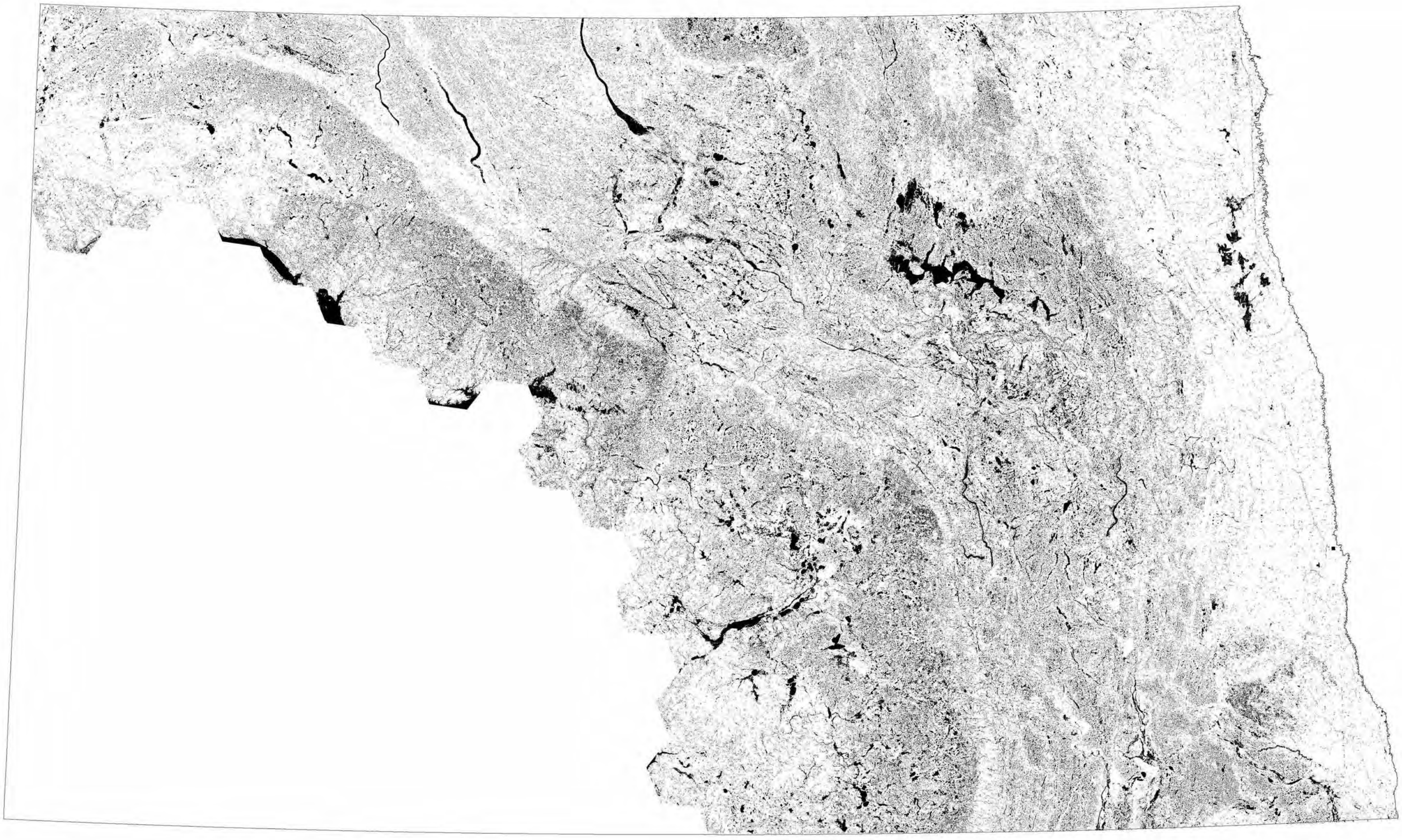
SORA(Porzana carolina)



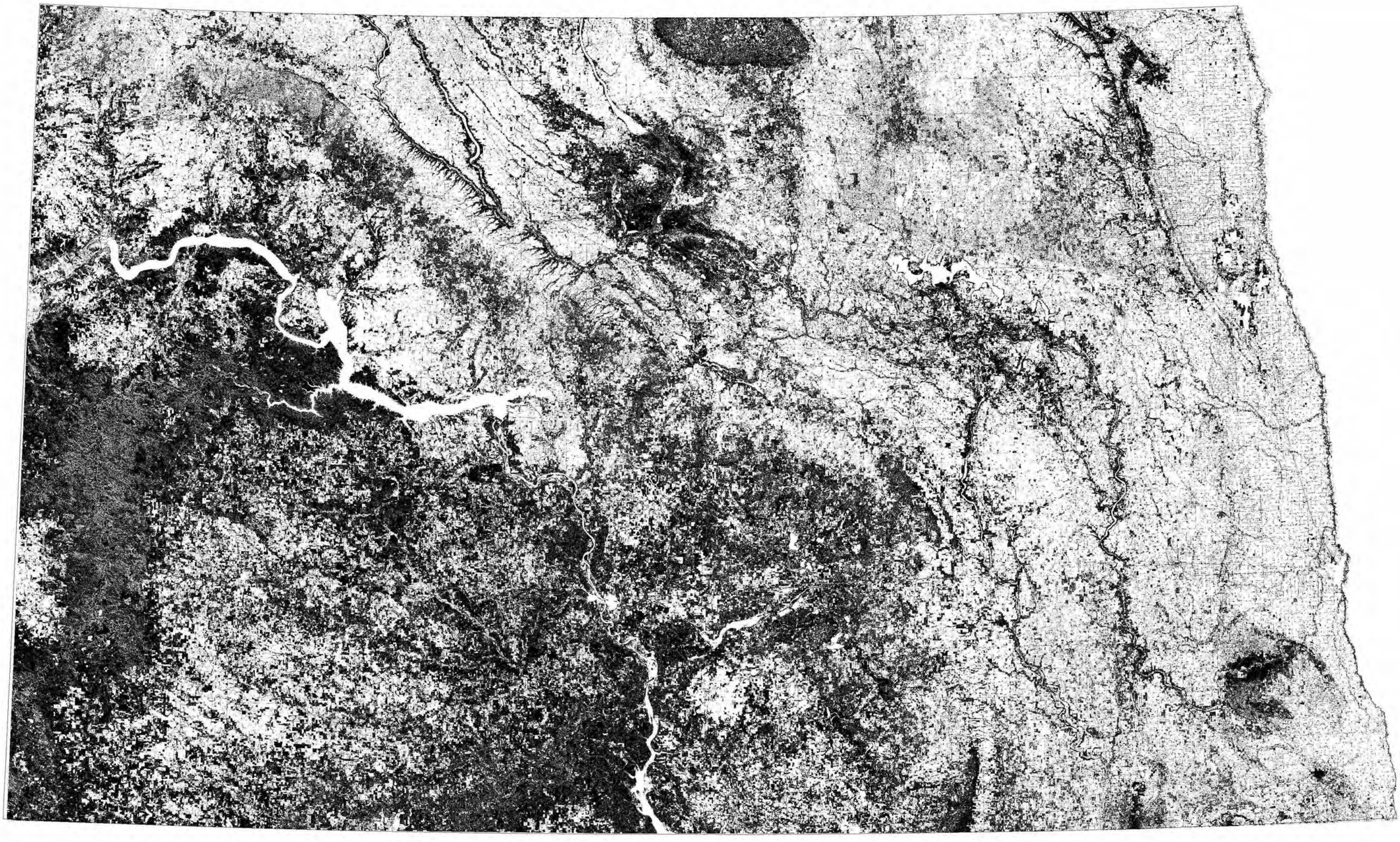
VIRGINIA RAIL(Rallus limicola)



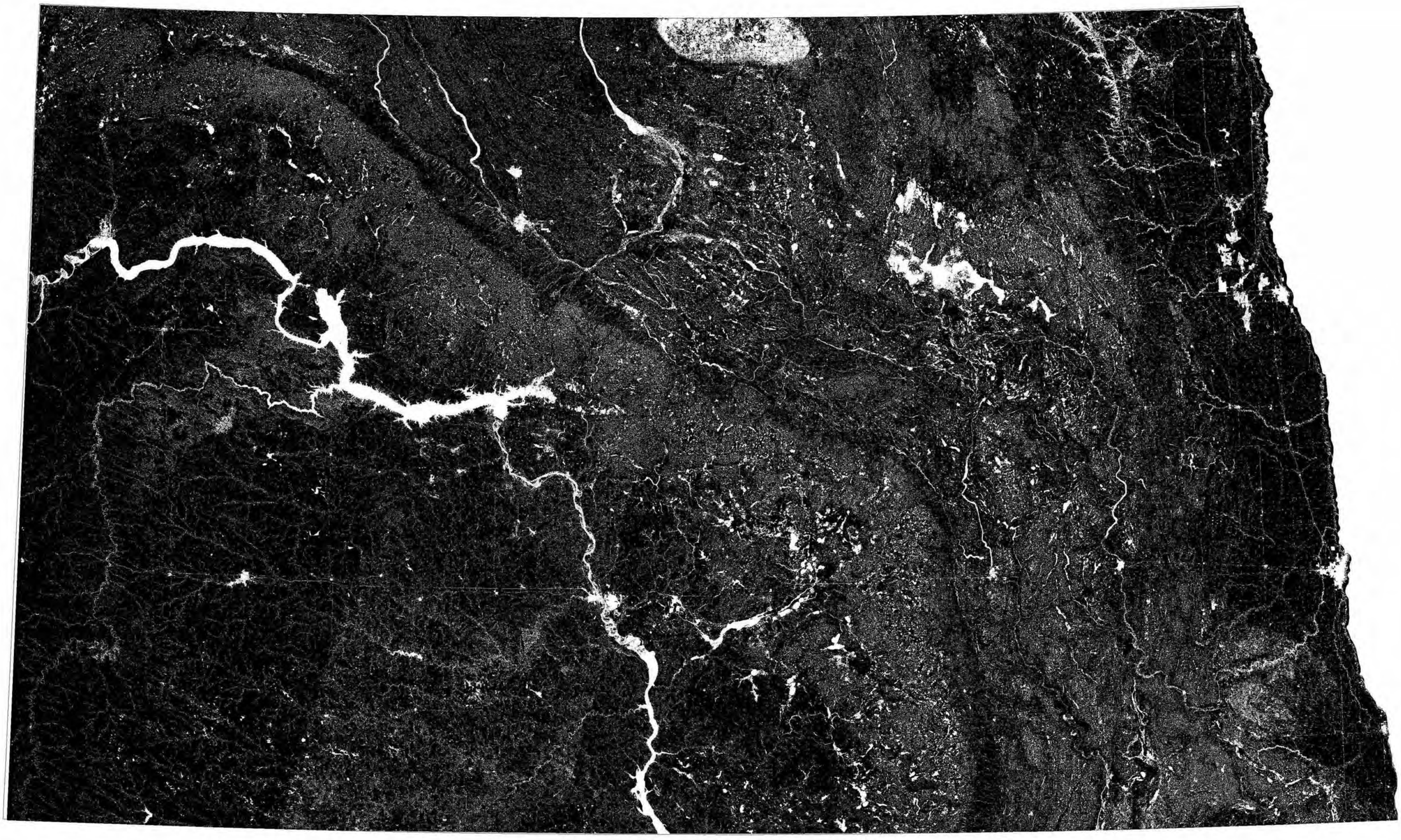
YELLOW RAIL(Coturnicops noveboracensis)



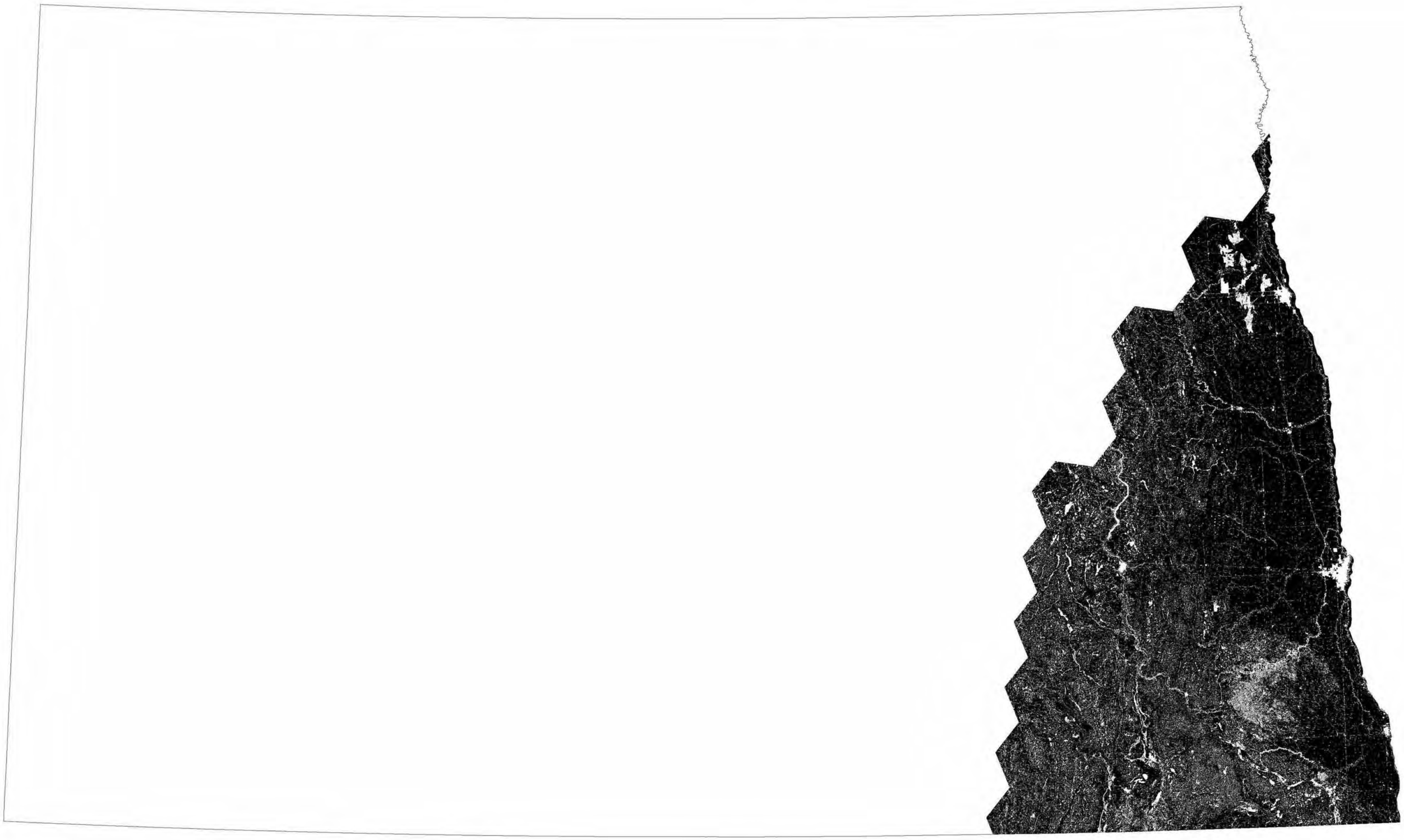
WILD TURKEY(Meleagris gallopavo)



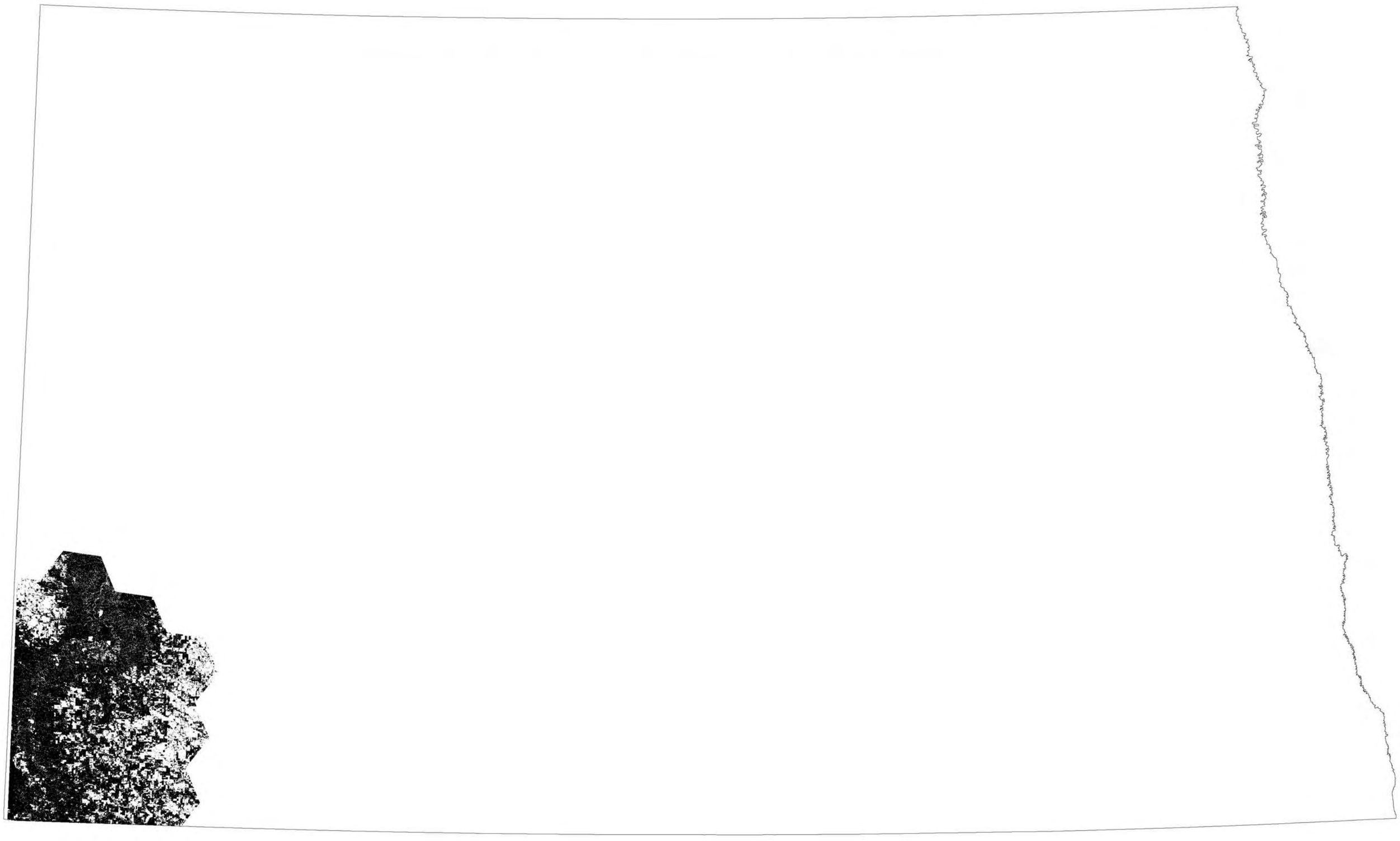
SHARP-TAILED GROUSE(Tympanuchus phasianellus)



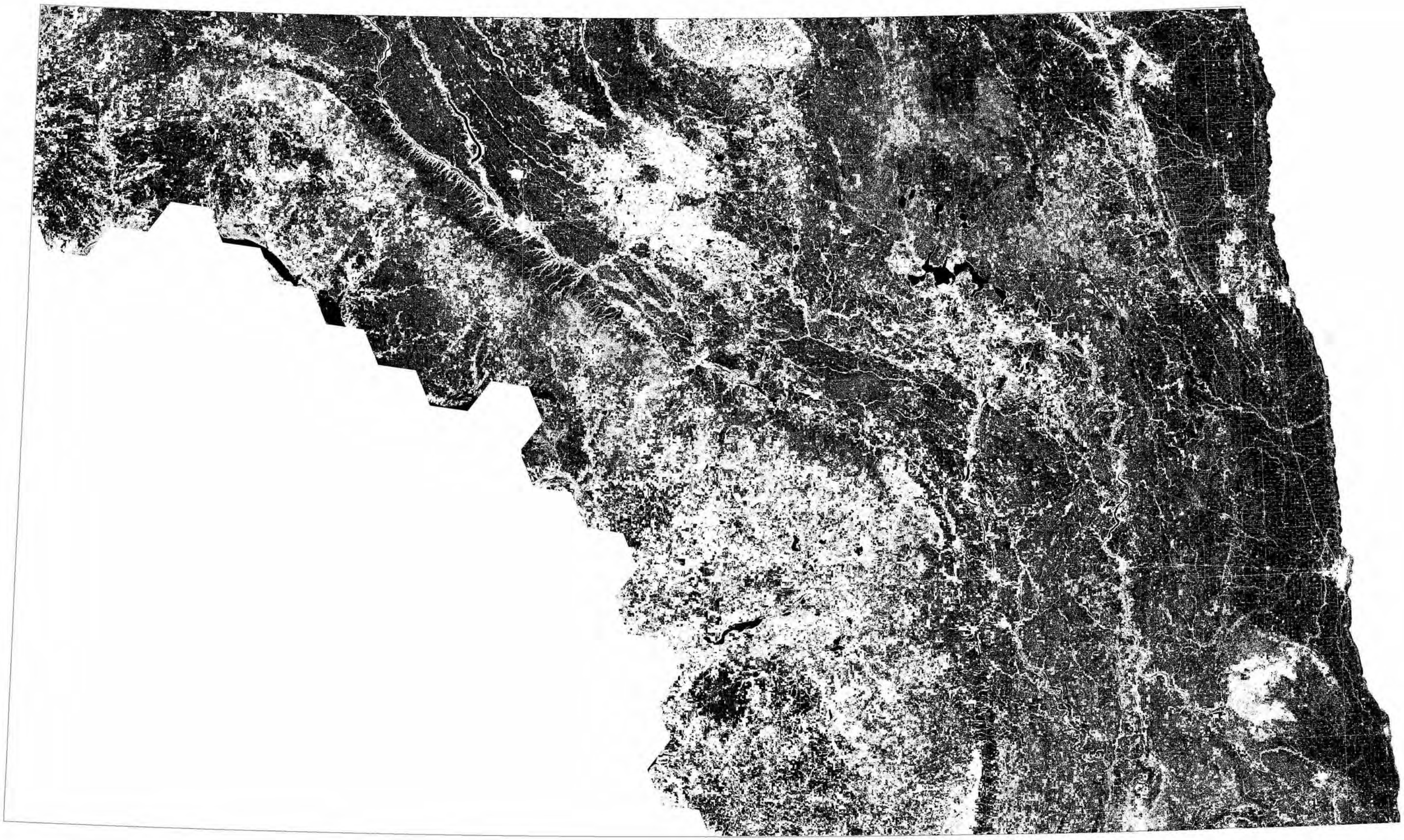
GREATER PRAIRIE-CHICKEN(Tympanuchus cupido)



SAGE GROUSE(Centrocercus urophasianus)

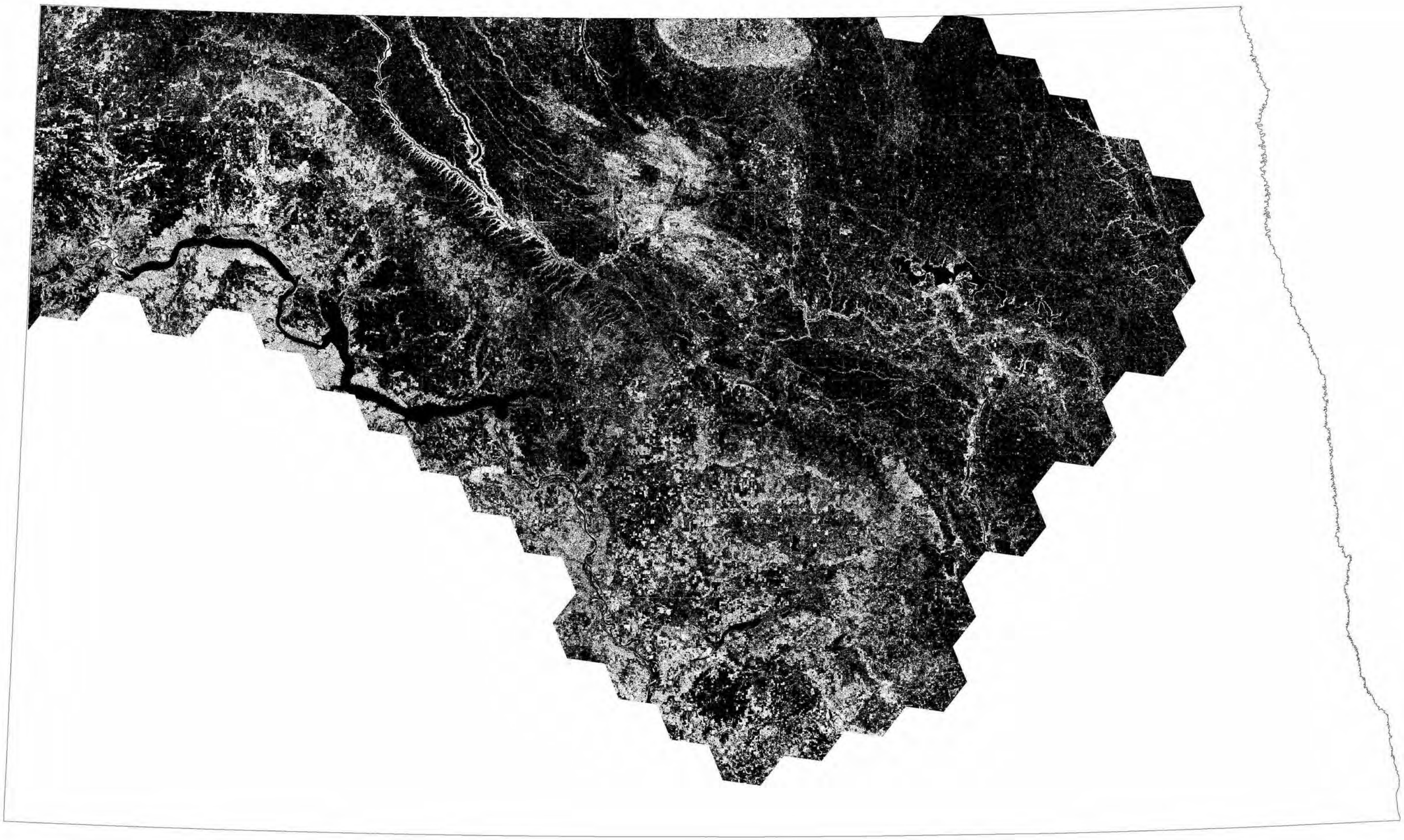


FRANKLIN'S GULL(Larus pipixcan)

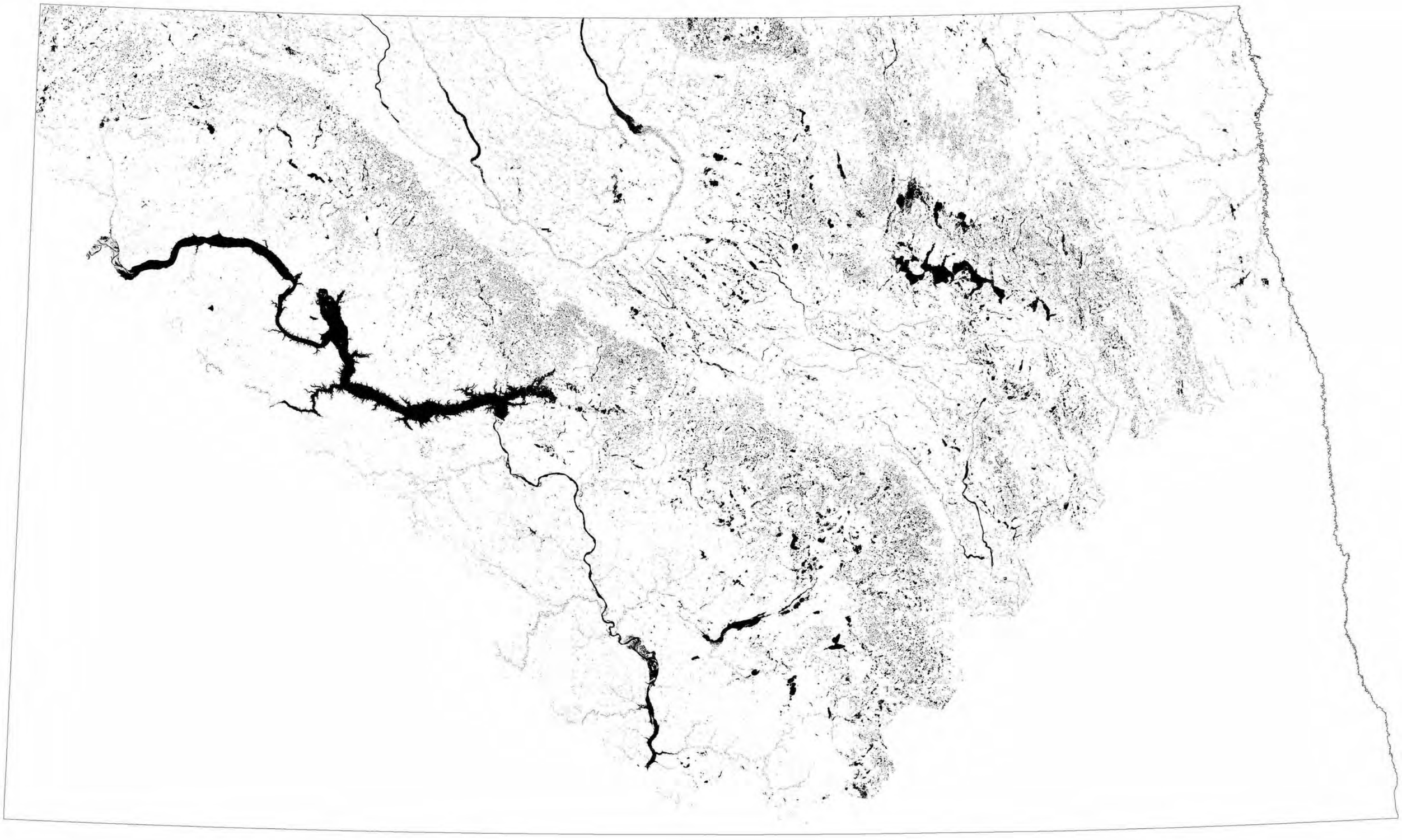


RING-BILLED GULL(Larus delawarensis)

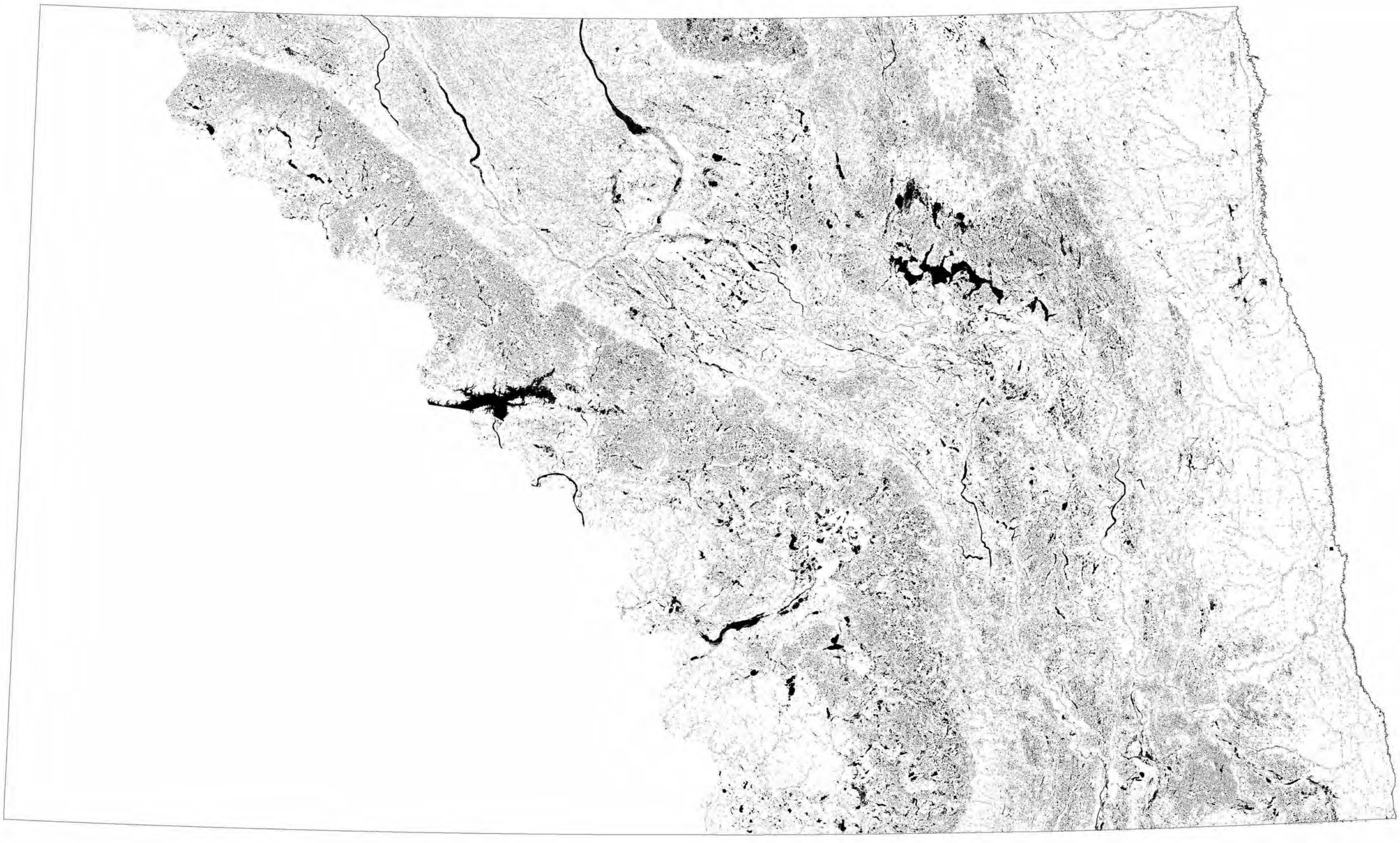
CALIFORNIA GULL(Larus californicus)



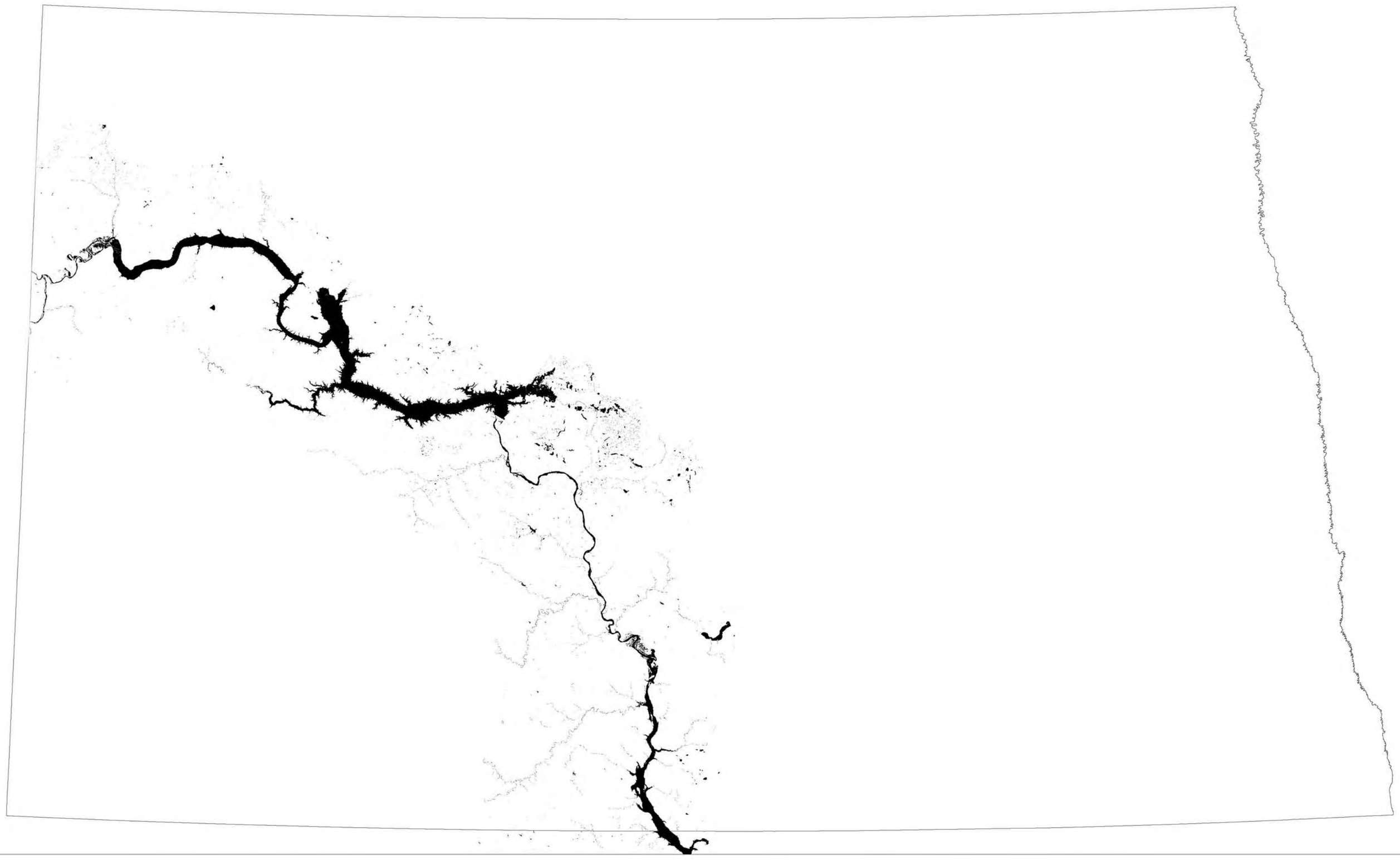
COMMON TERN(Sterna hirundo)



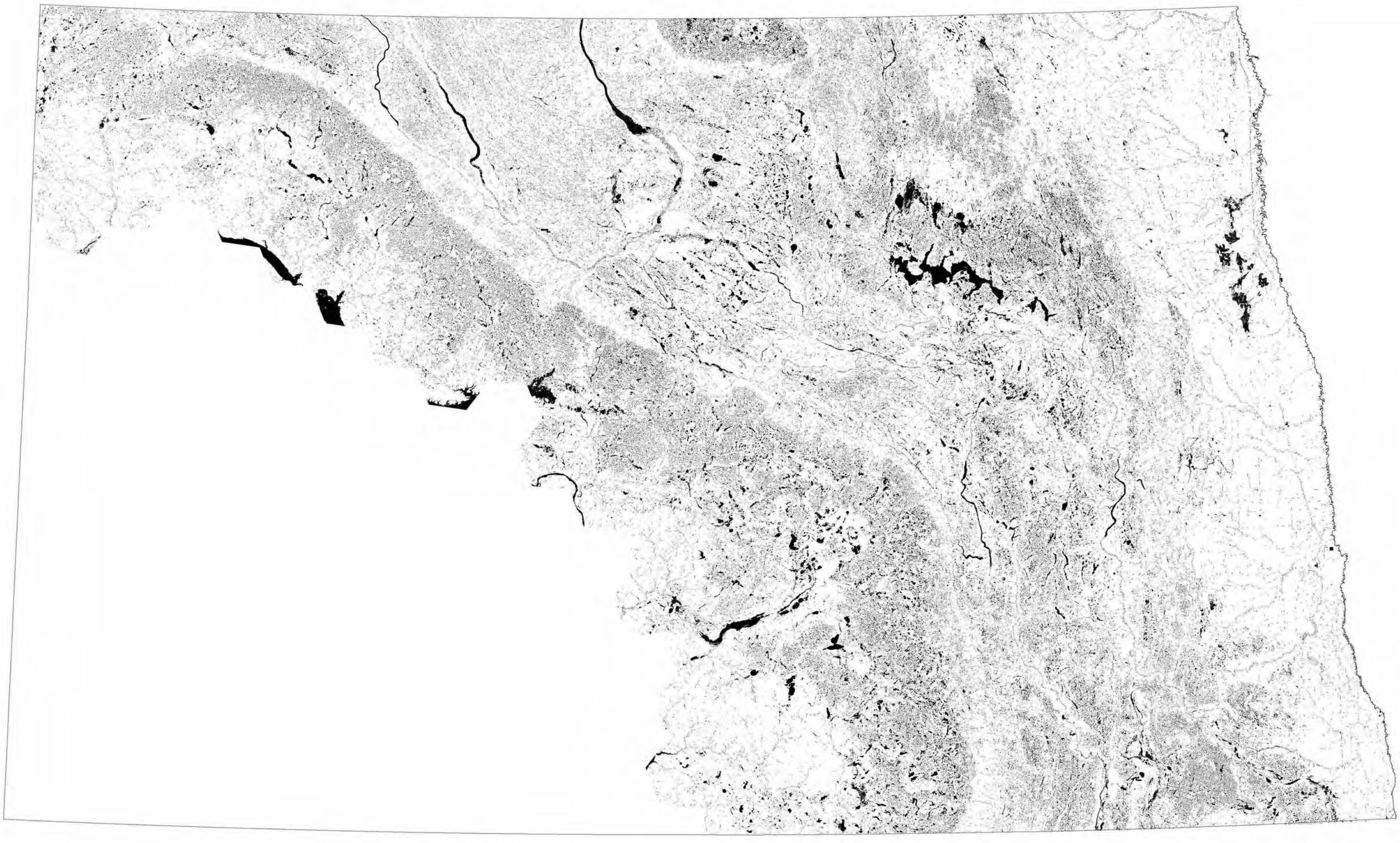
FORSTER'S TERN(Sterna forsteri)



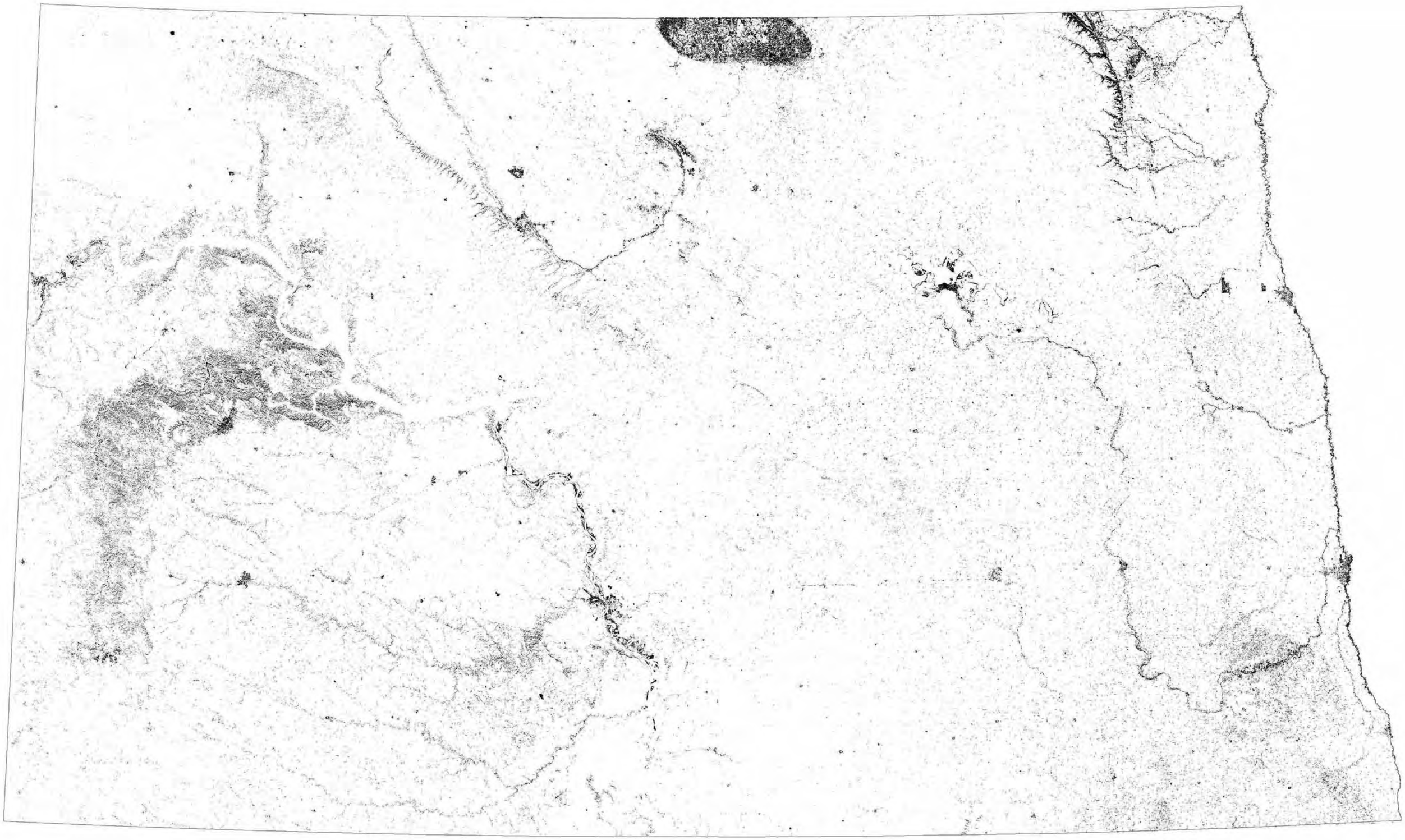
LEAST TERN(Sterna antillarum)



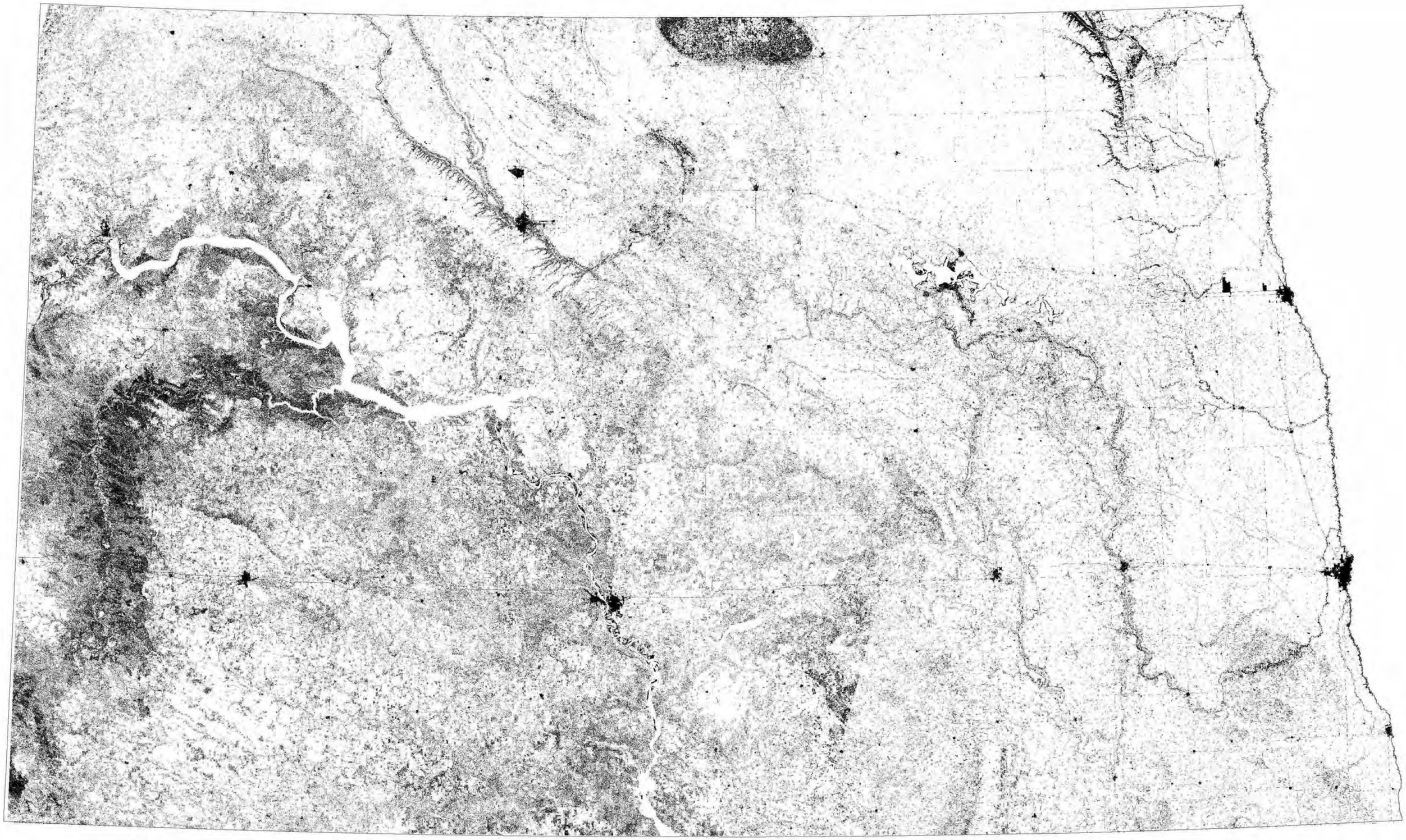
BLACK TERN(Chlidonias niger)



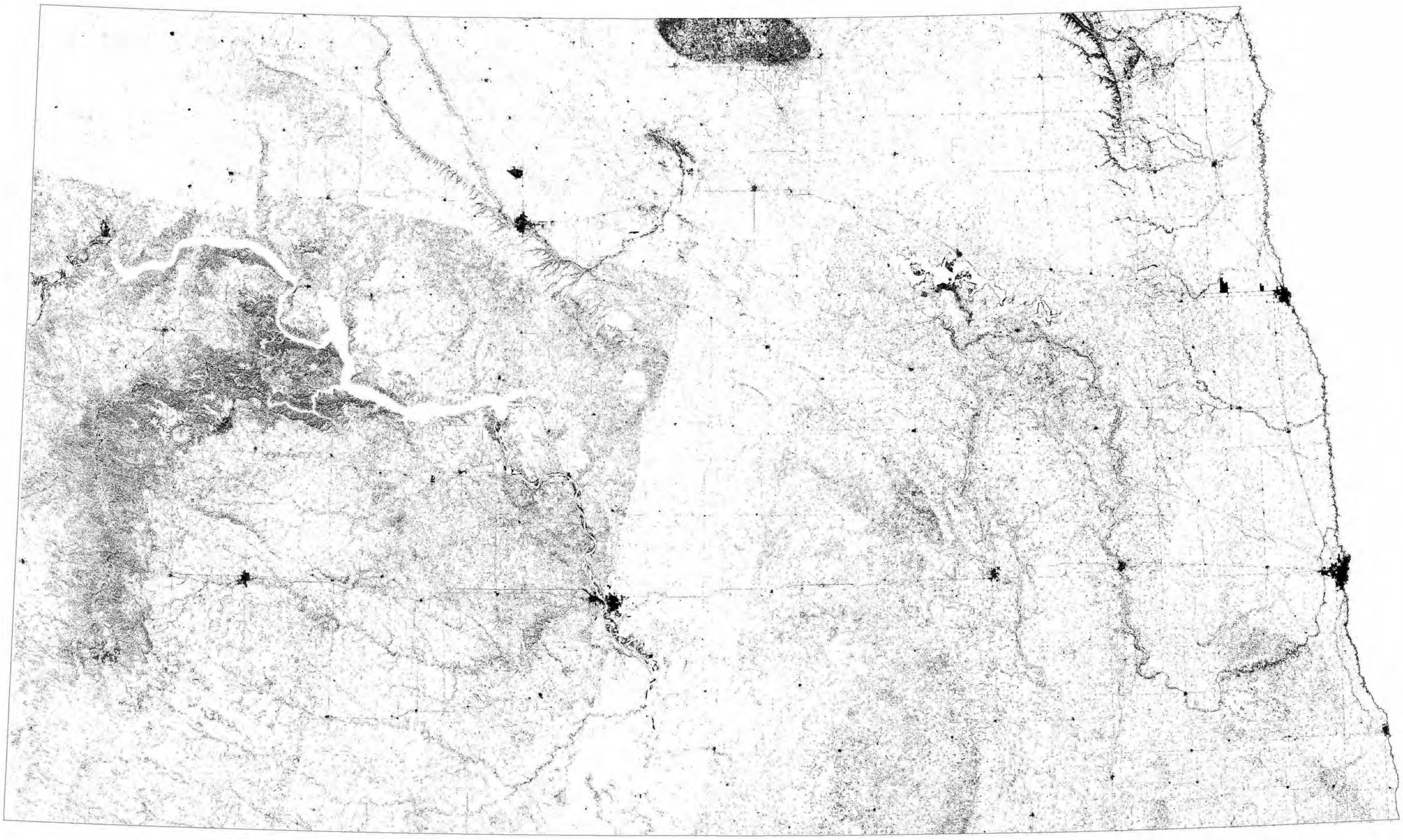
MOURNING DOVE(Zenaida macroura)



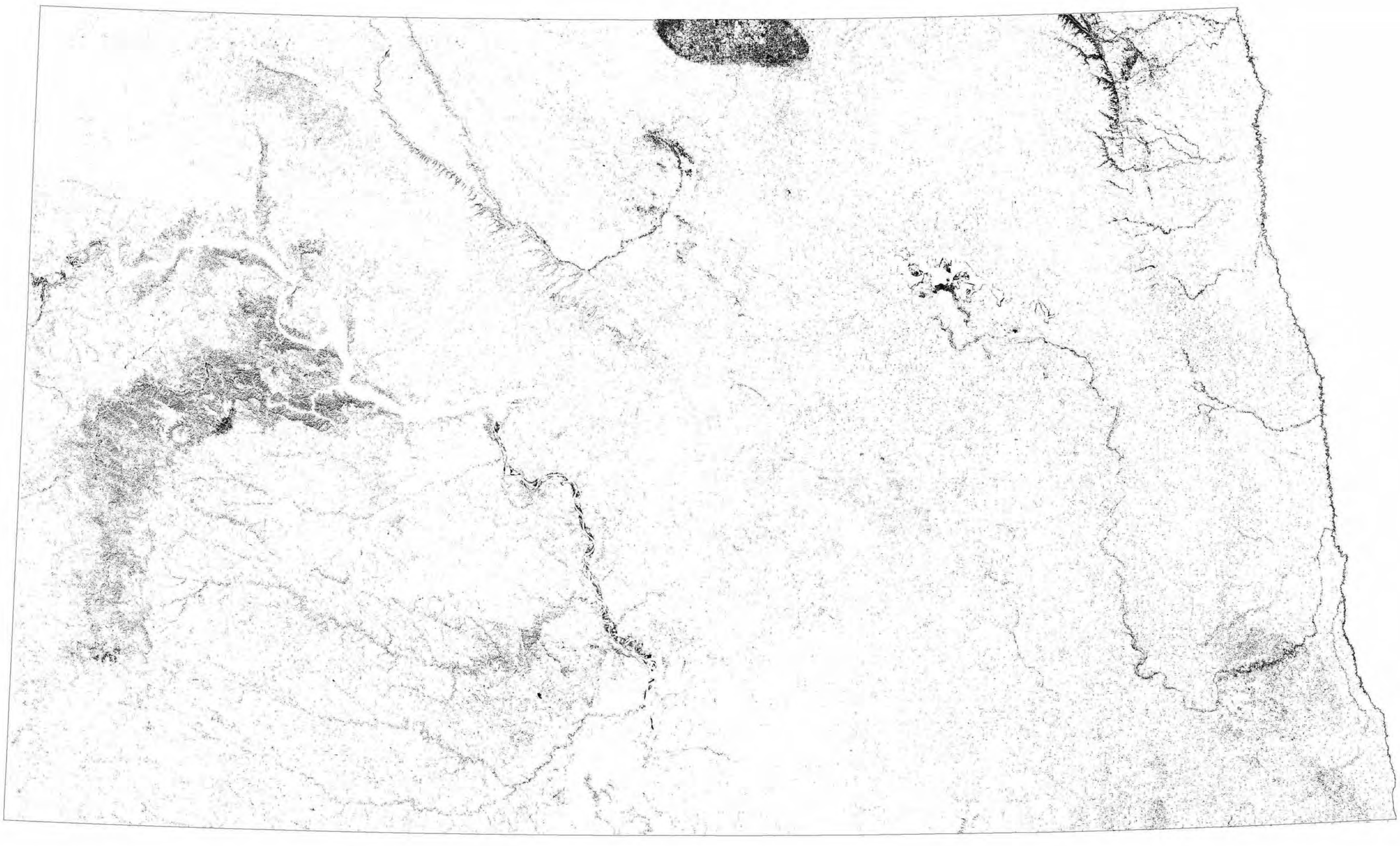
BLACK-BILLED CUCKOO(Coccyzus erythropthalmus)



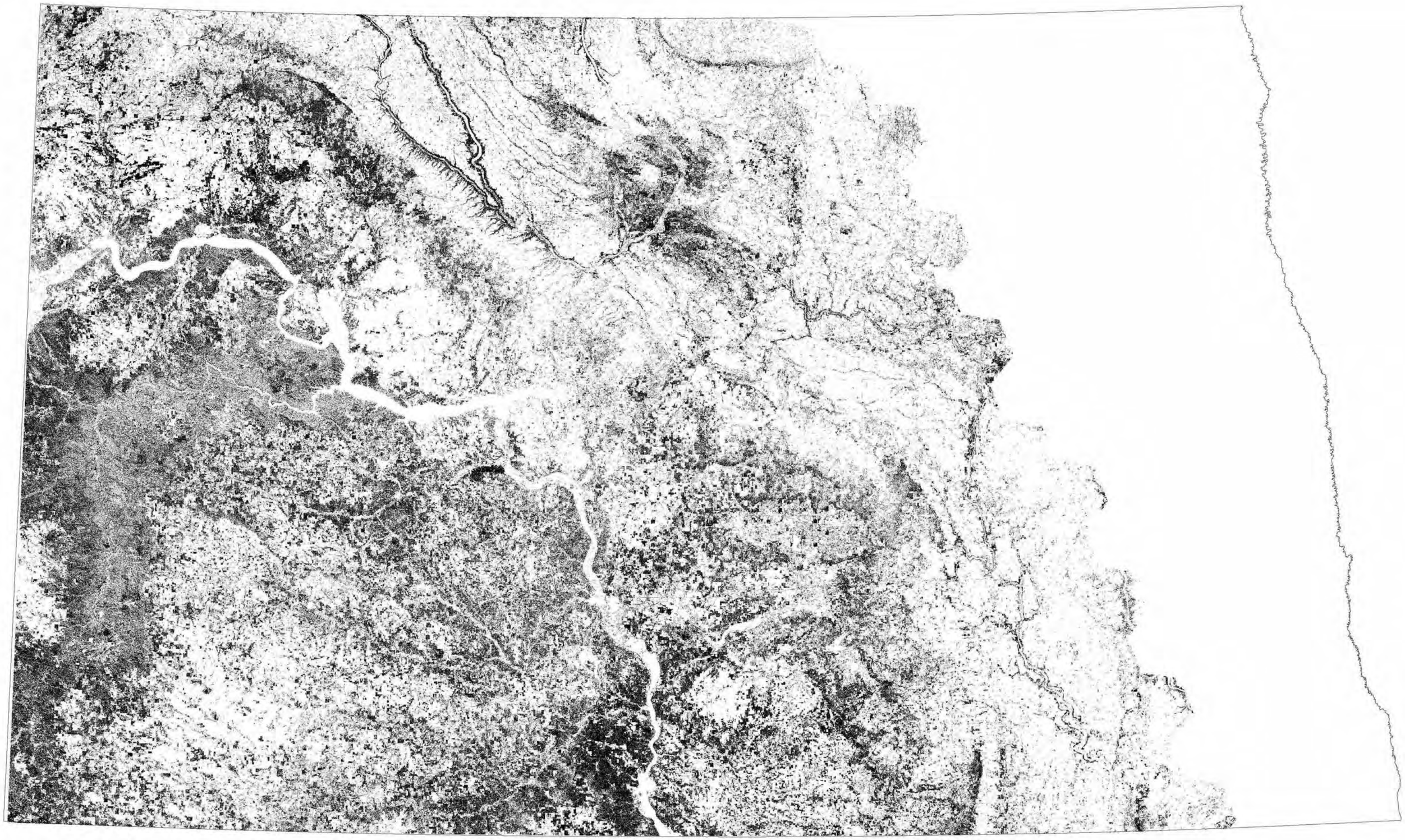
EASTERN SCREECH-OWL(Otus asio)



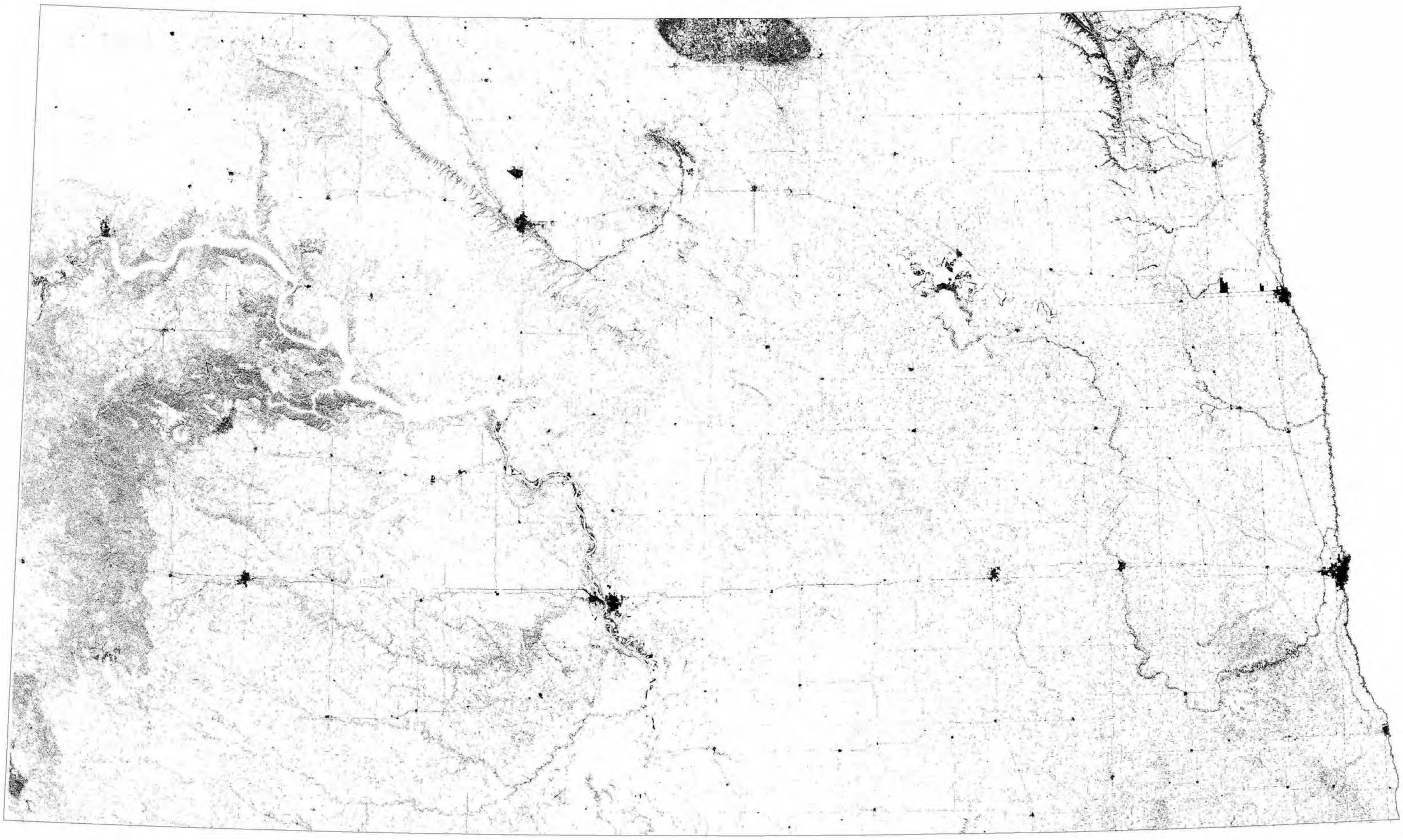
GREAT HORNED OWL(Bubo virginianus)



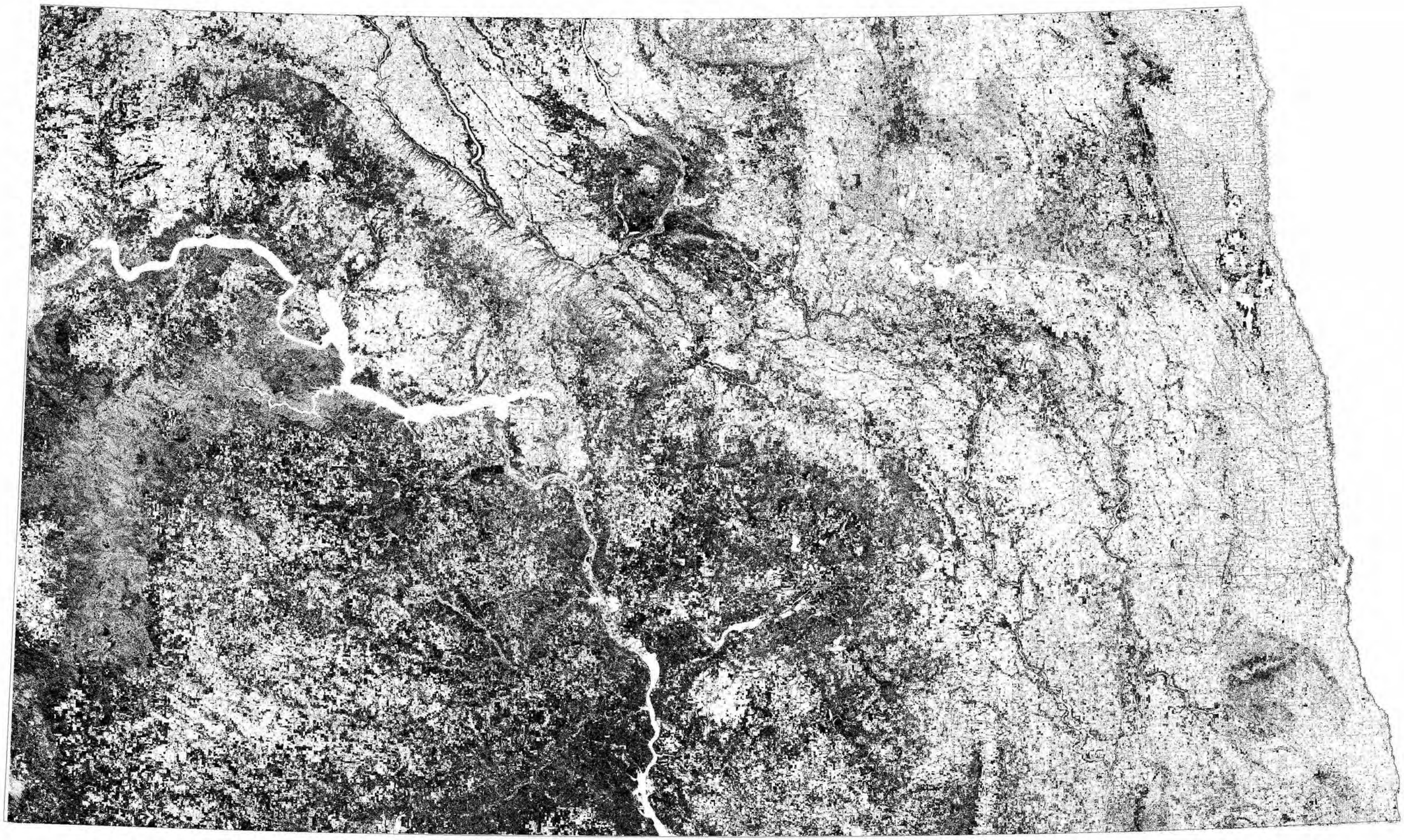
BURROWING OWL(Athene cunicularia)



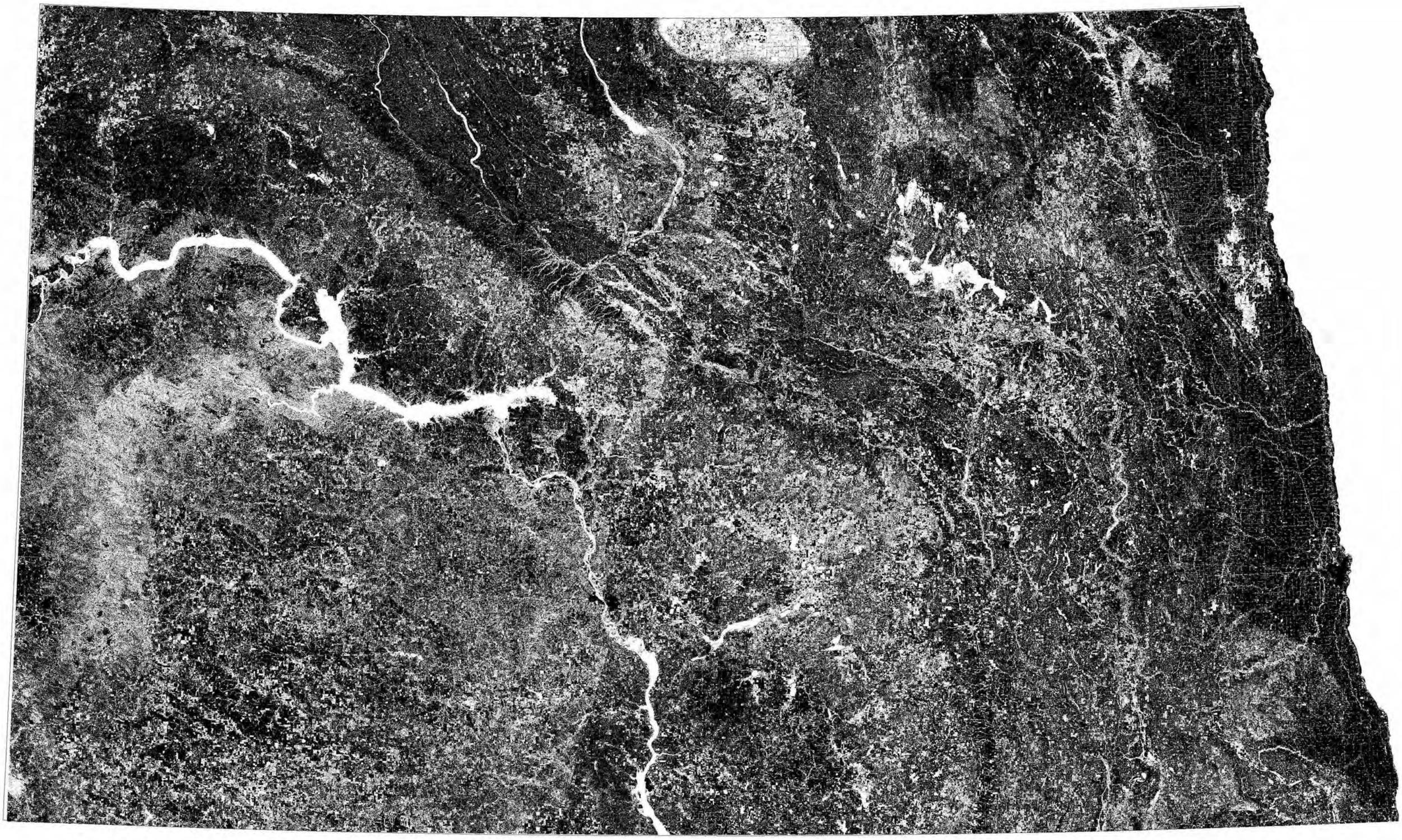
LONG-EARED OWL(Asio otus)



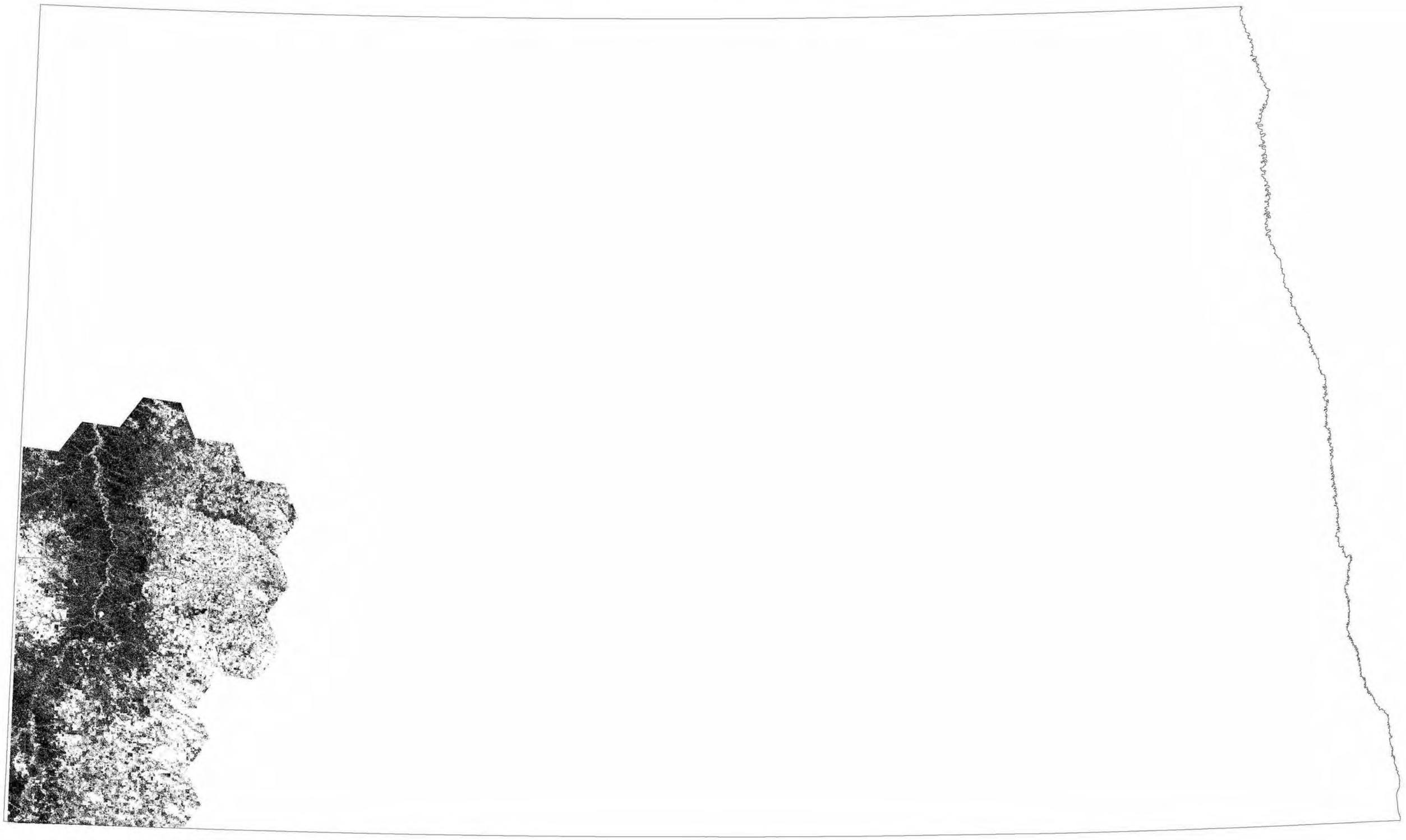
SHORT-EARED OWL(Asio flammeus)



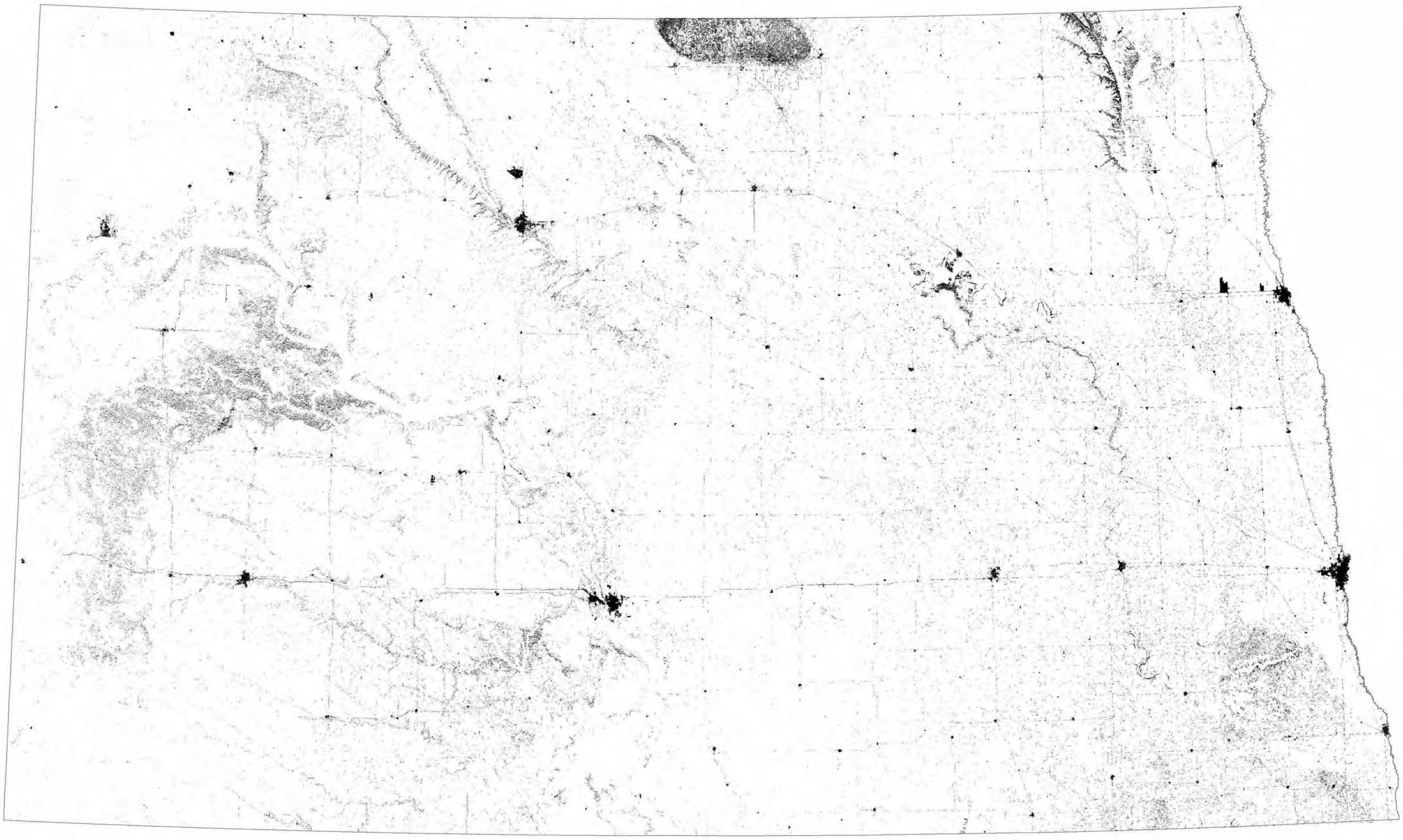
COMMON NIGHTHAWK(Chordeiles minor)



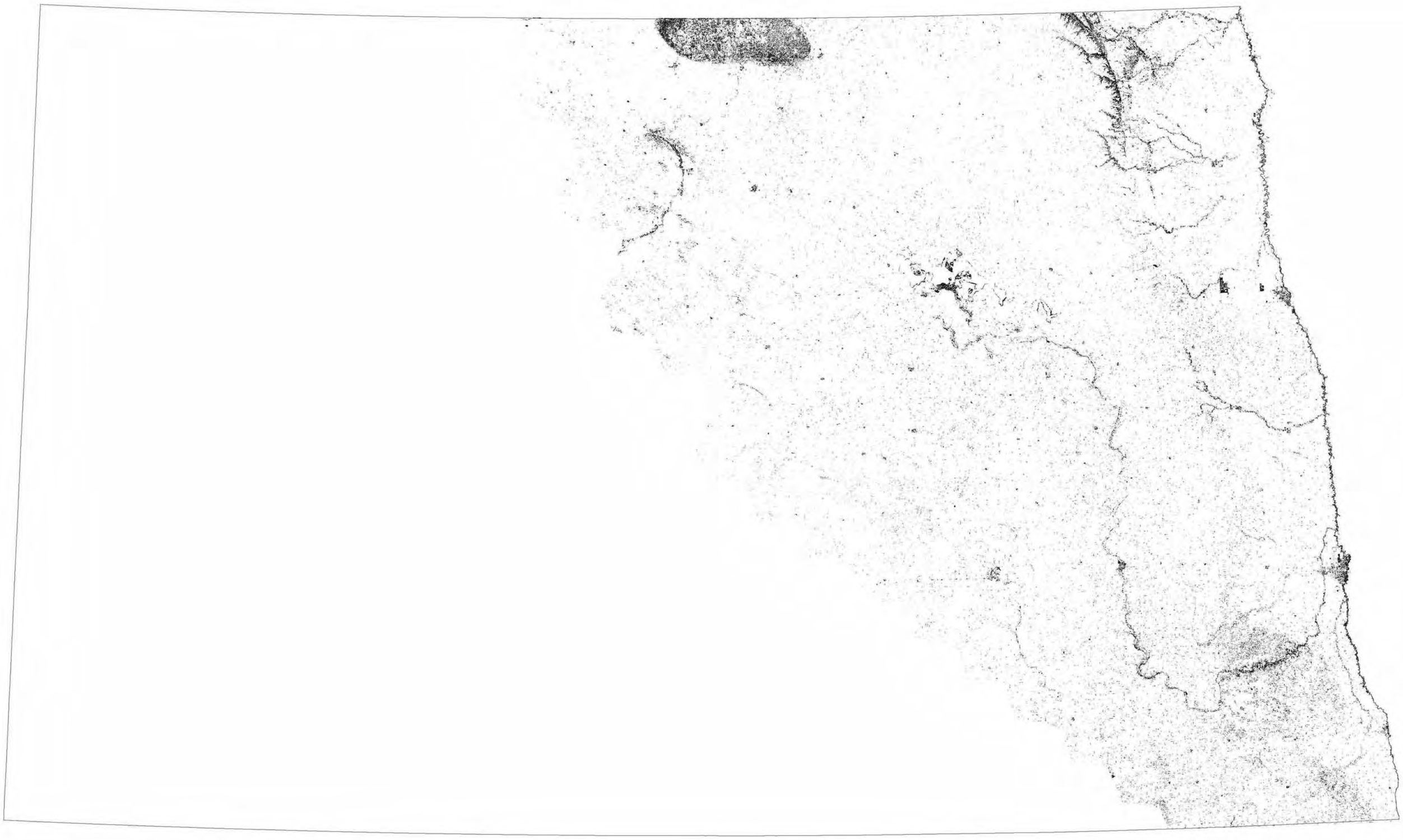
COMMON POORWILL(Phalaenoptilus nuttallii)



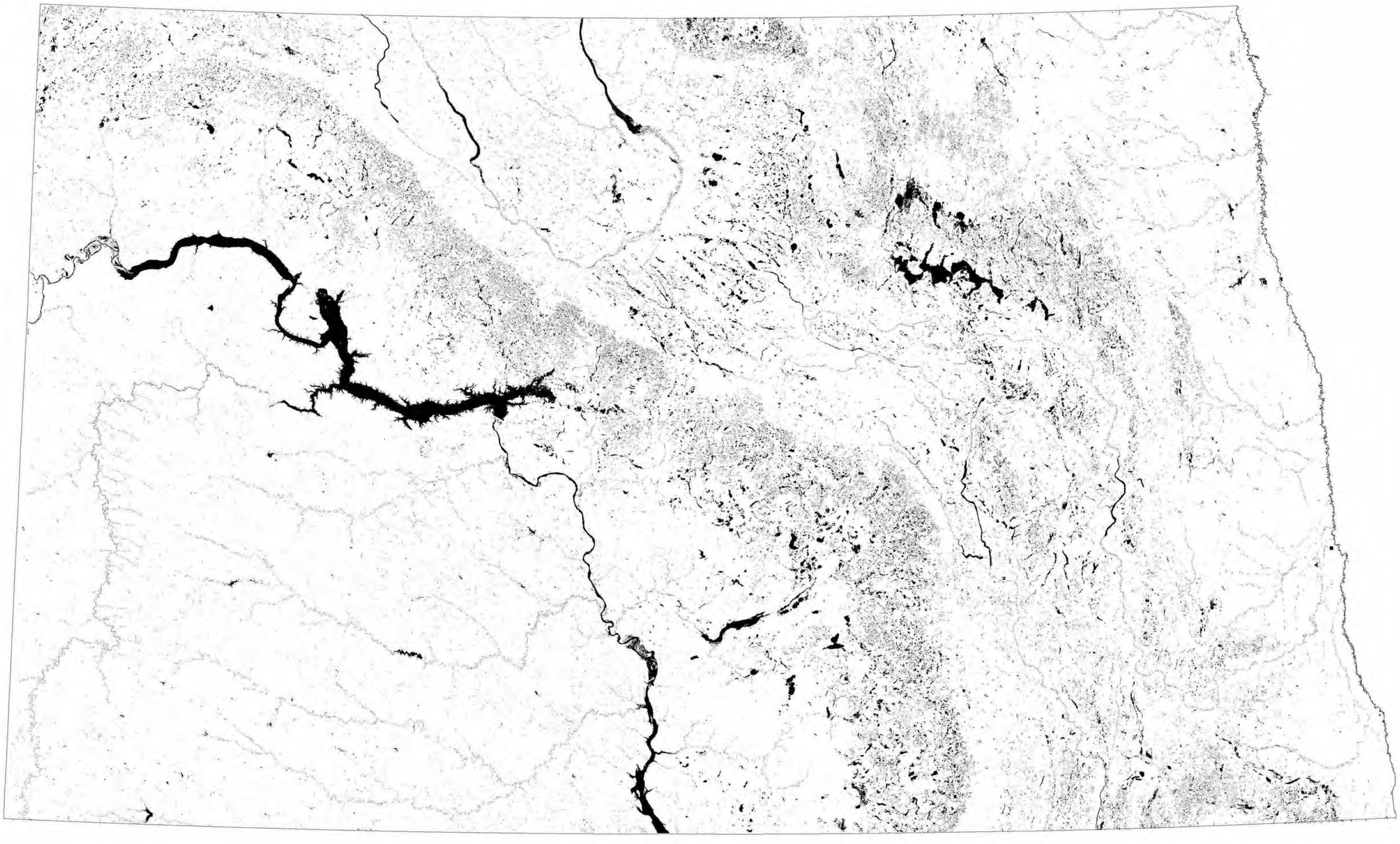
CHIMNEY SWIFT(Chaetura pelagica)



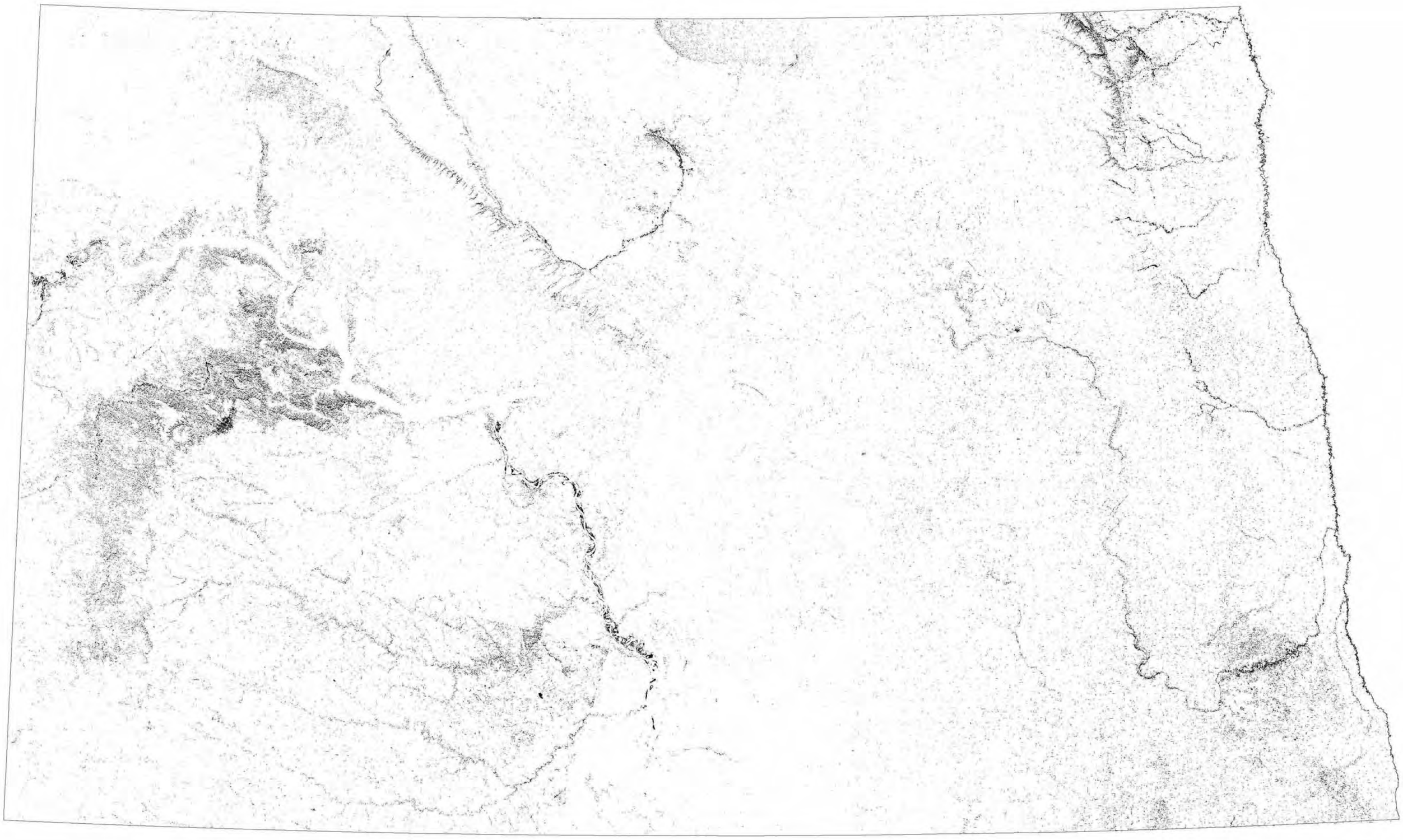
RUBY-THROATED HUMMINGBIRD(Archilochus colubris)



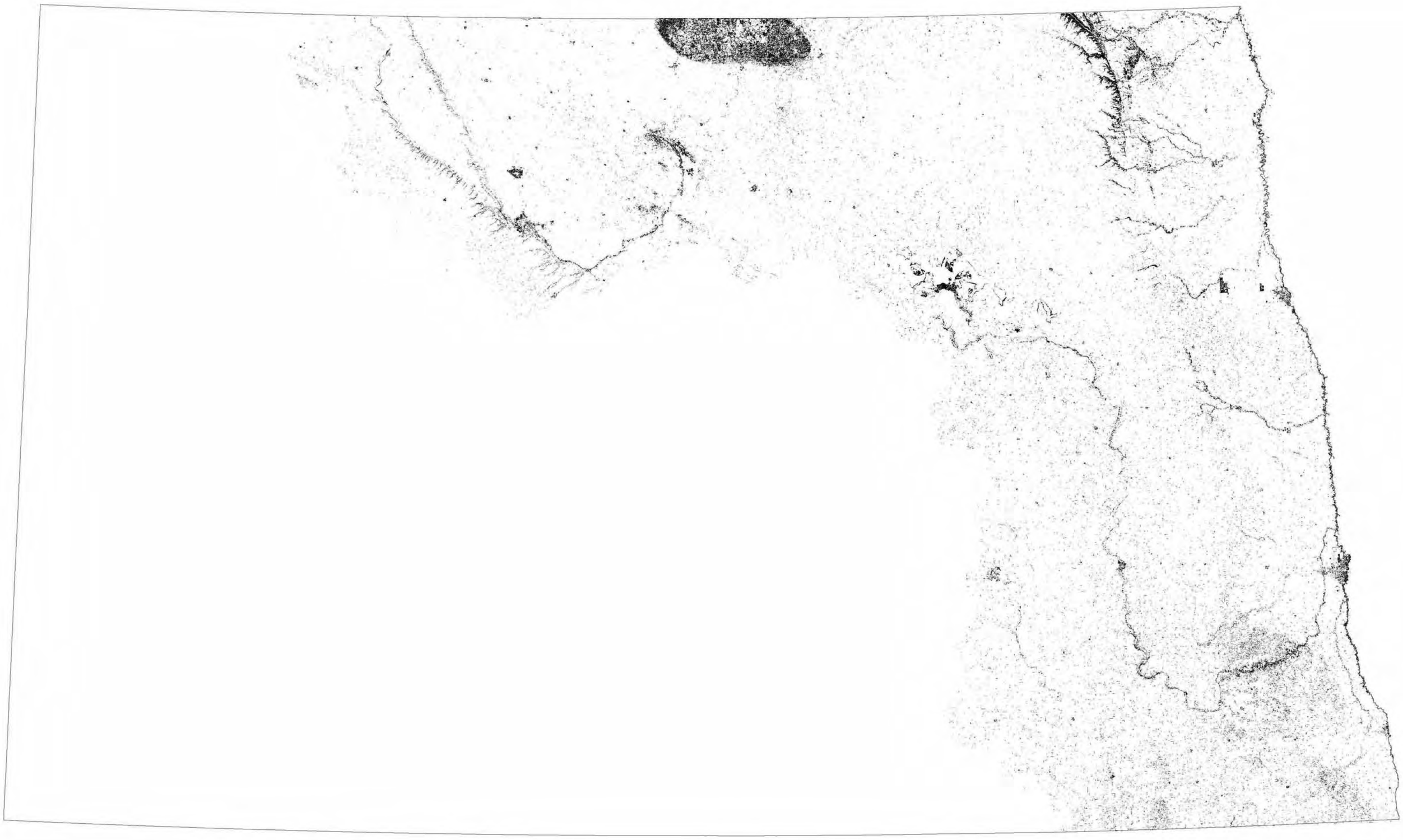
BELTED KINGFISHER(Ceryle alcyon)



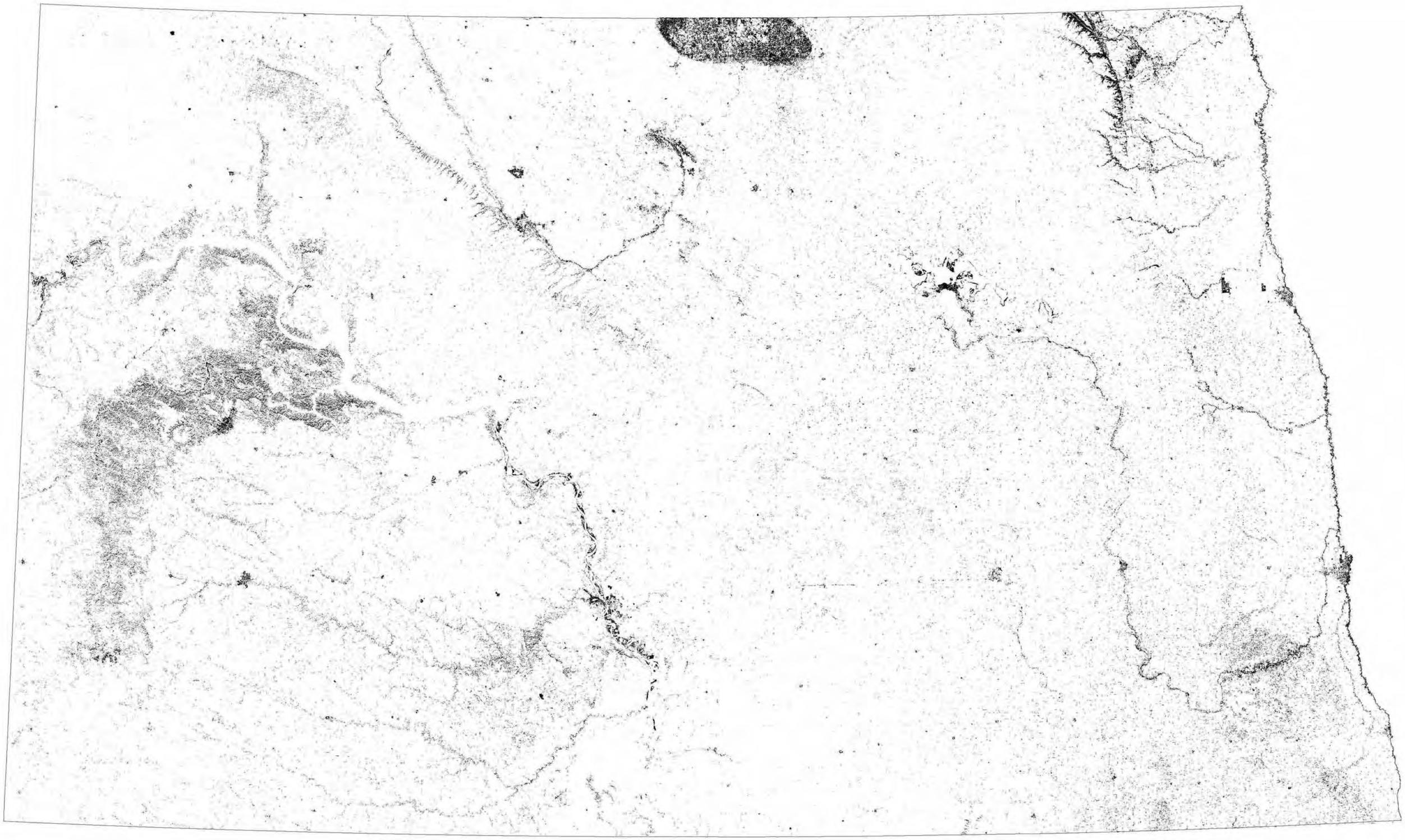
RED-HEADED WOODPECKER(Melanerpes erythrocephalus



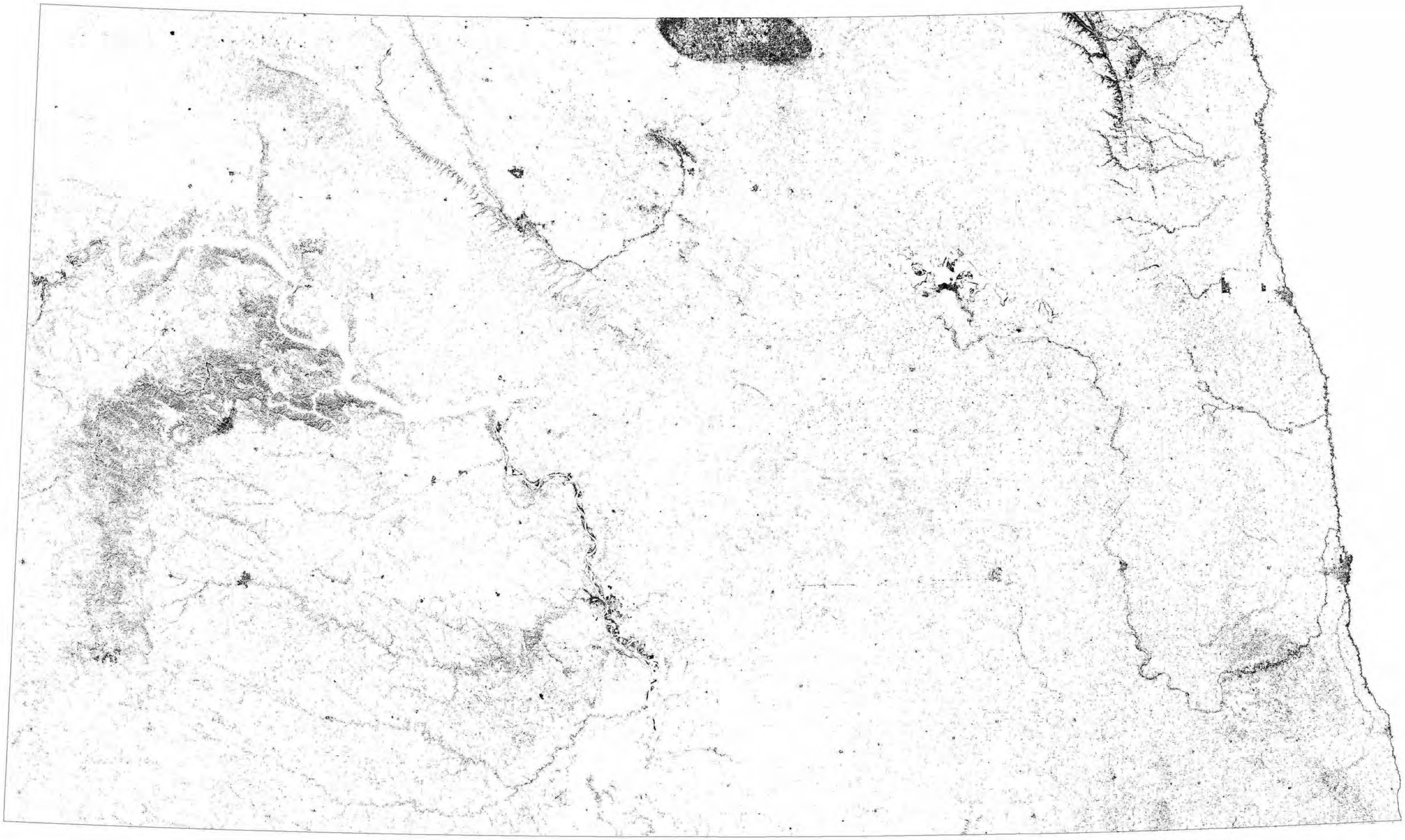
YELLOW-BELLIED SAPSUCKER(Sphyrapicus varius)



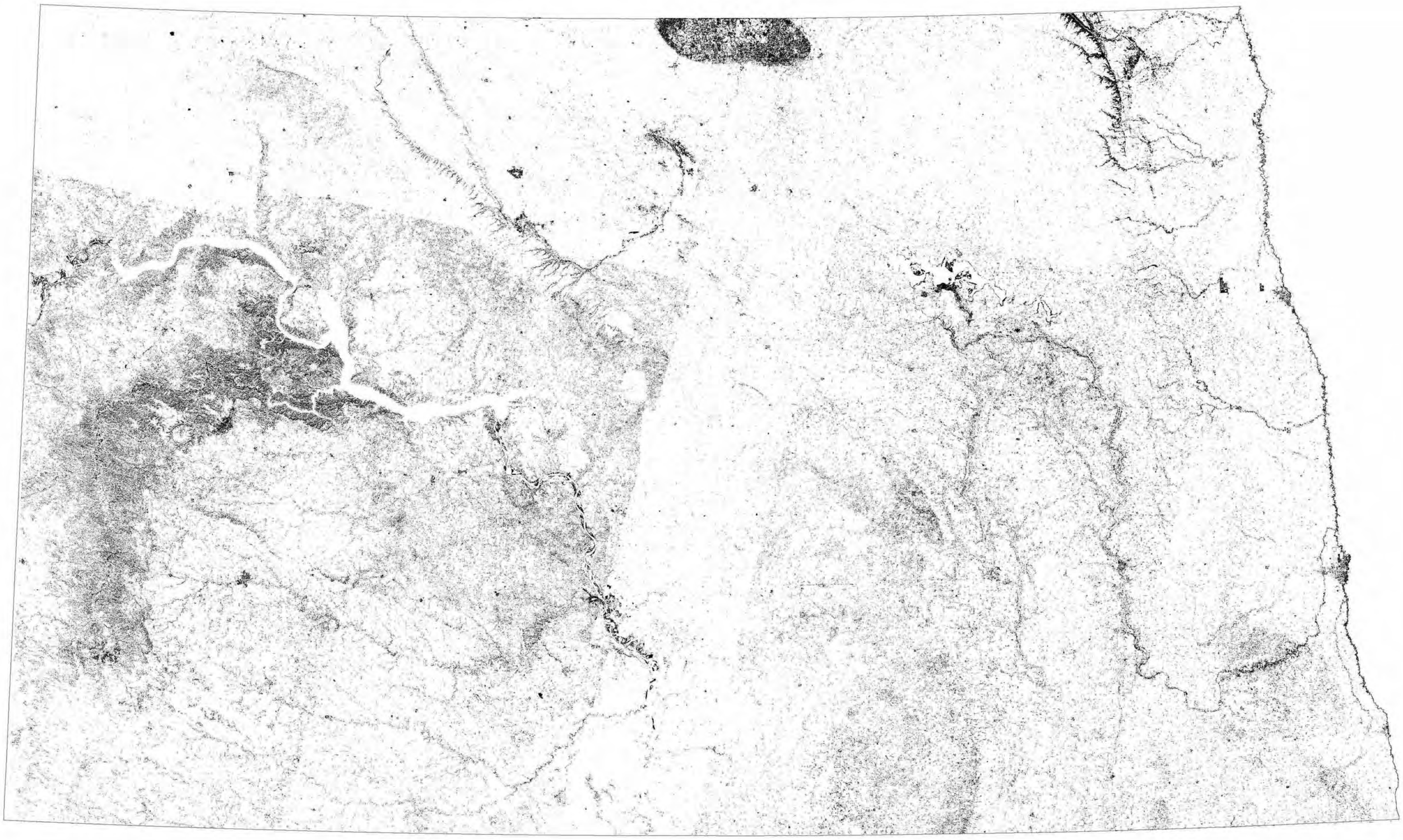
DOWNY WOODPECKER(Picoides pubescens)



HAIRY WOODPECKER(Picoides villosus)



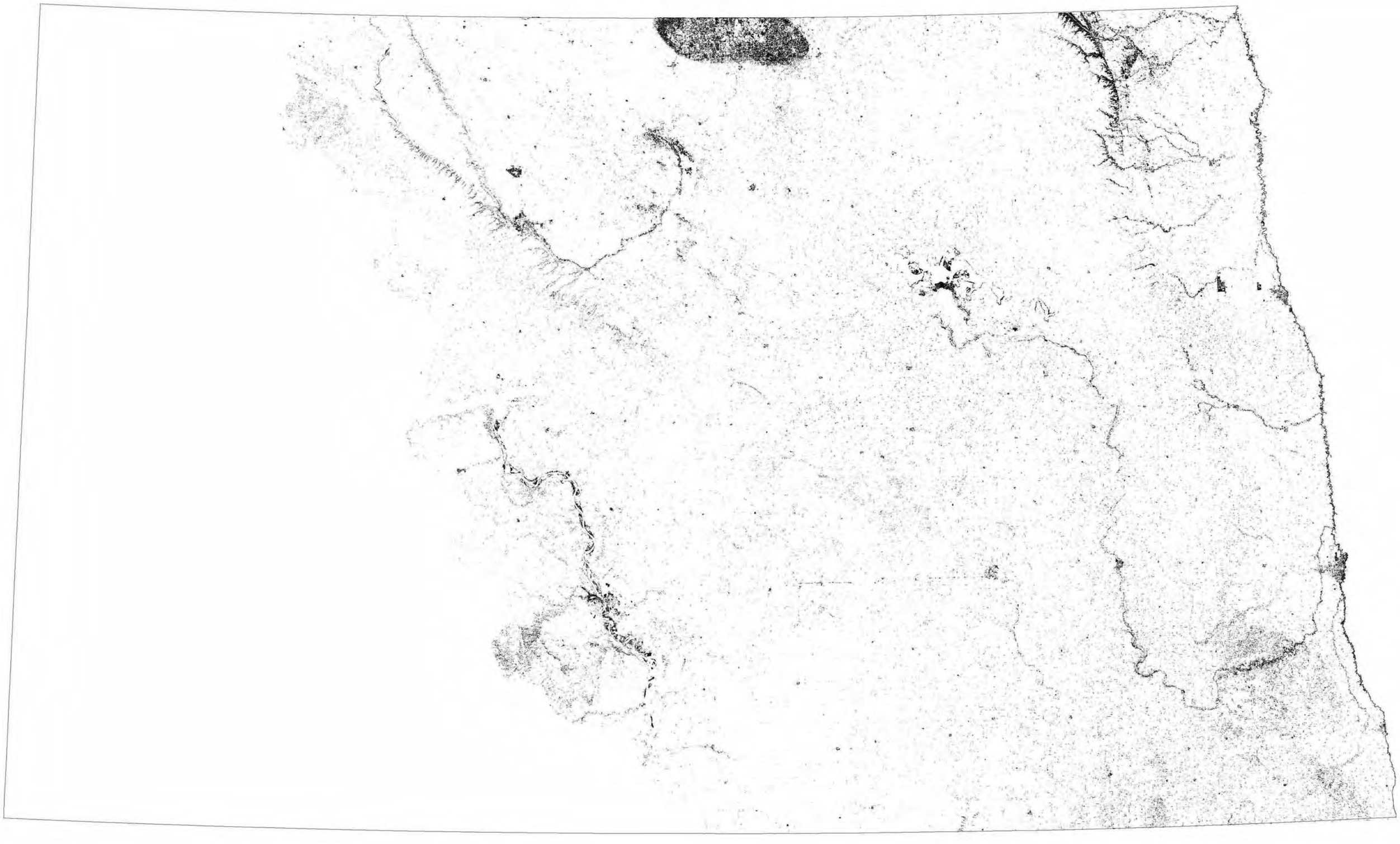
NORTHERN FLICKER(Colaptes auratus)



PILEATED WOODPECKER(Dryocopus pileatus)

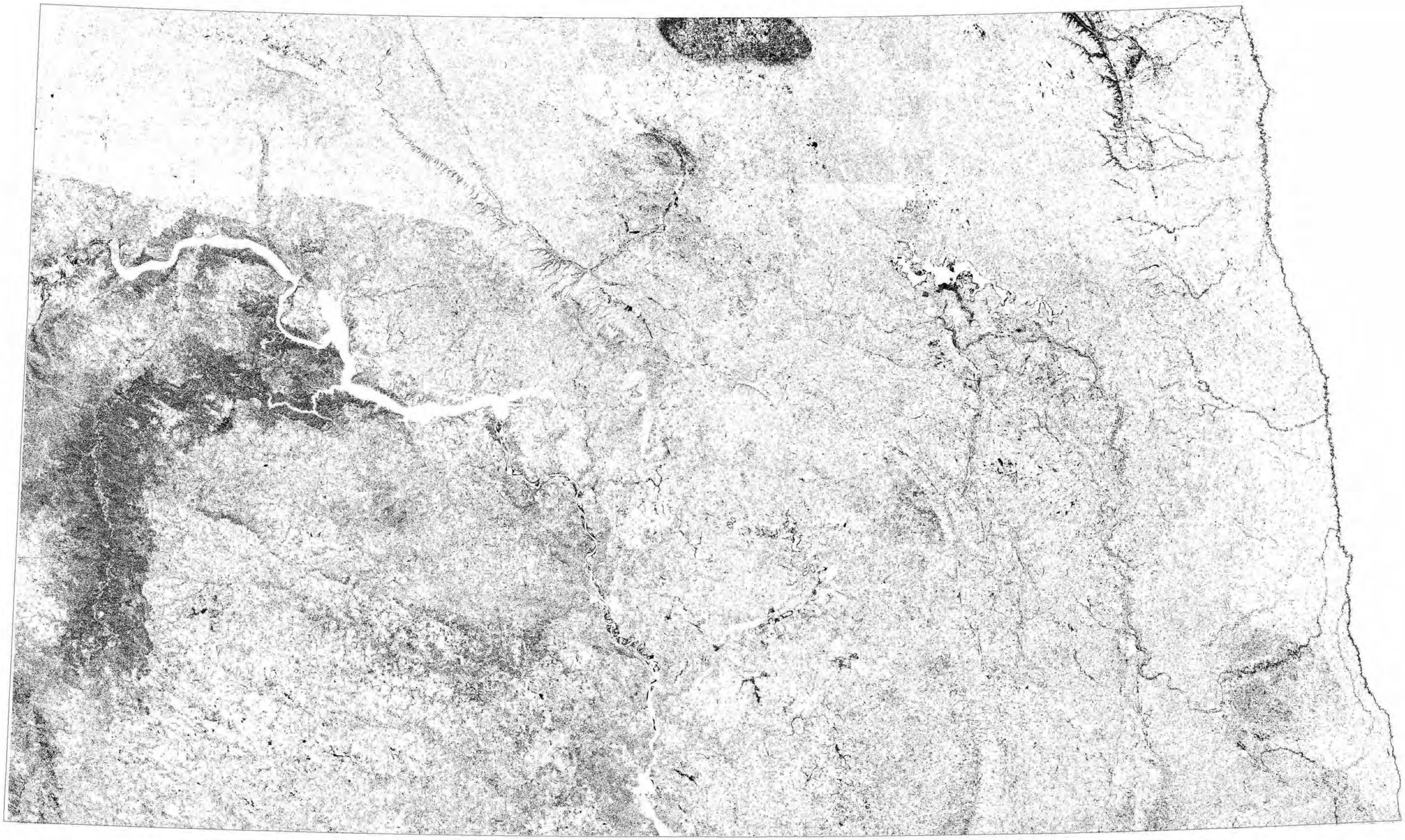
WESTERN WOOD-PEWEE(Contopus sordidulus)

EASTERN WOOD-PEWEE(Contopus virens)

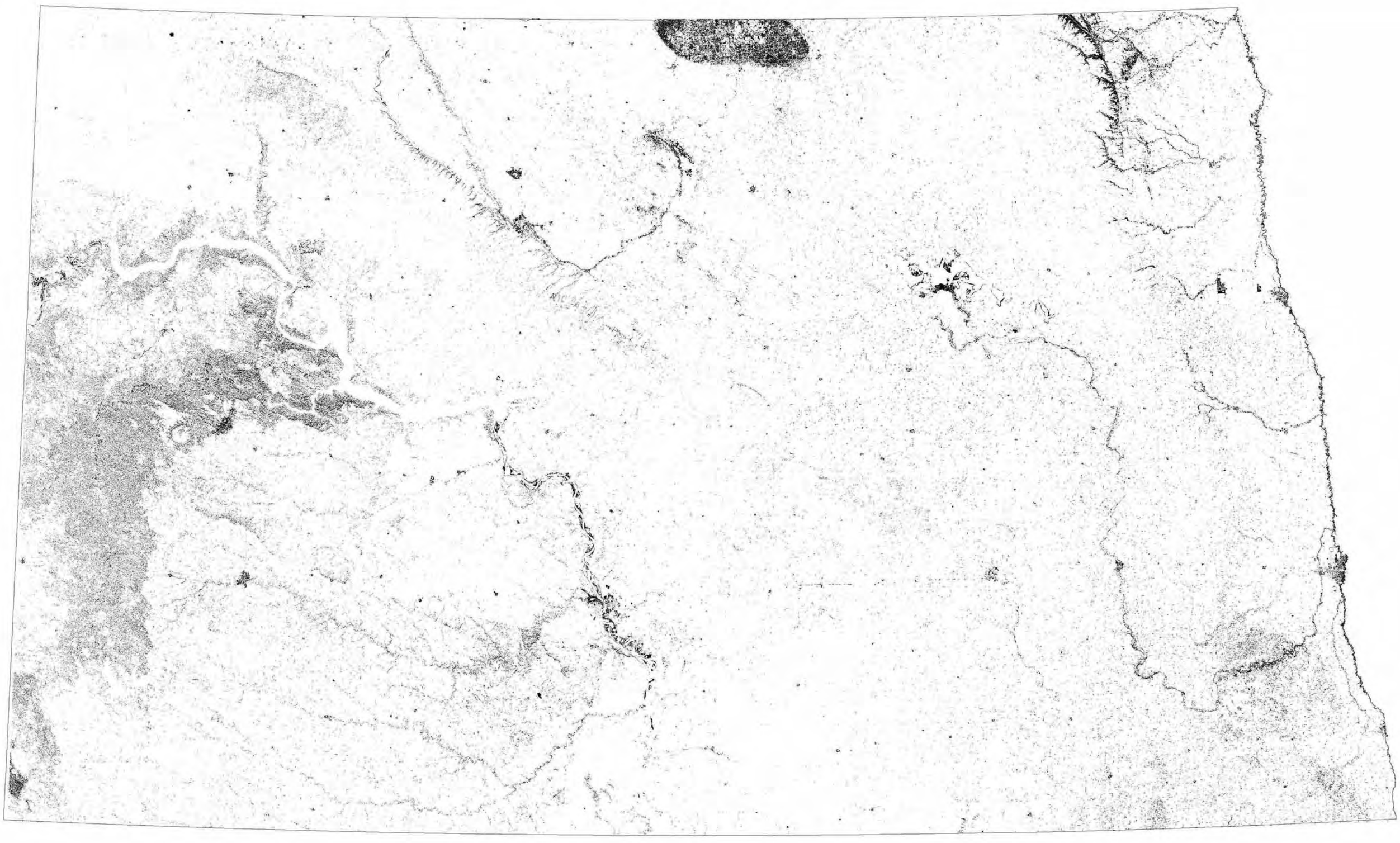


ALDER FLYCATCHER(Empidonax alnorum)

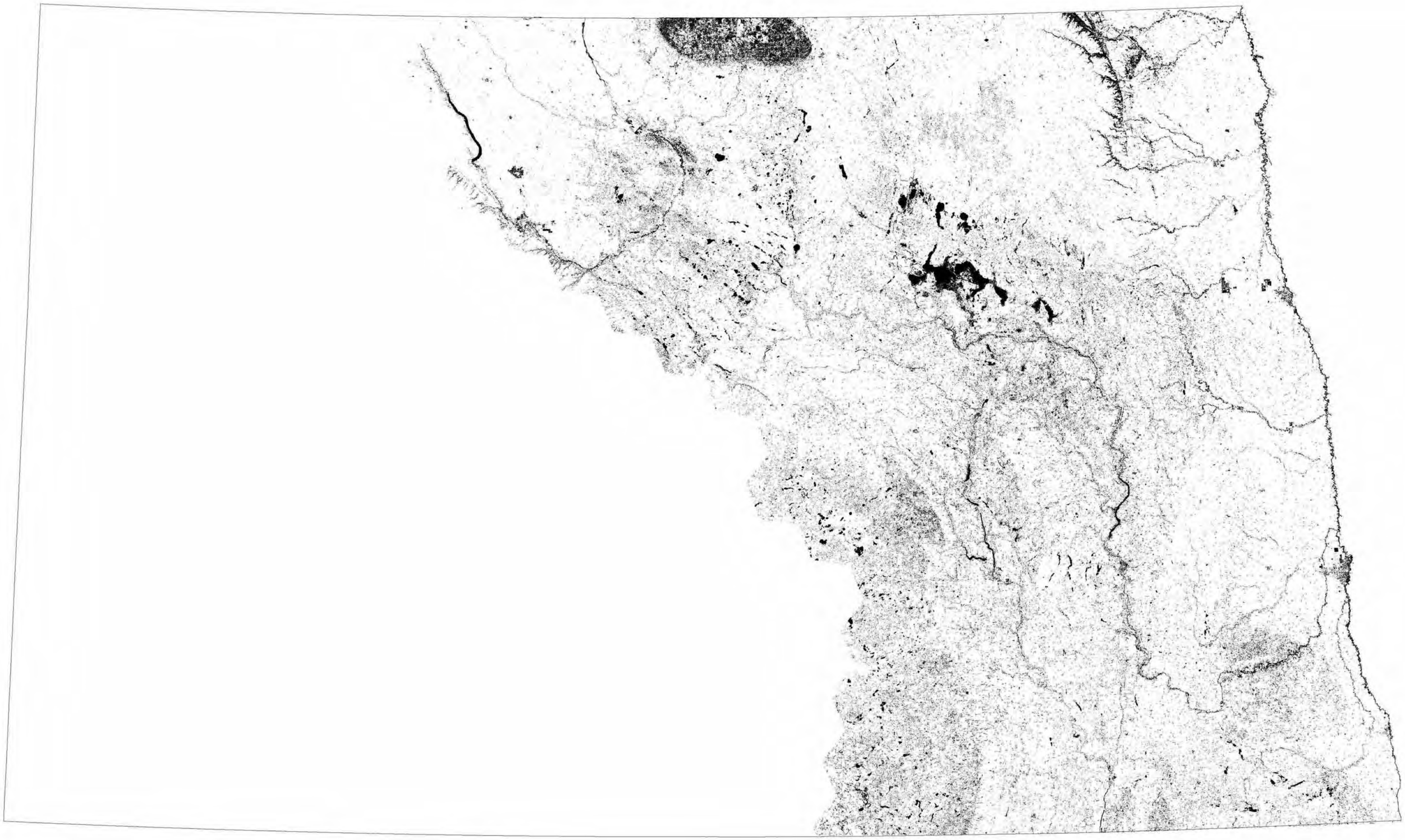
WILLOW FLYCATCHER(Empidonax traillii)



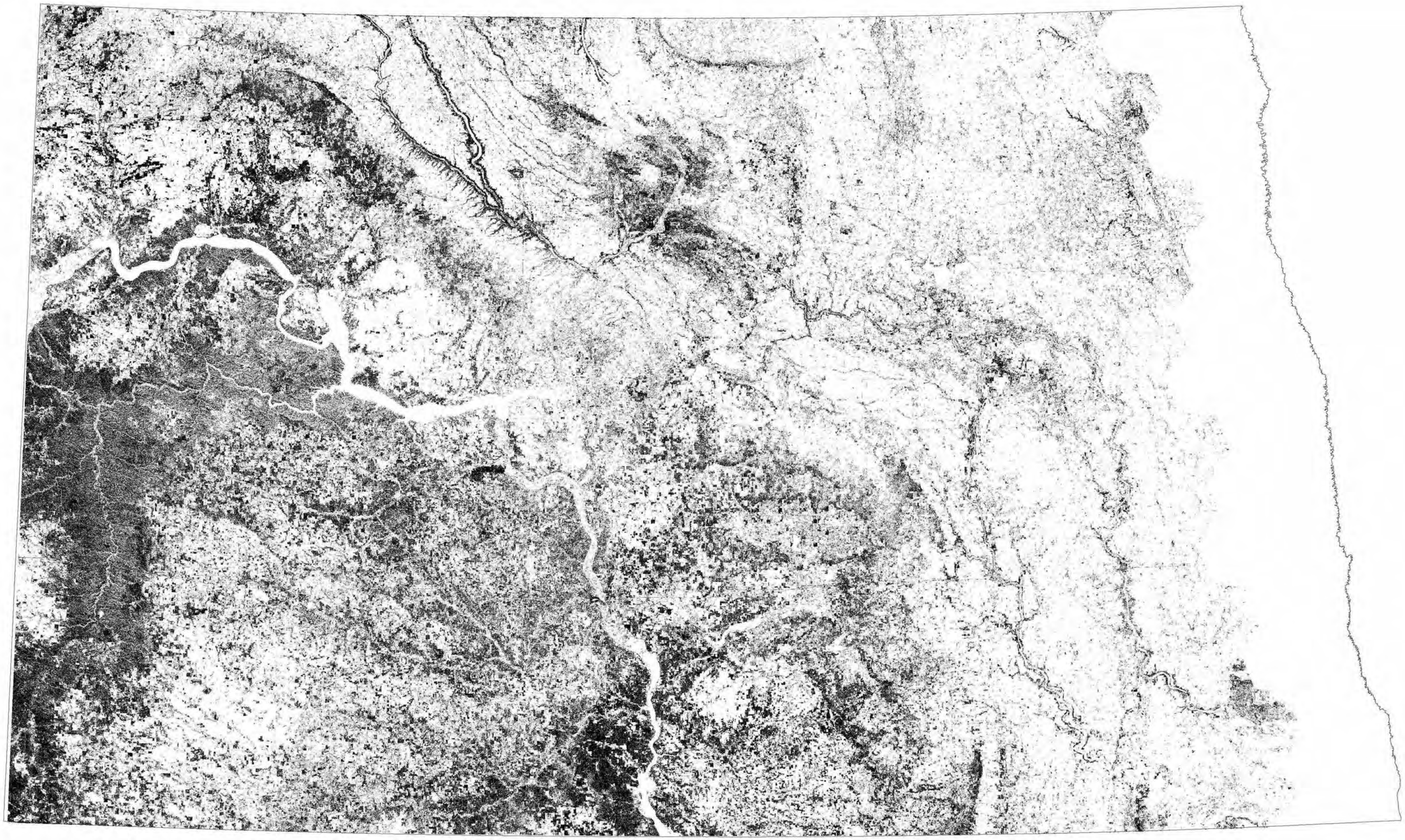
LEAST FLYCATCHER(Empidonax minimus)



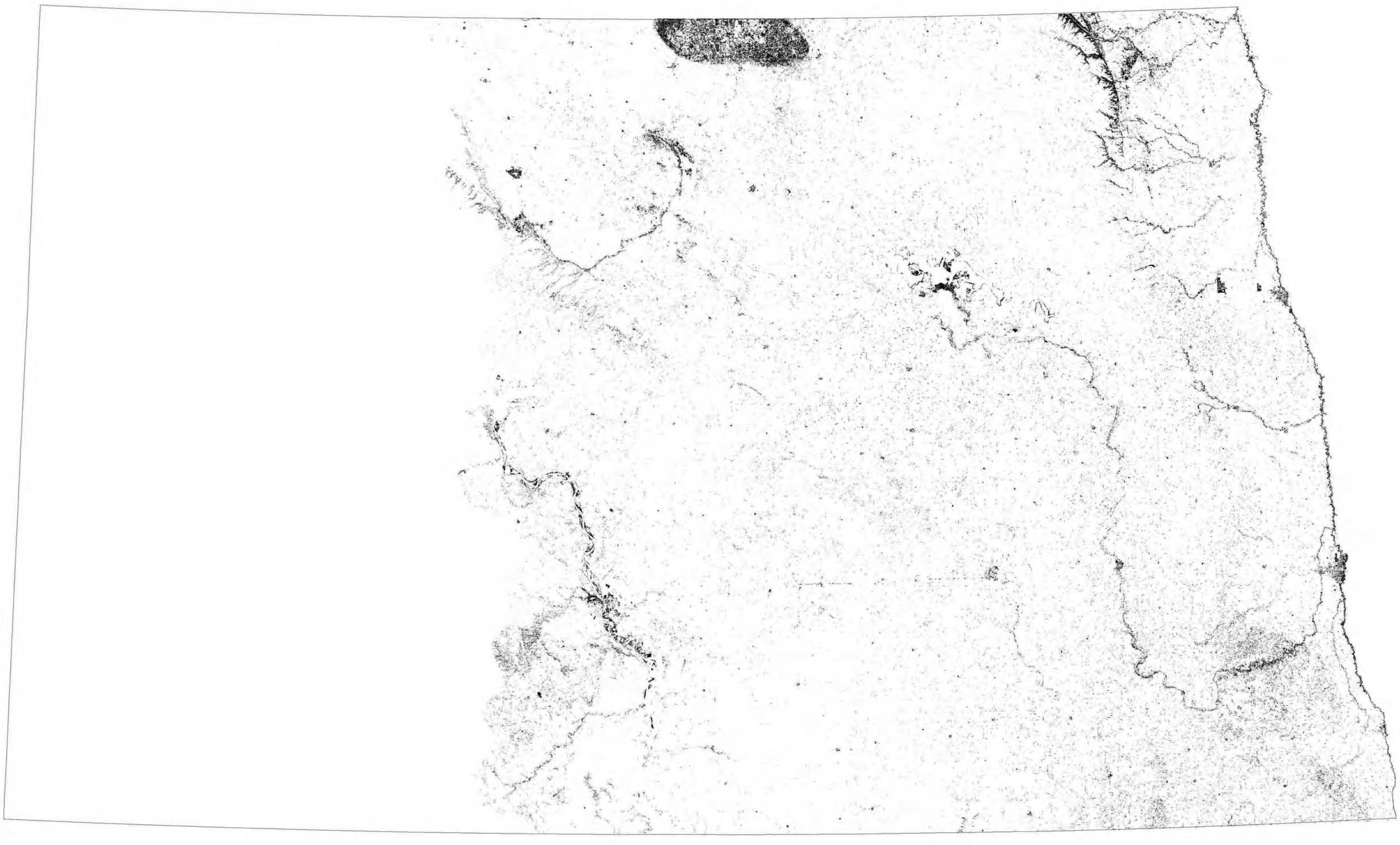
EASTERN PHOEBE(Sayornis phoebe)



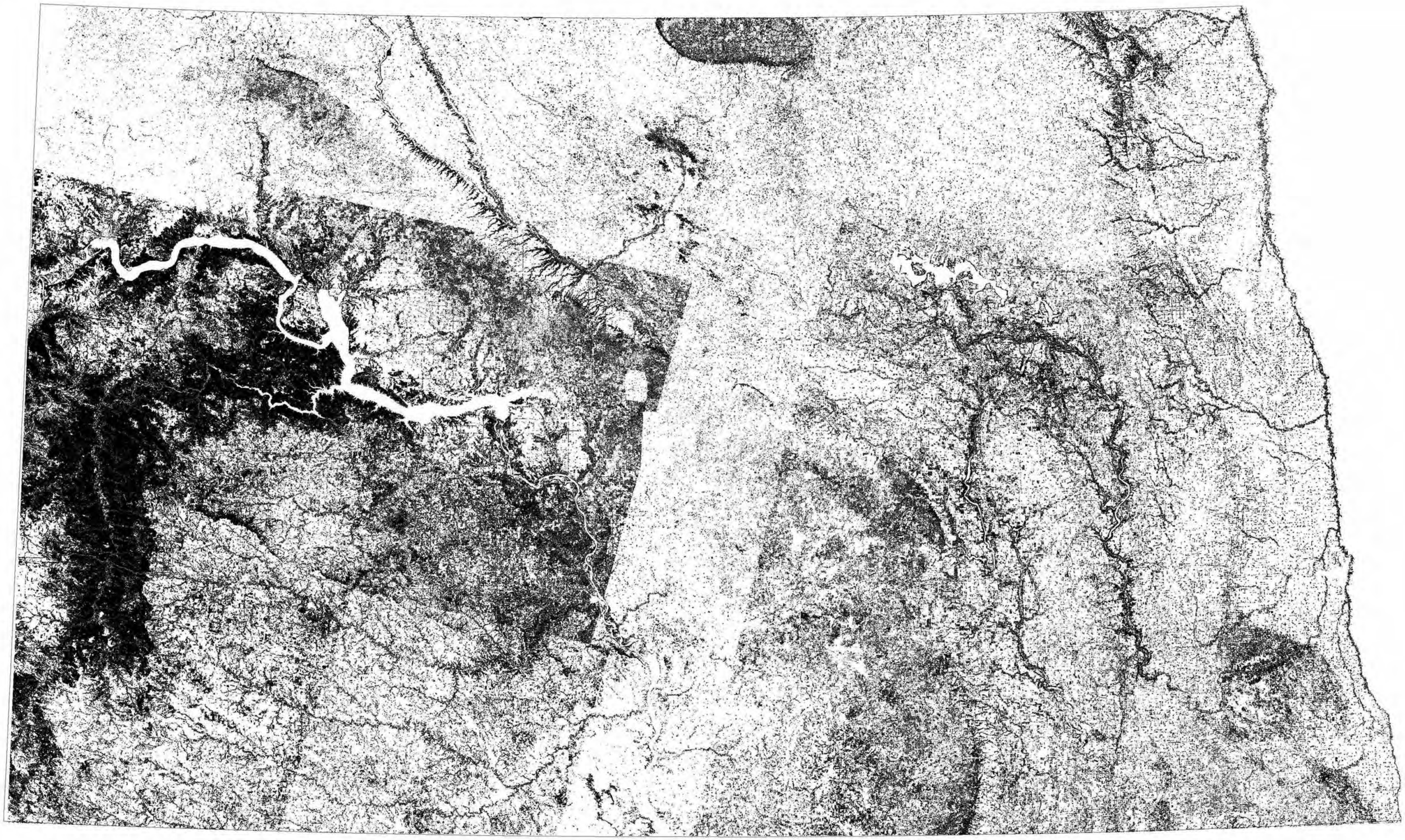
SAY'S PHOEBE(Sayornis saya)



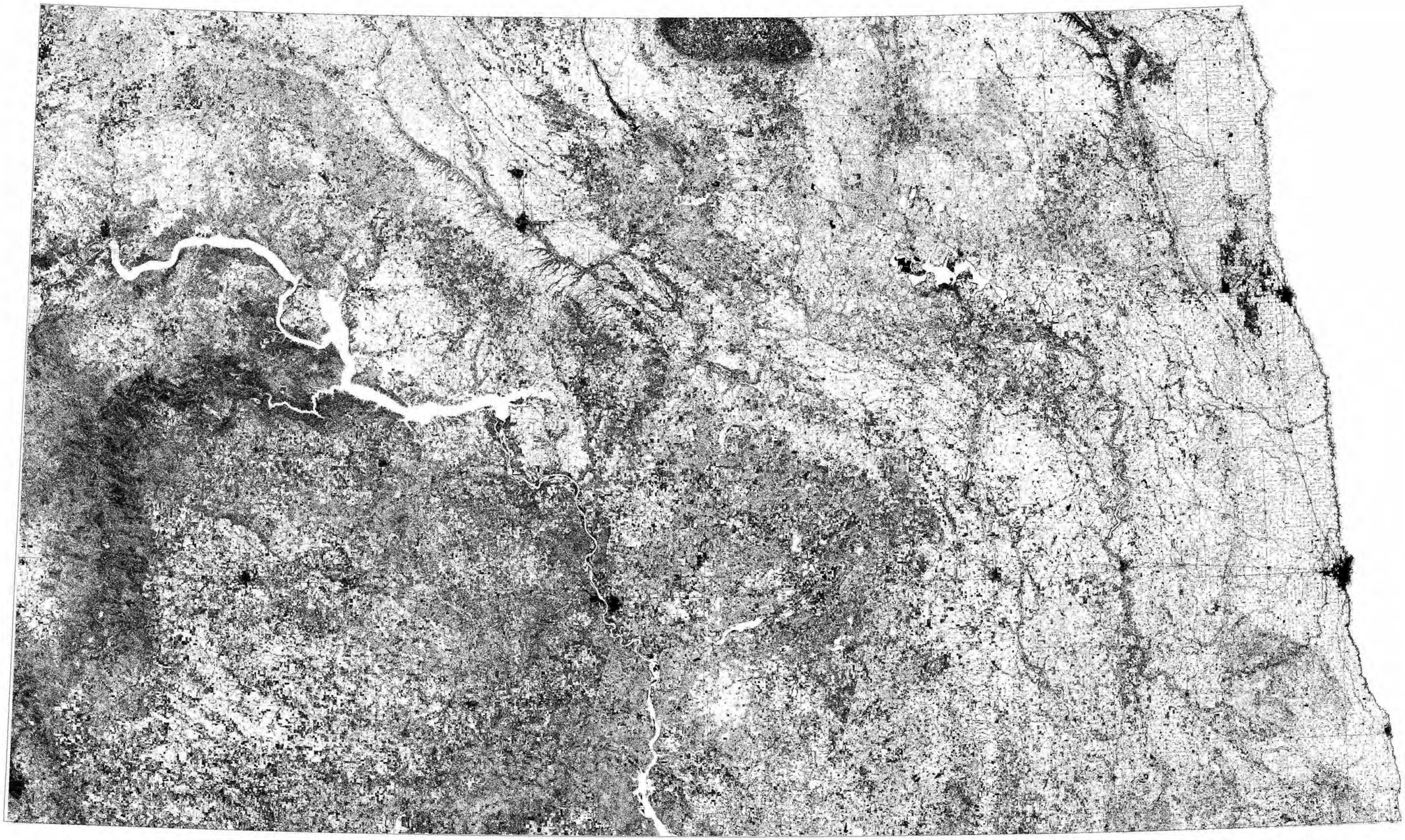
GREAT CRESTED FLYCATCHER(Myiarchus crinitus)



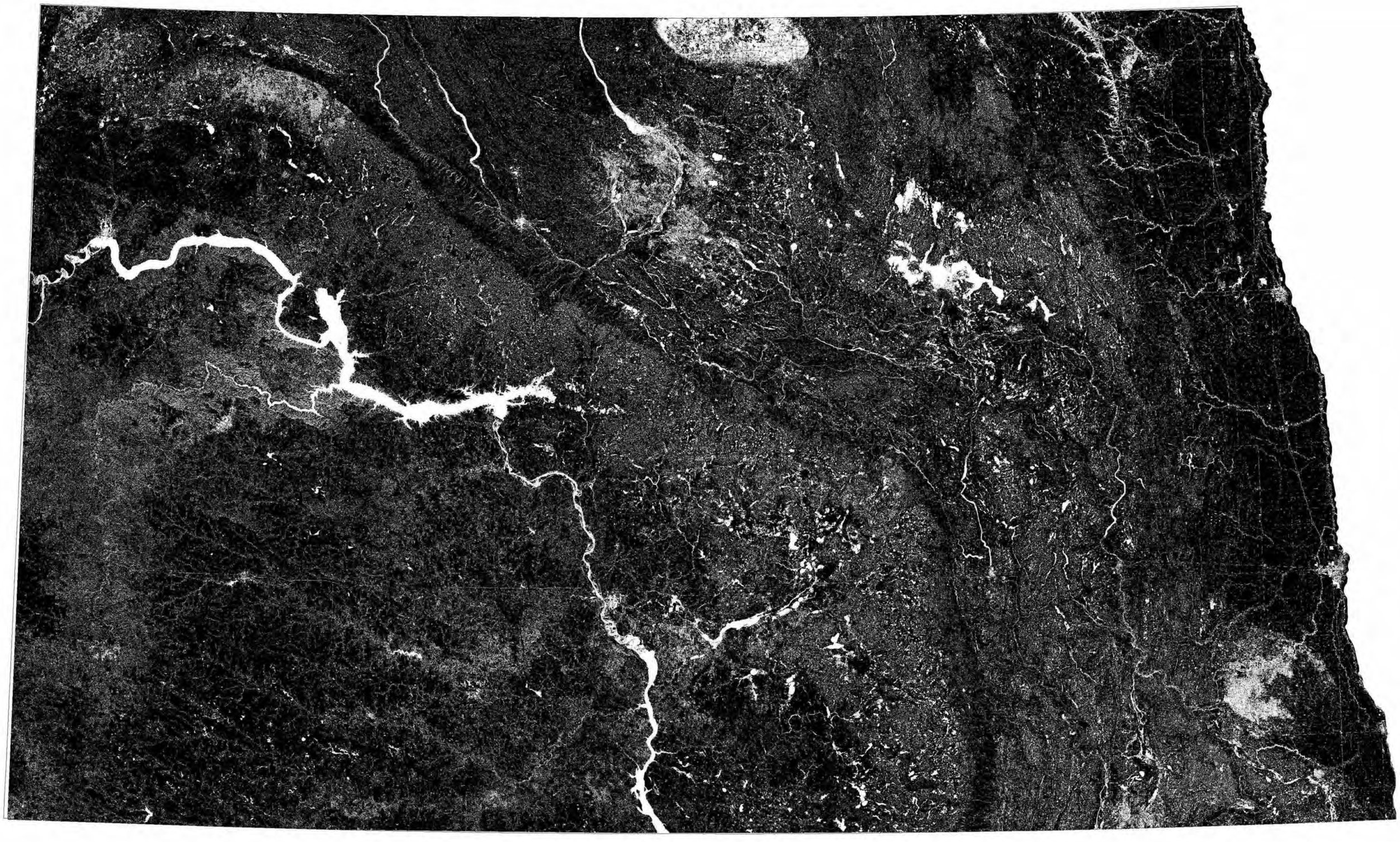
WESTERN KINGBIRD(Tyrannus verticalis)



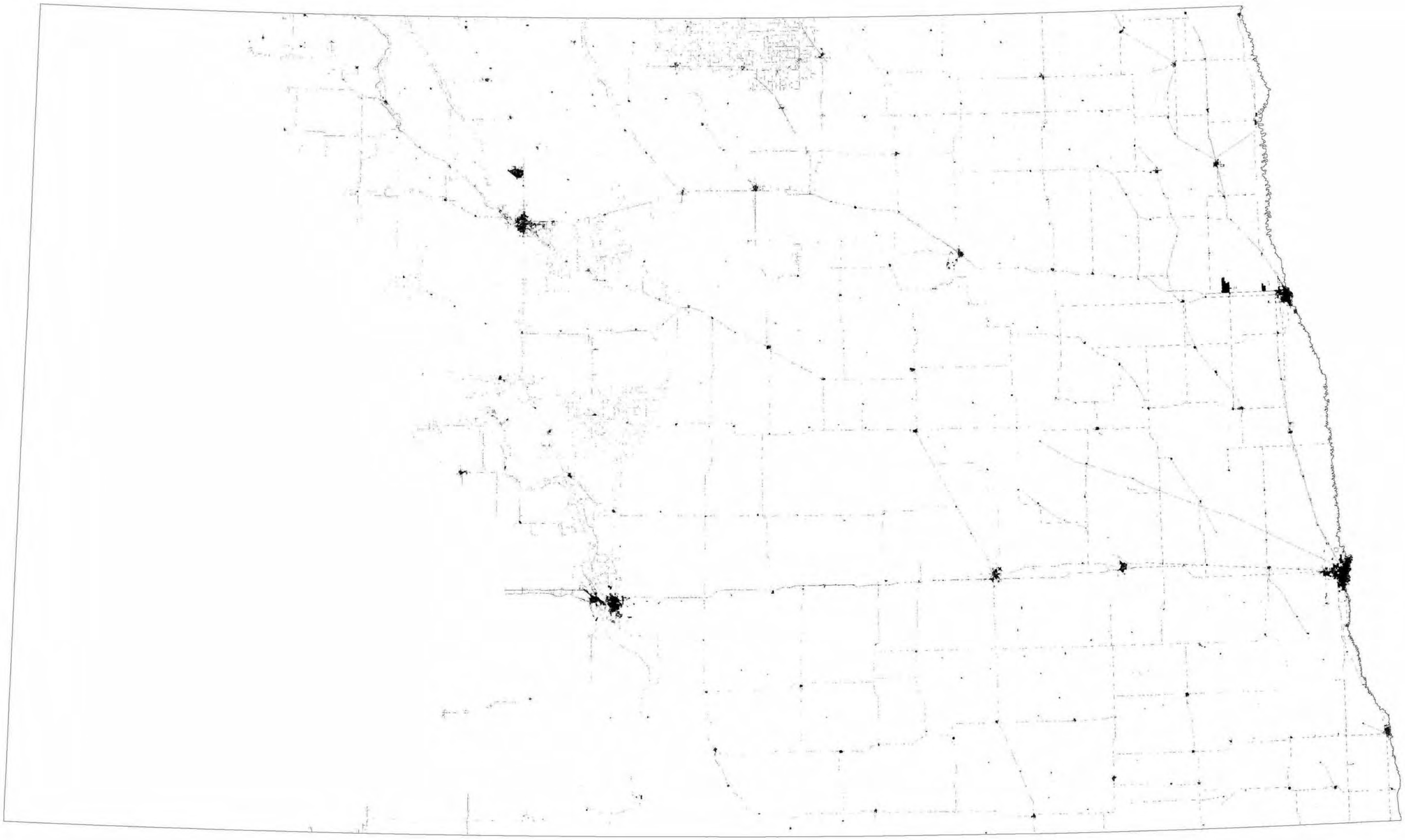
EASTERN KINGBIRD(Tyrannus tyrannus)



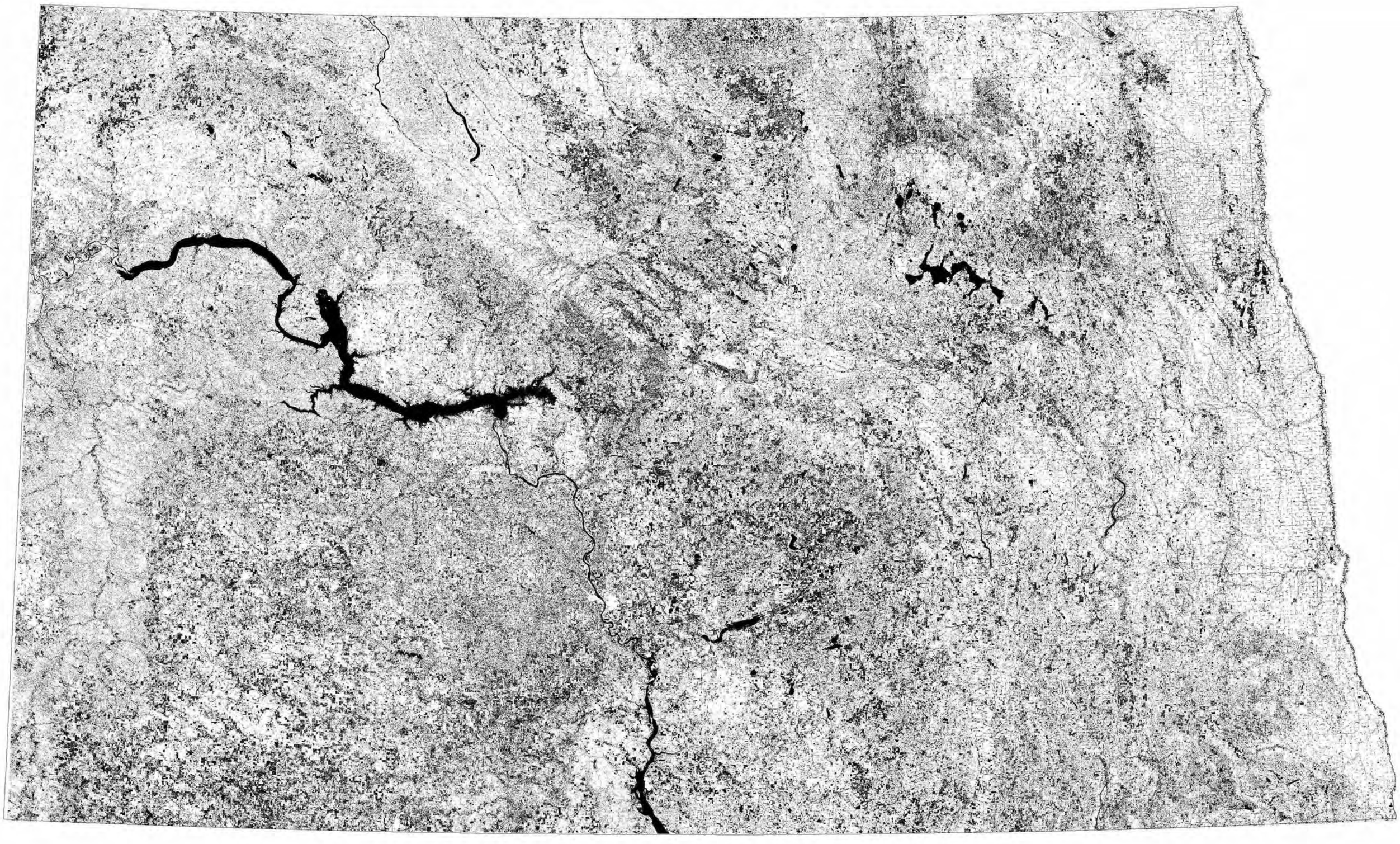
HORNED LARK(Eremophila alpestris)



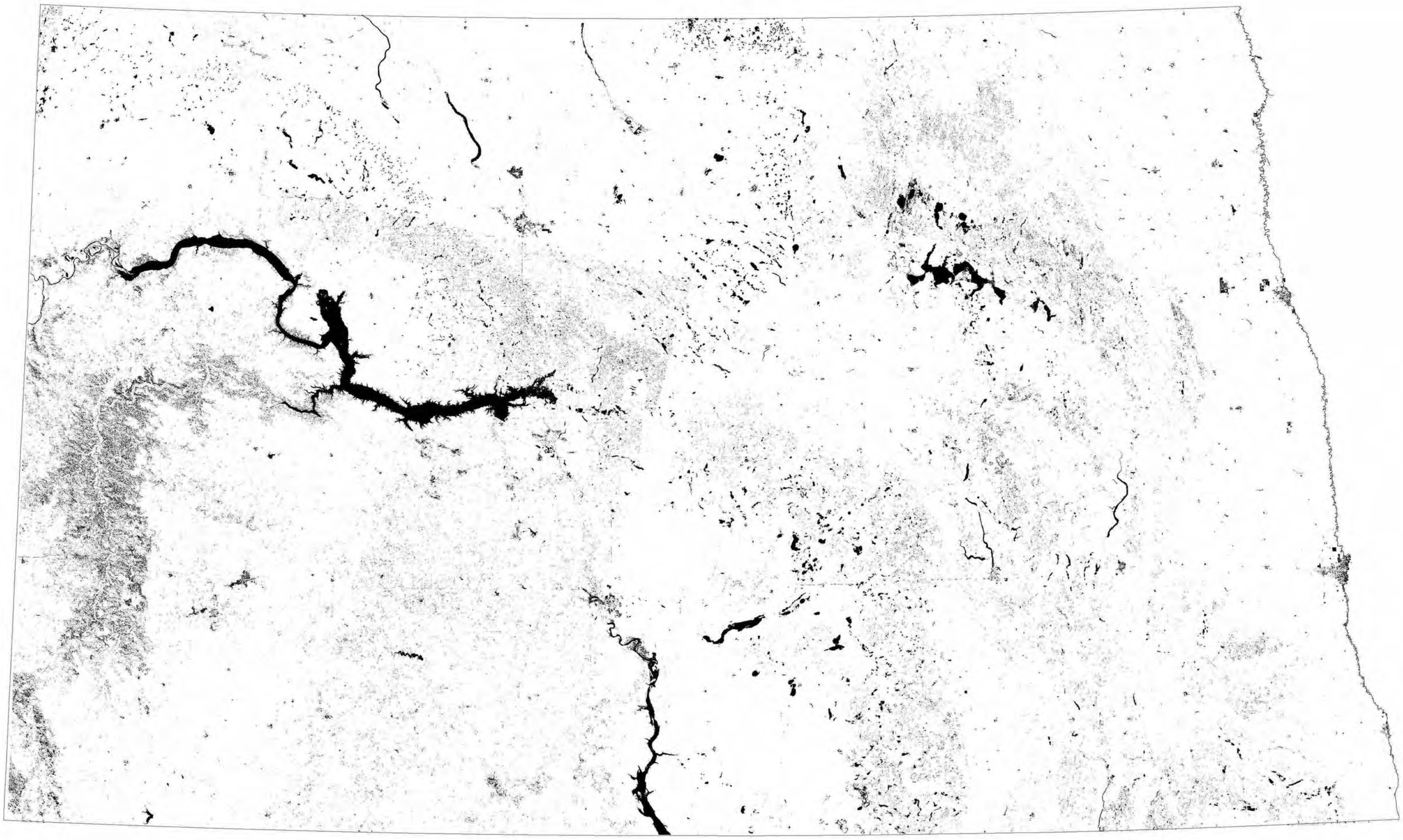
PURPLE MARTIN(Progne subis)



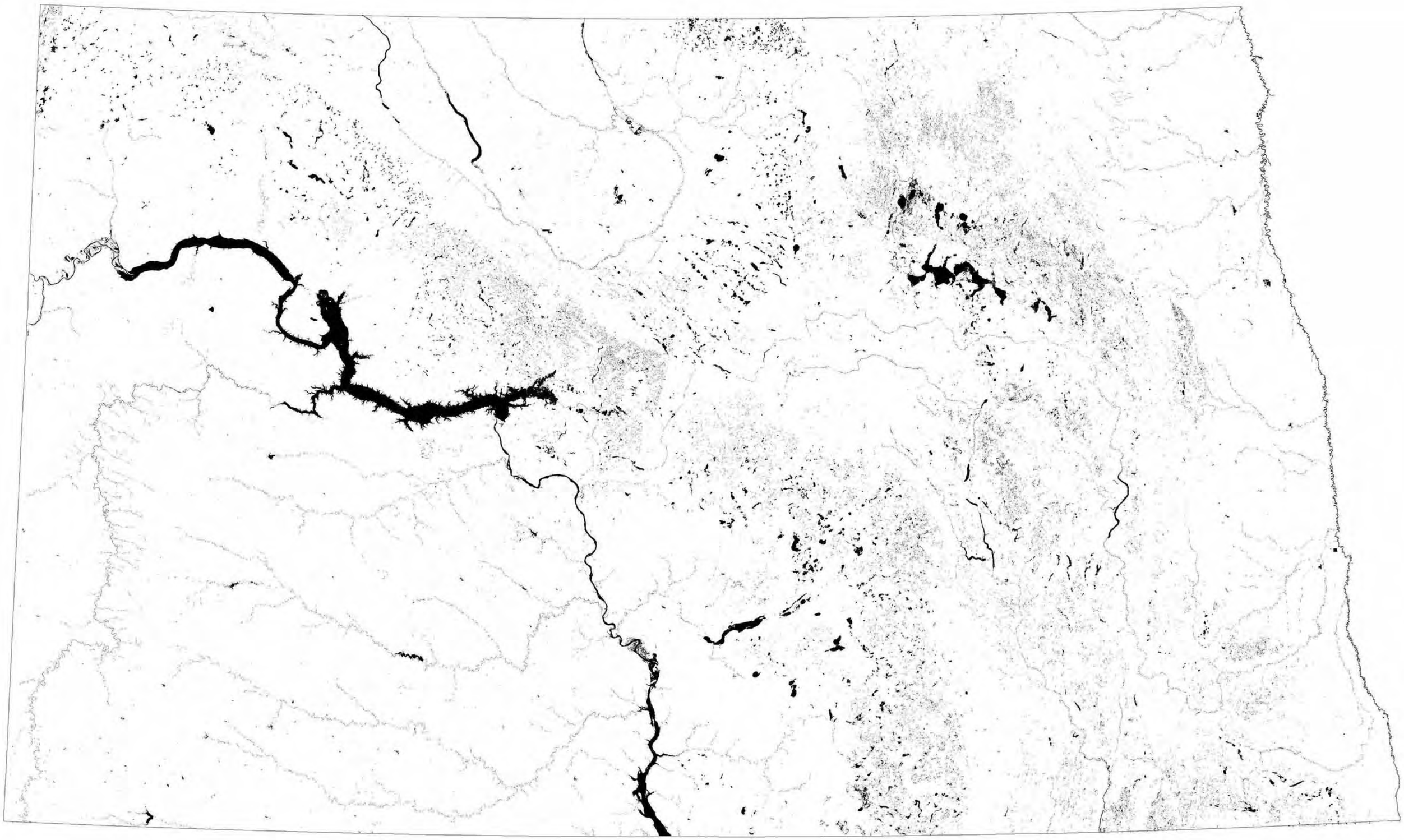
TREE SWALLOW(Tachycineta bicolor)



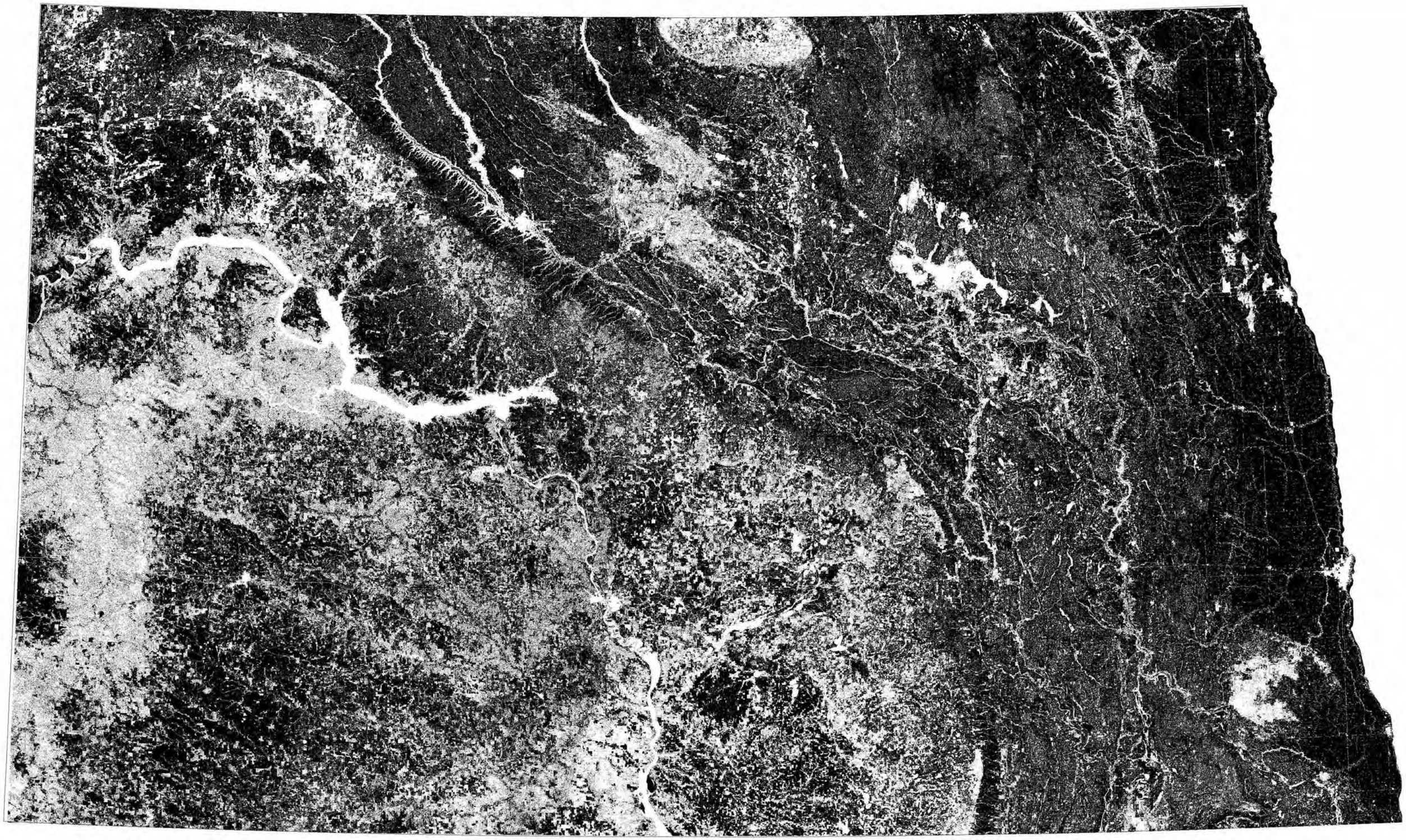
NORTHERN ROUGH-WINGED SWALLOW(Stelgidopteryx s



BANK SWALLOW(Riparia riparia)

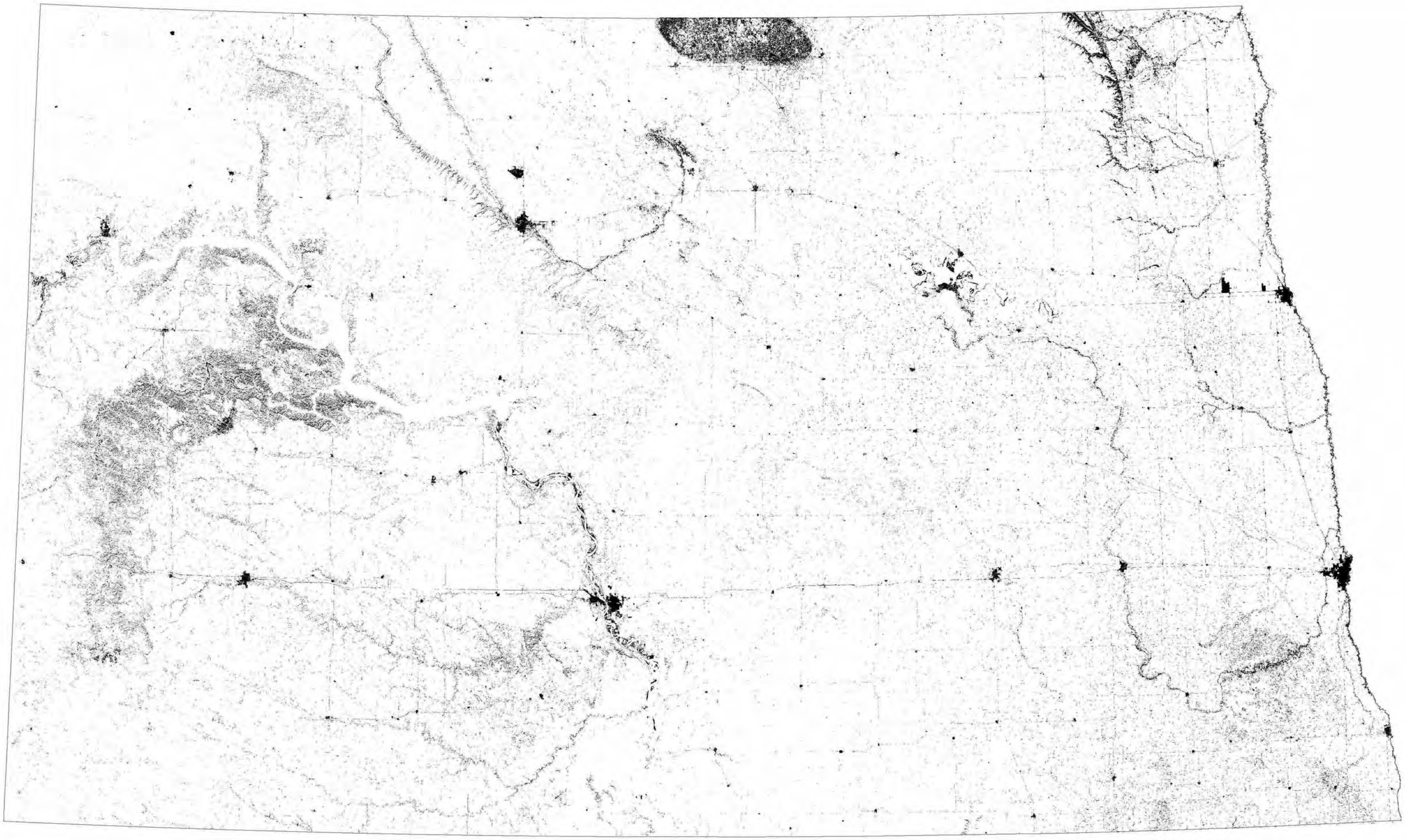


CLIFF SWALLOW(Petrochelidon pyrrhonota)

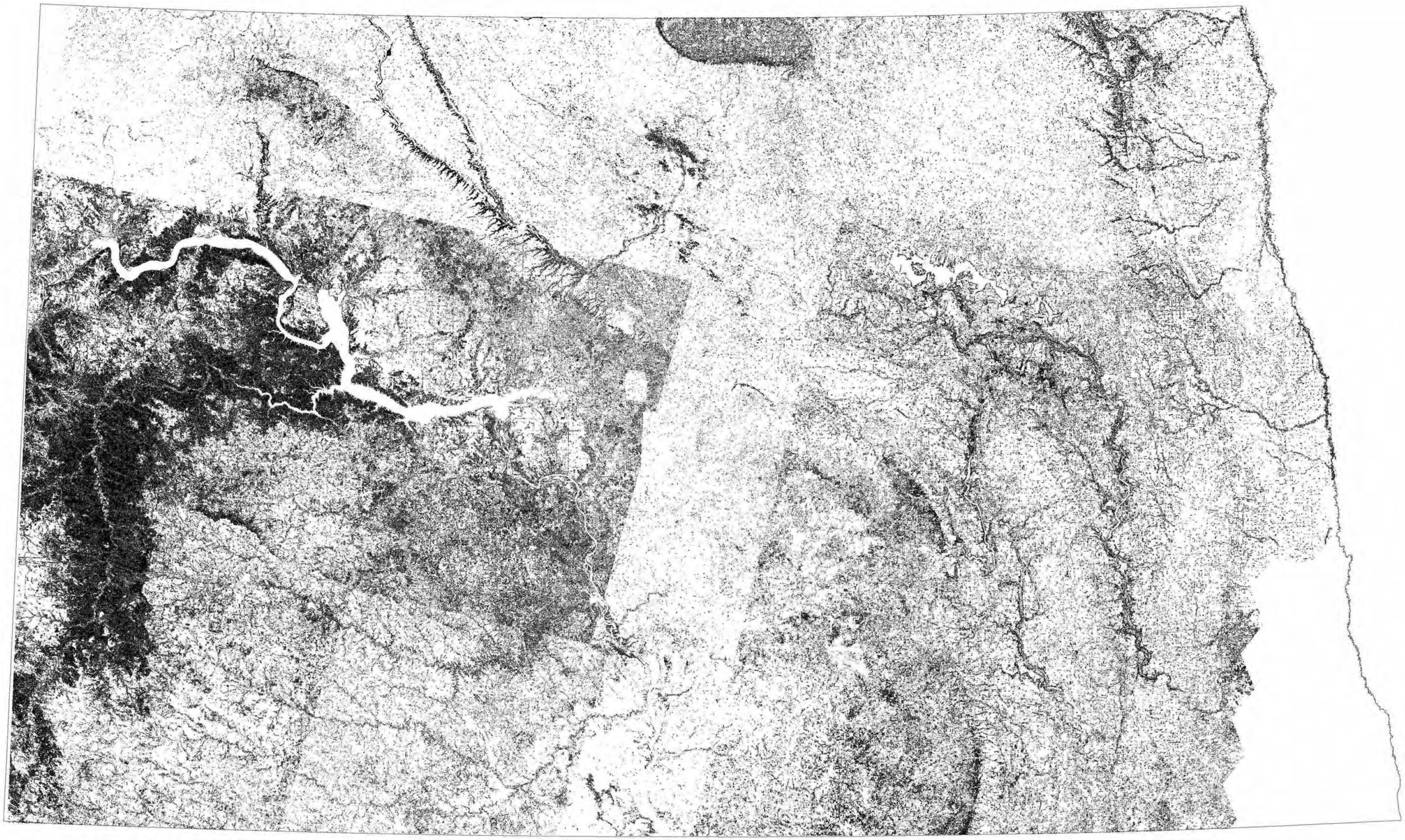


BARN SWALLOW(Hirundo rustica)

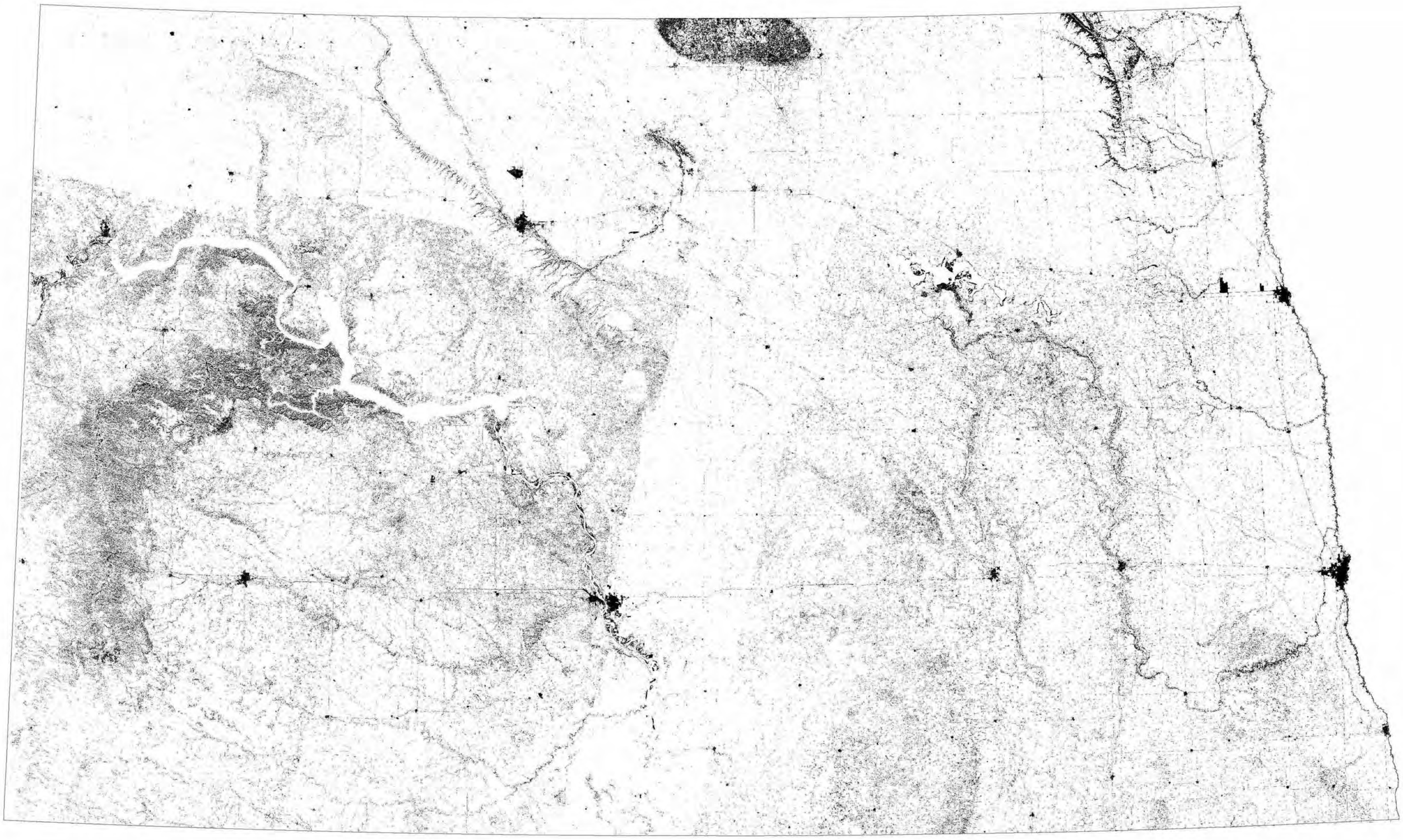
BLUE JAY(Cyanocitta cristata)



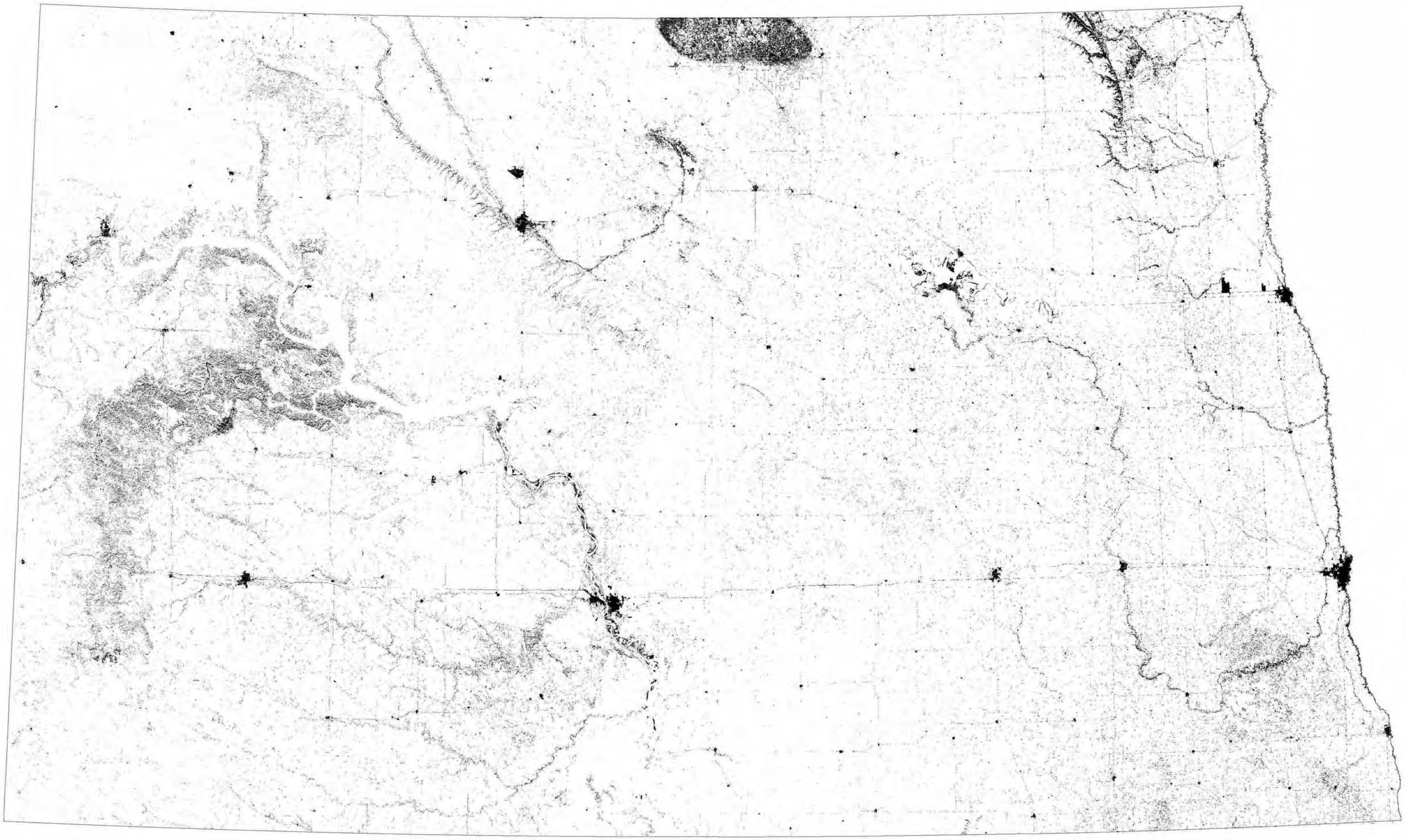
BLACK-BILLED MAGPIE(Pica pica)



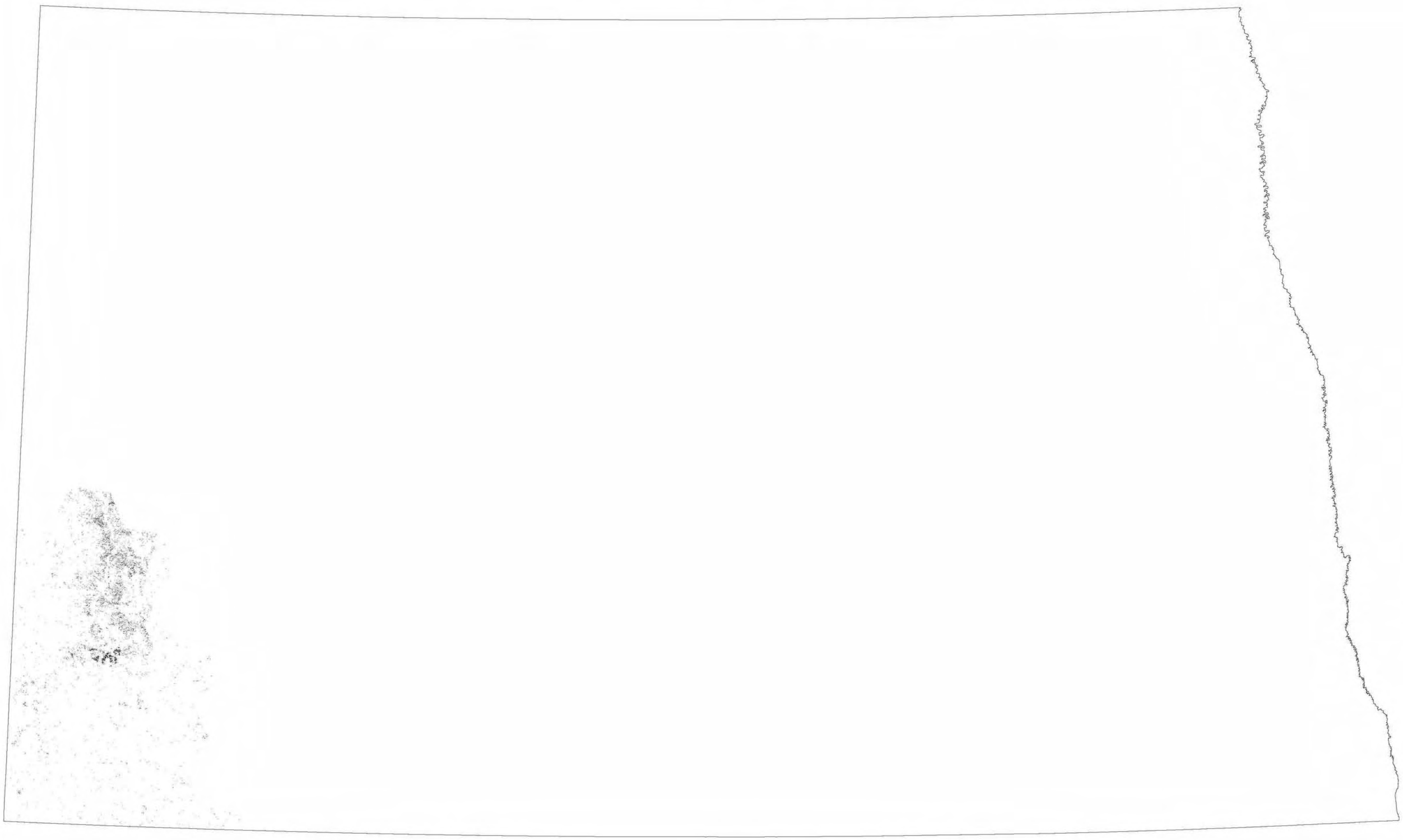
AMERICAN CROW(Corvus brachyrhynchos)



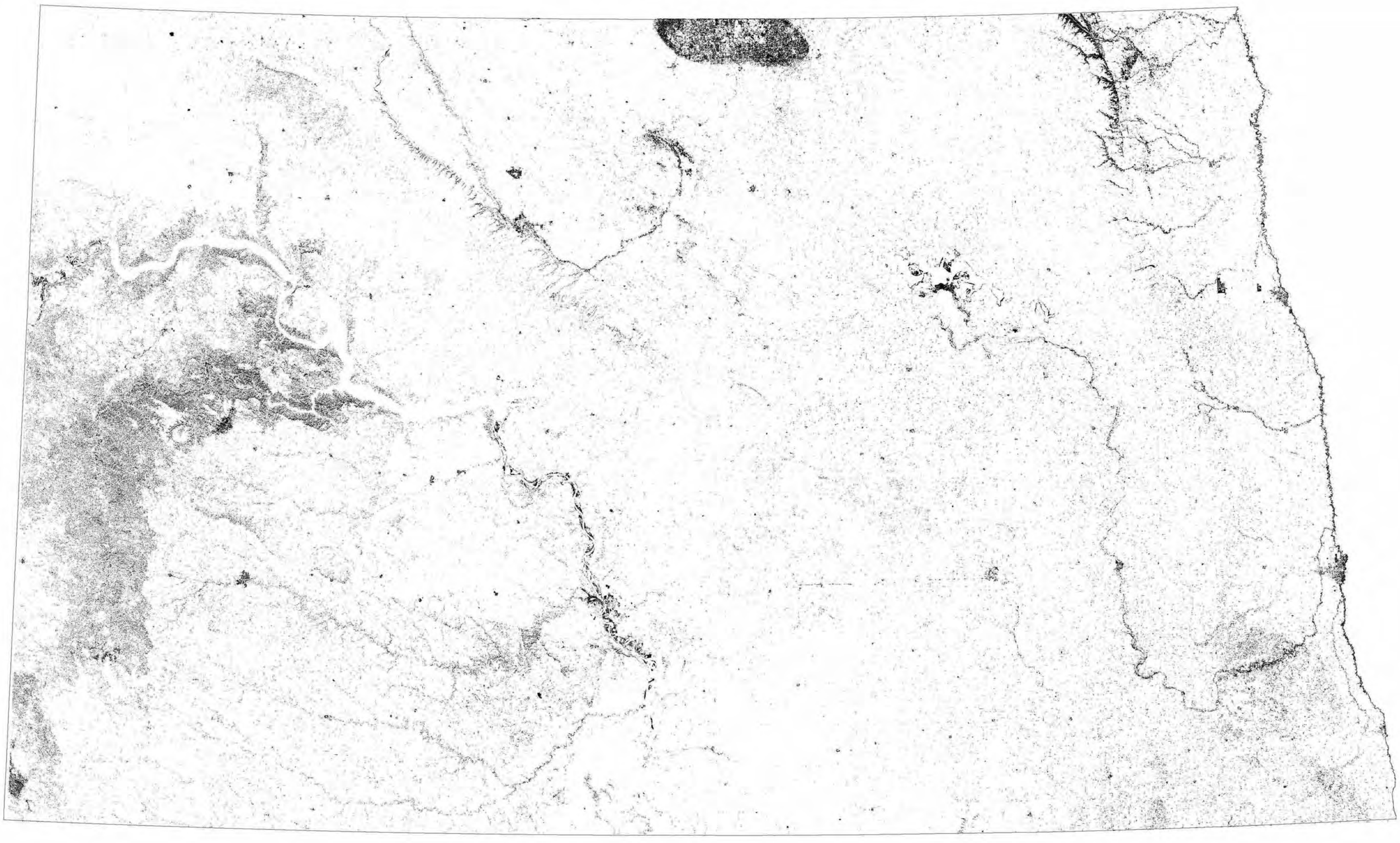
BLACK-CAPPED CHICKADEE(Poecile atricapillus)



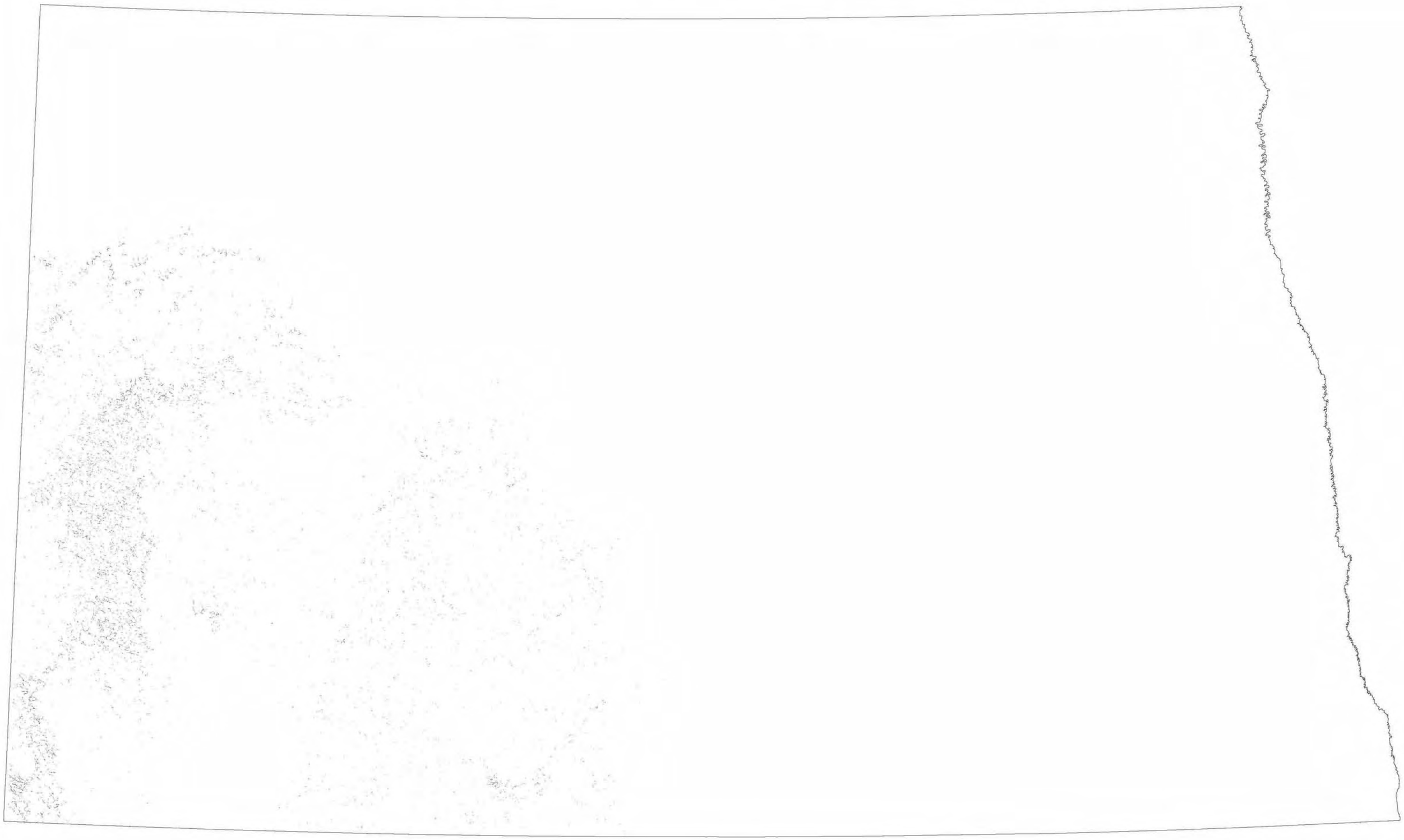
RED-BREASTED NUTHATCH(Sitta canadensis)



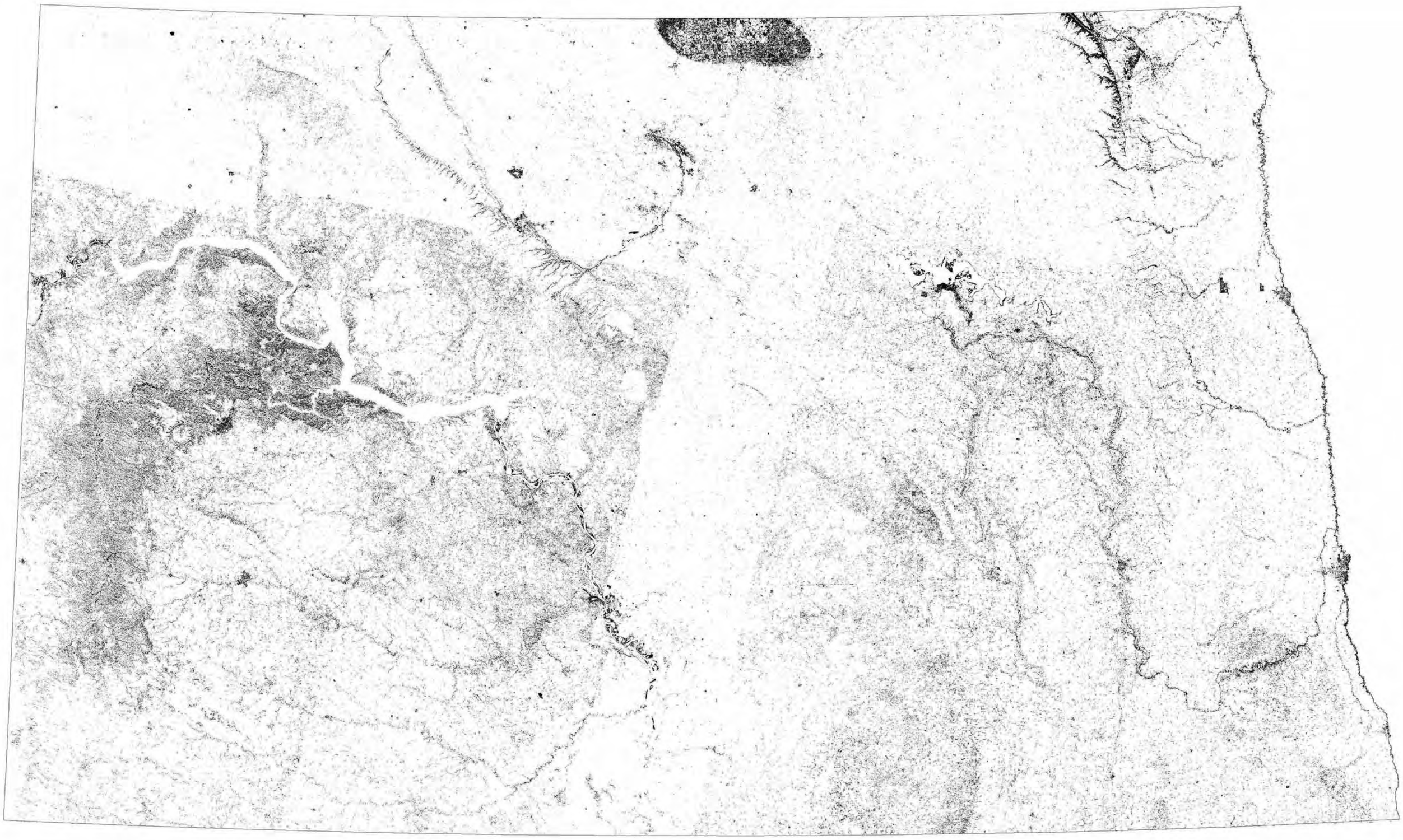
WHITE-BREASTED NUTHATCH(Sitta carolinensis)



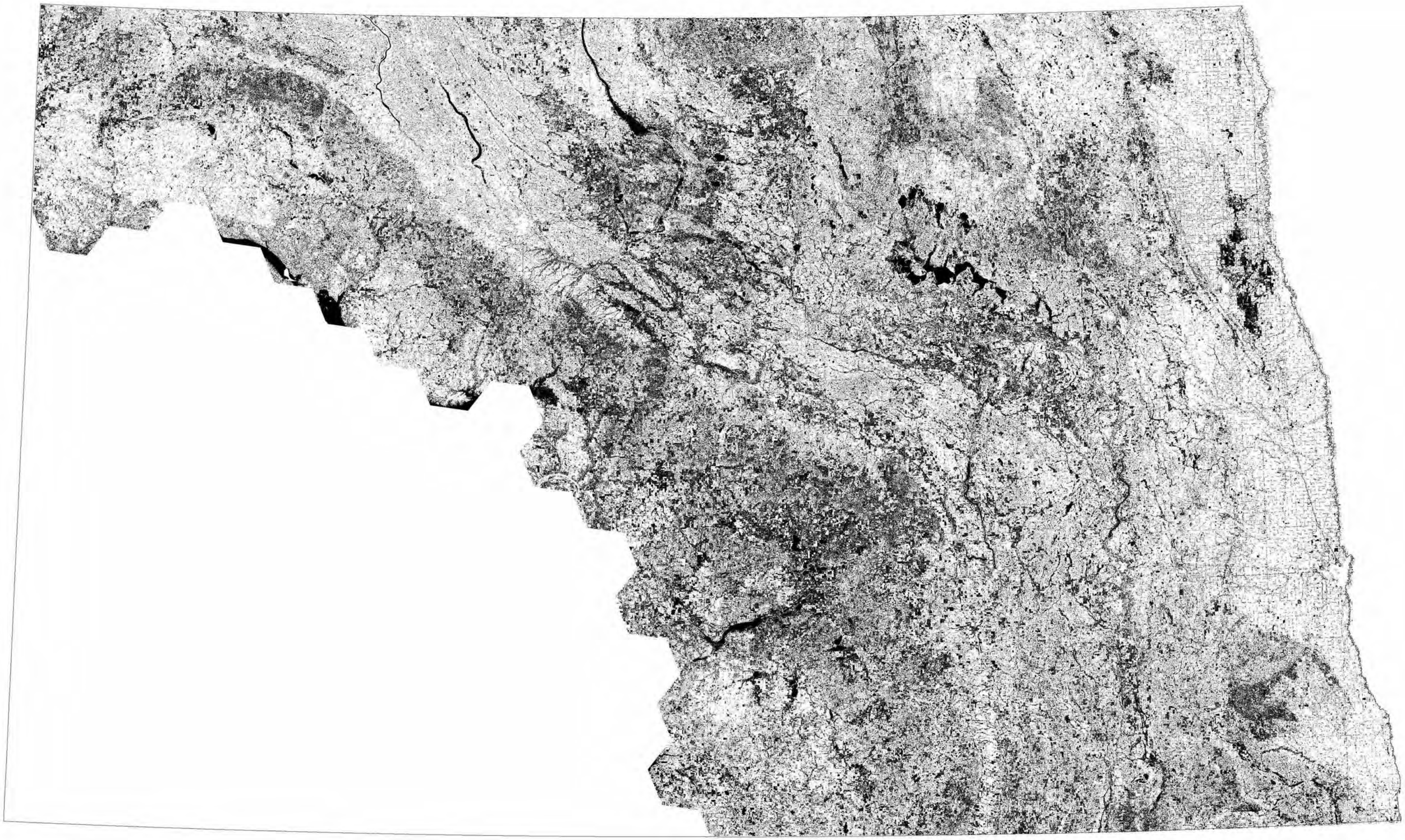
ROCK WREN(Salpinctes obsoletus)



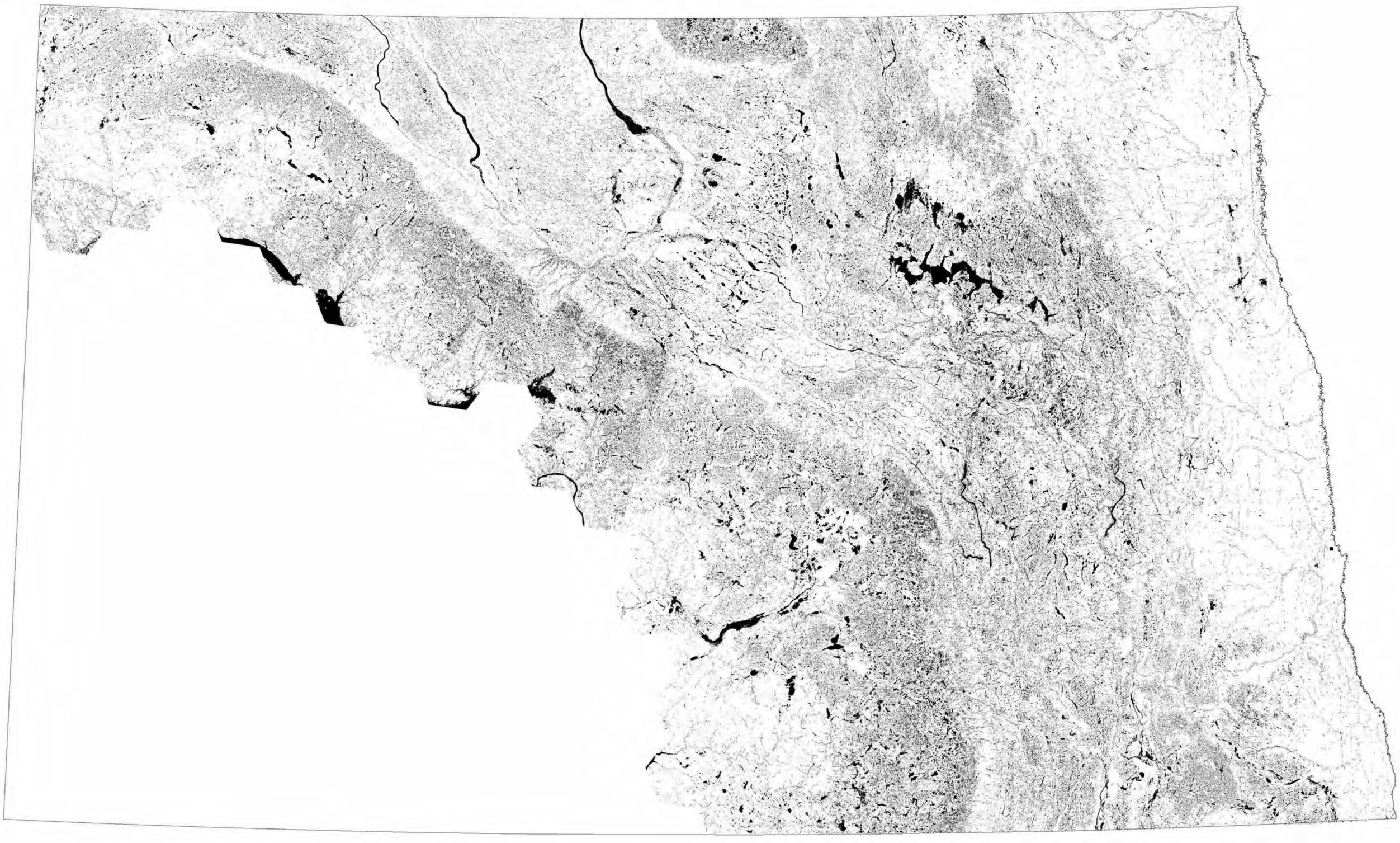
HOUSE WREN(Troglodytes aedon)



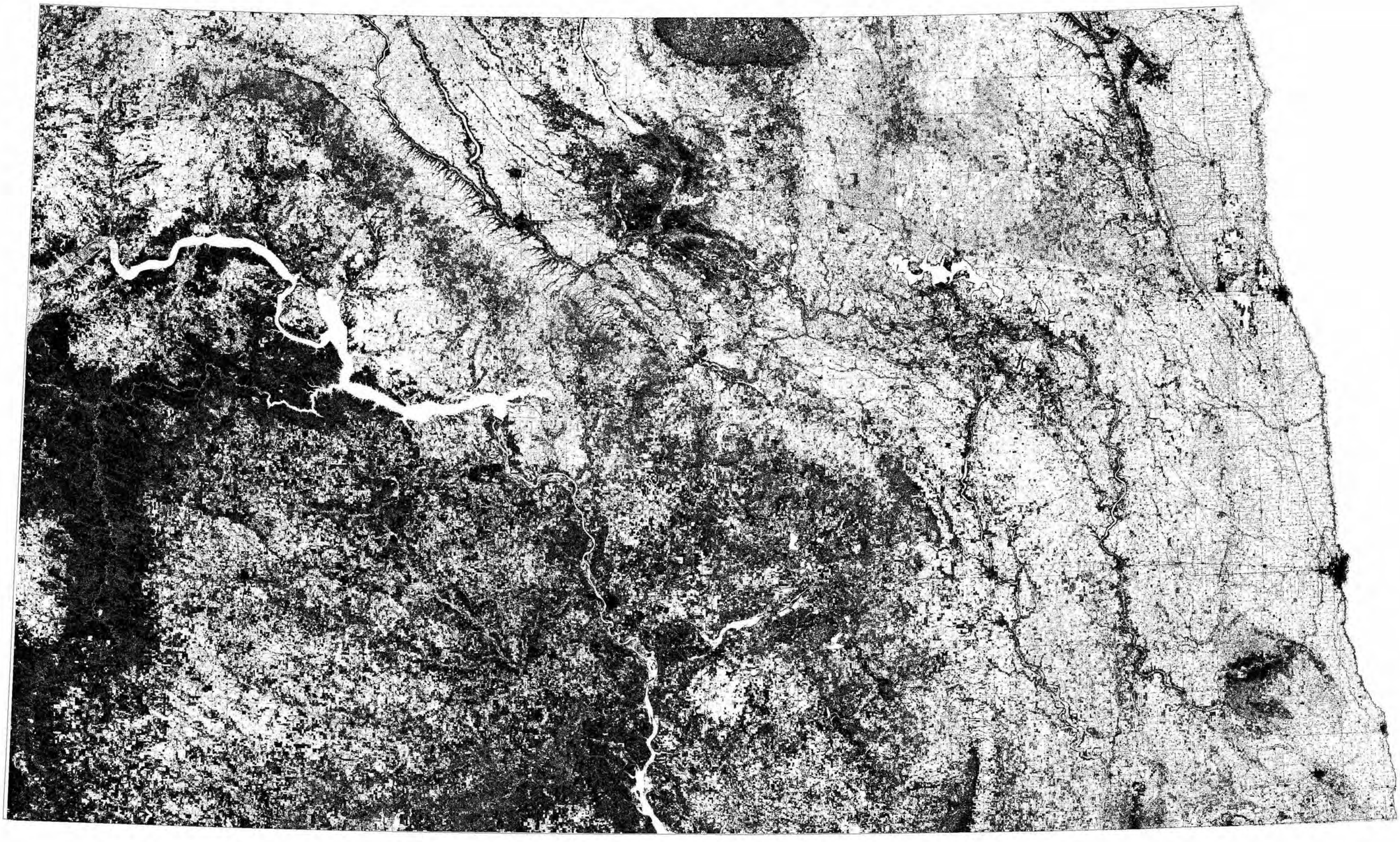
SEDGE WREN(Cistothorus platensis)



MARSH WREN(Cistothorus palustris)

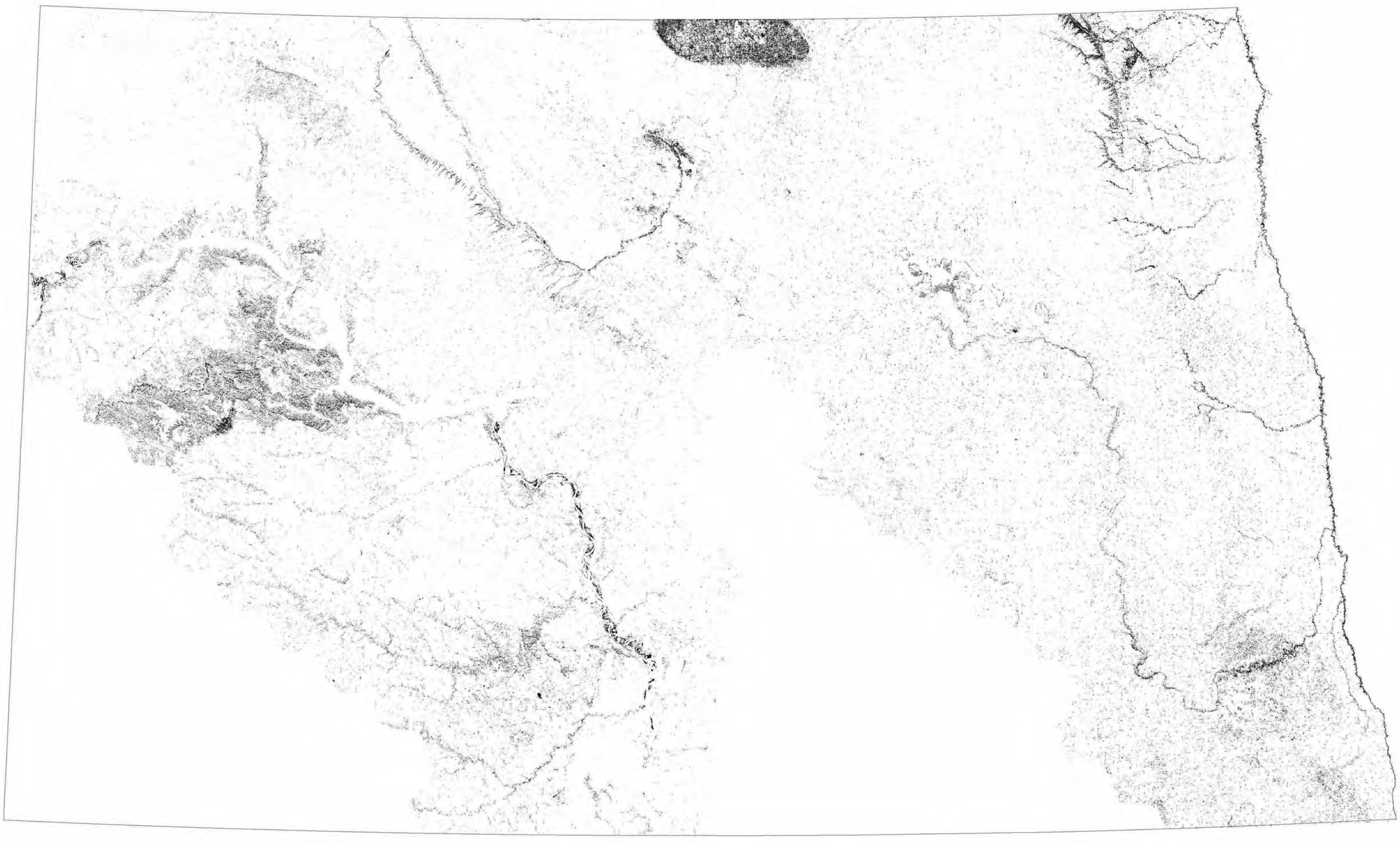


EASTERN BLUEBIRD(Sialia sialis)

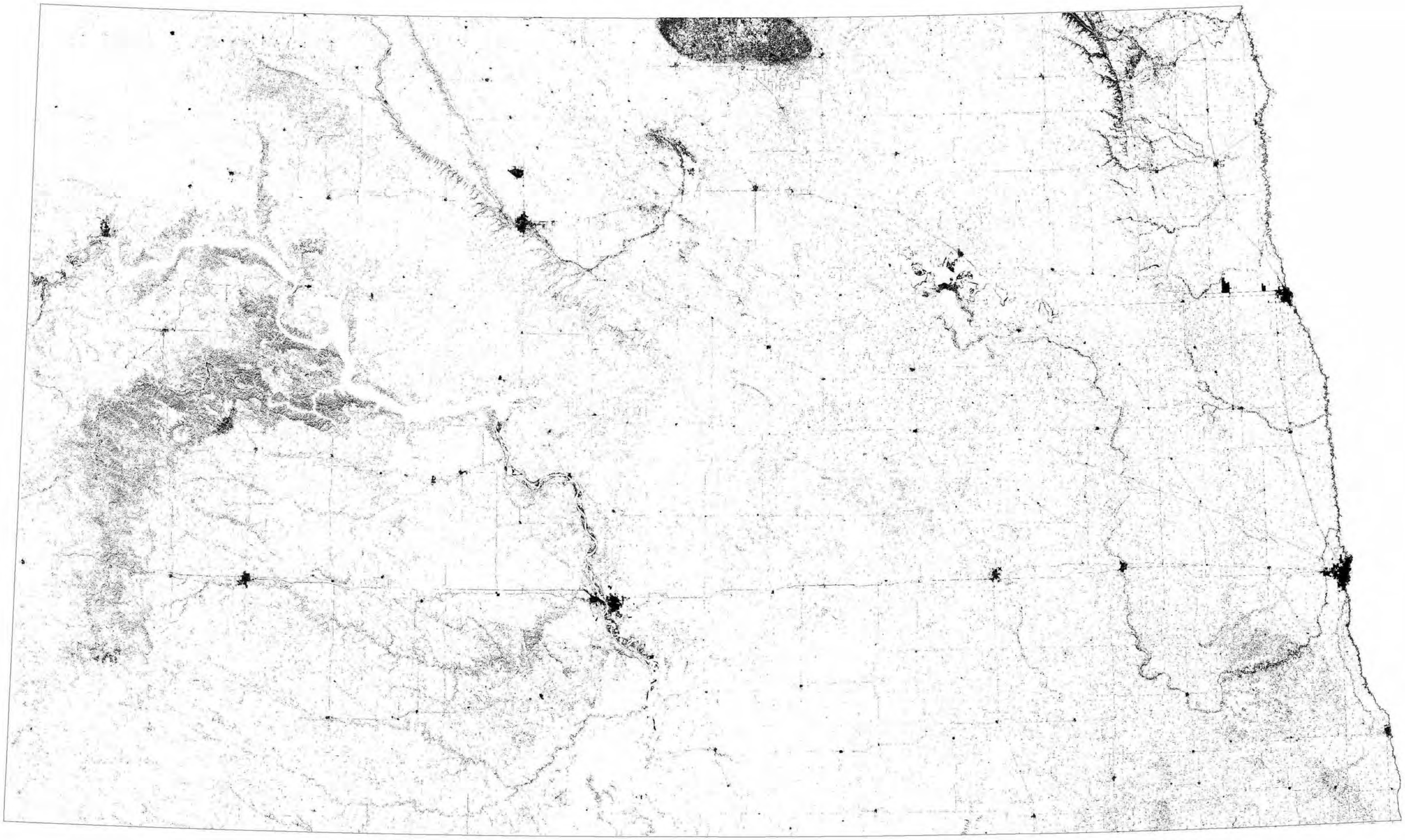


MOUNTAIN BLUEBIRD(Sialia currucoides)

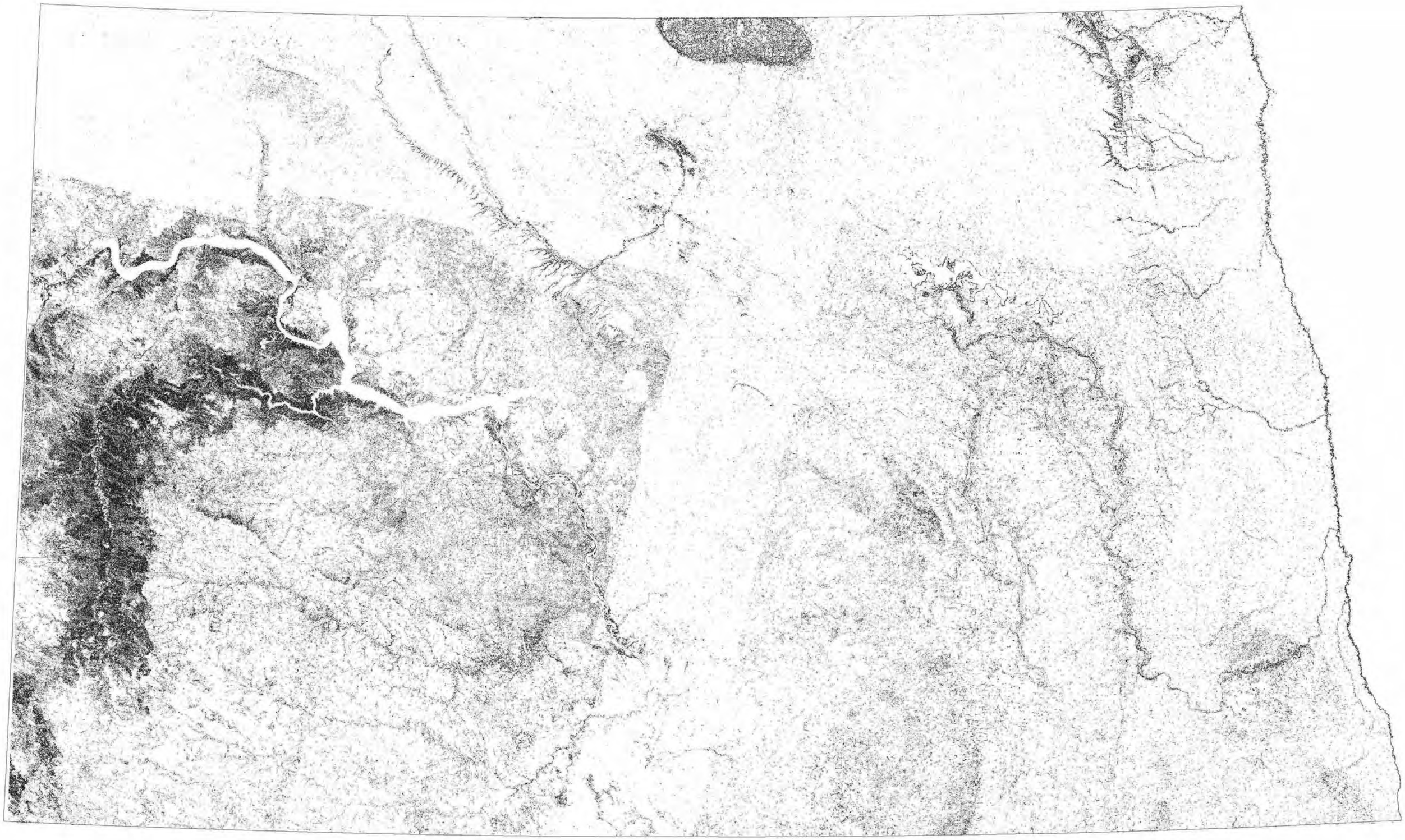
VEERY(Catharus fuscescens)



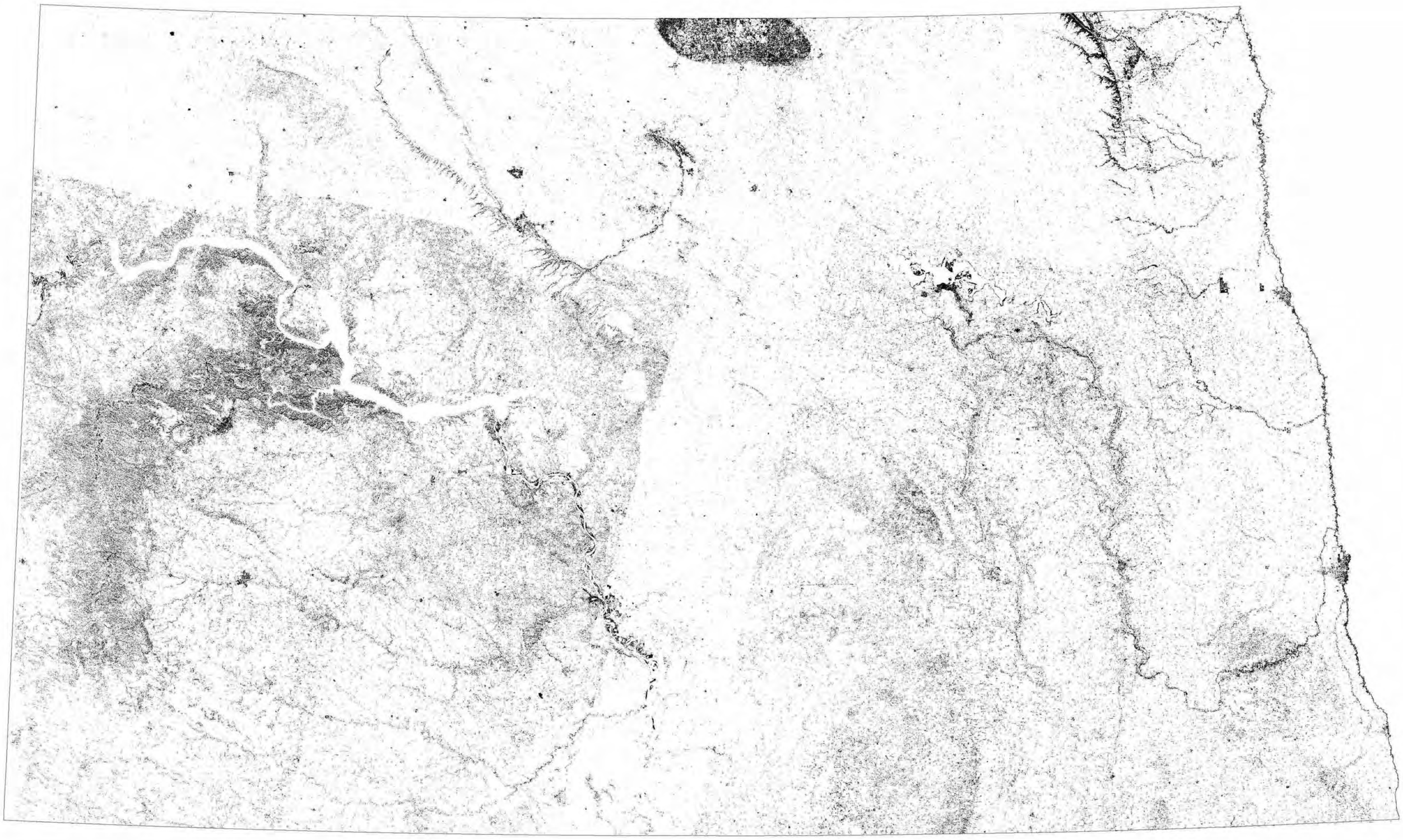
AMERICAN ROBIN(Turdus migratorius)



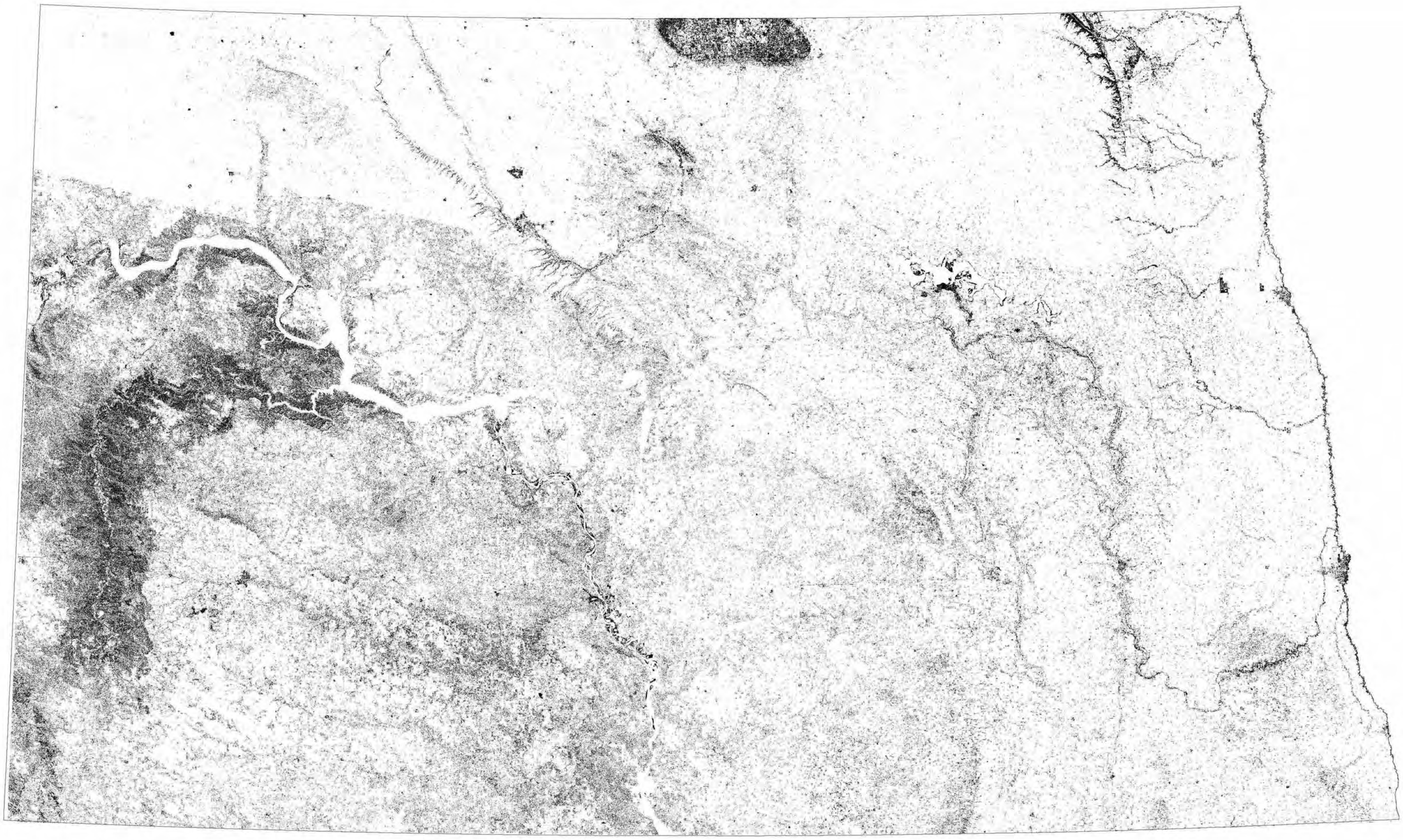
GRAY CATBIRD(Dumetella carolinensis)



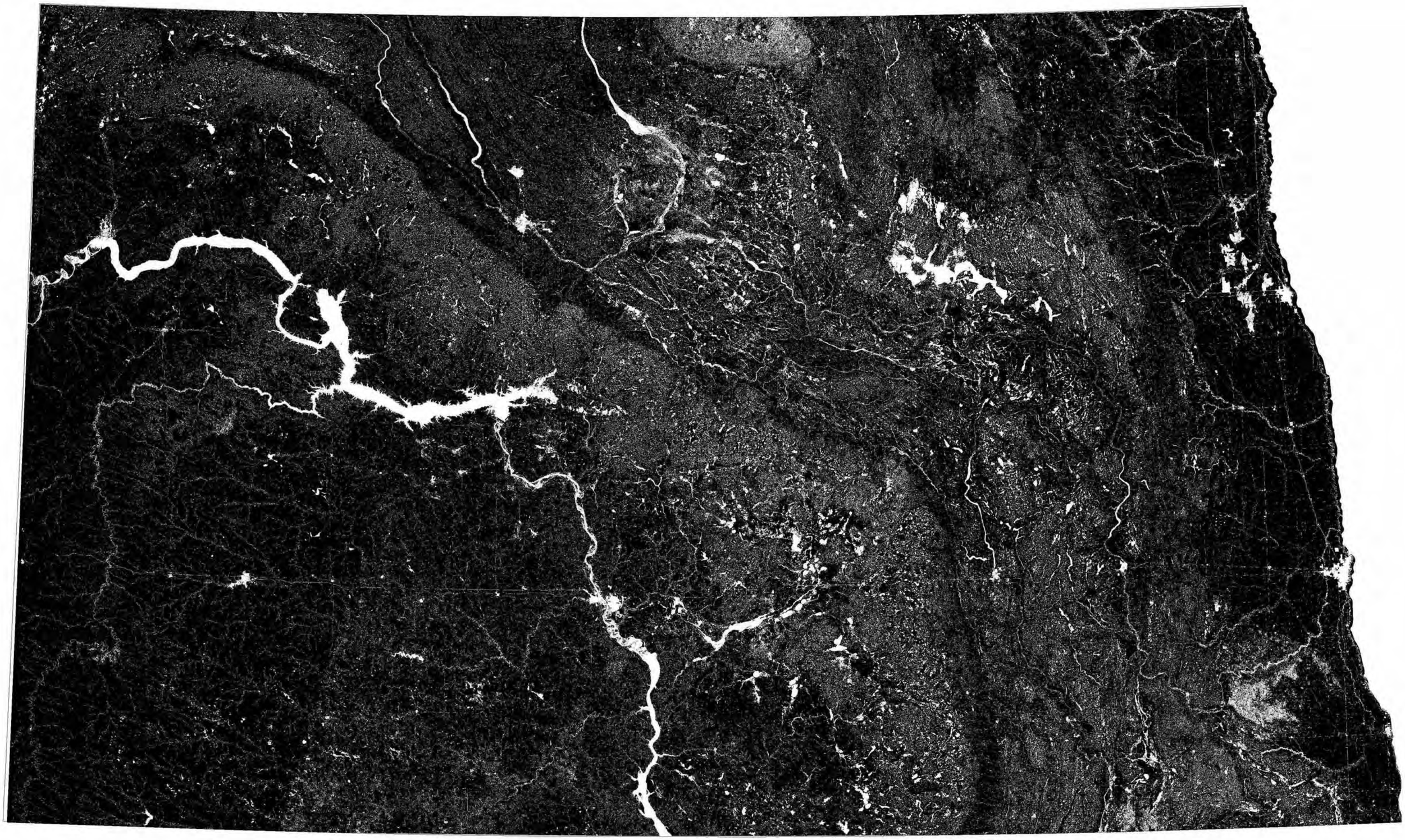
NORTHERN MOCKINGBIRD(Mimus polyglottos)



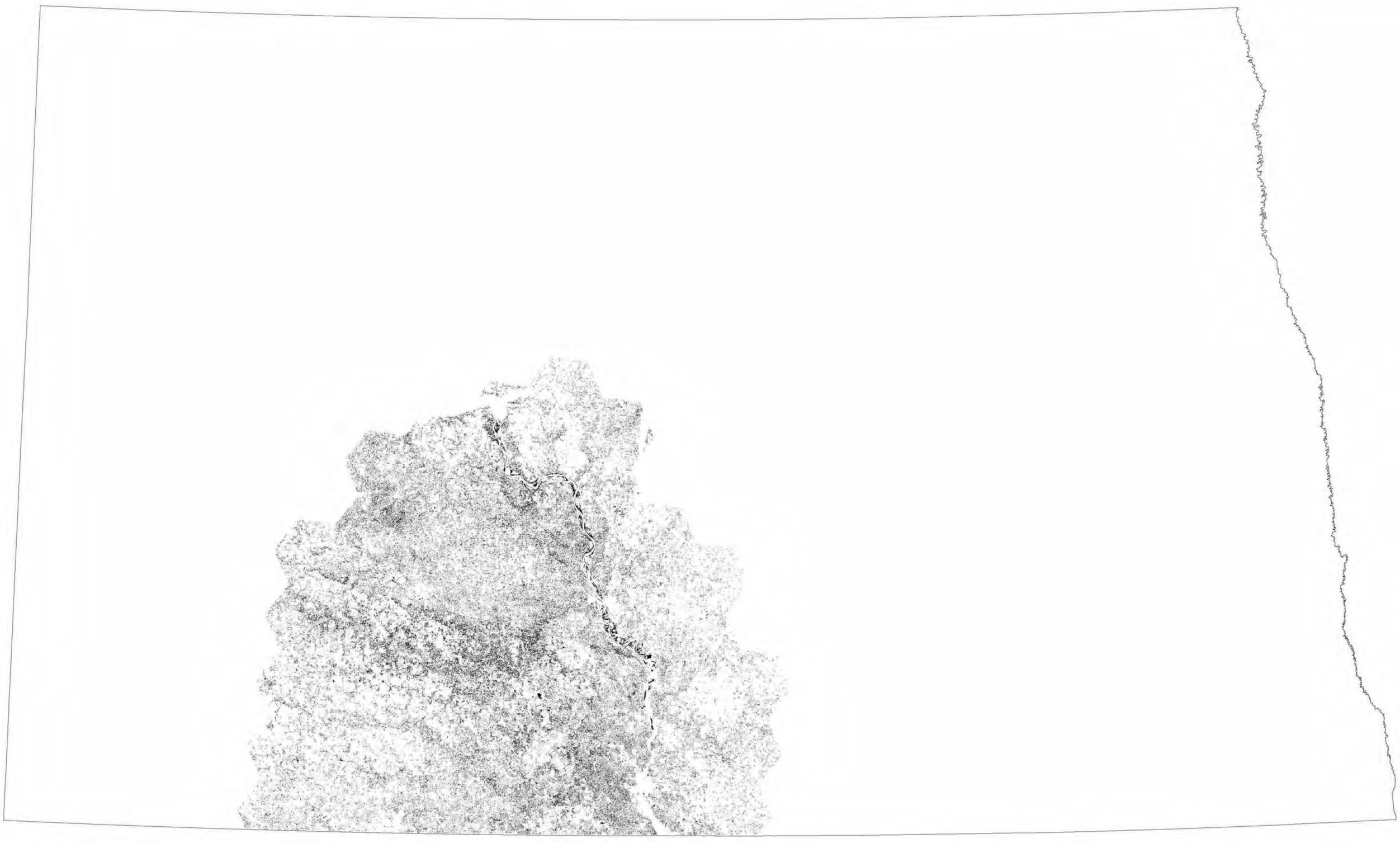
BROWN THRASHER(Toxostoma rufum)



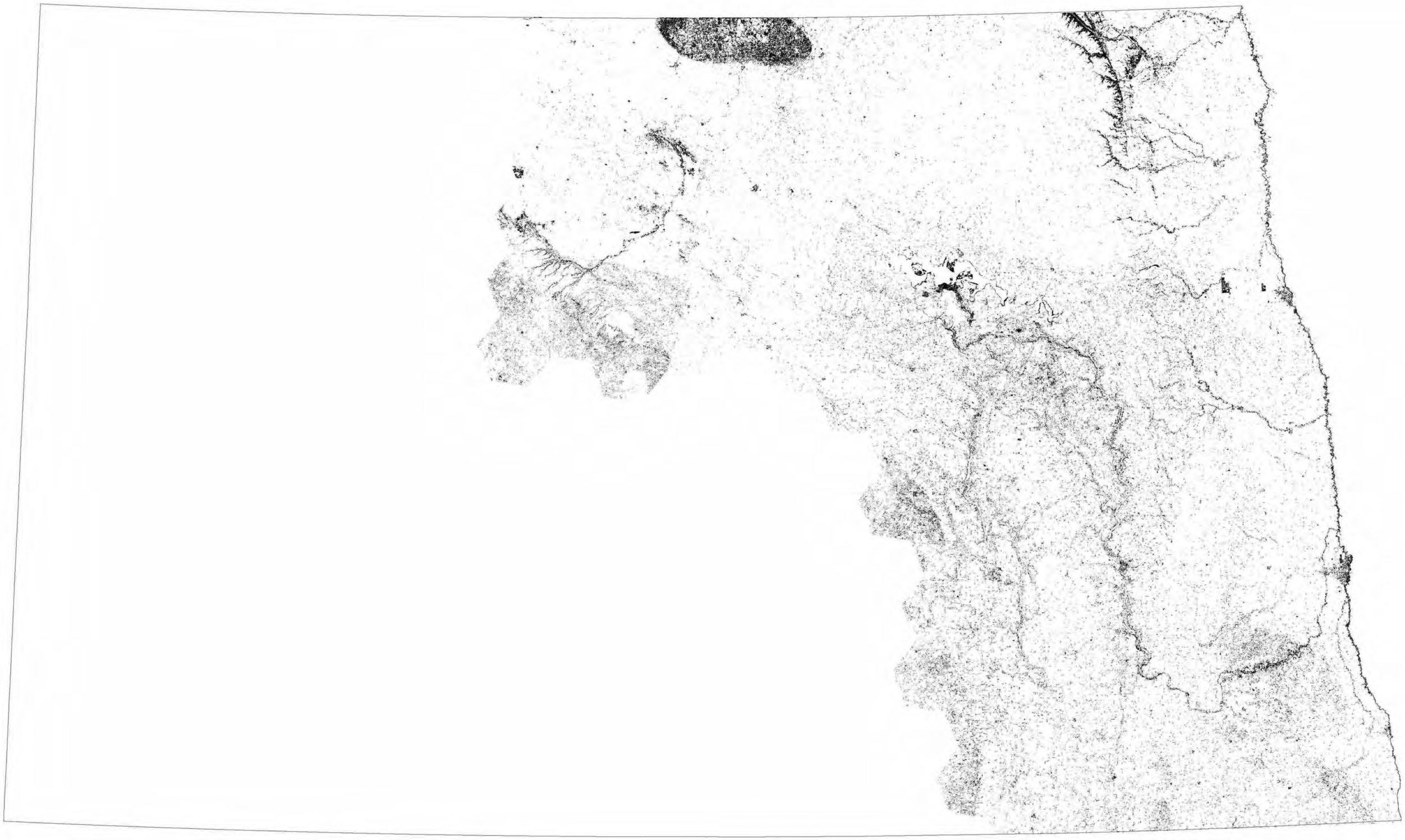
LOGGERHEAD SHRIKE(Lanius ludovicianus)



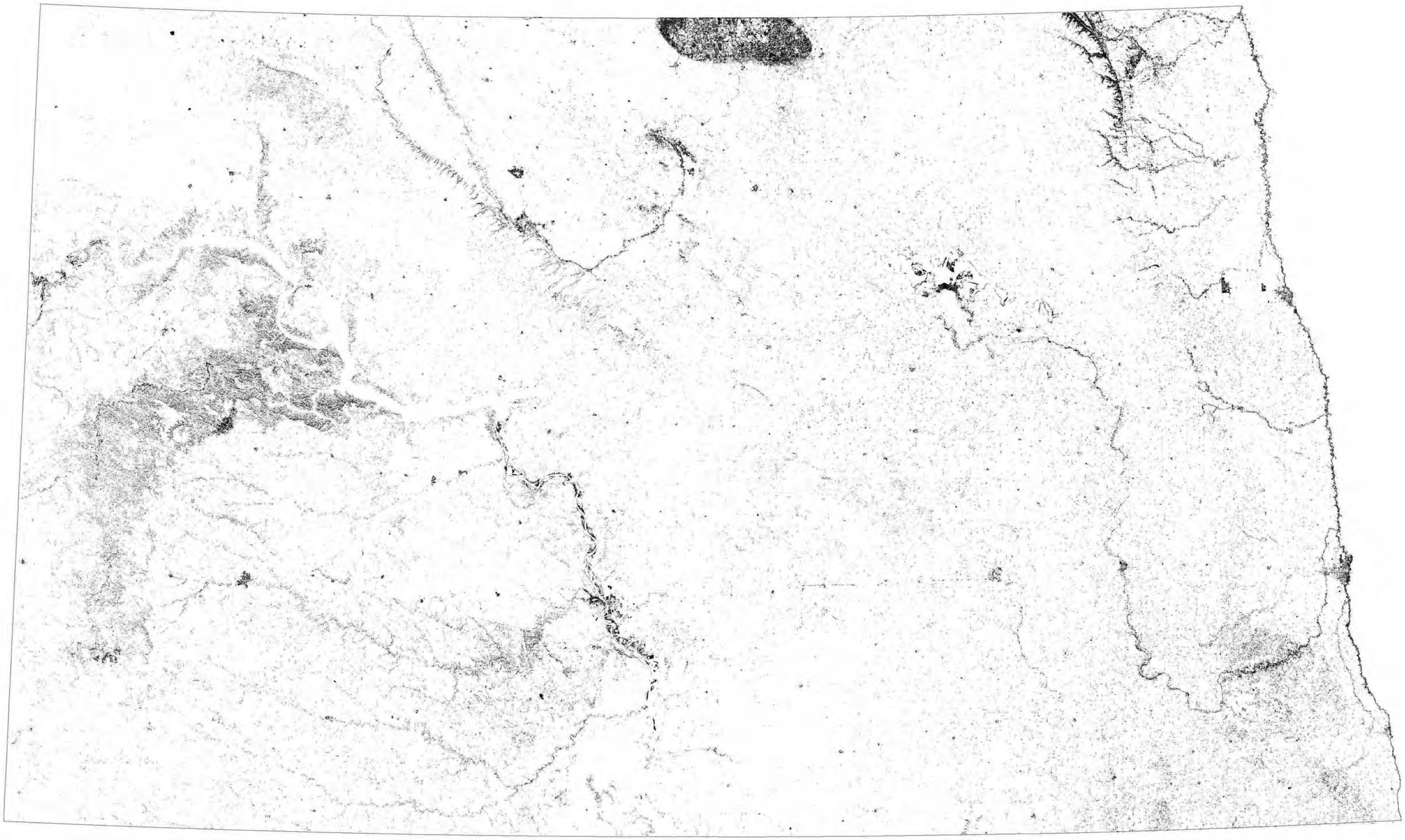
BELL'S VIREO(Vireo bellii)



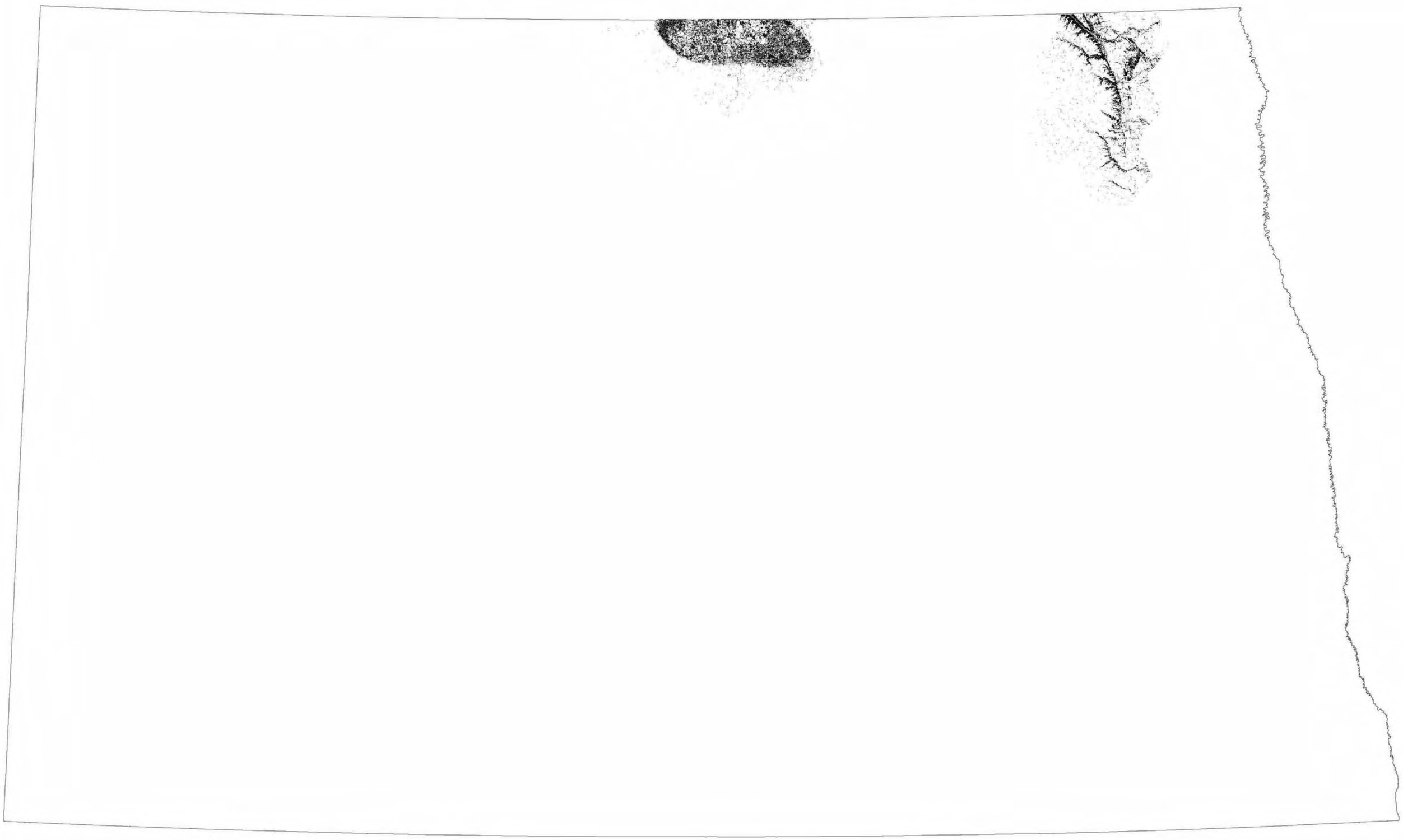
YELLOW-THROATED VIREO(Vireo flavifrons)



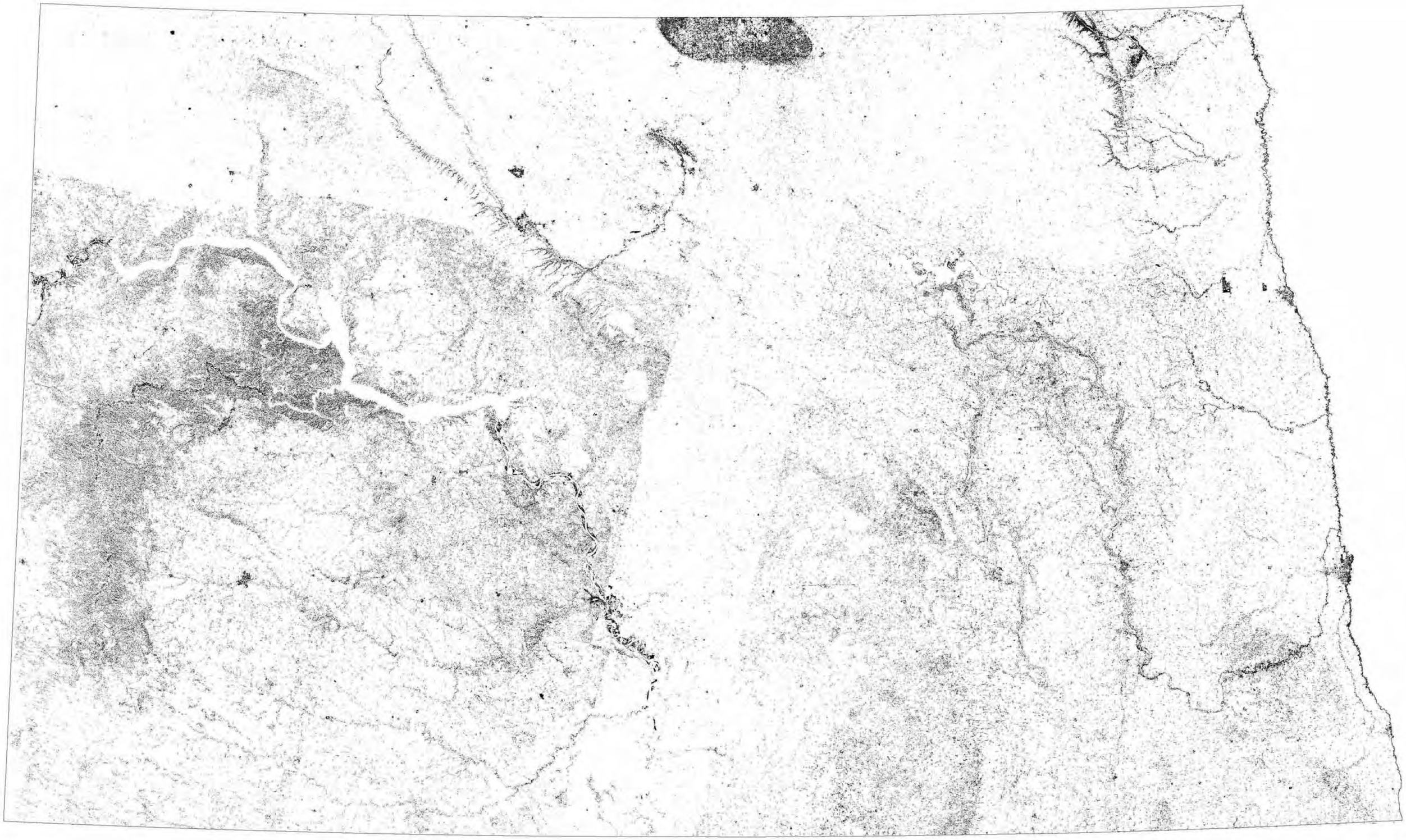
WARBLING VIREO(Vireo gilvus)



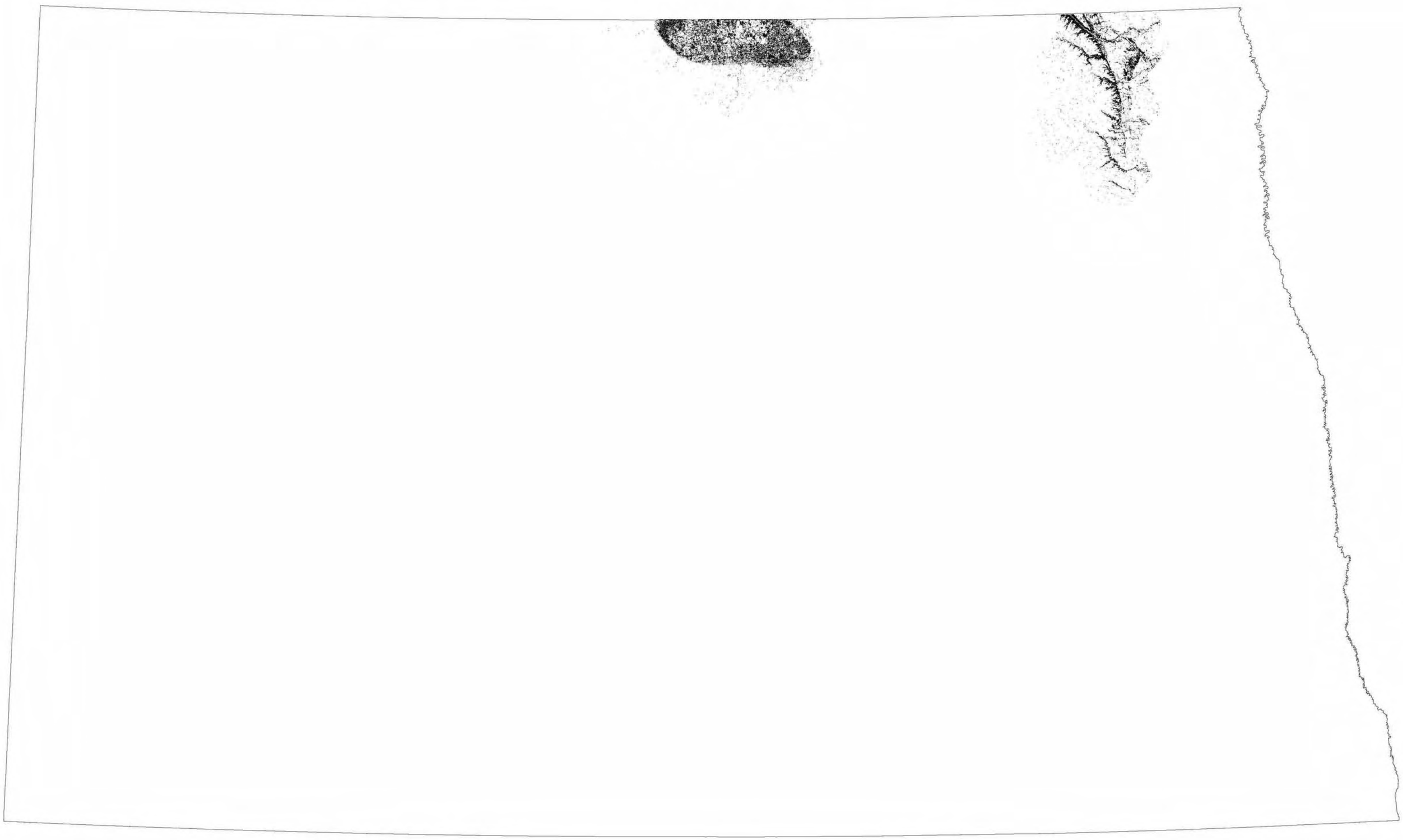
PHILADELPHIA VIREO(Vireo philadelphicus)



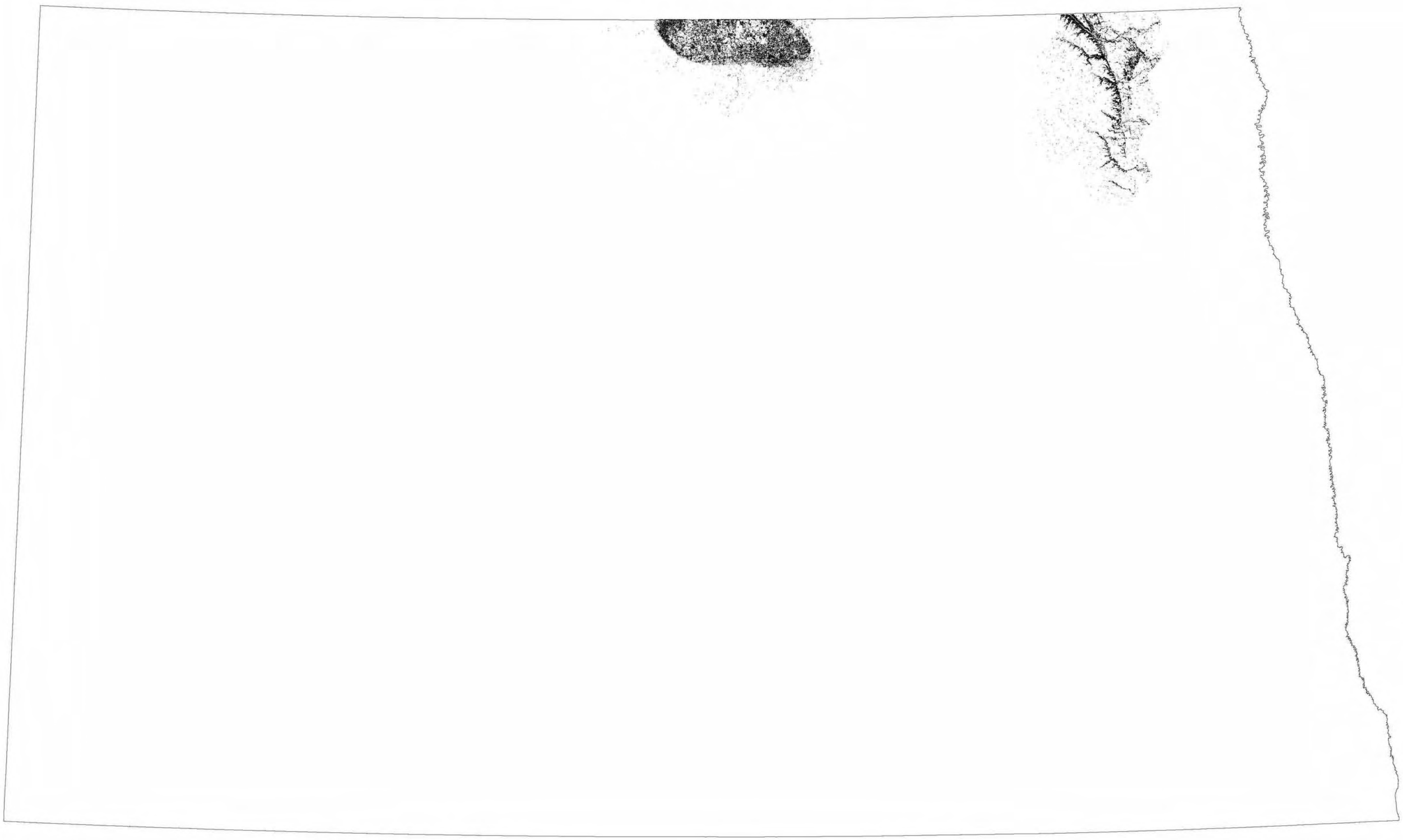
RED-EYED VIREO(Vireo olivaceus)



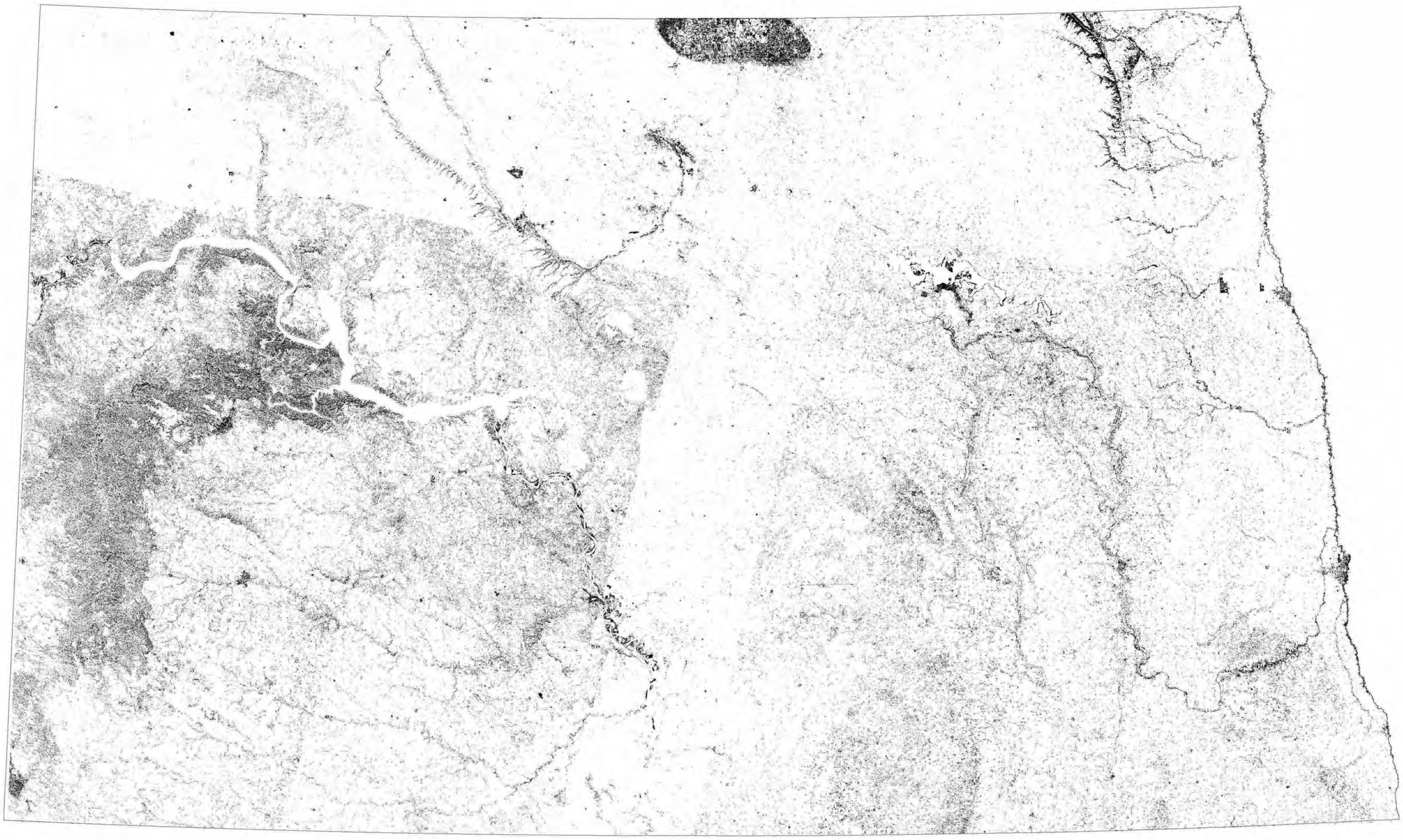
ORANGE-CROWNED WARBLER(Vermivora celata)



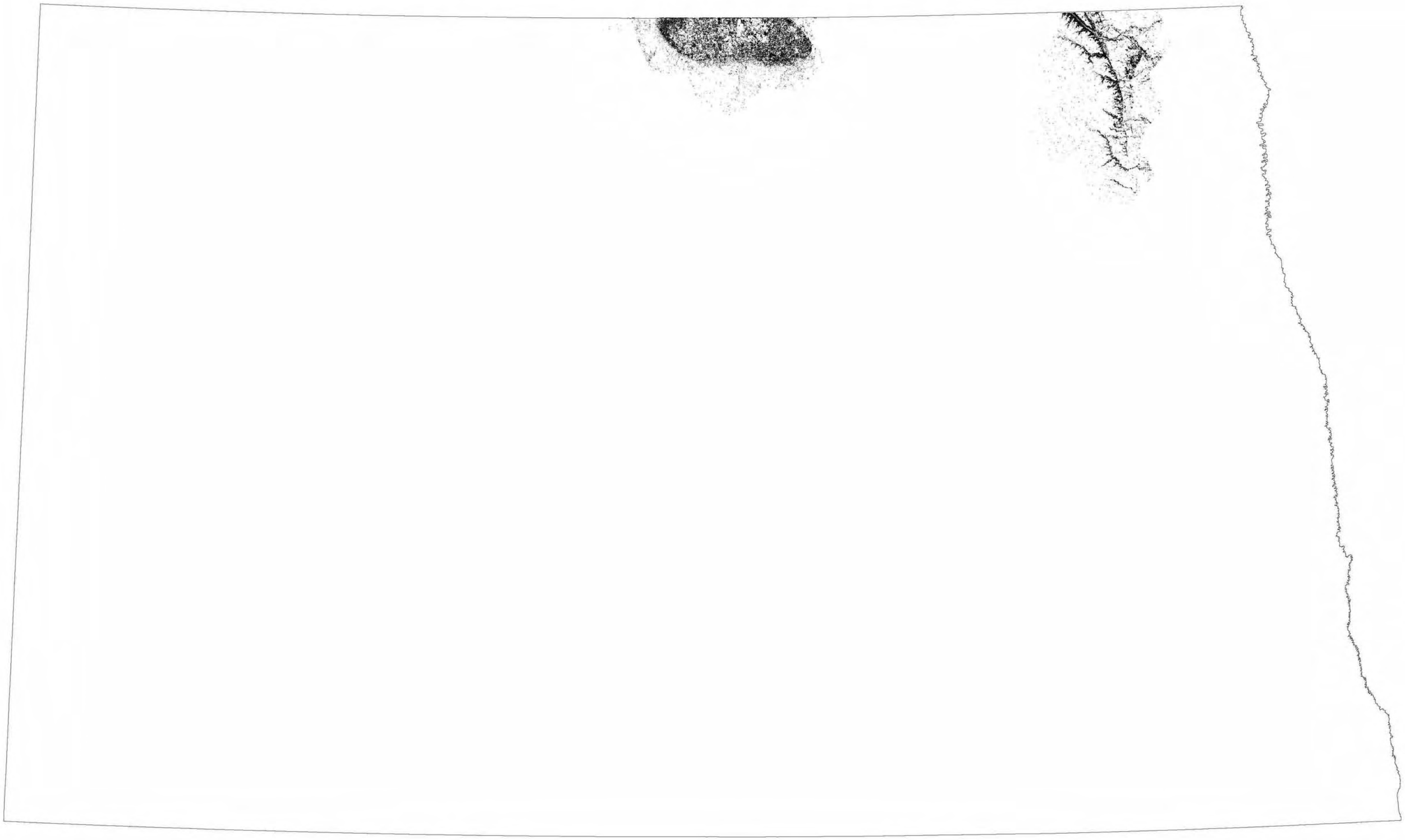
NASHVILLE WARBLER(Vermivora ruficapilla)



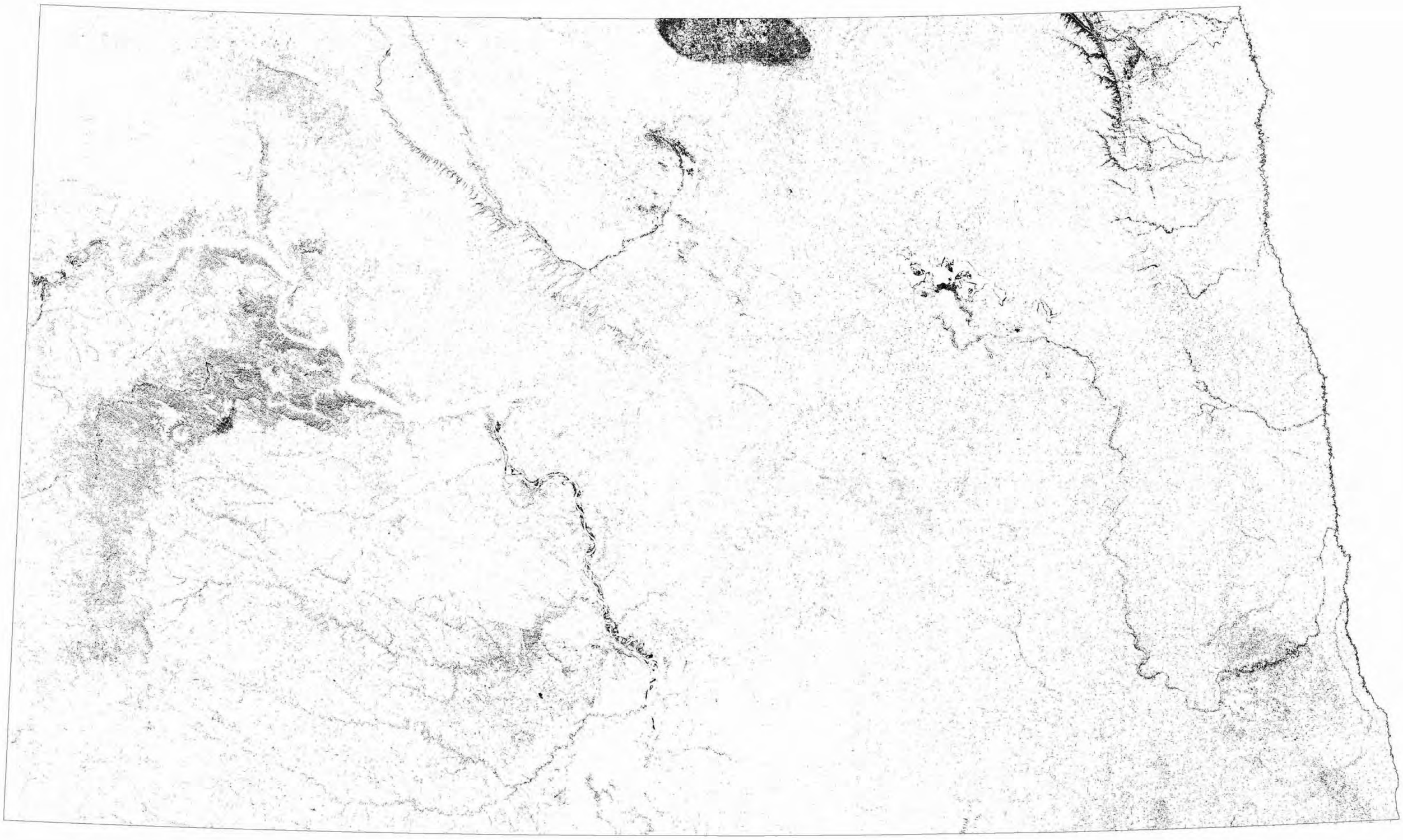
YELLOW WARBLER(Dendroica petechia)



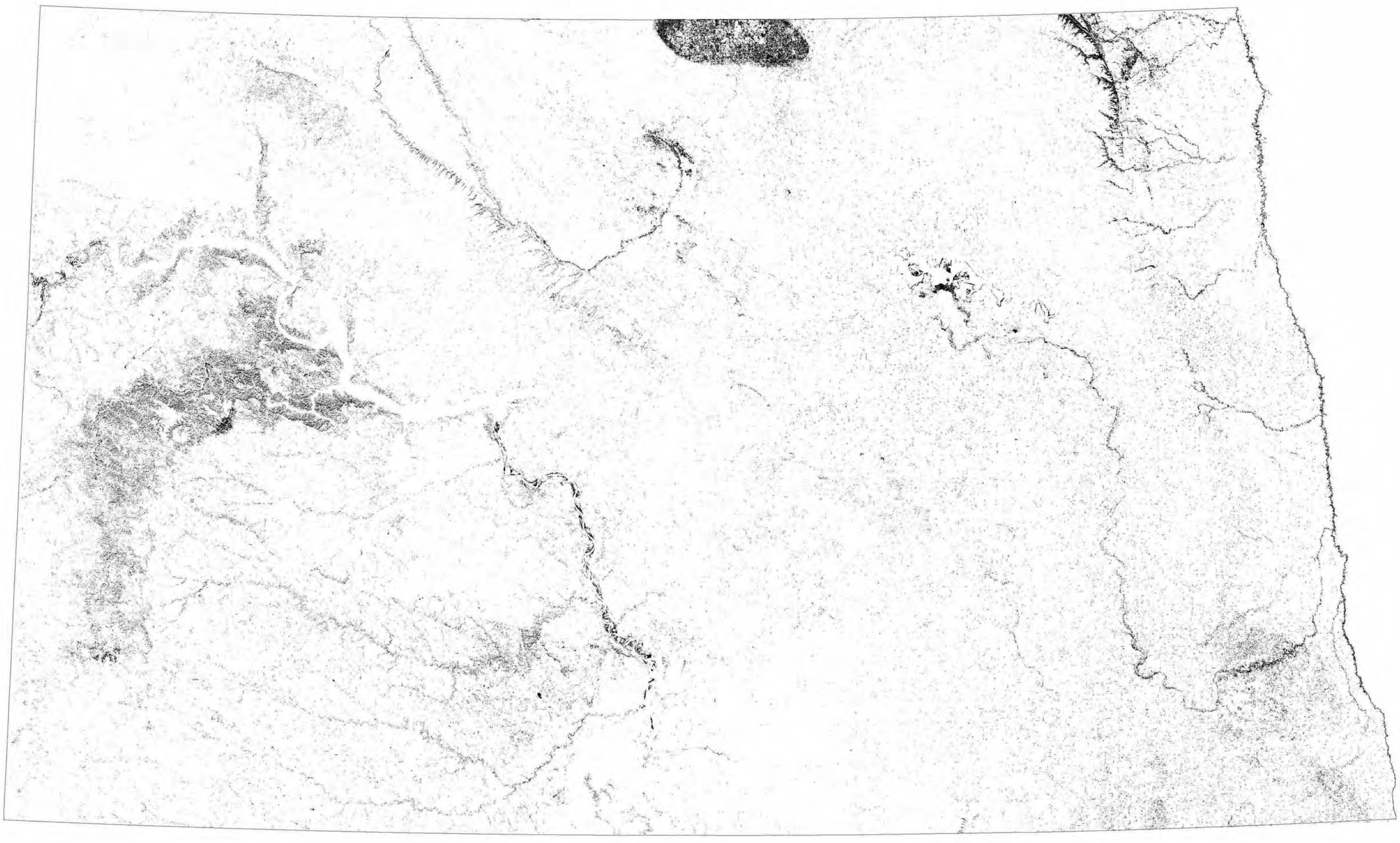
CHESTNUT-SIDED WARBLER(Dendroica pensylvanica)



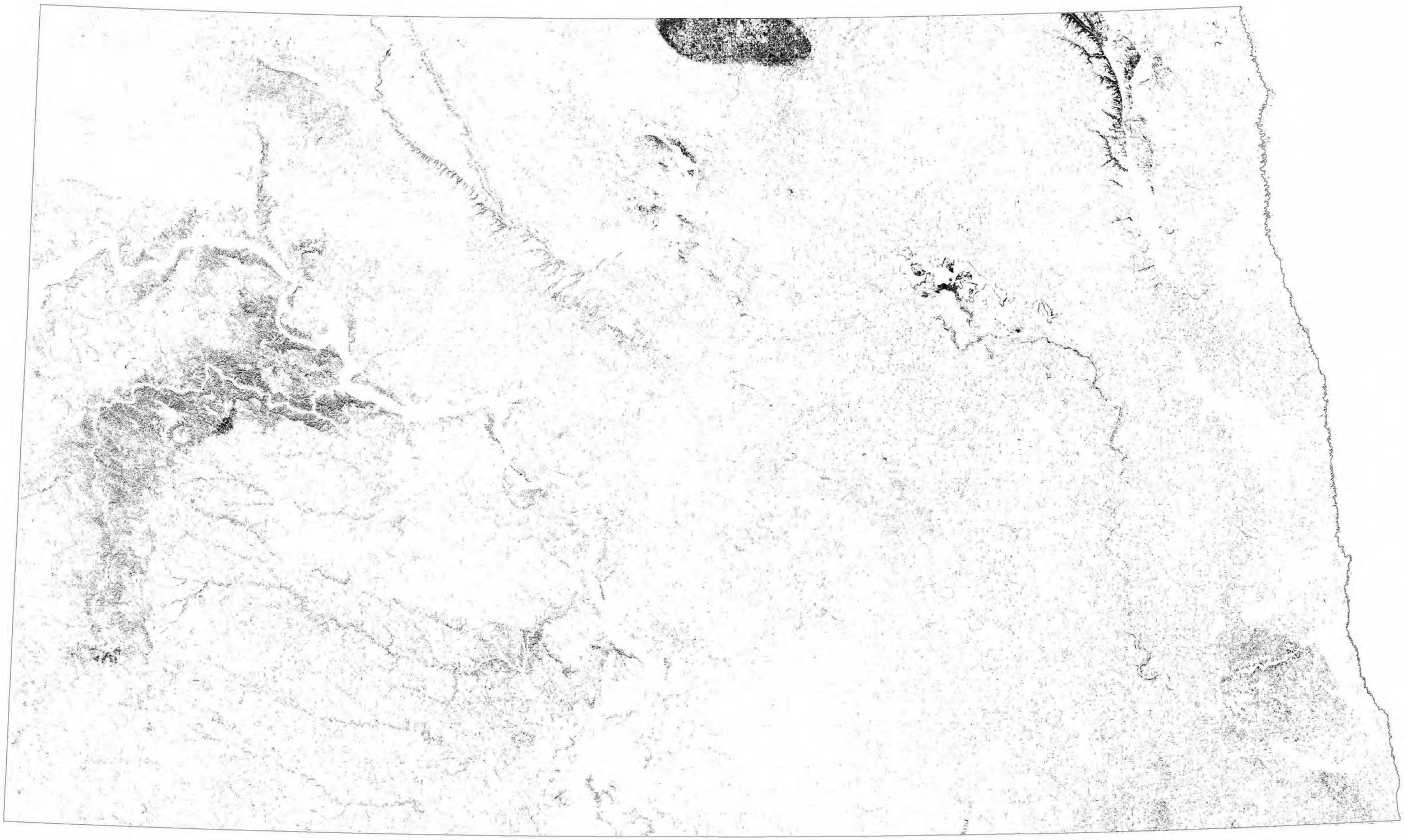
BLACK-AND-WHITE WARBLER(Mniotilta varia)



AMERICAN REDSTART(Setophaga ruticilla)

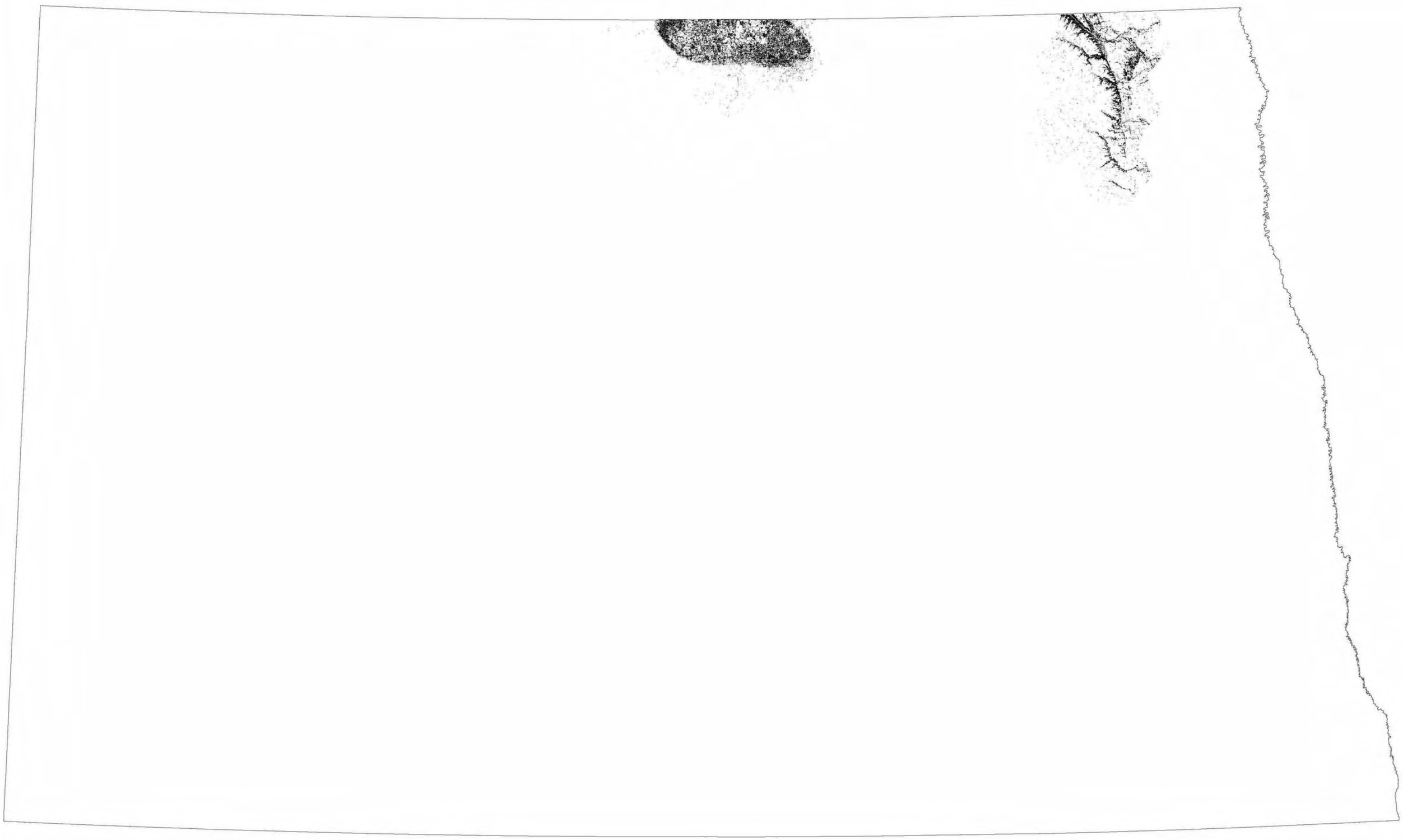


OVENBIRD(Seiurus aurocapillus)

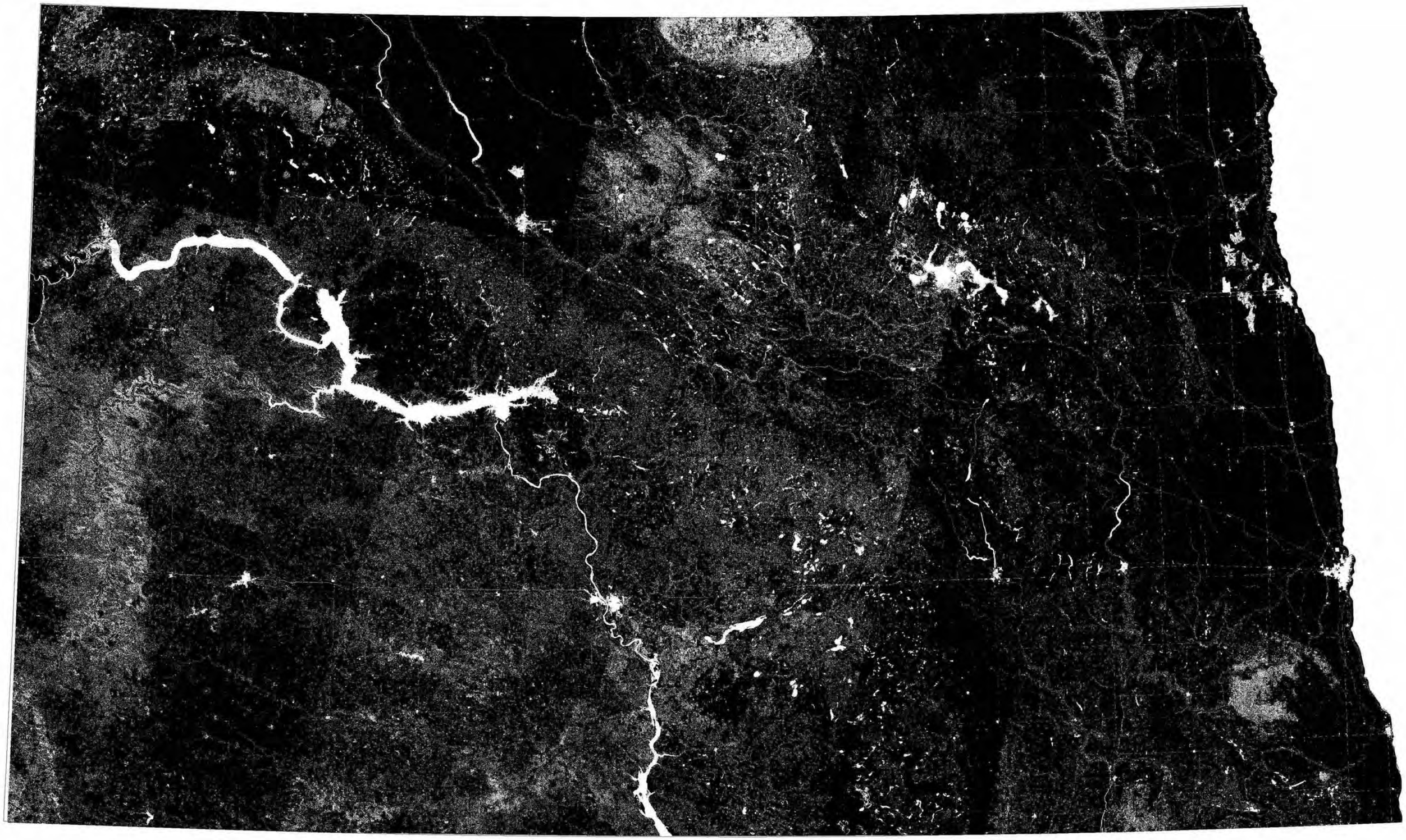


NORTHERN WATERTHRUSH(Seiurus noveboracensis)

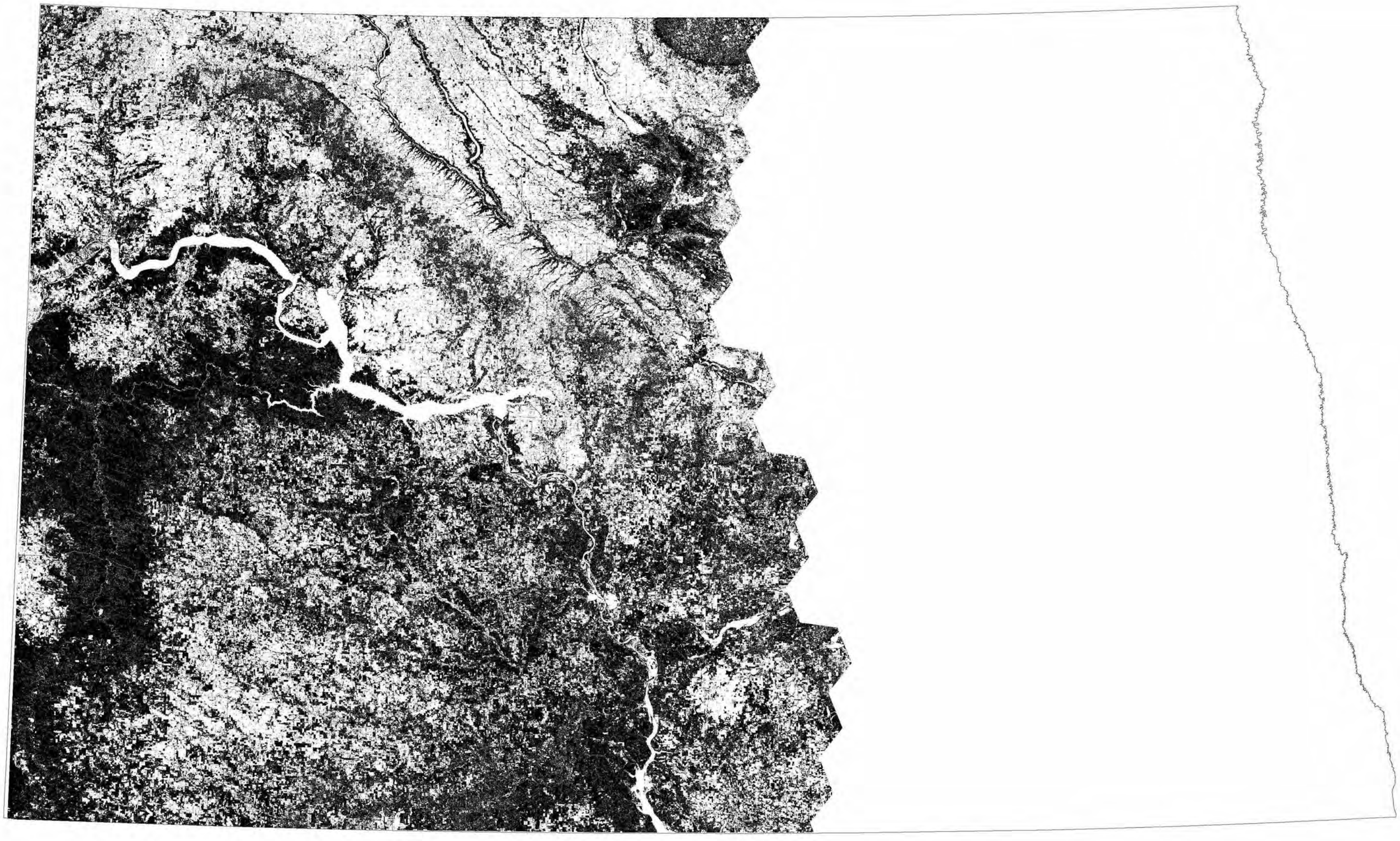
MOURNING WARBLER(Oporornis philadelphia)



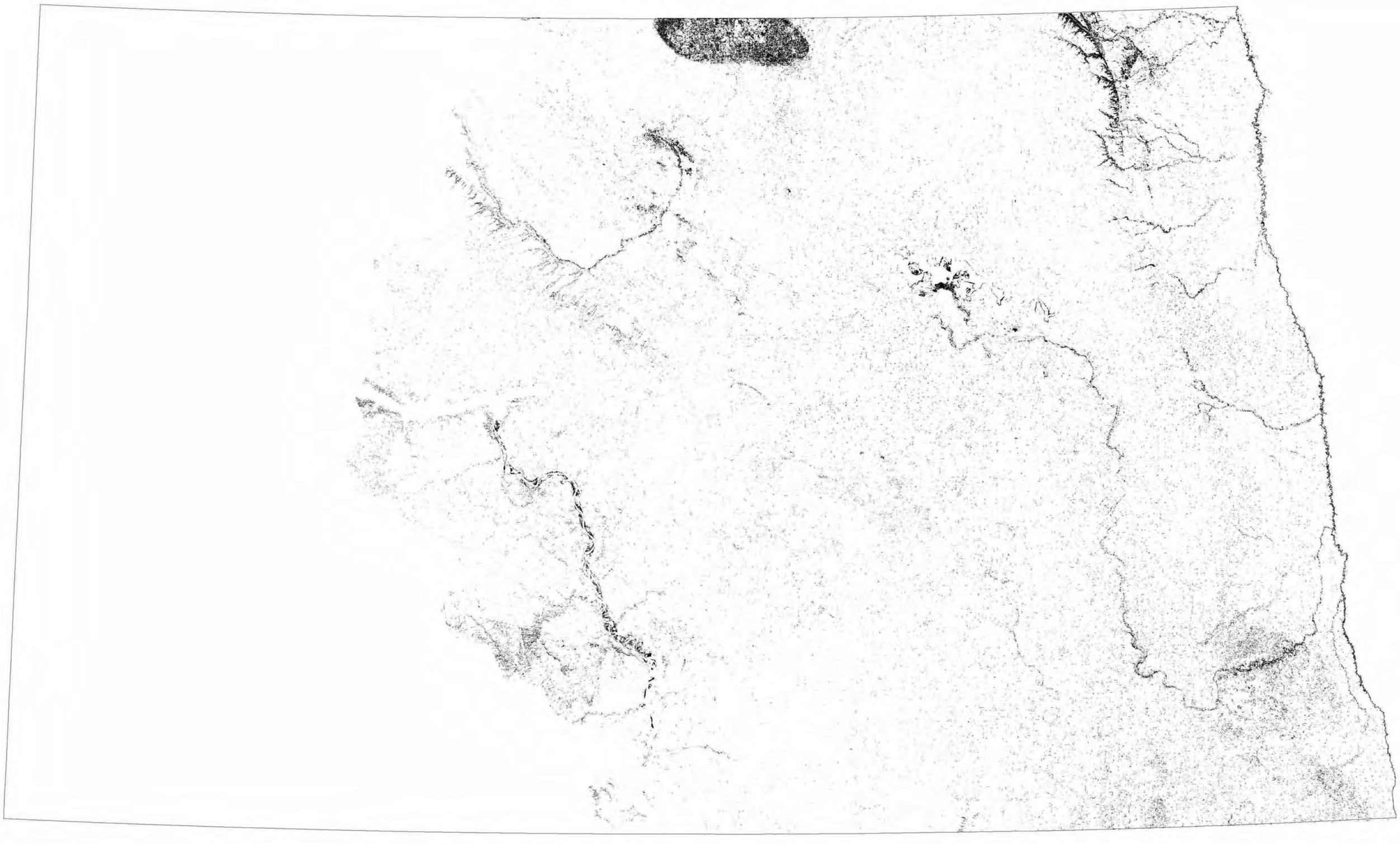
COMMON YELLOWTHROAT(Geothlypis trichas)



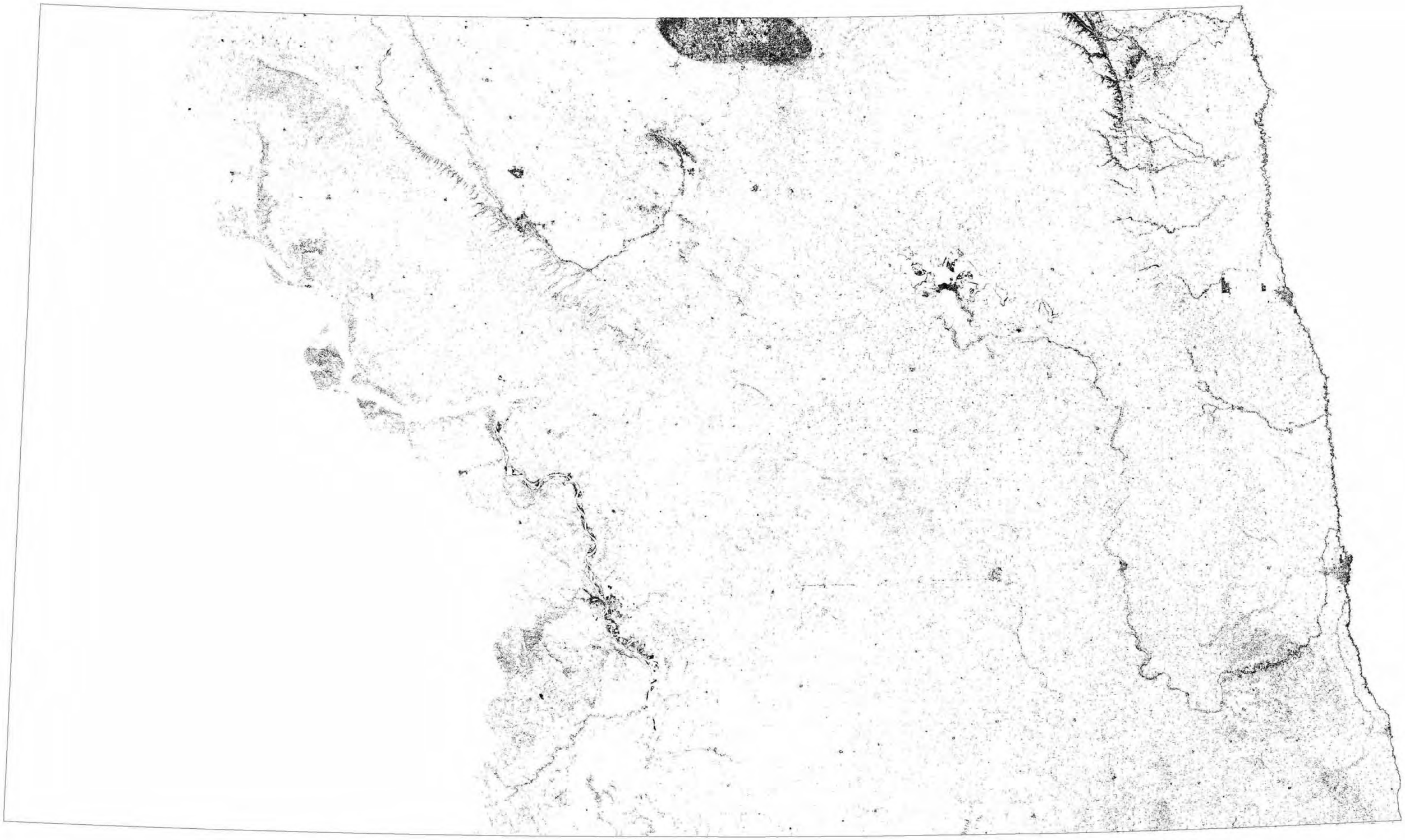
YELLOW-BREASTED CHAT(Icteria virens)



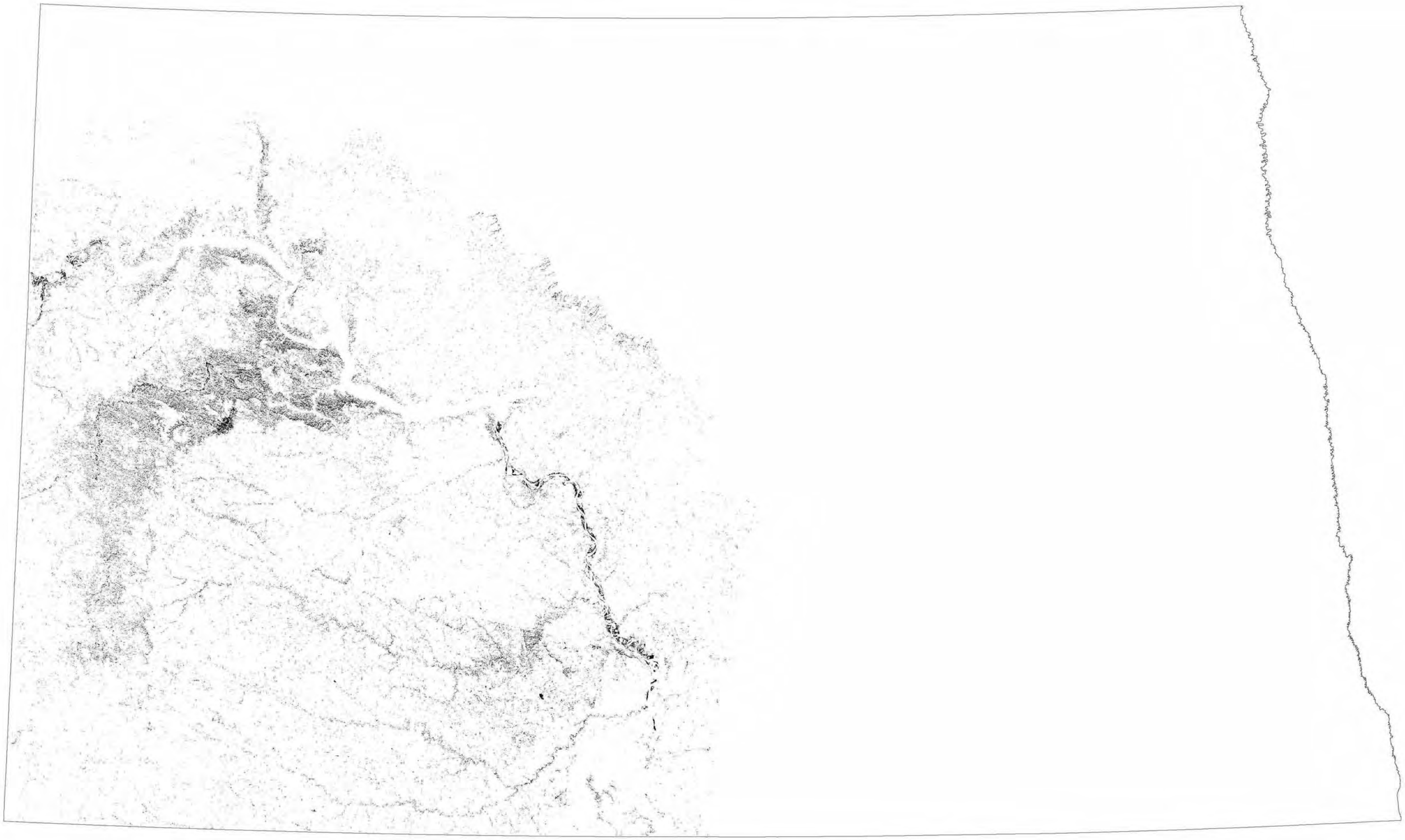
SCARLET TANAGER(Piranga olivacea)



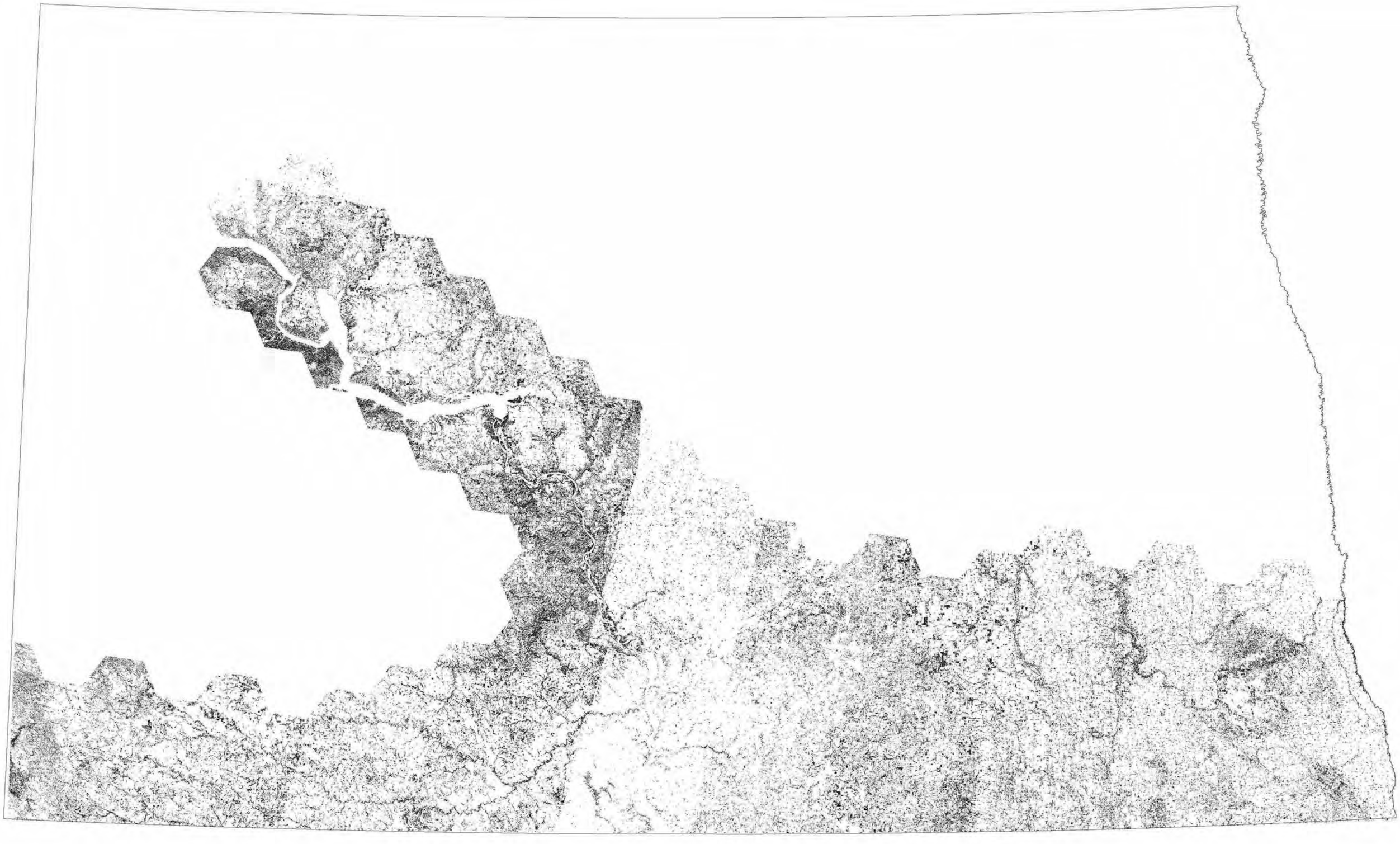
ROSE-BREASTED GROSBEAK(Pheucticus ludovicianus)



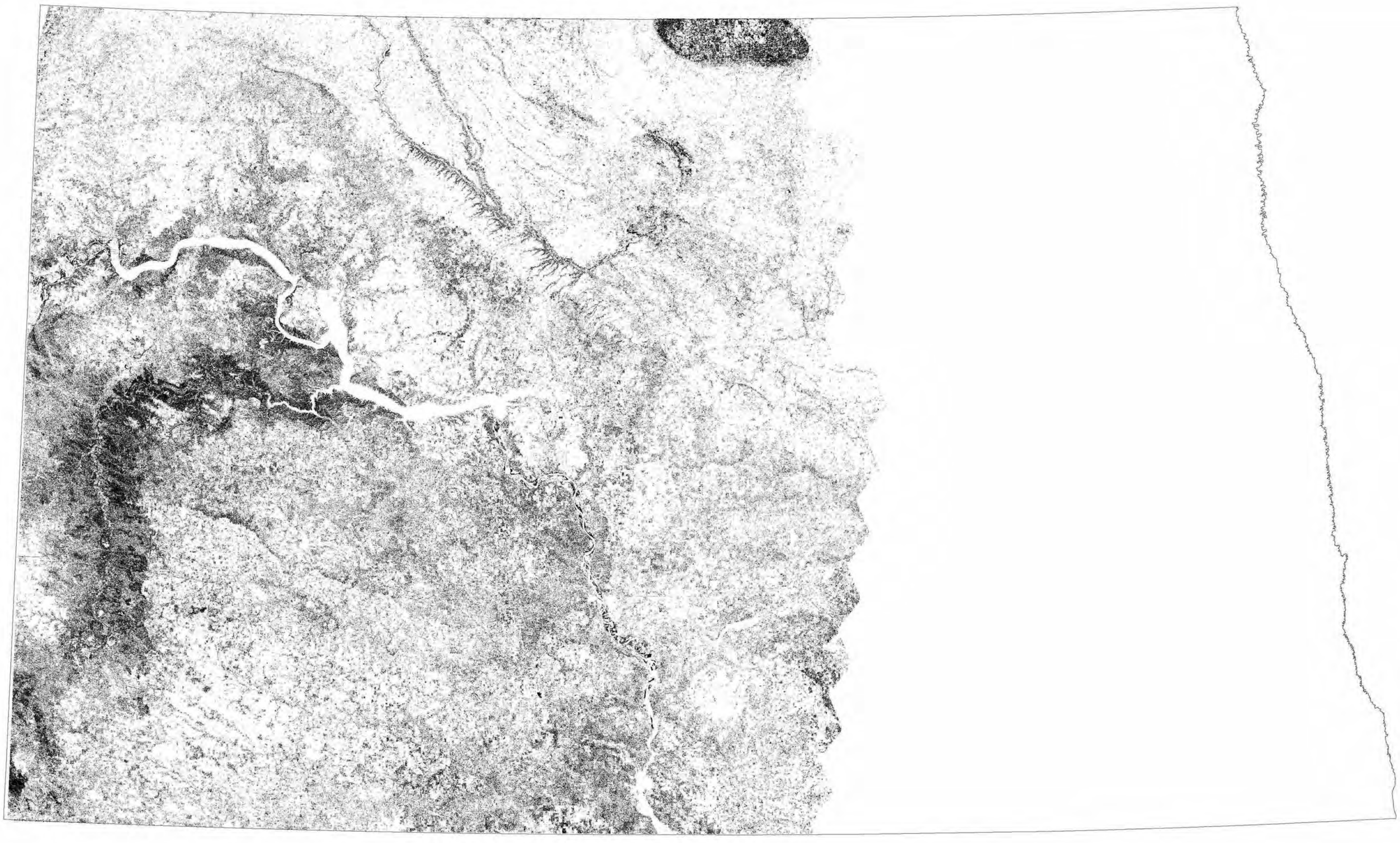
BLACK-HEADED GROSBEAK(Pheucticus melanocephalus



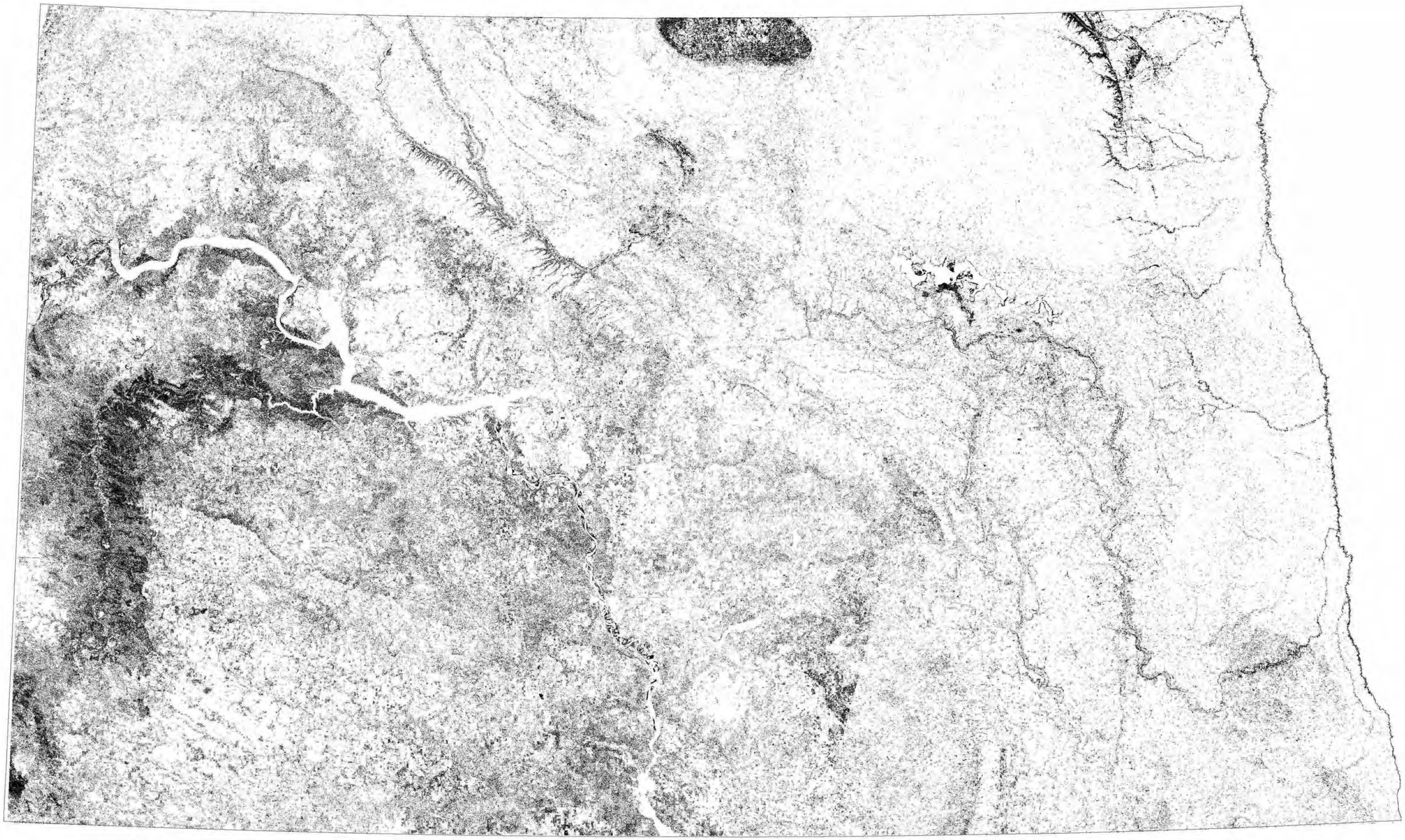
BLUE GROSBEAK(Guiraca caerulea)



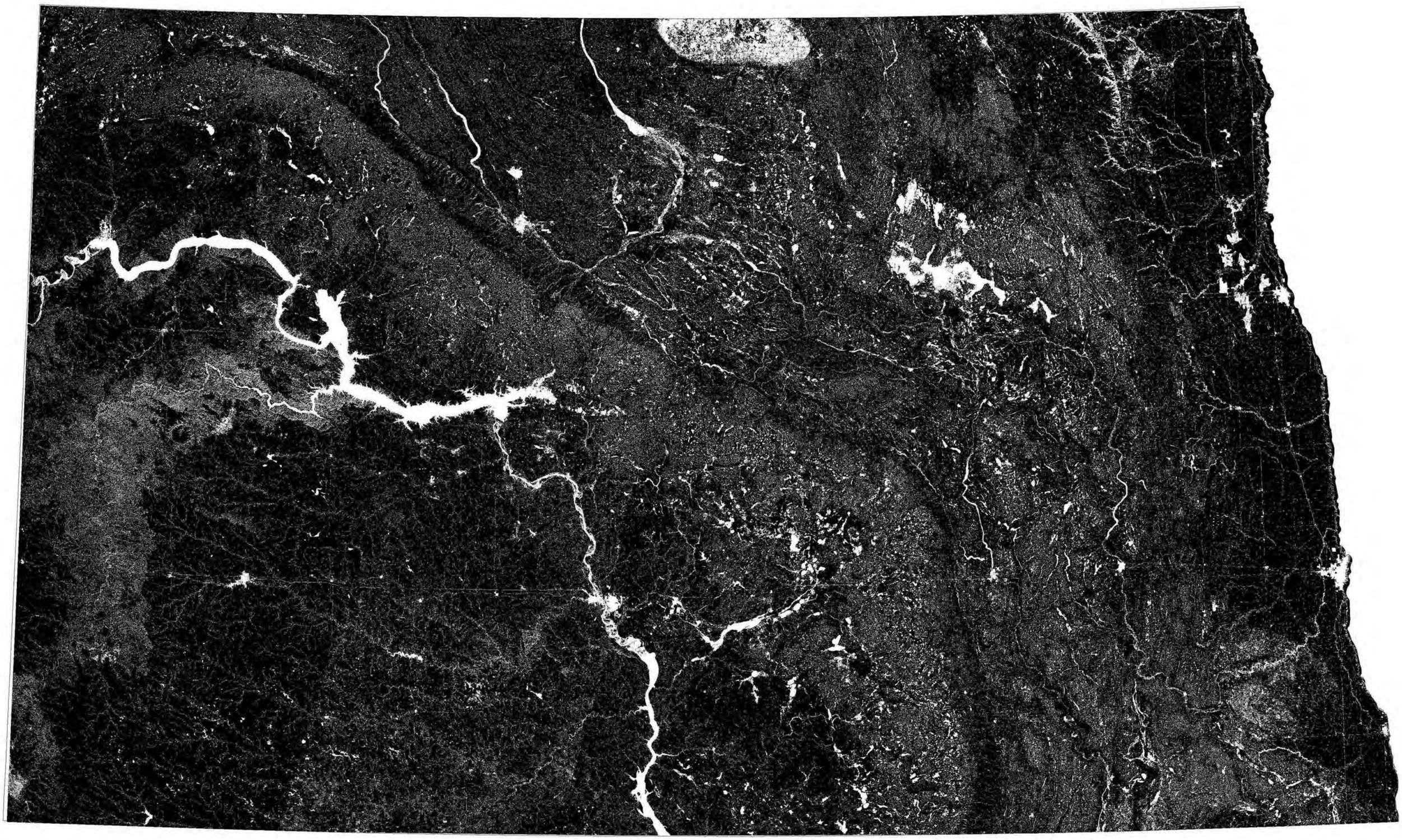
LAZULI BUNTING(Passerina amoena)



INDIGO BUNTING(Passerina cyanea)

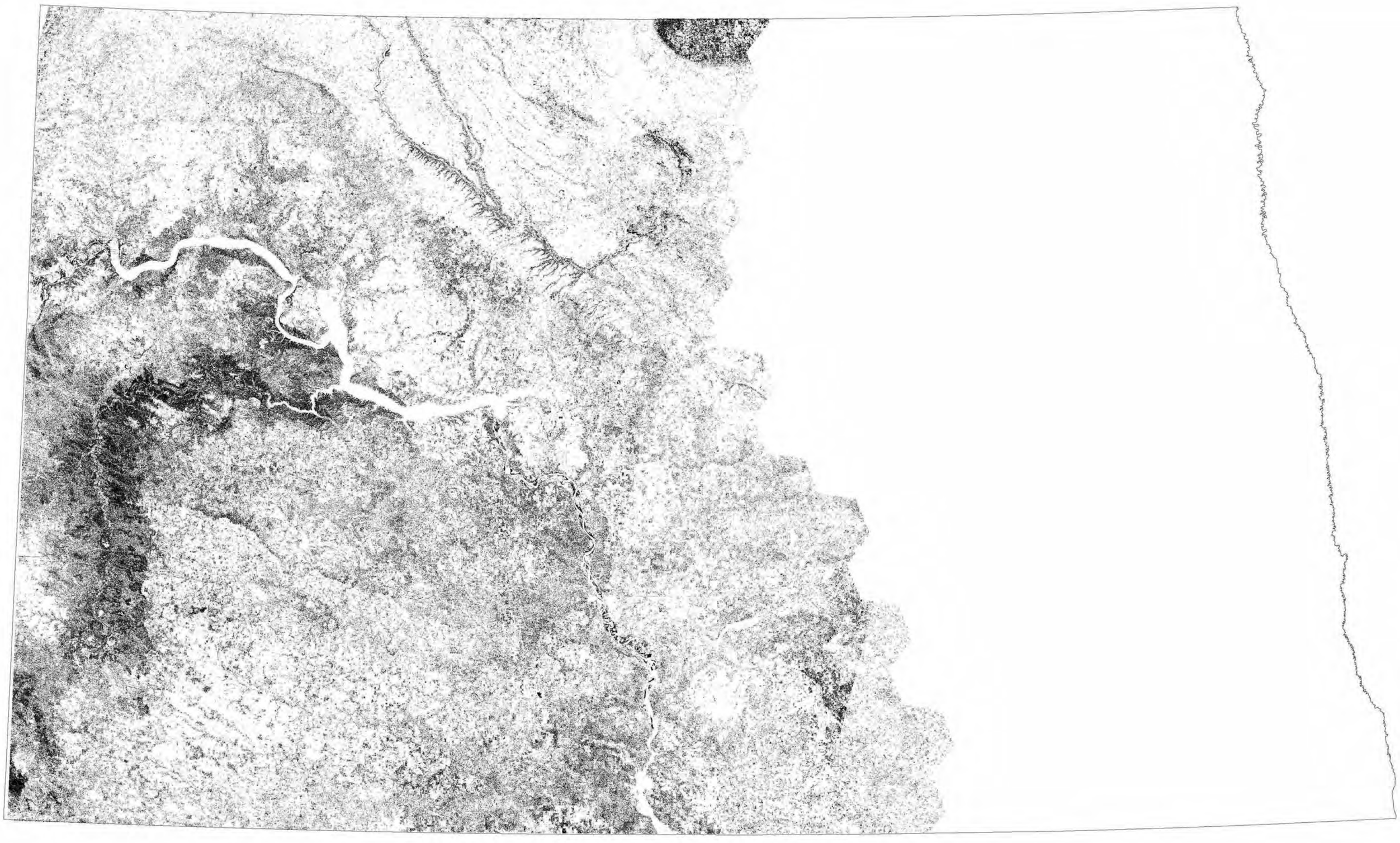


DICKCISSEL(Spiza americana)

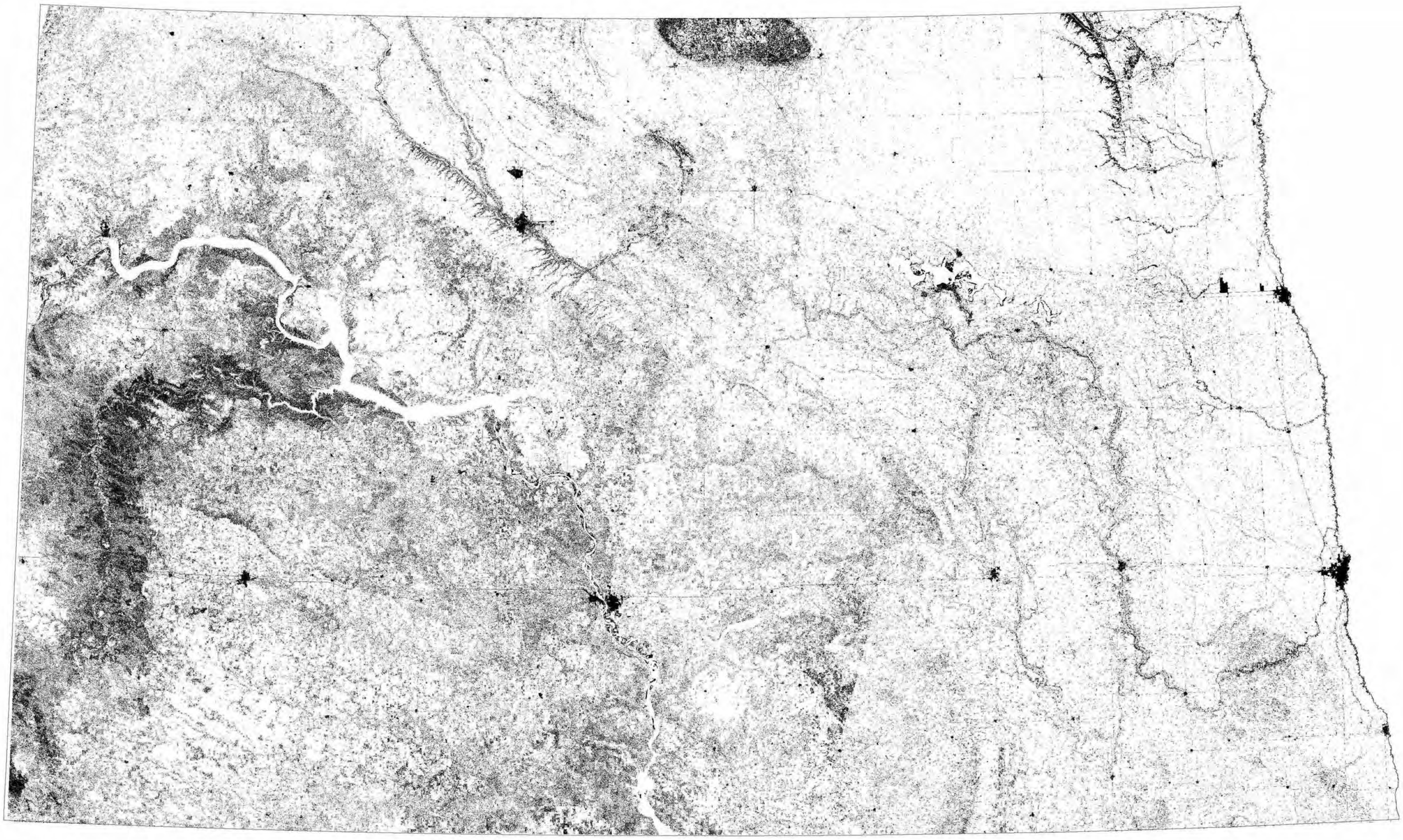


EASTERN TOWHEE(Pipilo erythrophthalmus)

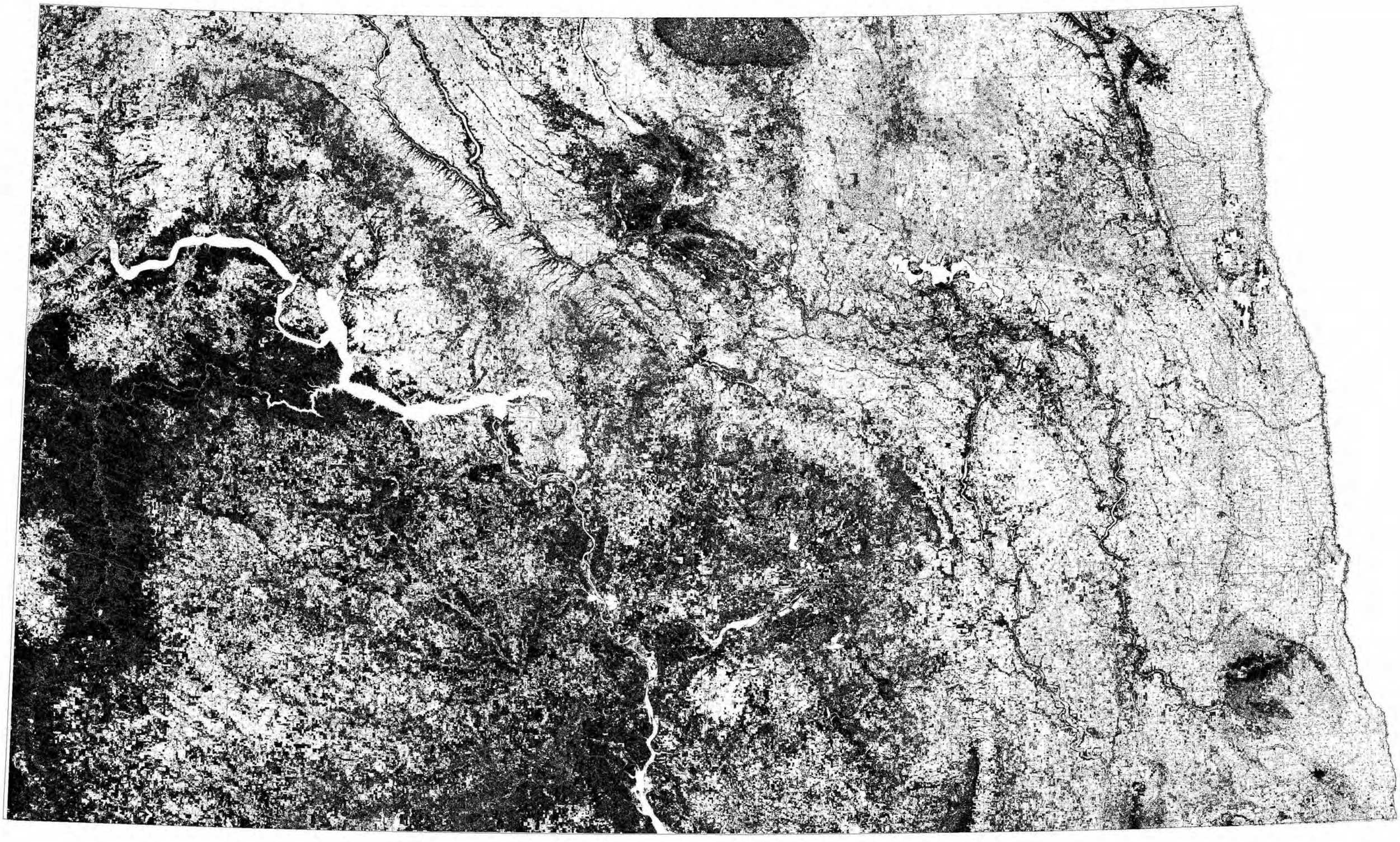
SPOTTED TOWHEE(Pipilo maculatus)



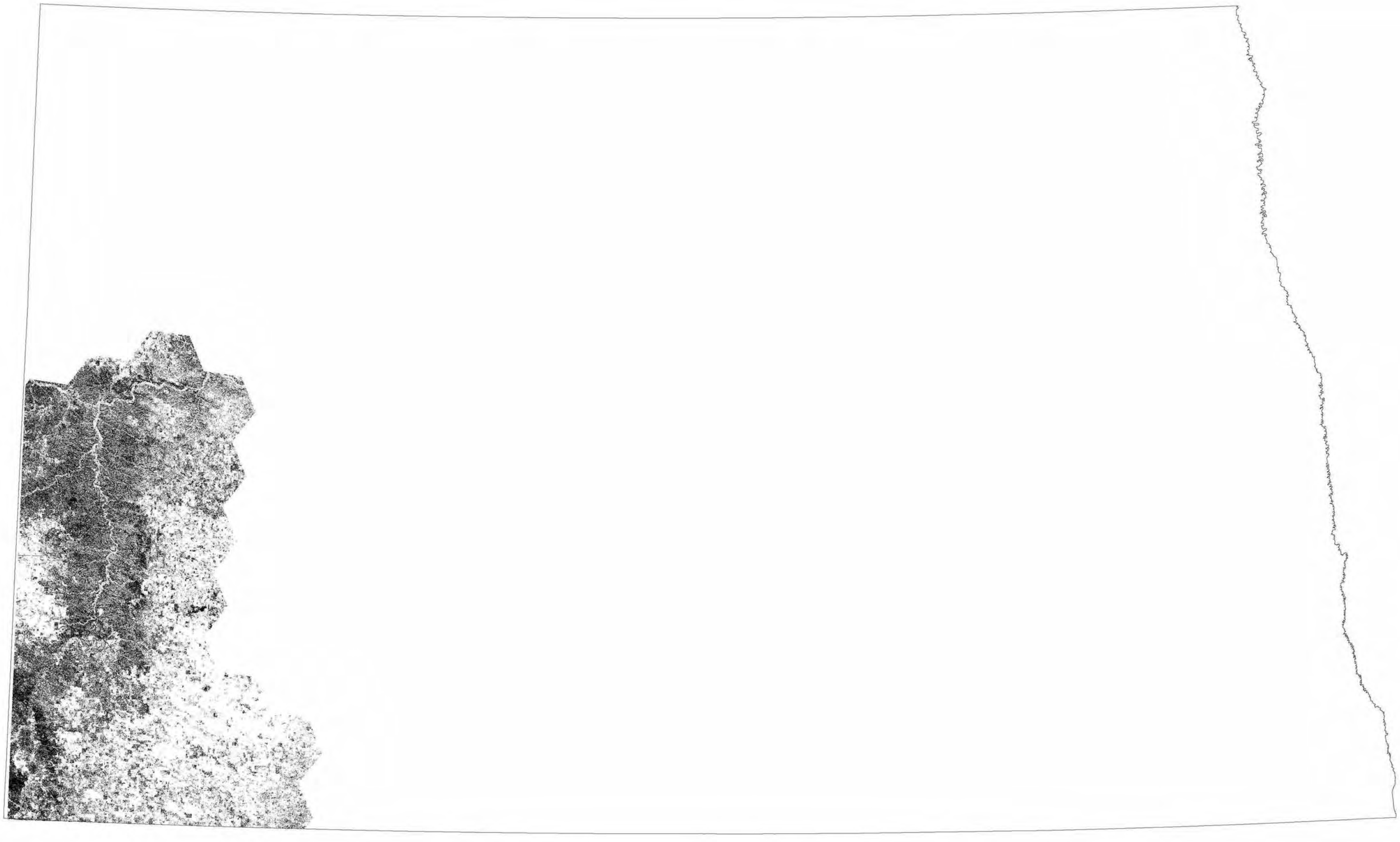
CHIPPING SPARROW(Spizella passerina)



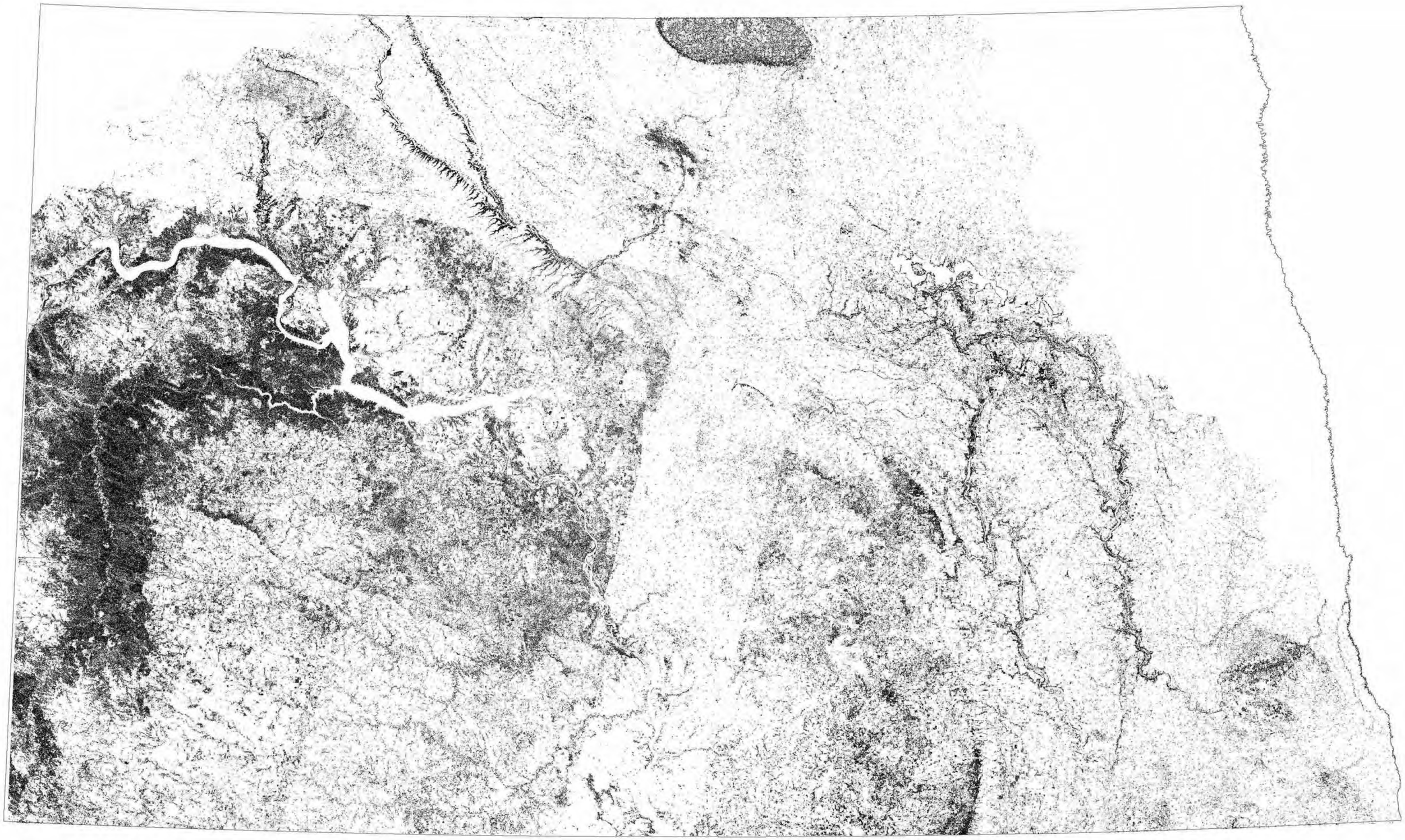
CLAY-COLORED SPARROW(Spizella pallida)



BREWER'S SPARROW(Spizella breweri)



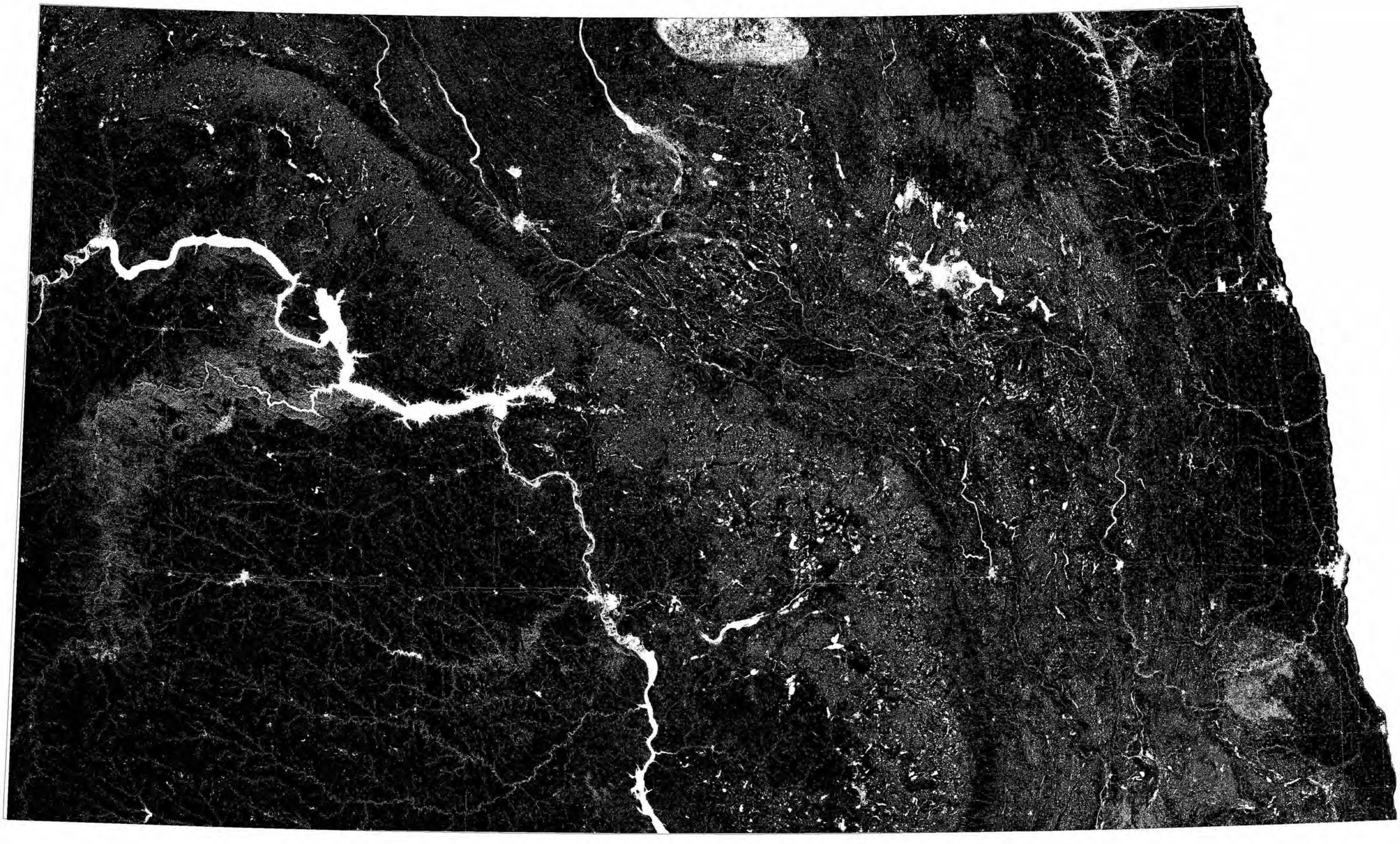
FIELD SPARROW(Spizella pusilla)



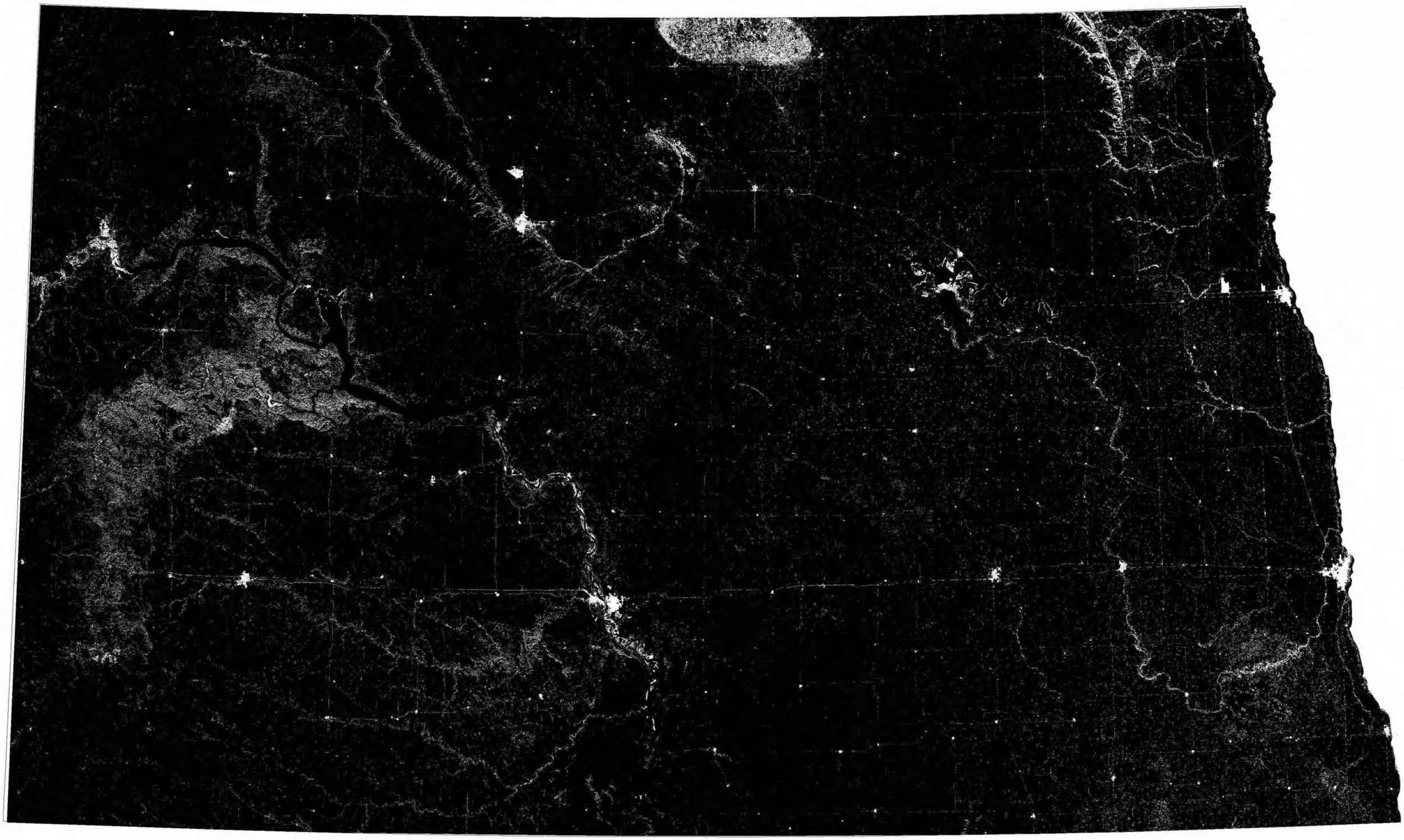
VESPER SPARROW(Pooecetes gramineus)

LARK SPARROW(Chondestes grammacus)

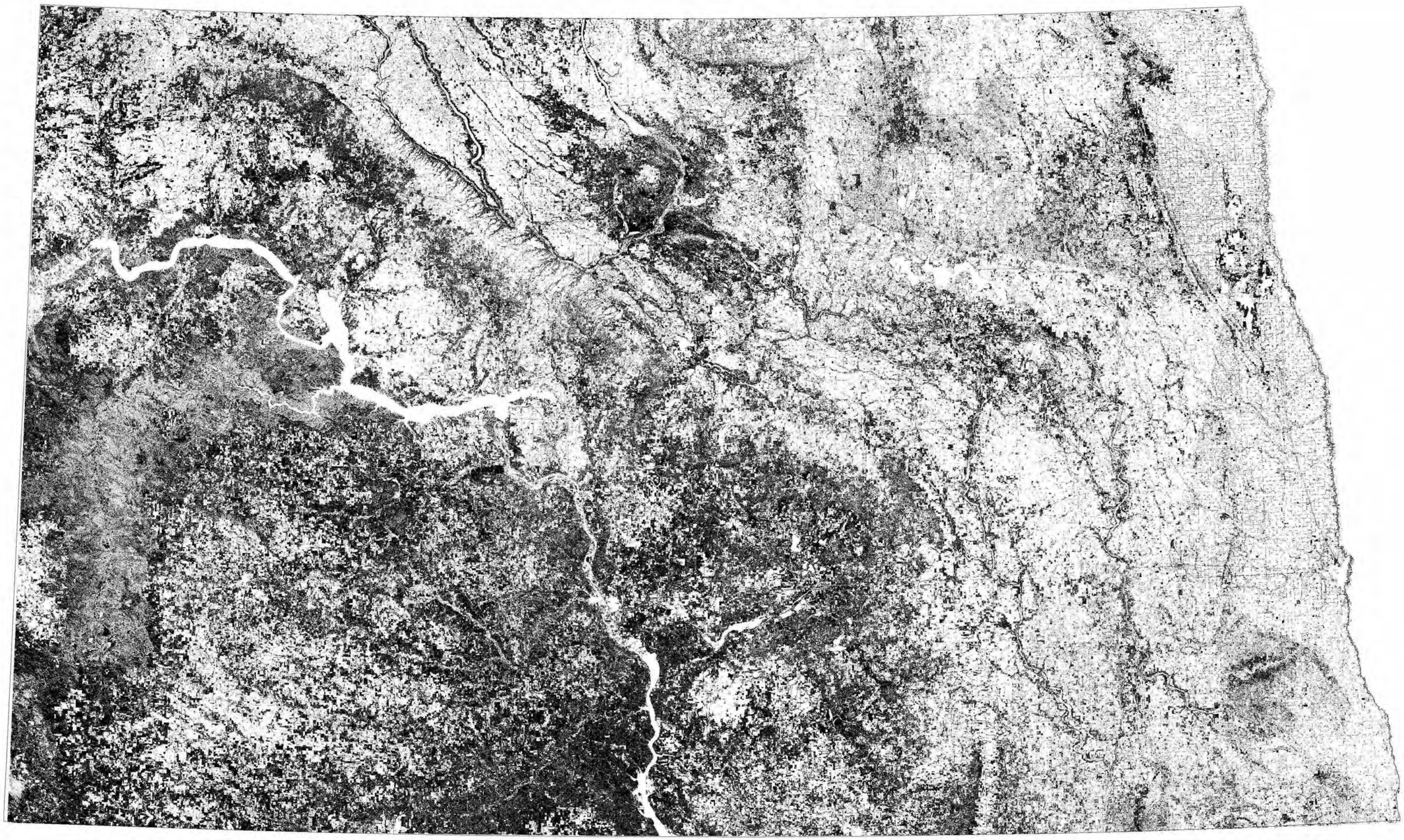
LARK BUNTING(Calamospiza melanocorys)



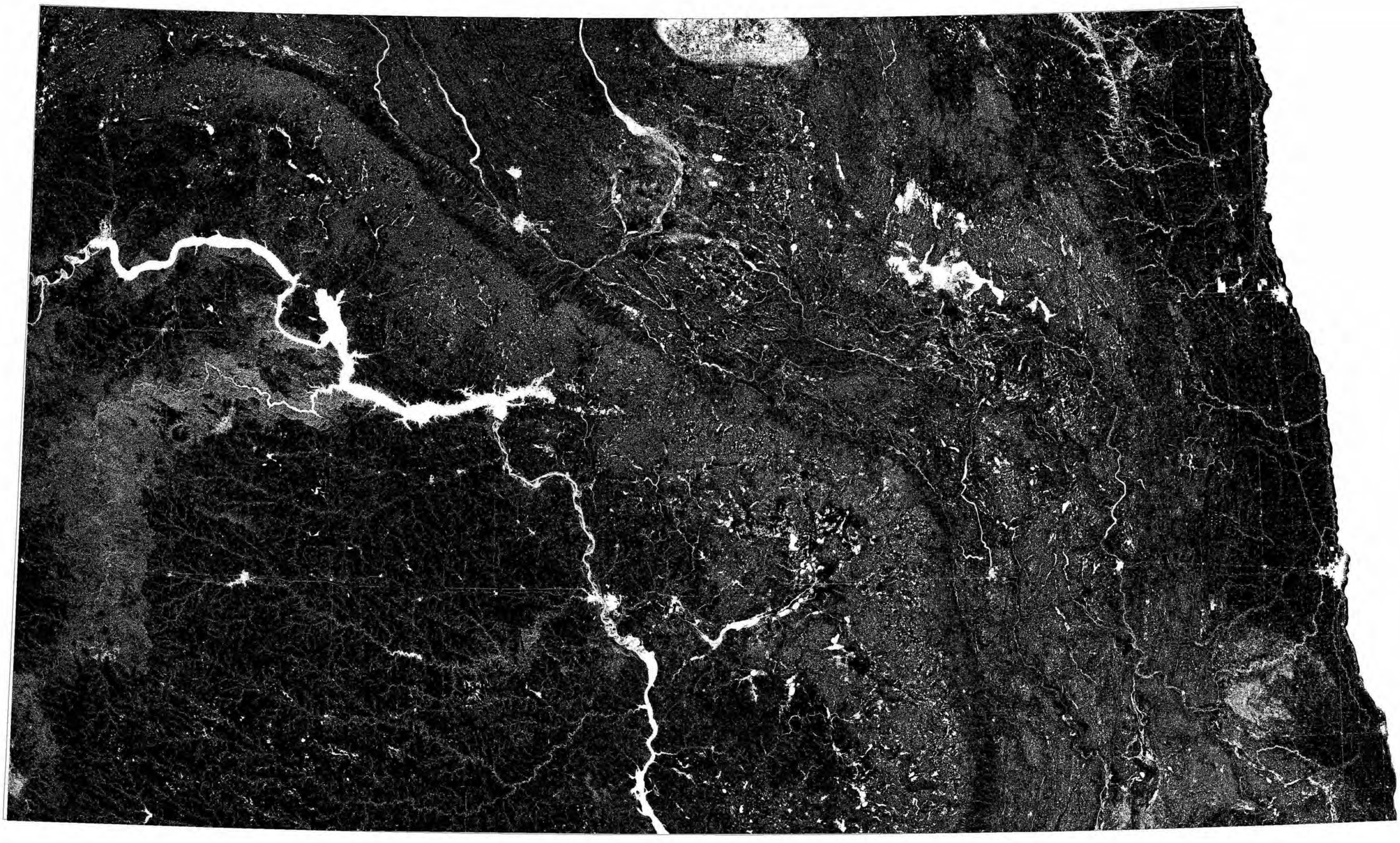
SAVANNAH SPARROW(Passerculus sandwichensis)



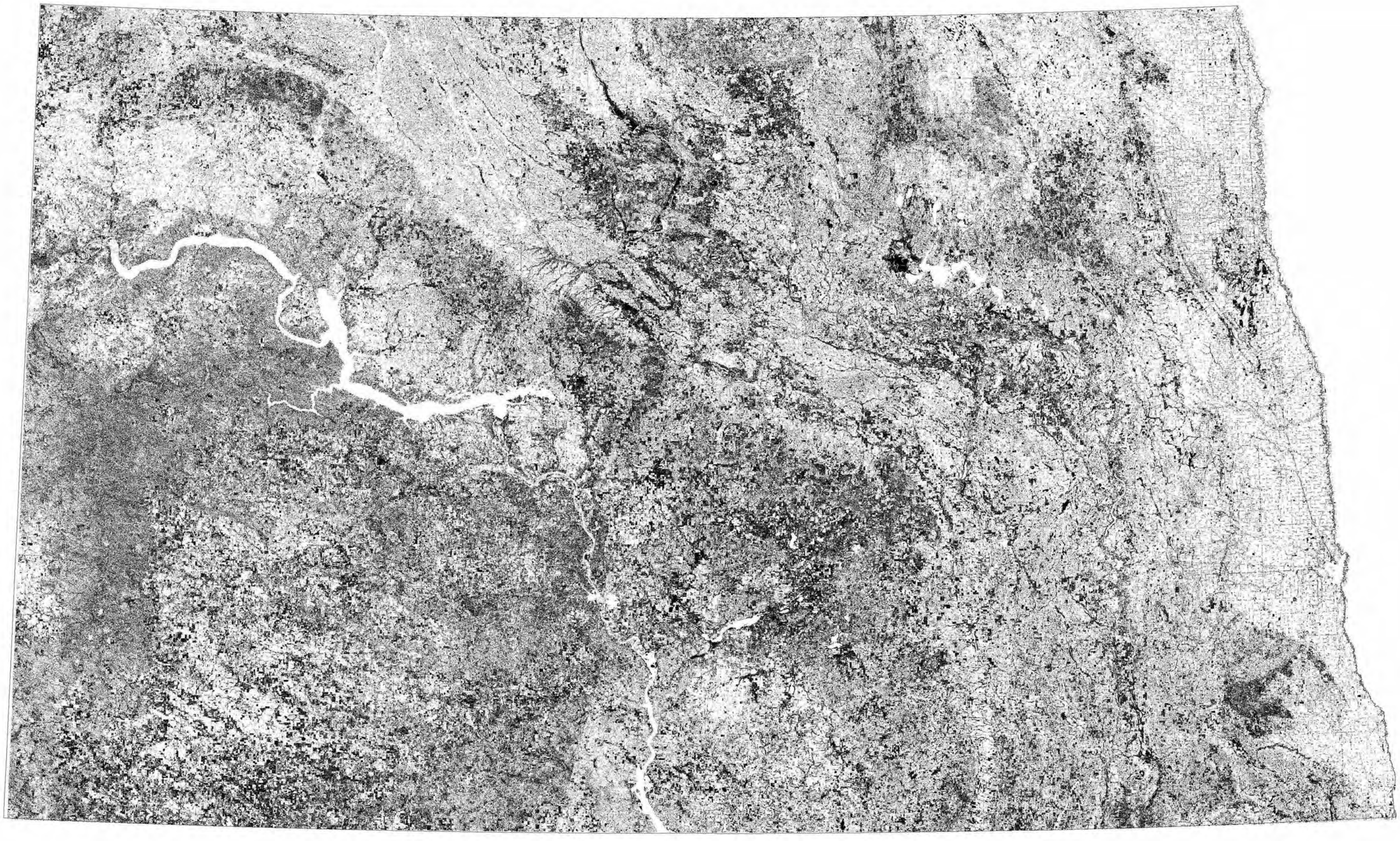
BAIRD'S SPARROW(Ammodramus bairdii)



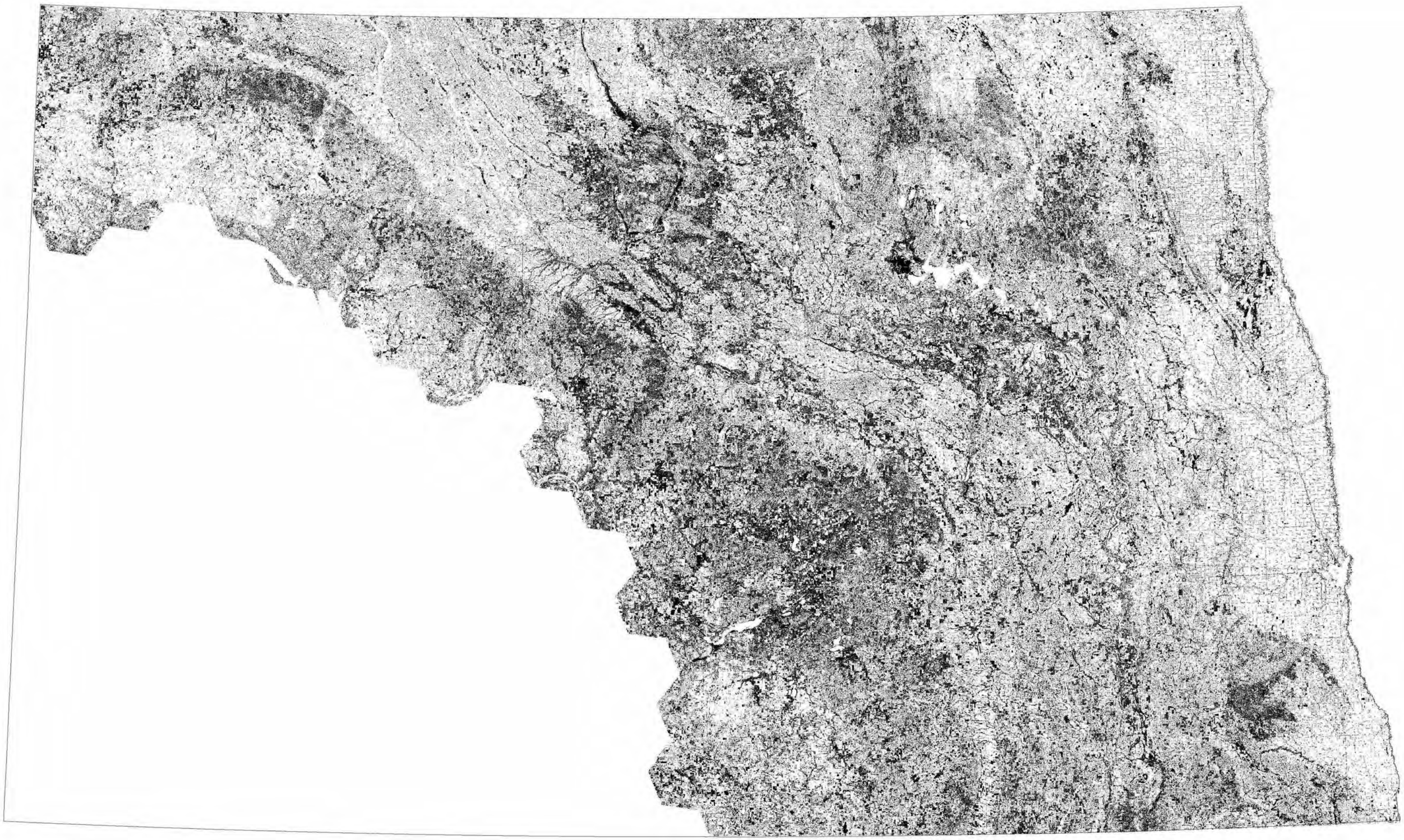
GRASSHOPPER SPARROW(Ammodramus savannarum)



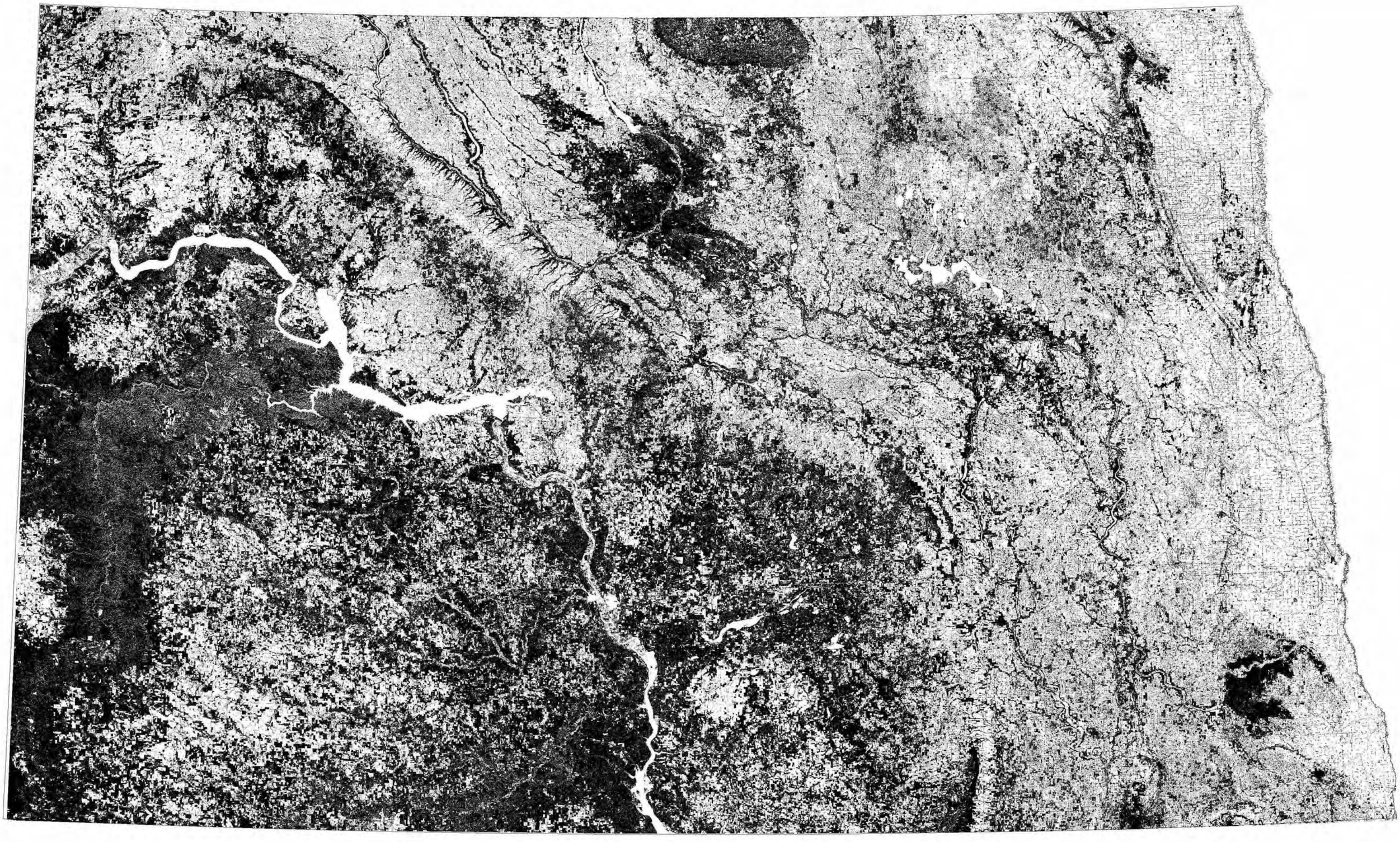
LE CONTE'S SPARROW(Ammodramus leconteii)



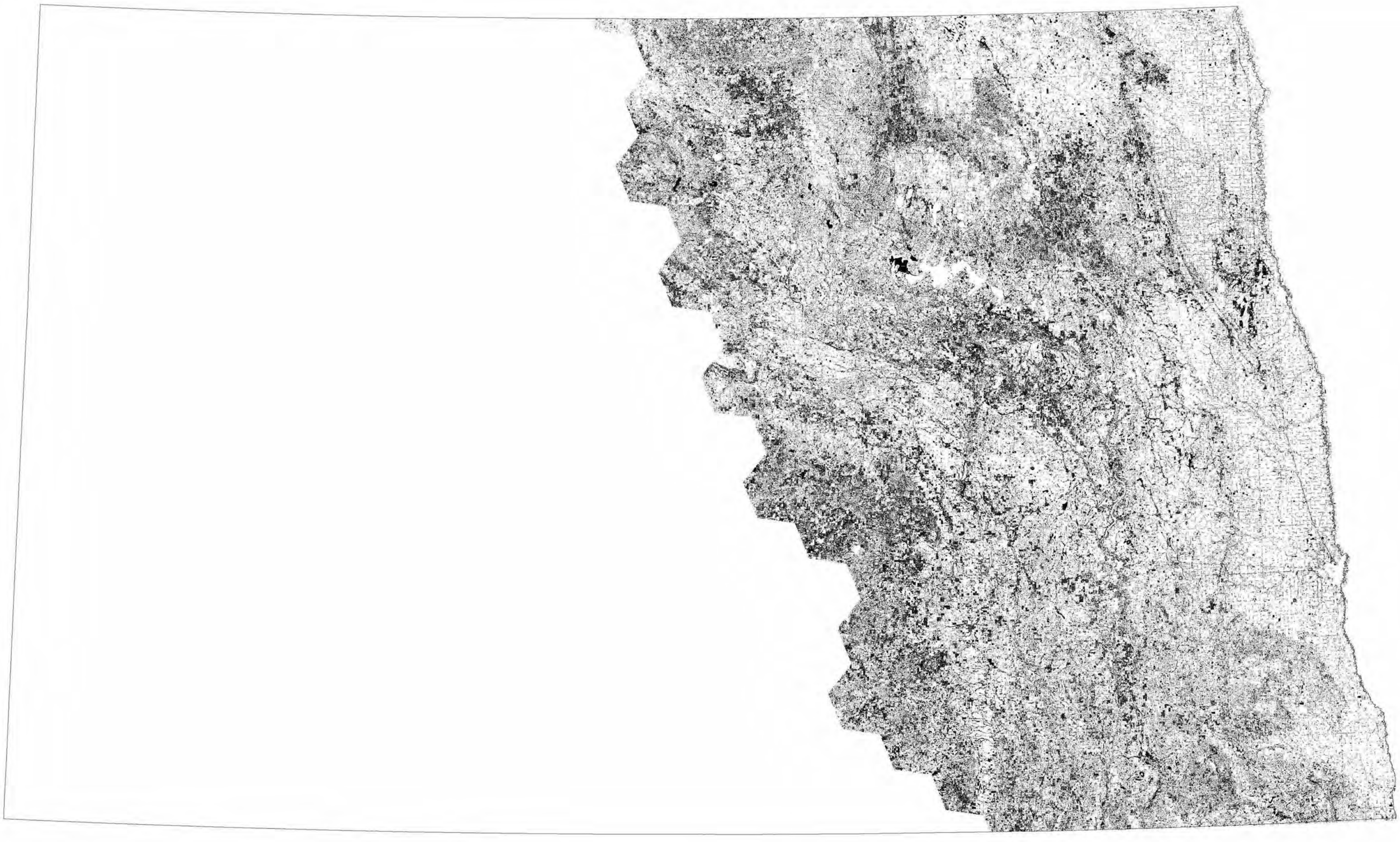
NELSON'S SHARP-TAILED SPARROW(Ammodramus nels



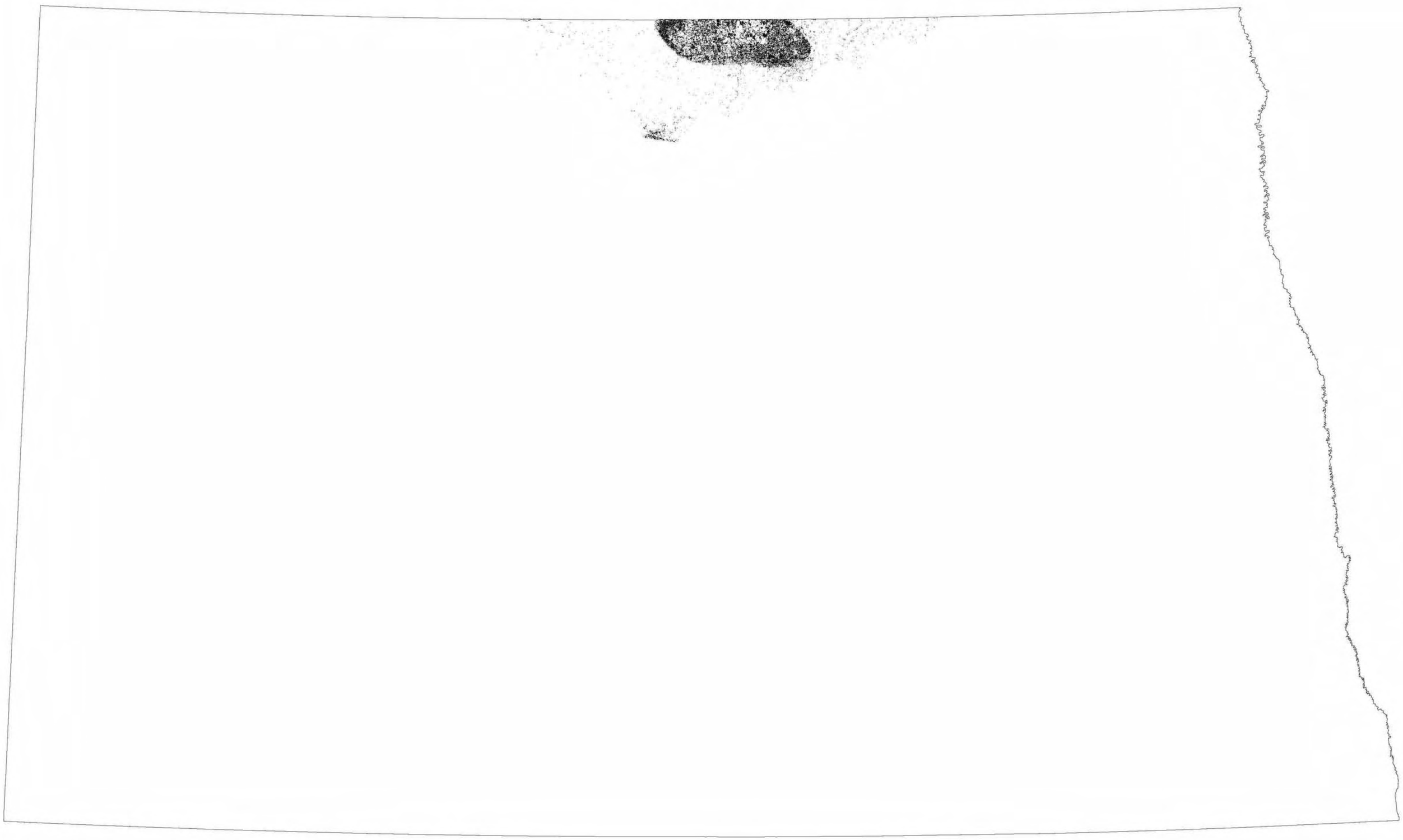
SONG SPARROW(Melospiza melodia)



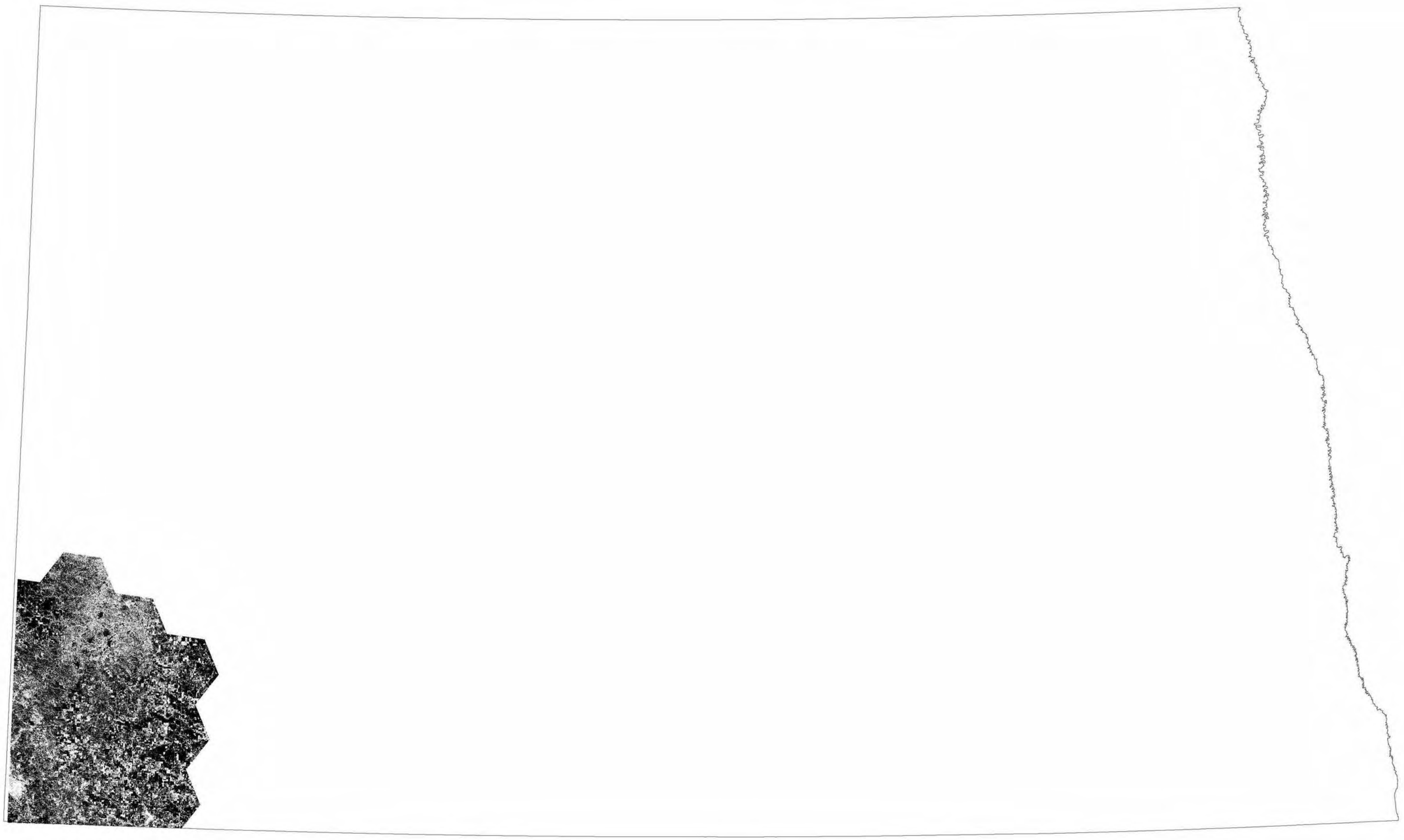
SWAMP SPARROW(Melospiza georgiana)



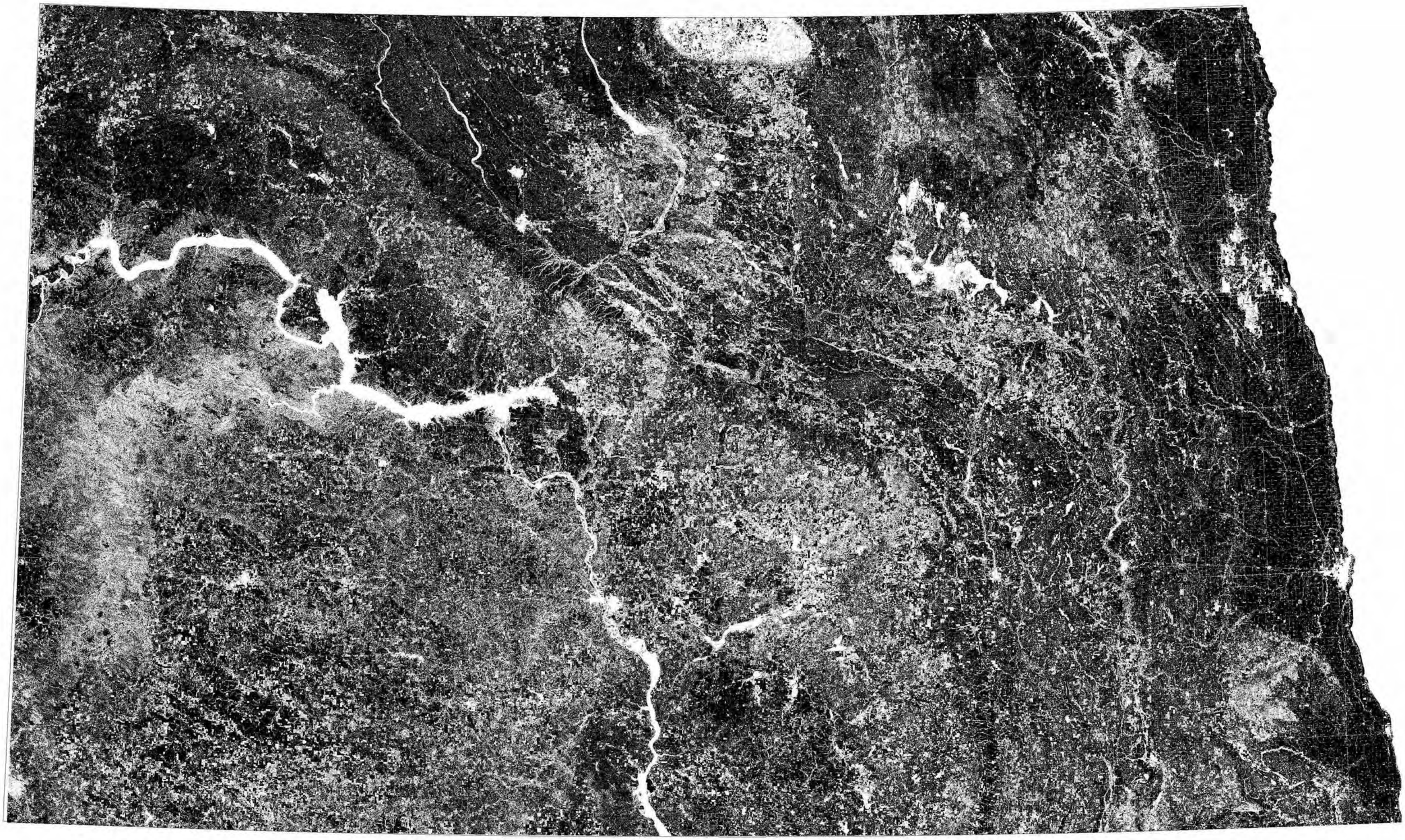
WHITE-THROATED SPARROW(Zonotrichia albicollis)



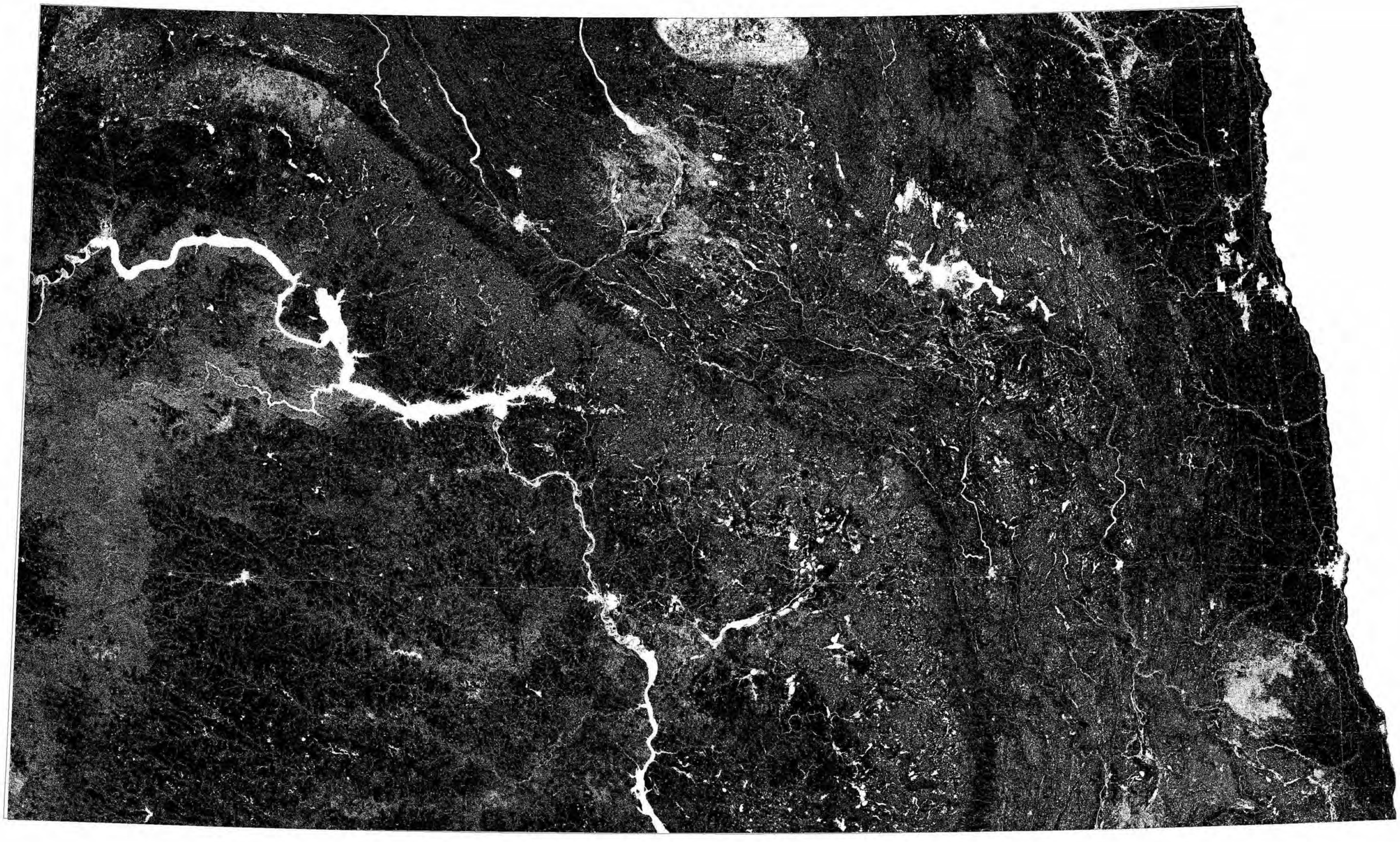
MCCOWN'S LONGSPUR(Calcarius mccownii)



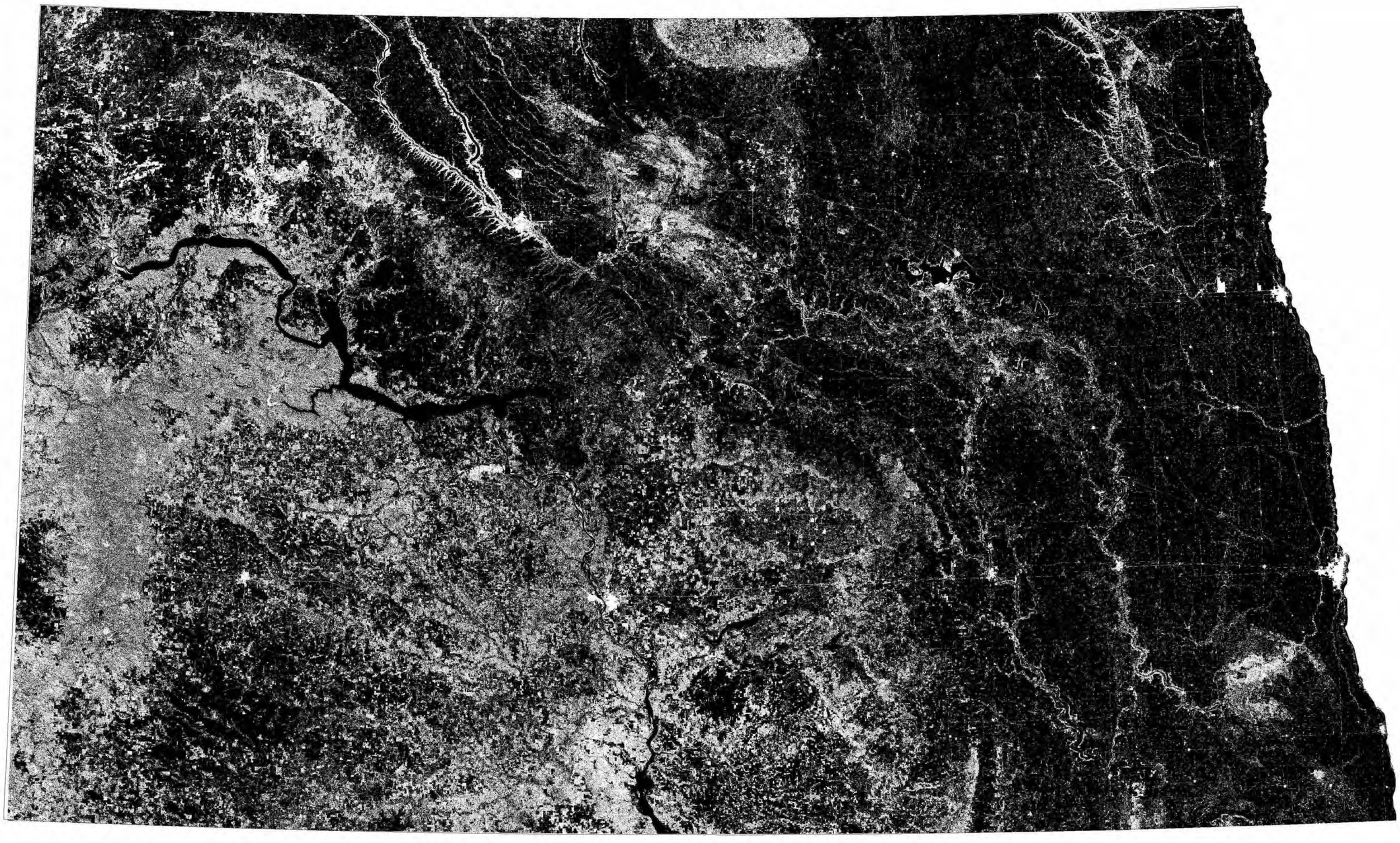
CHESTNUT-COLLARED LONGSPUR(Calcarius ornatus)



BOBOLINK(Dolichonyx oryzivorus)

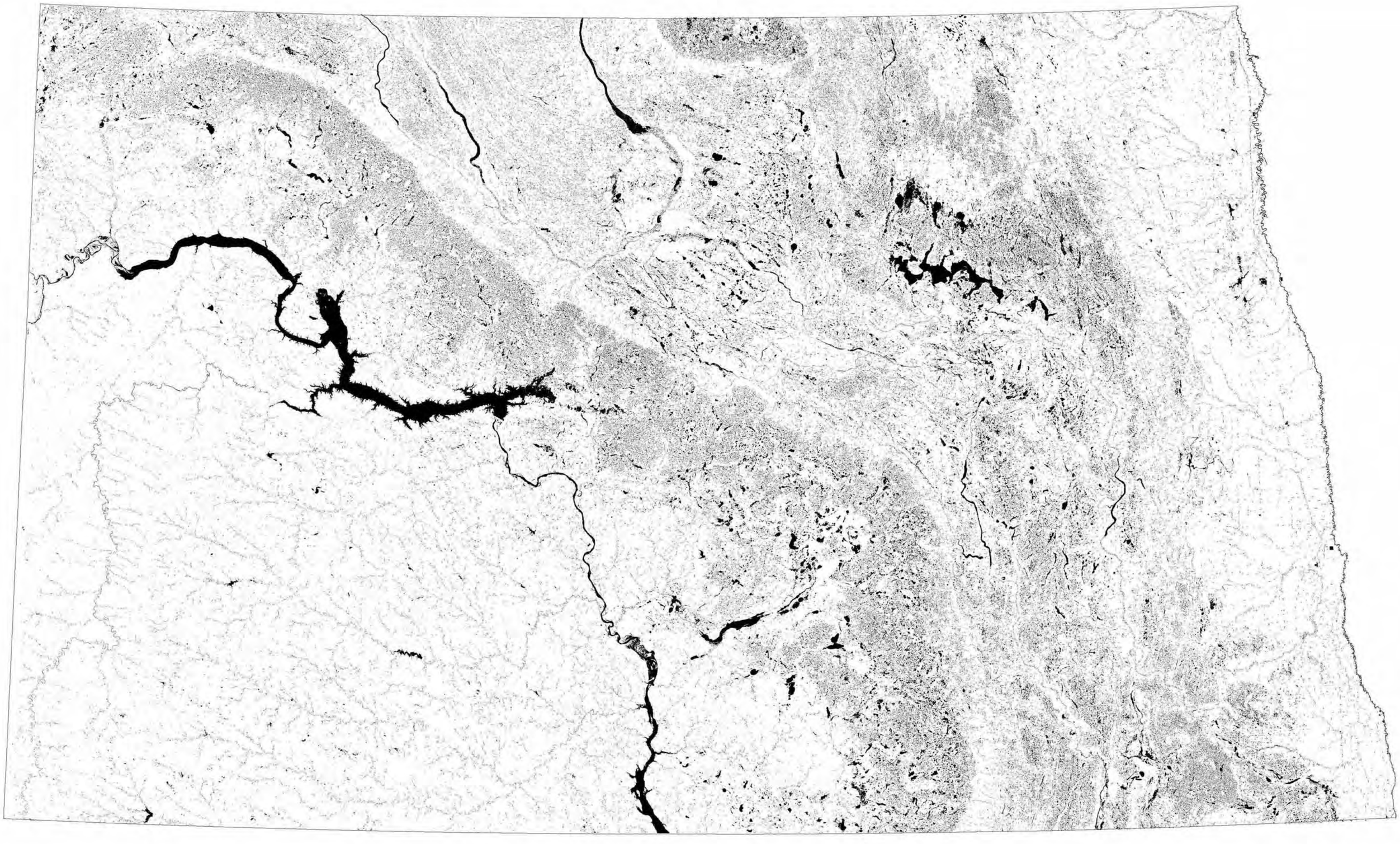


RED-WINGED BLACKBIRD(Agelaius phoeniceus)

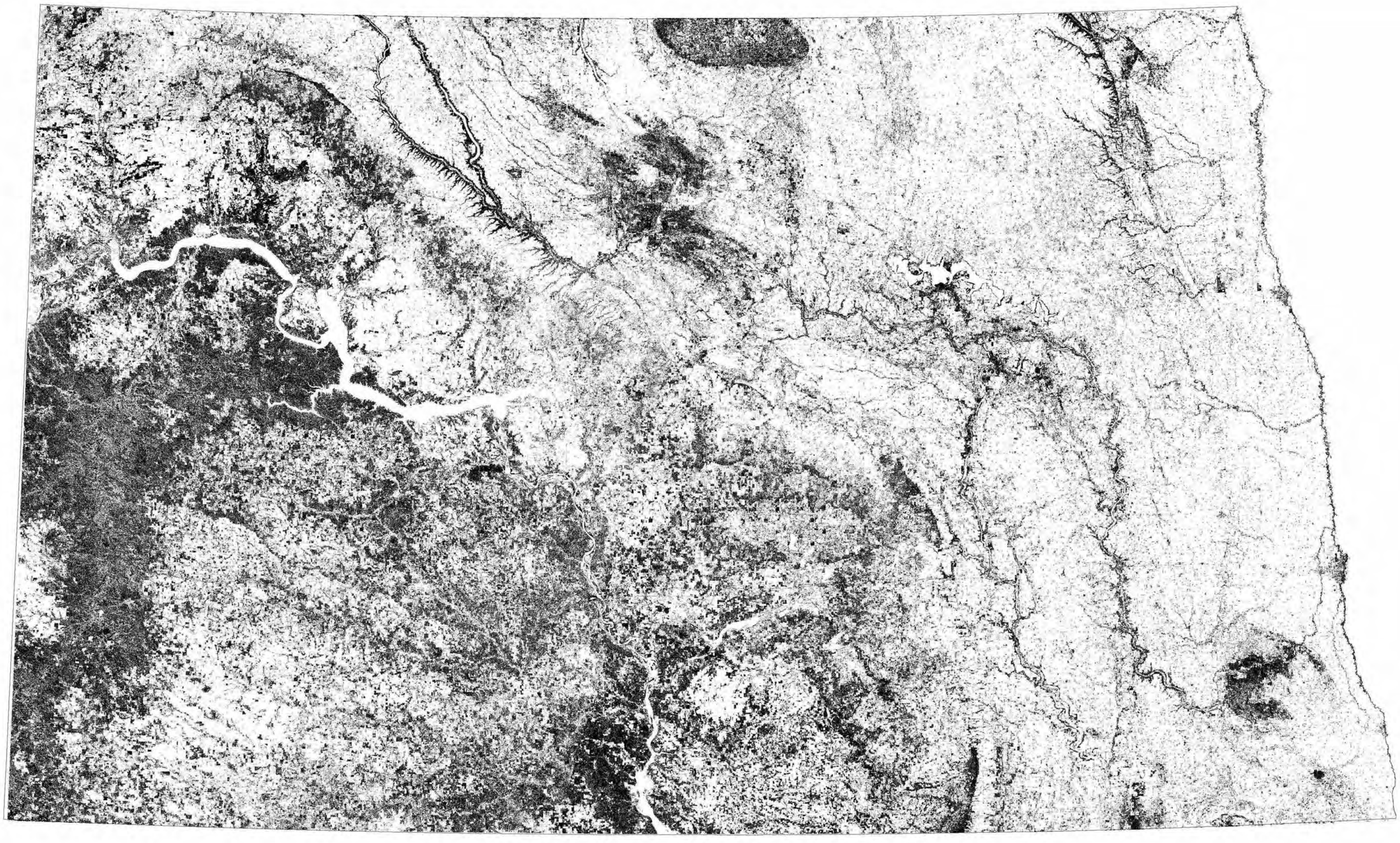


WESTERN MEADOWLARK(Sturnella neglecta)

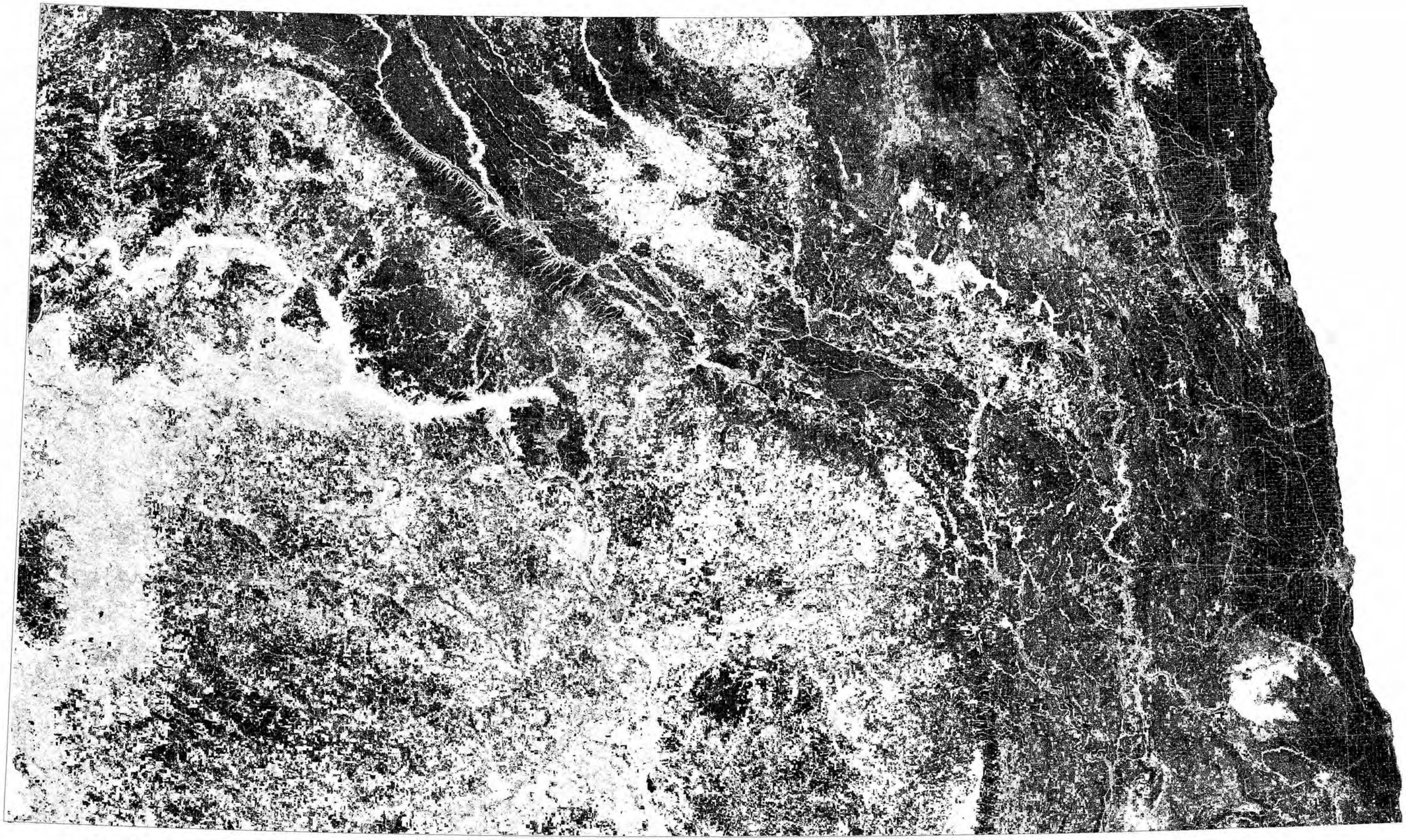
YELLOW-HEADED BLACKBIRD(Xanthocephalus xanthoce



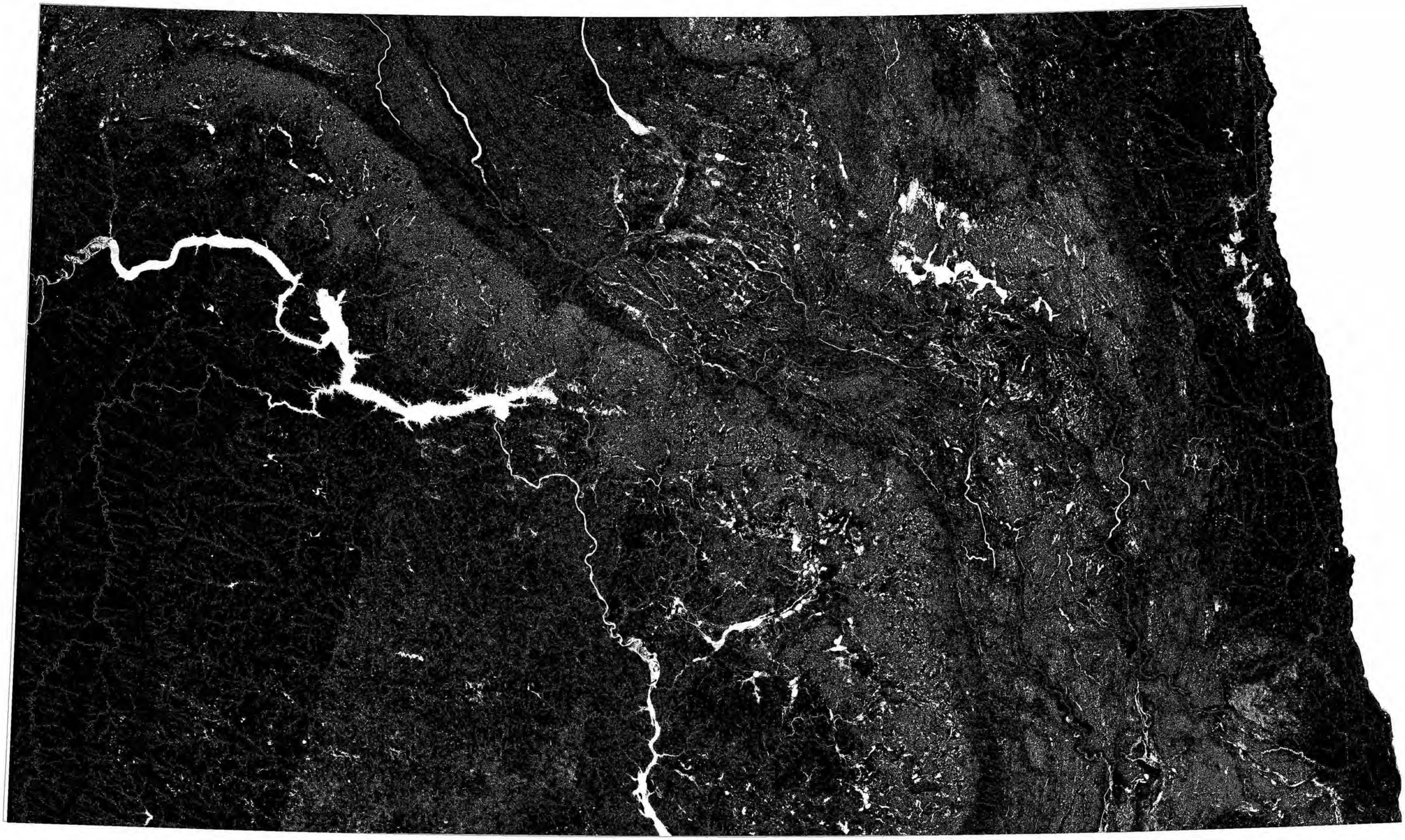
BREWER'S BLACKBIRD(Euphagus cyanocephalus)



COMMON GRACKLE(Quiscalus quiscula)

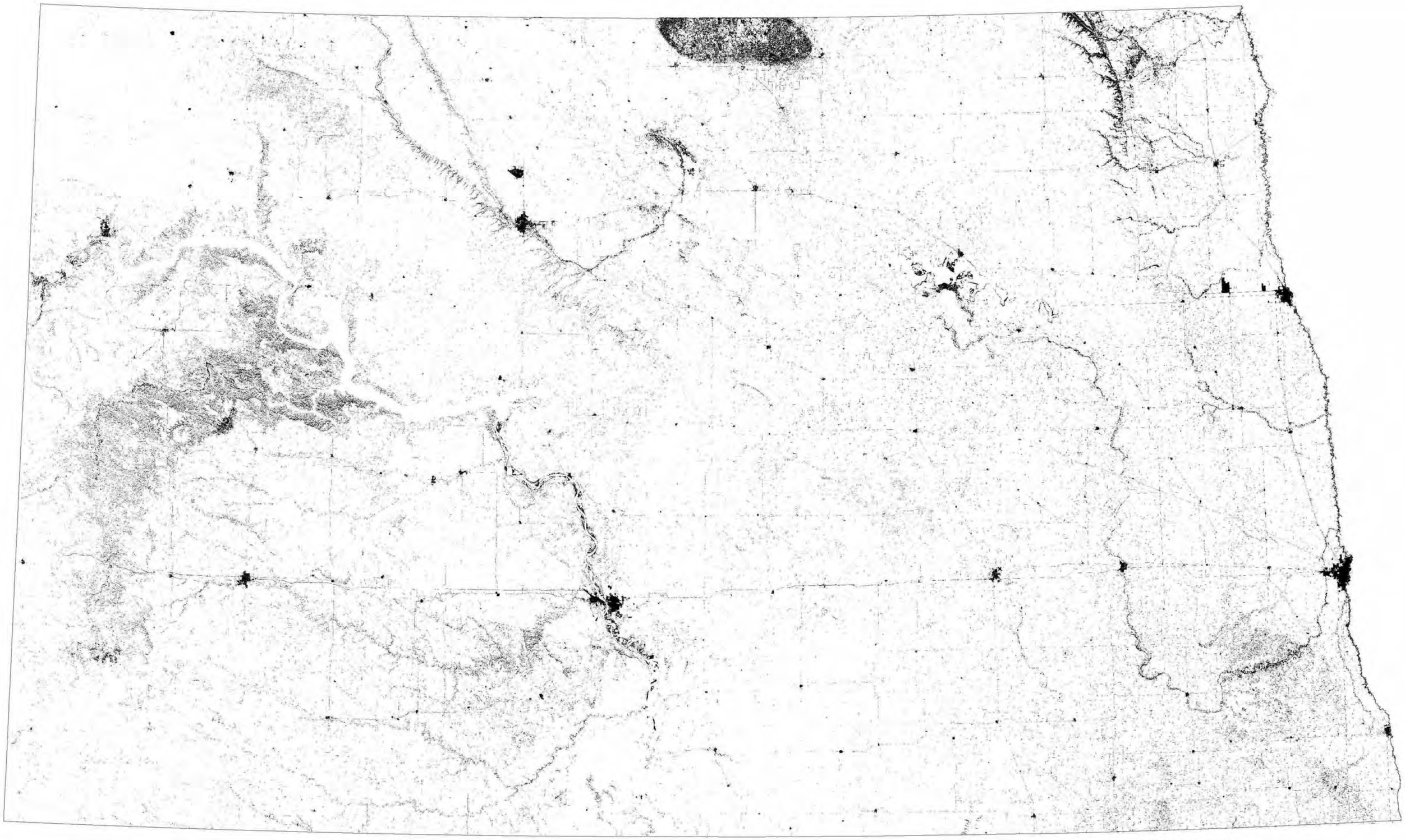


BROWN-HEADED COWBIRD(Molothrus ater)



ORCHARD ORIOLE(Icterus spurius)

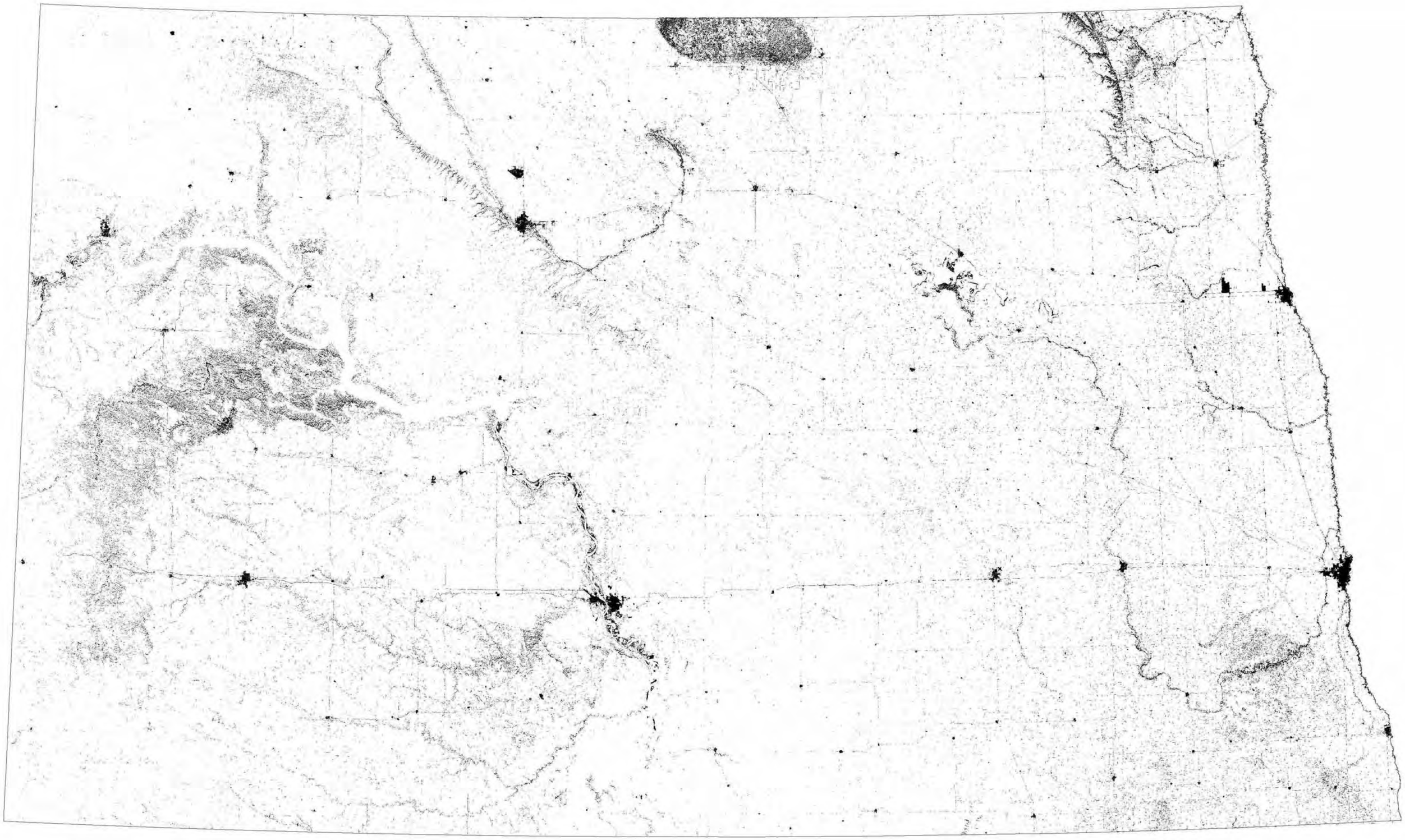
BALTIMORE ORIOLE(Icterus galbula)



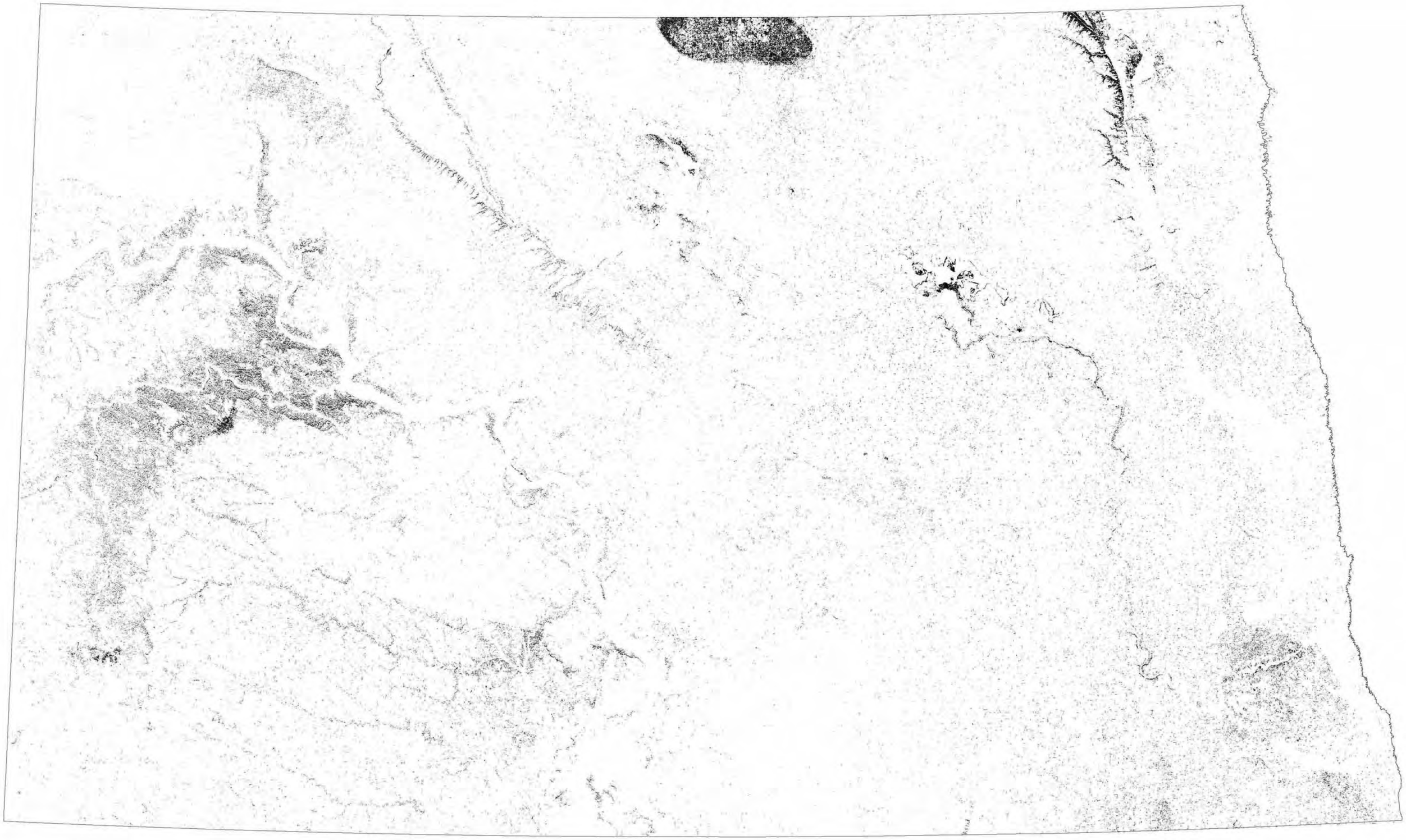
BULLOCK'S ORIOLE(Icterus bullockii)

PURPLE FINCH(Carpodacus purpureus)

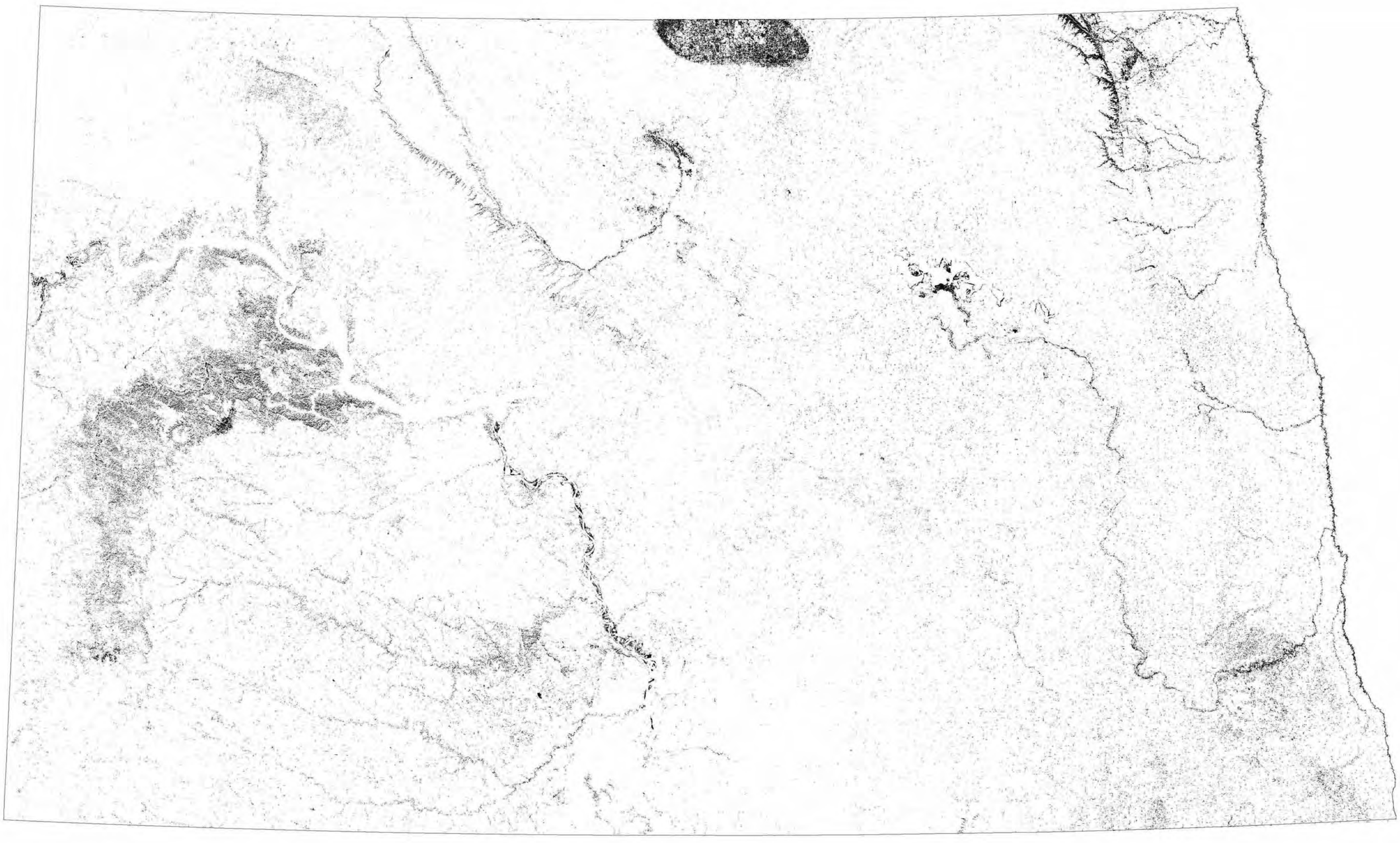
HOUSE FINCH(Carpodacus mexicanus)



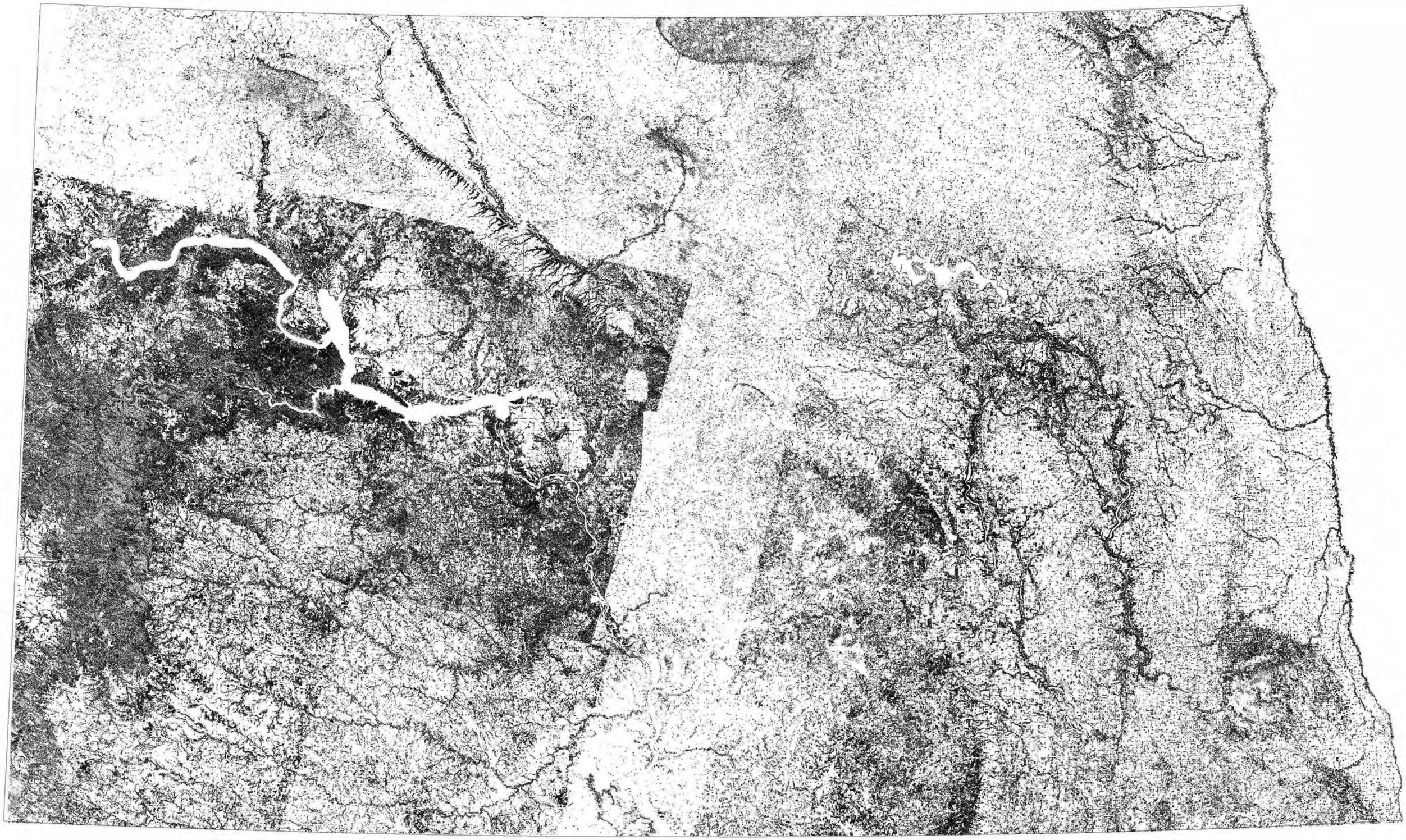
RED CROSSBILL(Loxia curvirostra)



PINE SISKIN(Carduelis pinus)

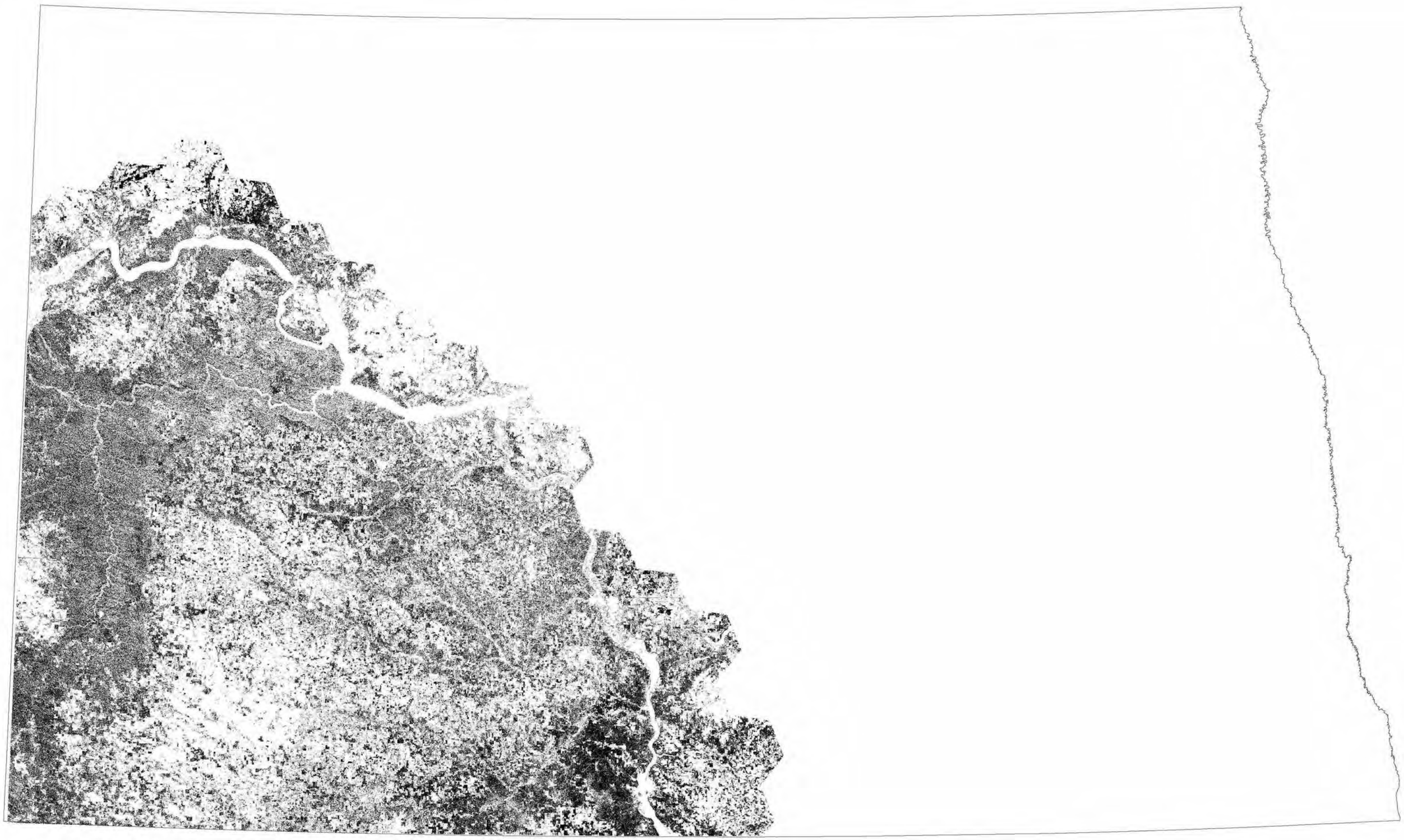


AMERICAN GOLDFINCH(Carduelis tristis)

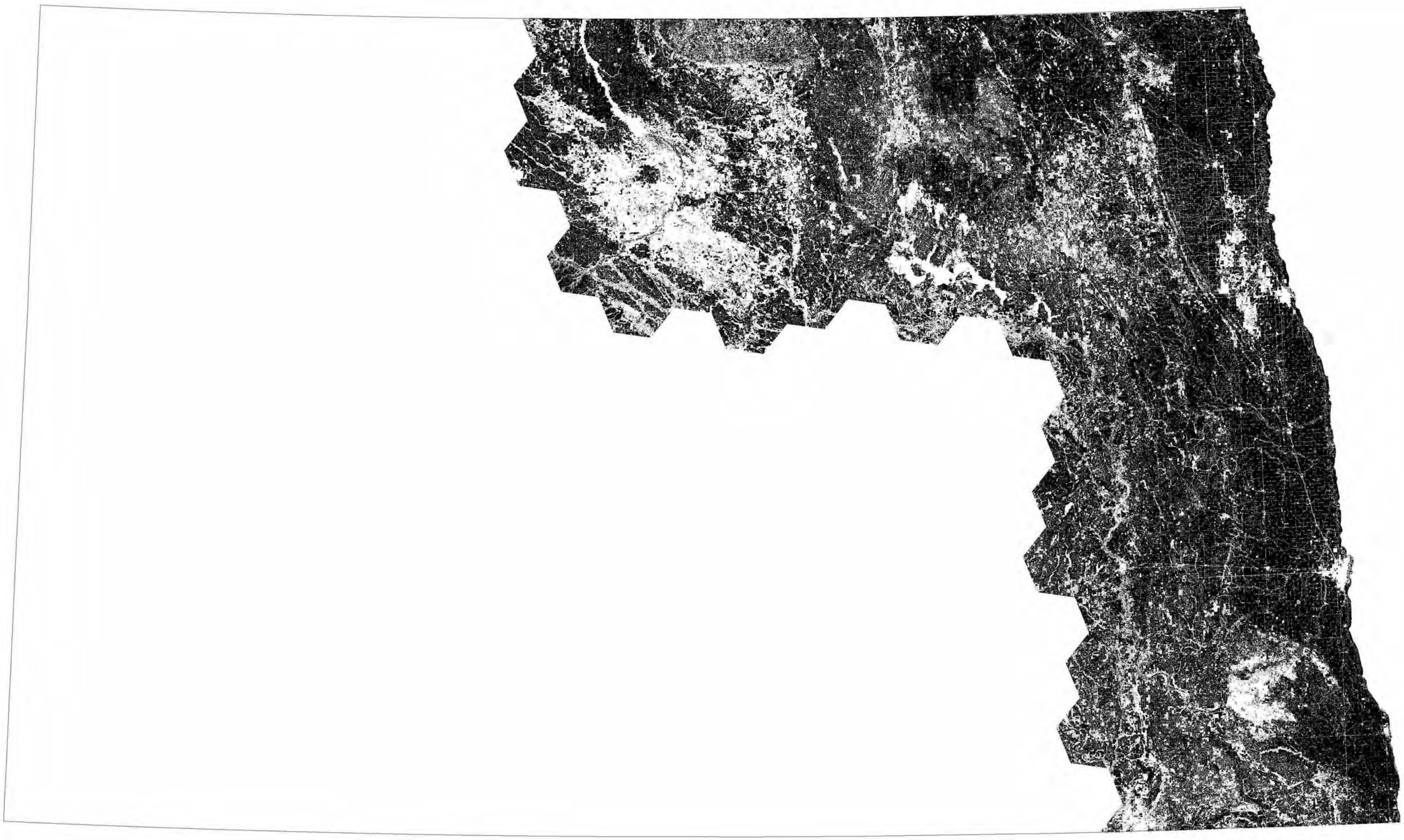


Virginia Opossum(Didelphis virginiana)

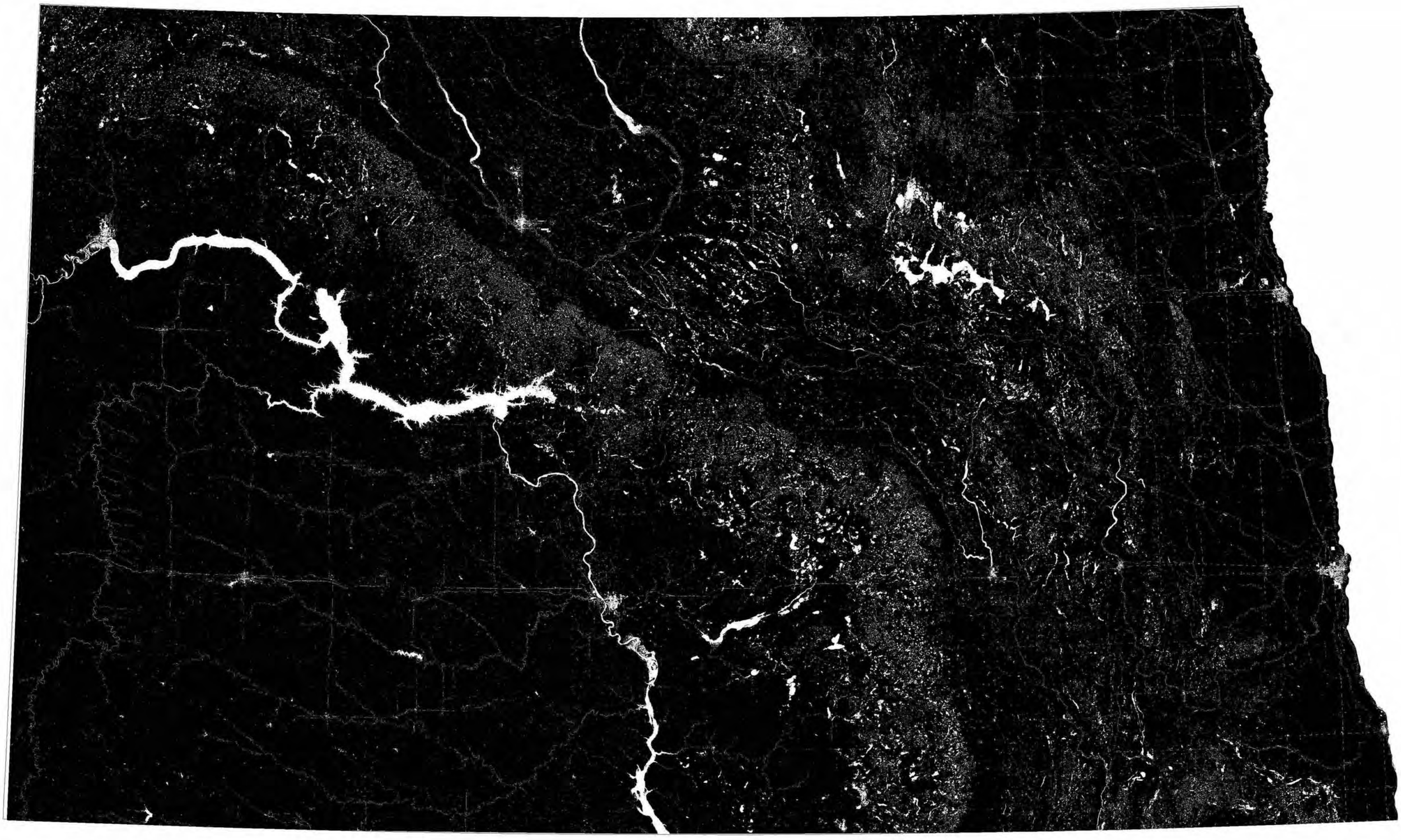
Pronghorn(Antilocapridae americana)



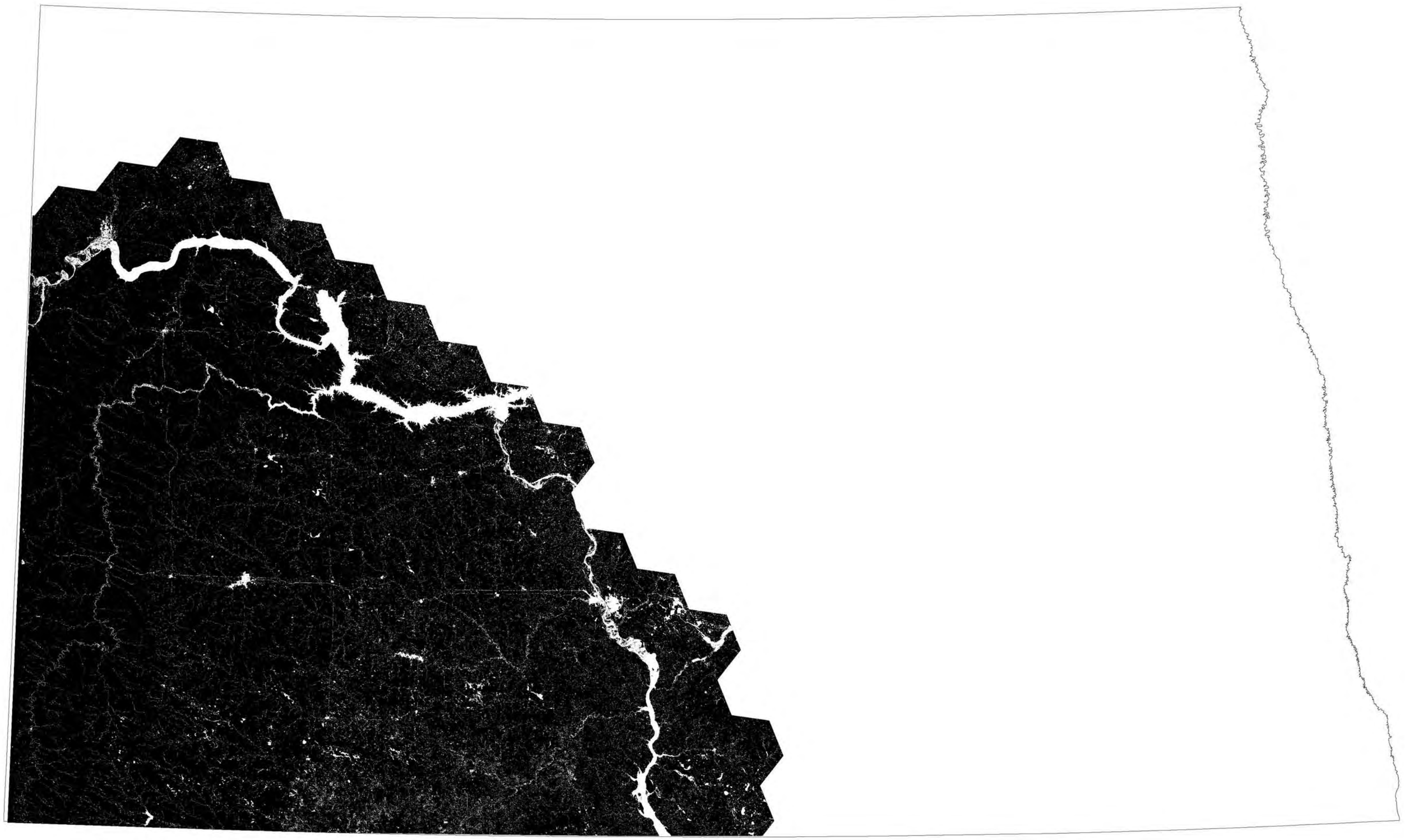
Moose(Alces Alces)



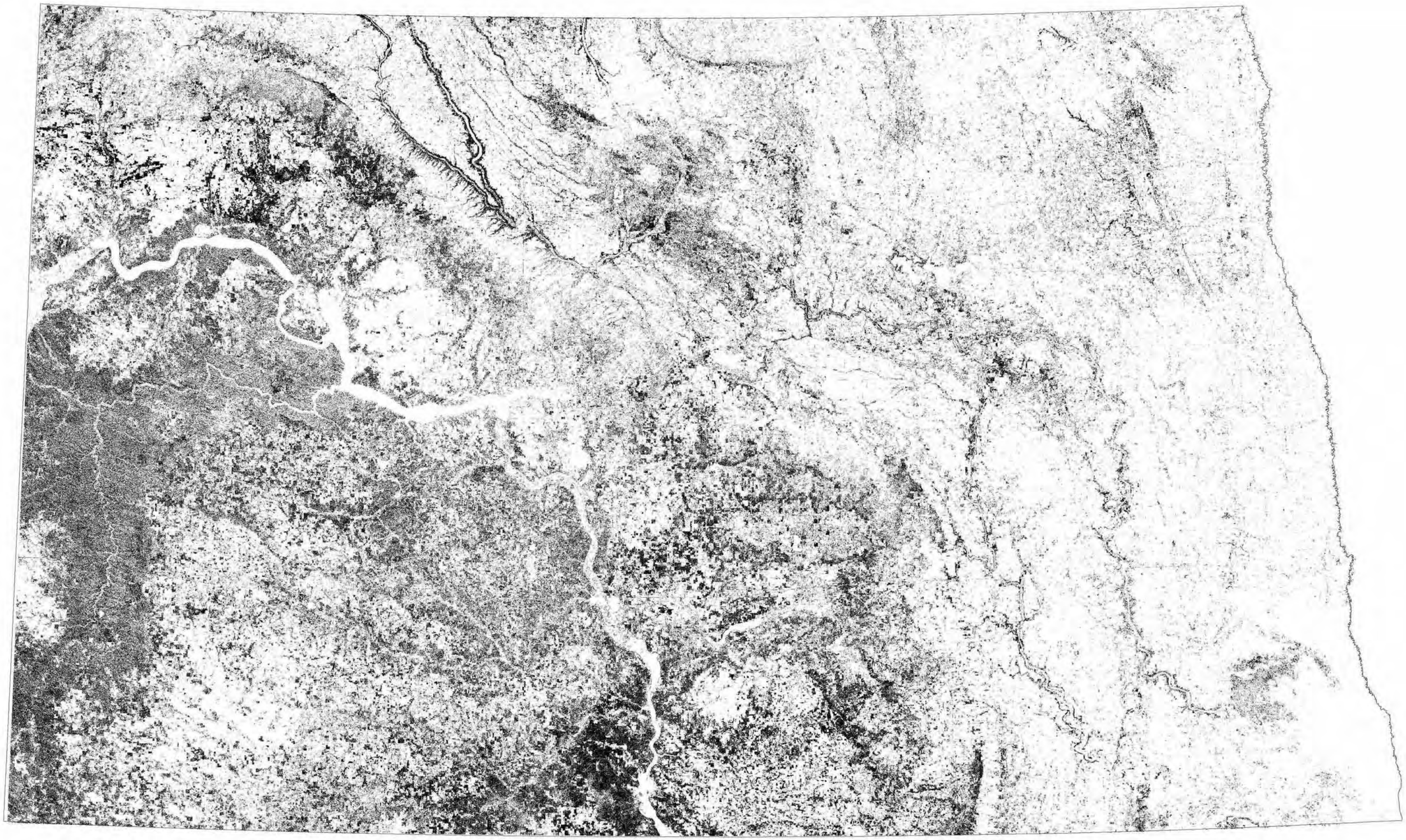
White-tailed Deer(Odocoileus virginianus)



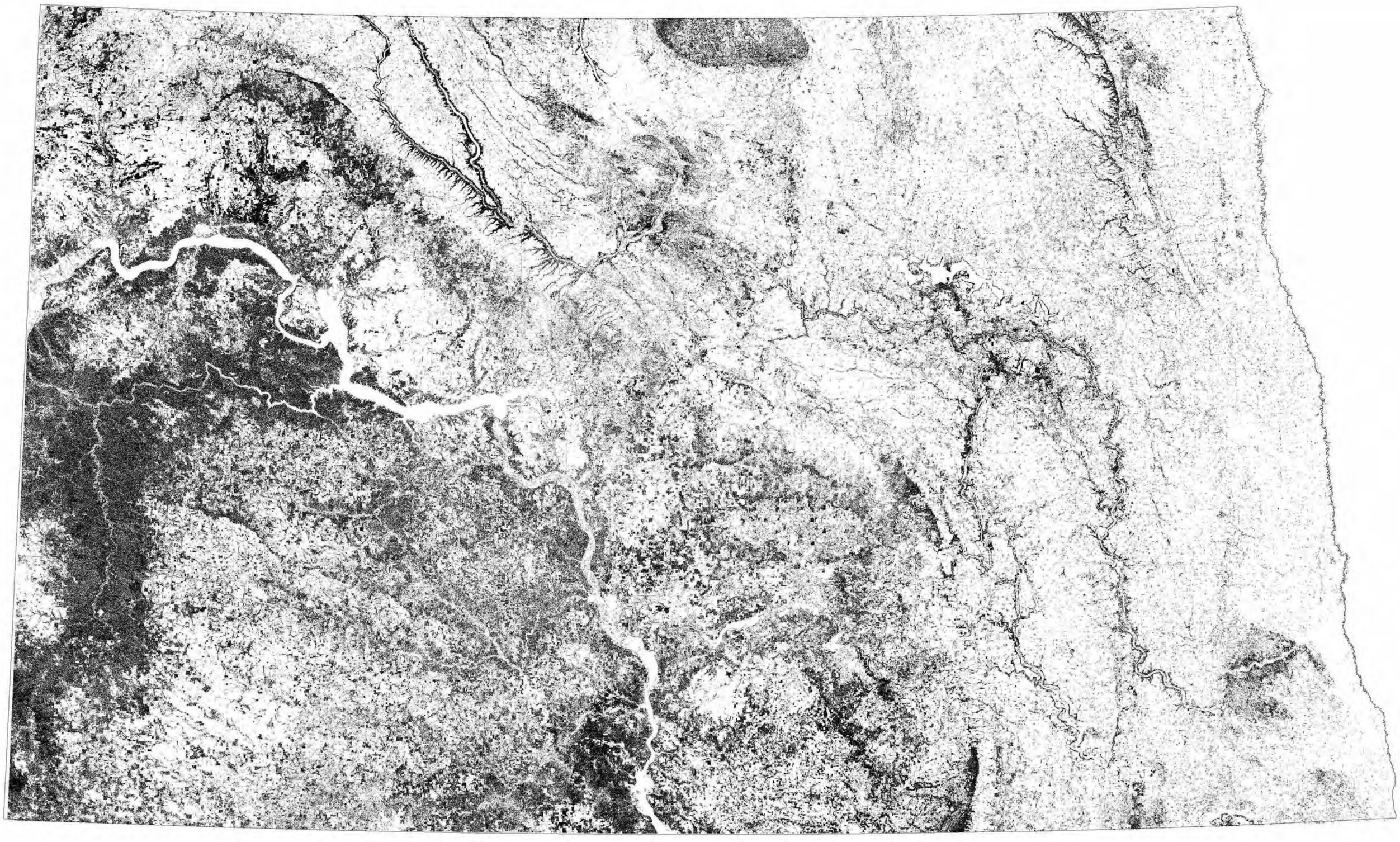
Mule Deer(Odocoileus hemionus)



Elk (Cervus elaphus)

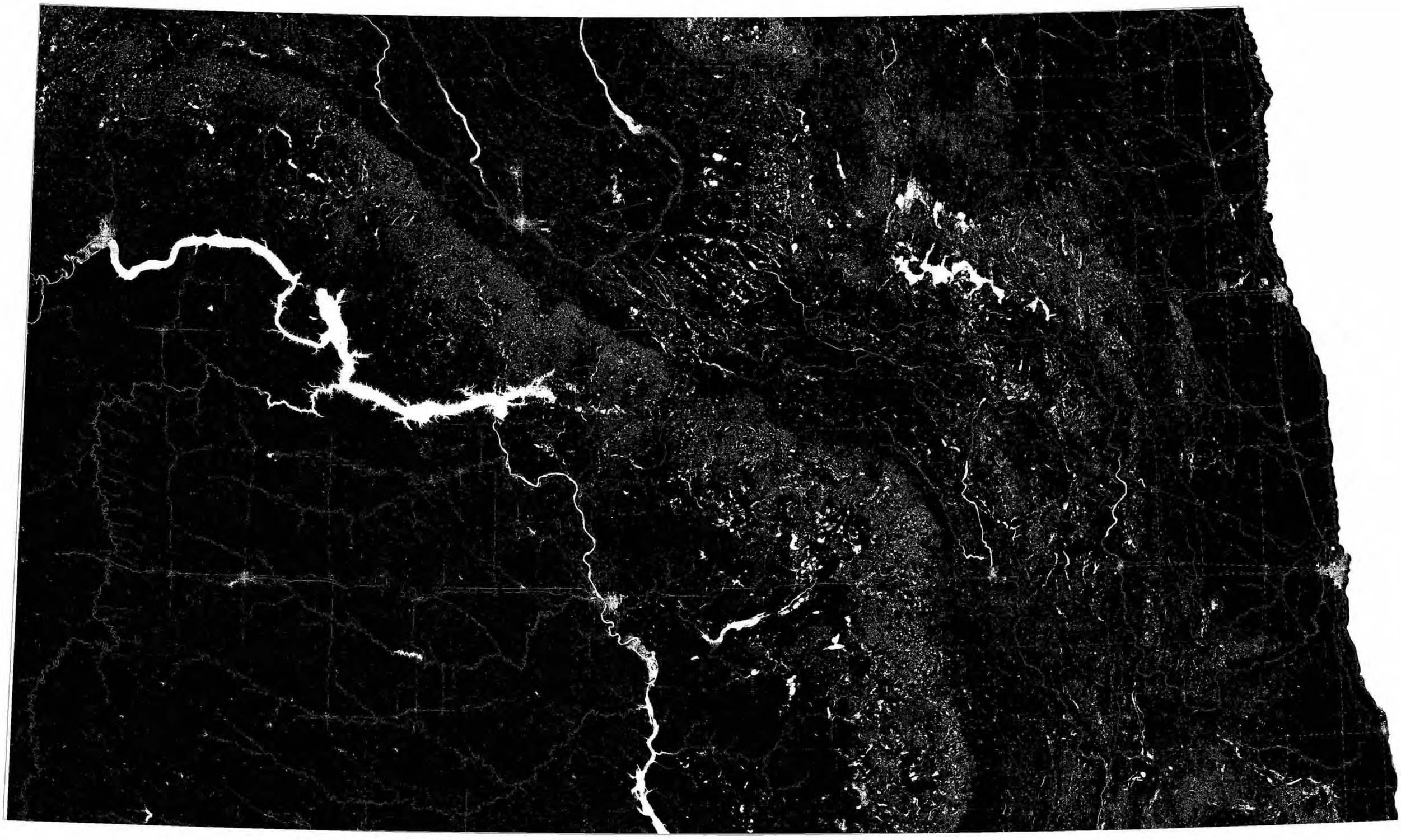


Bobcat(Felis rufus)



River Otter(Lutra canadensis)

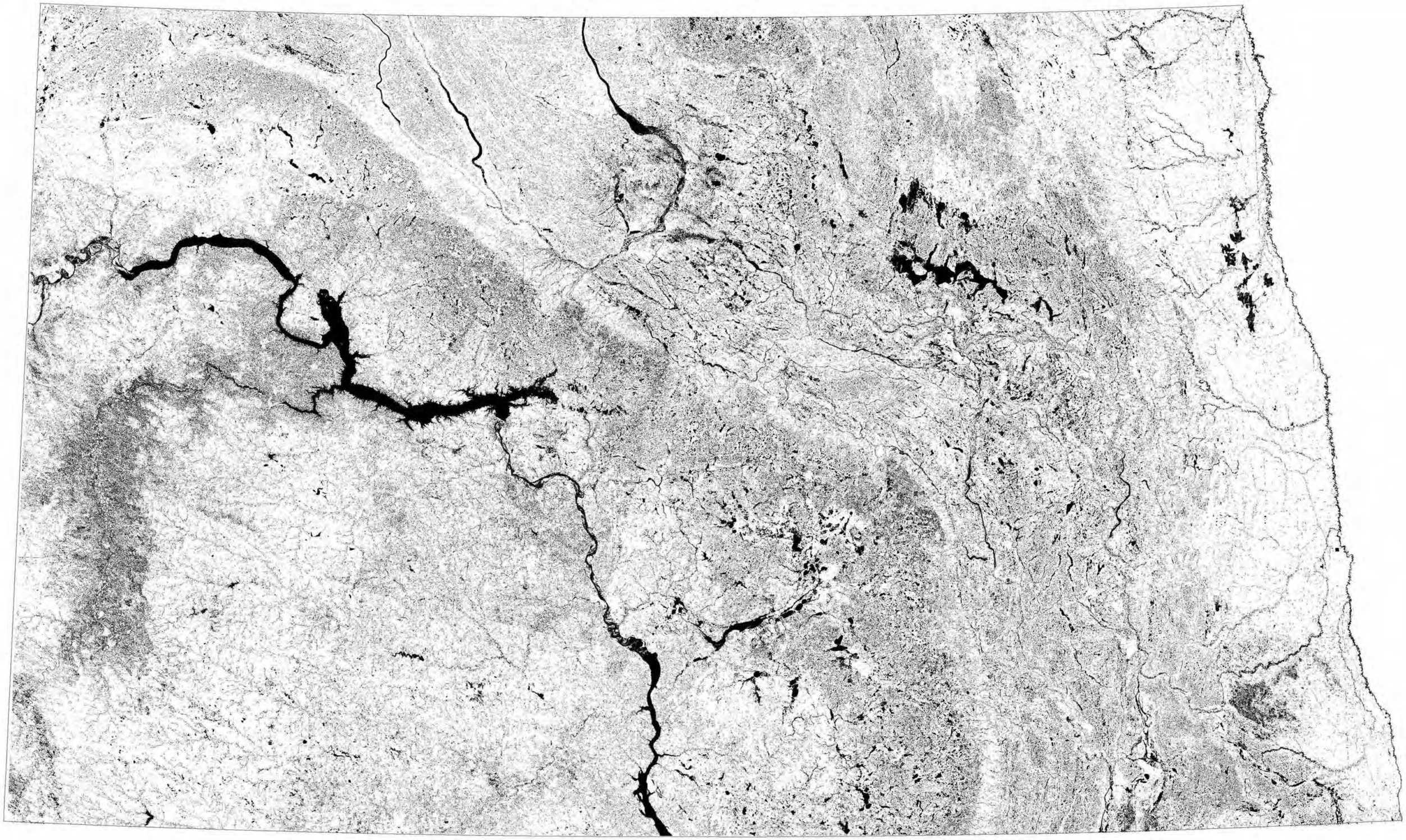
Striped Skunk(Mephitis mephitis)



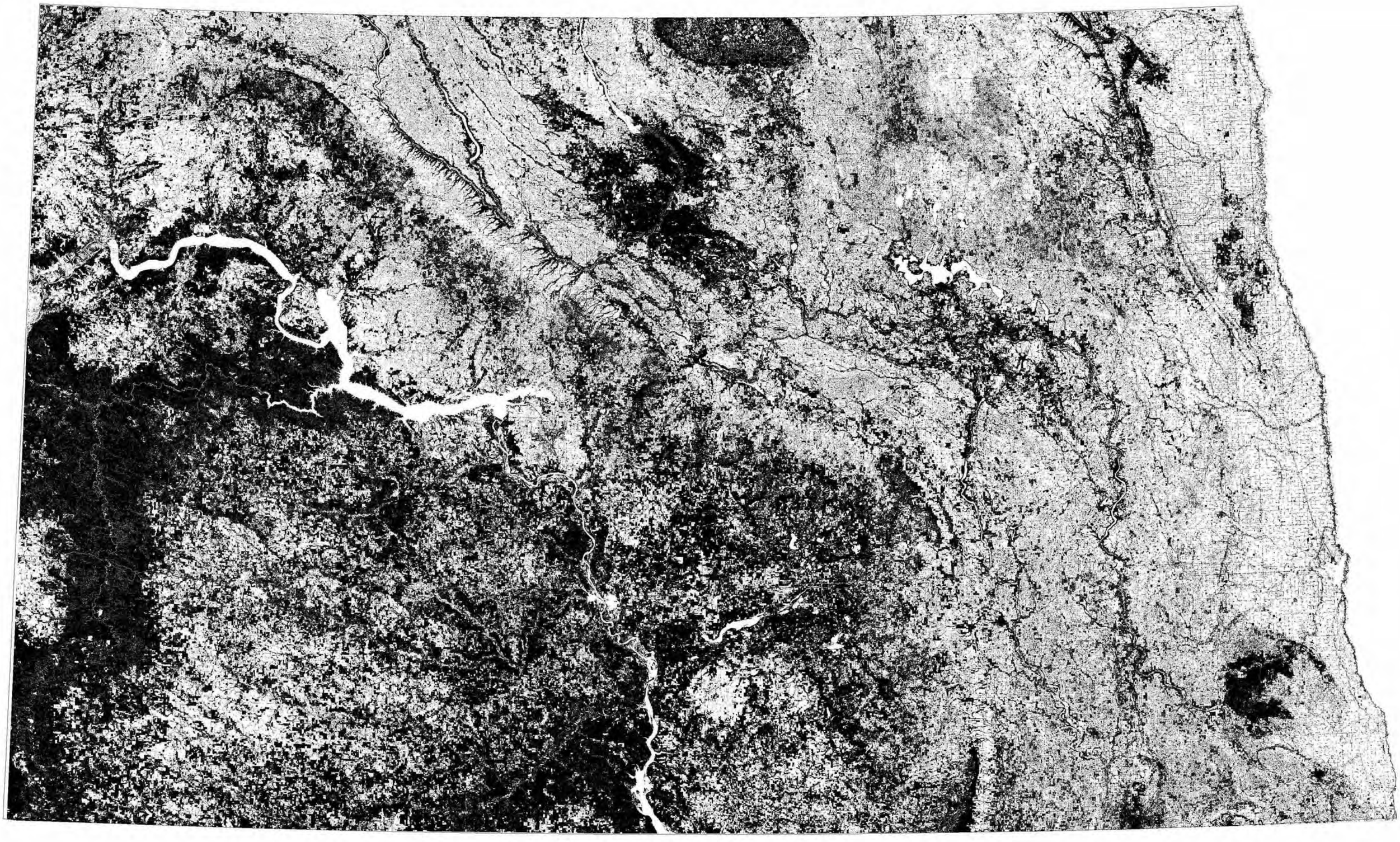
Eastern Spotted Skunk(Spilogale putorious)

American Badger(Taxidea taxus)

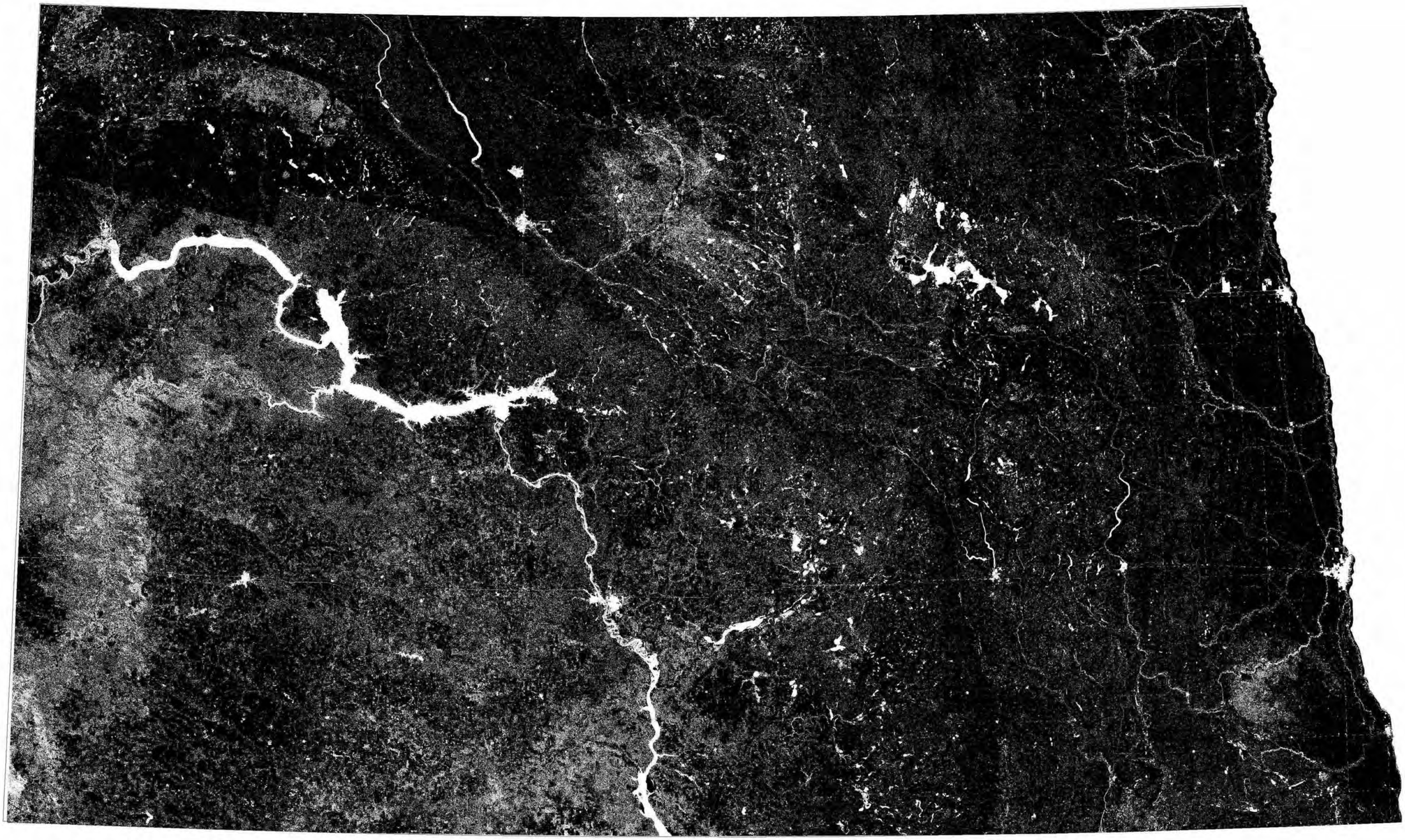
Mink(Mustela vison)



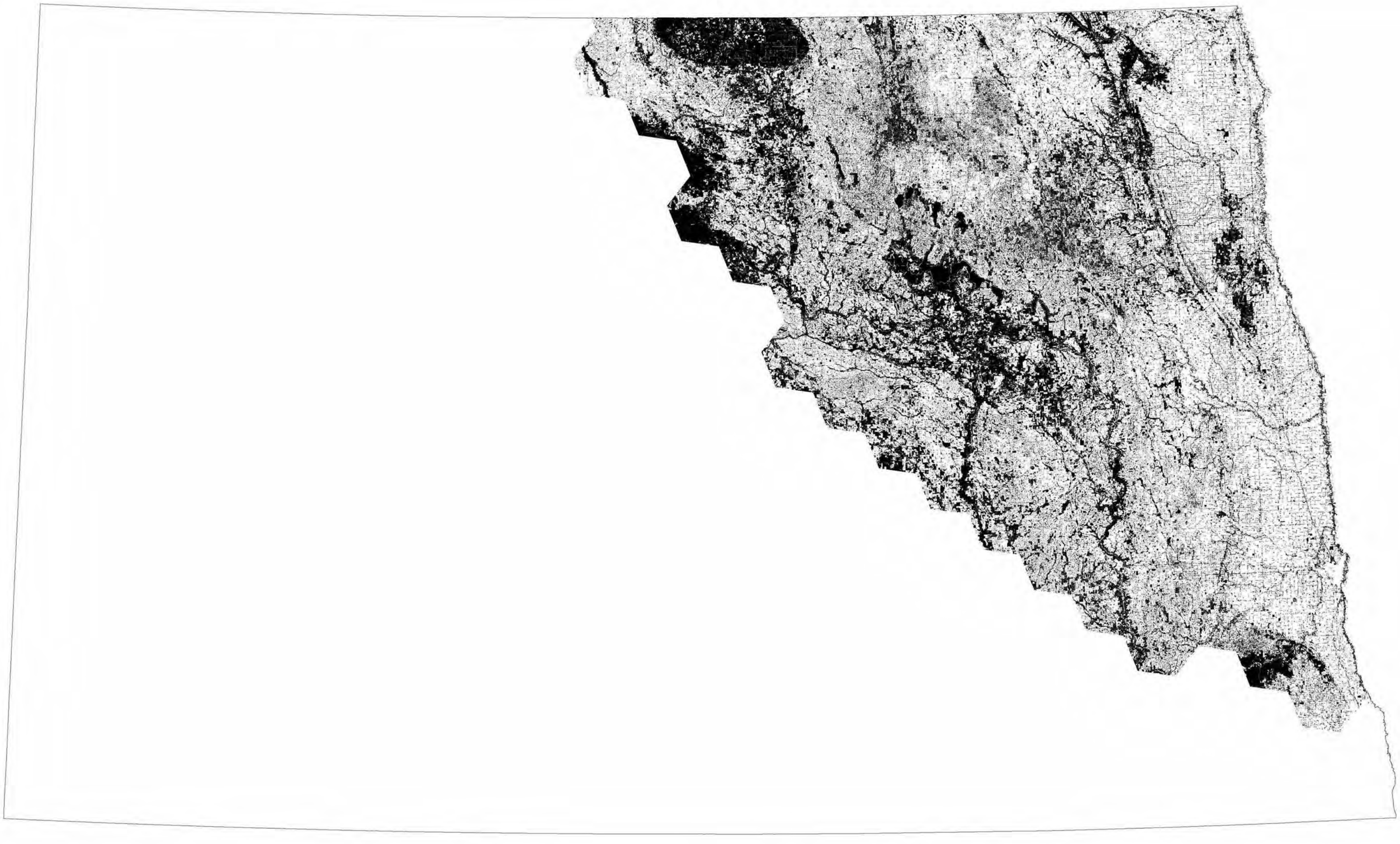
Long-tailed Weasel(Mustela frenata)

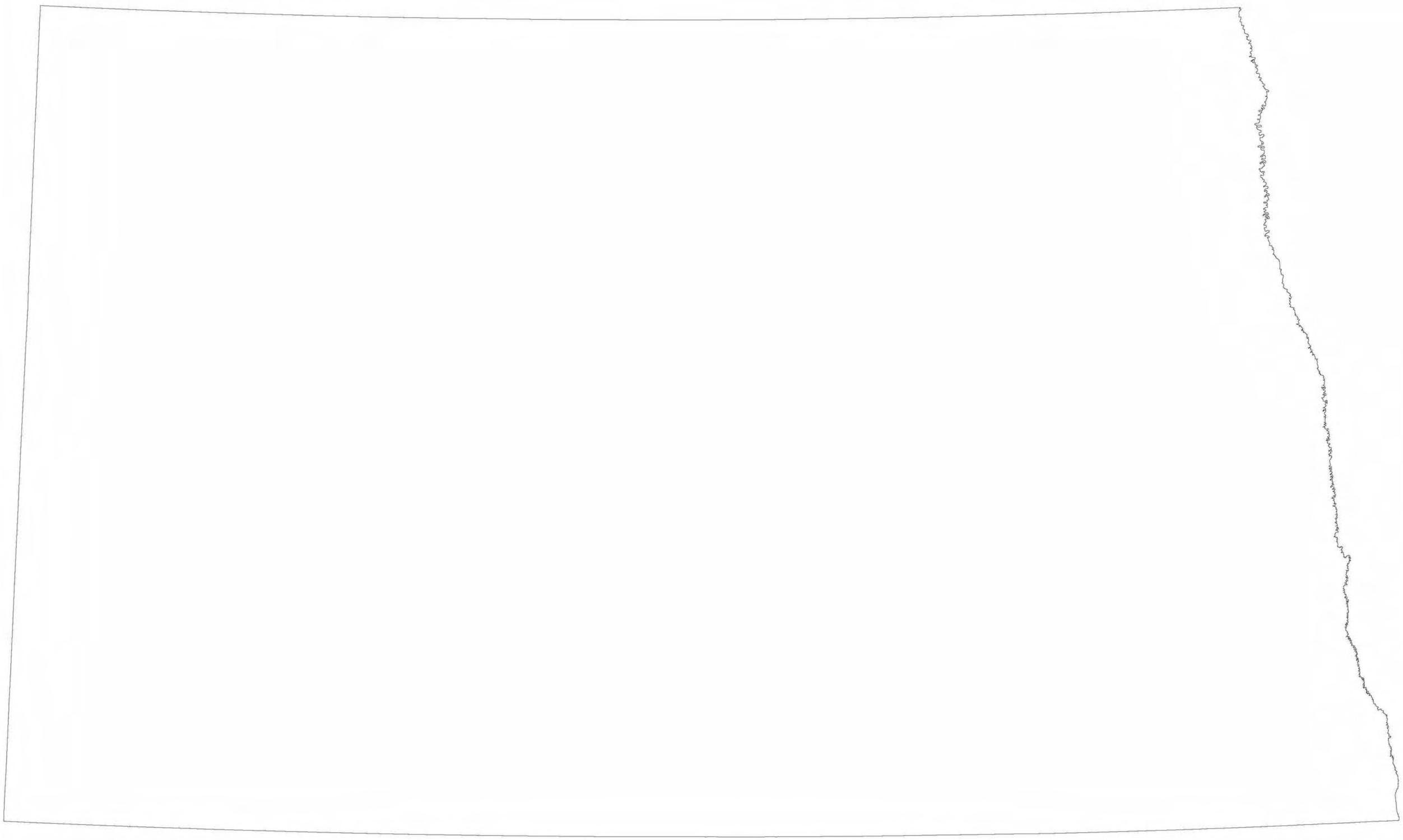


Least Weasel(Mustela nivalis)

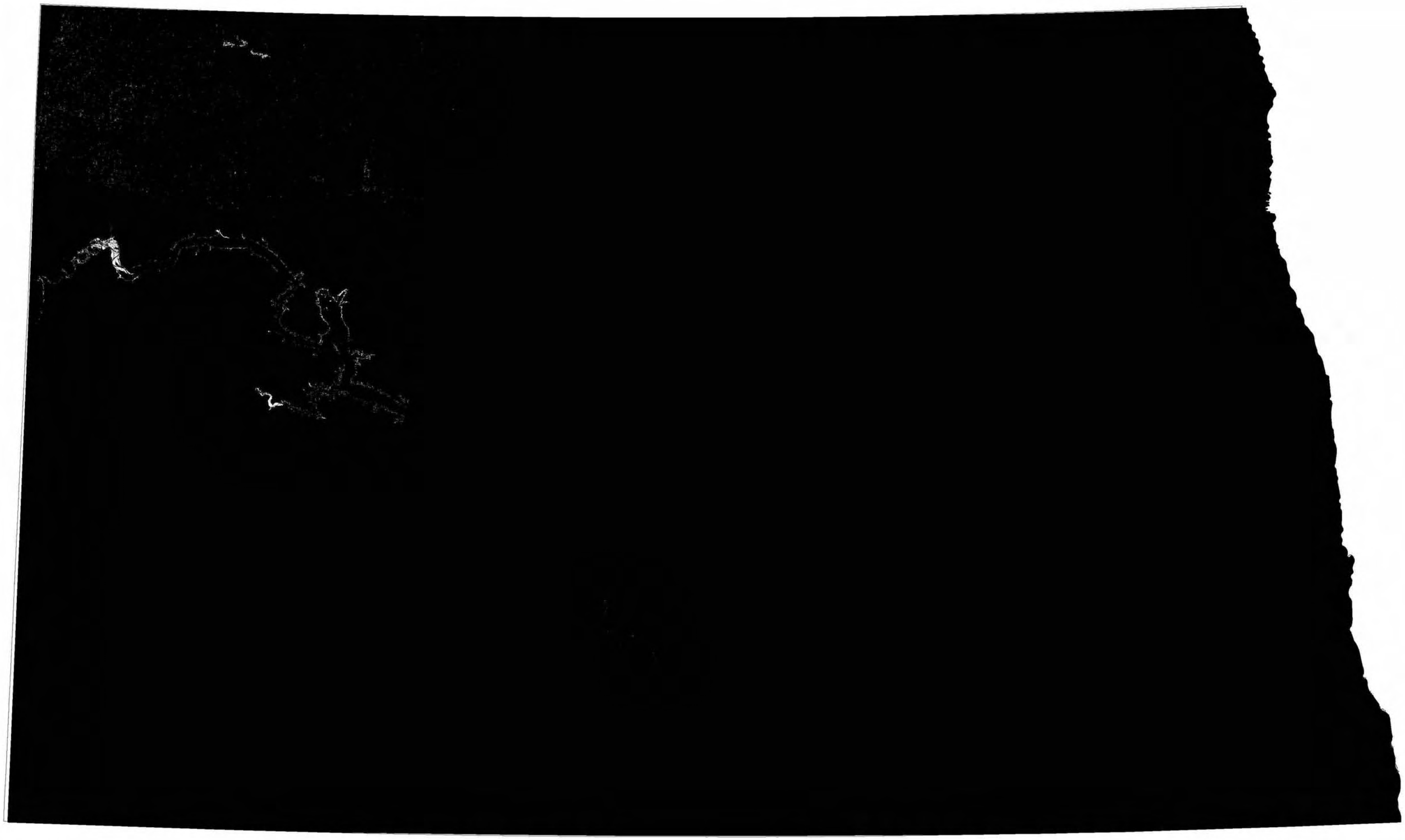


Ermine(Mustela erminea)

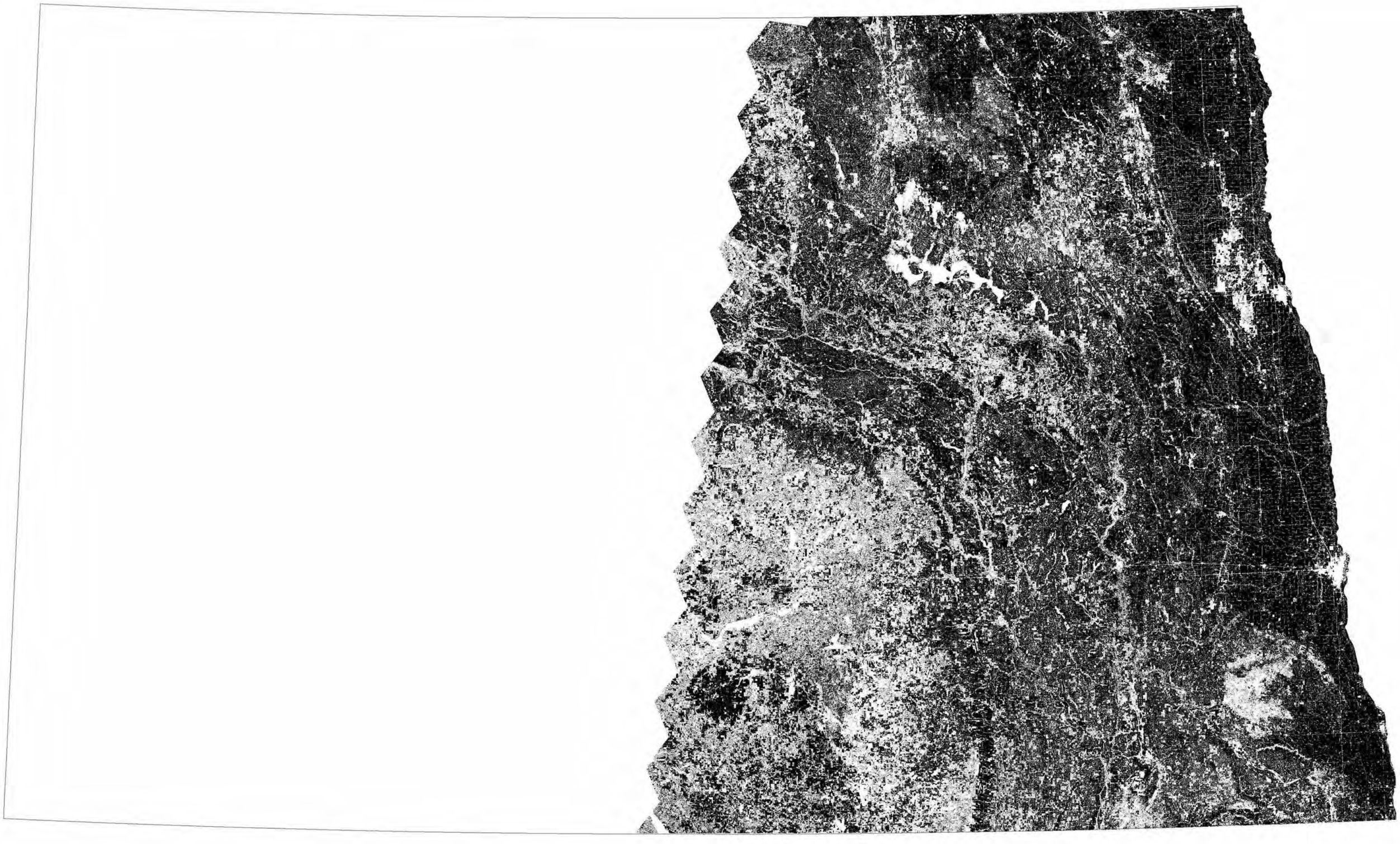




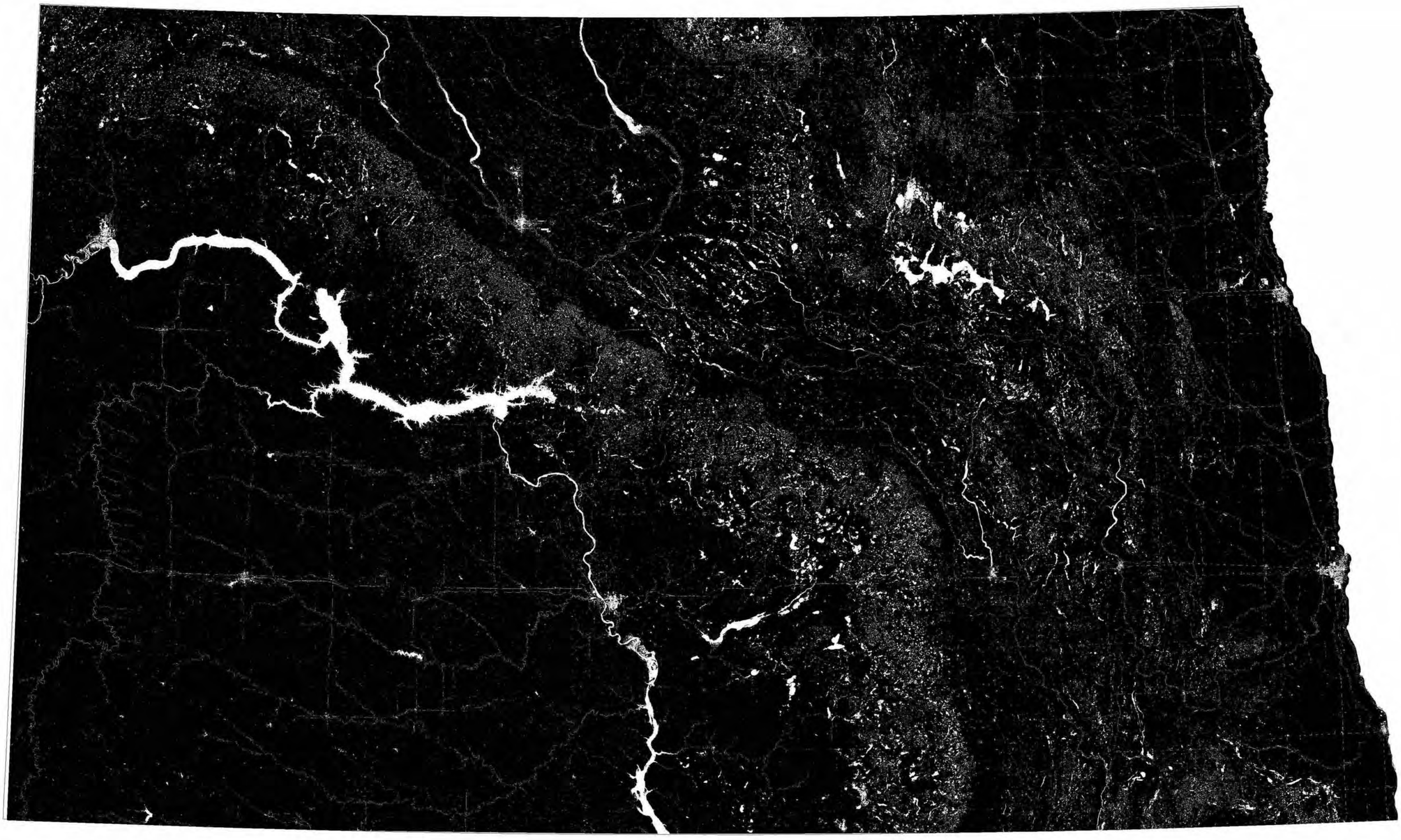
Common Raccoon(Procyon lotor)



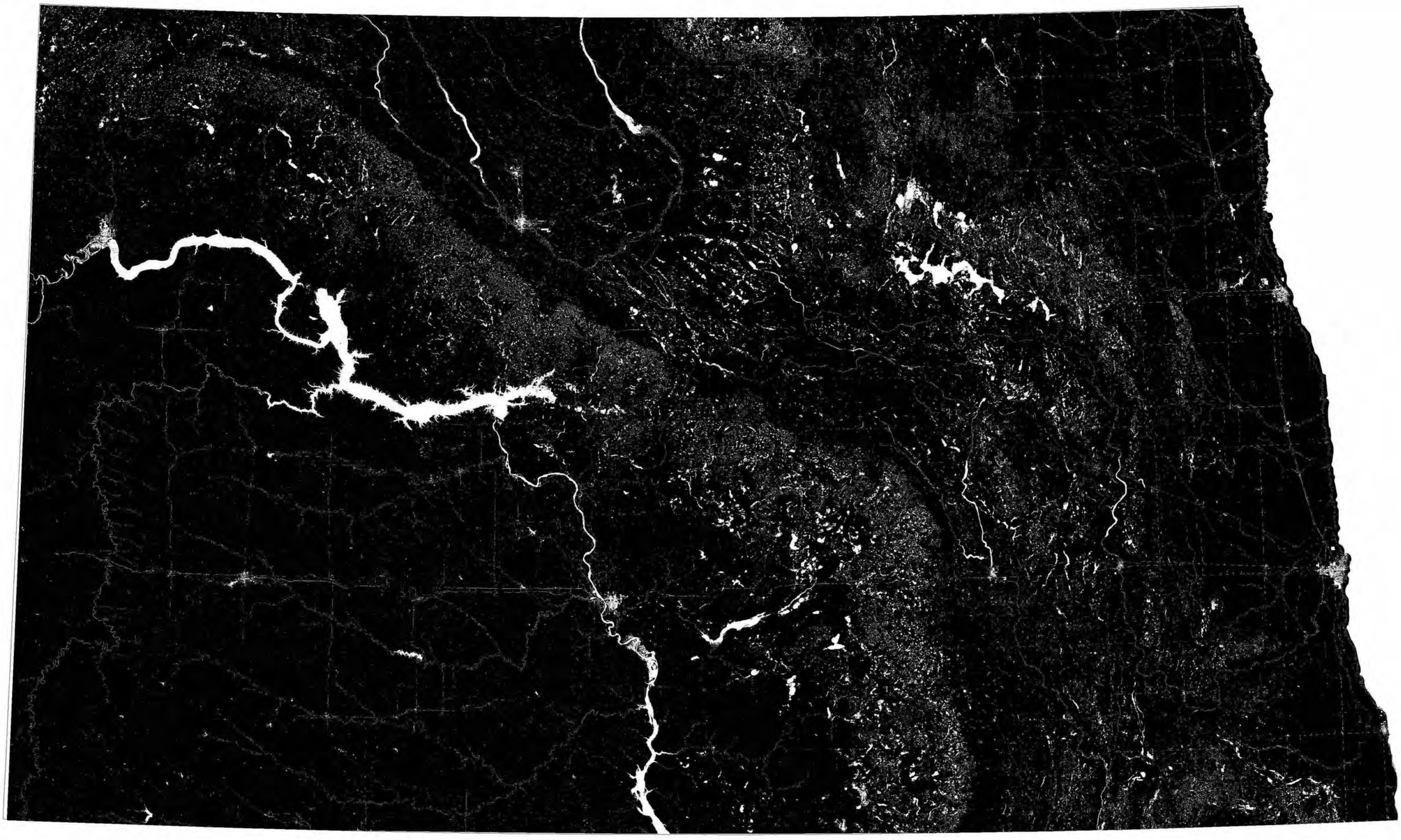
Common Gray Fox(Urocyon cineroargenteus)



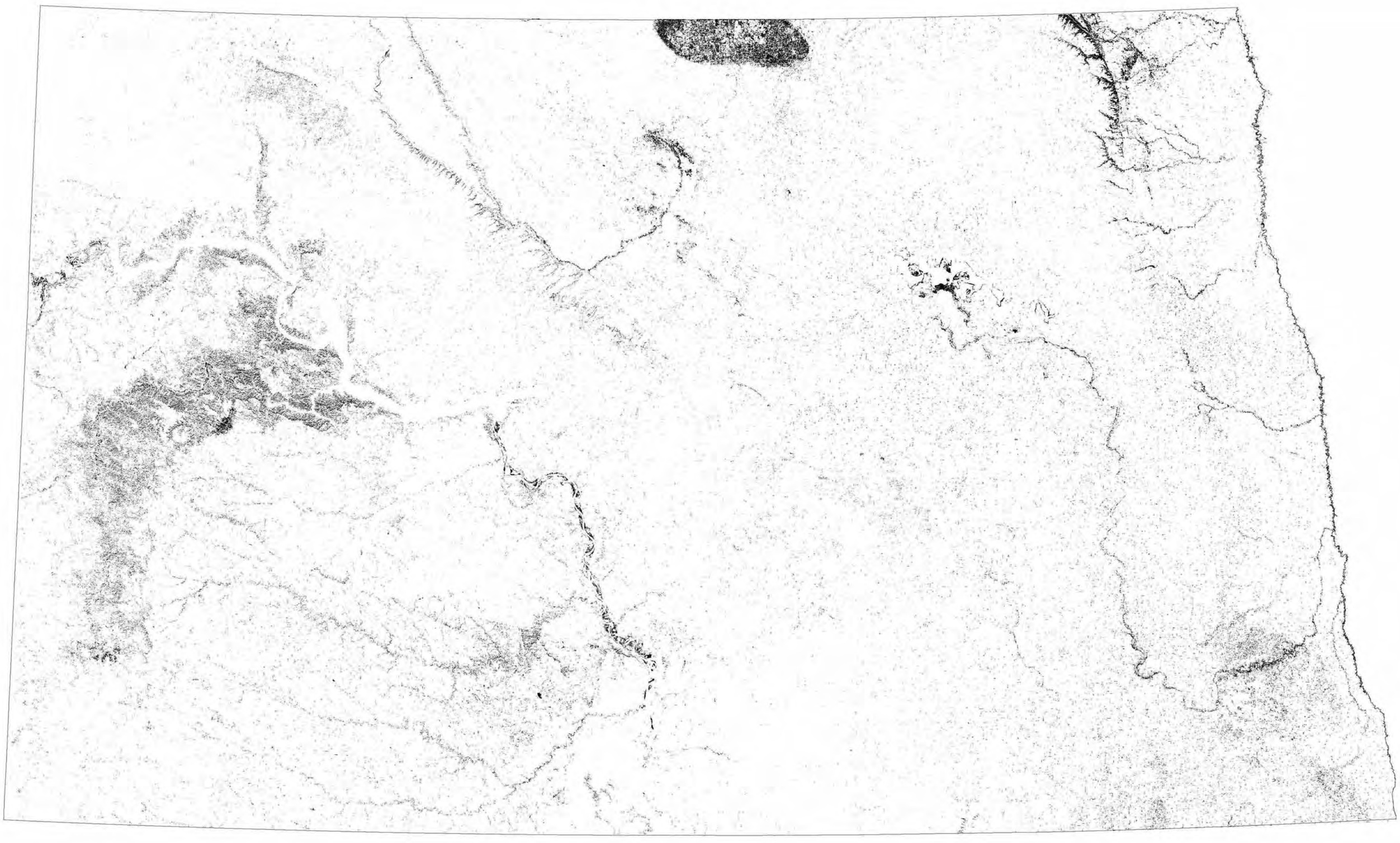
Red Fox(Vulpes vulpes)



Coyote(Canis Latrans)

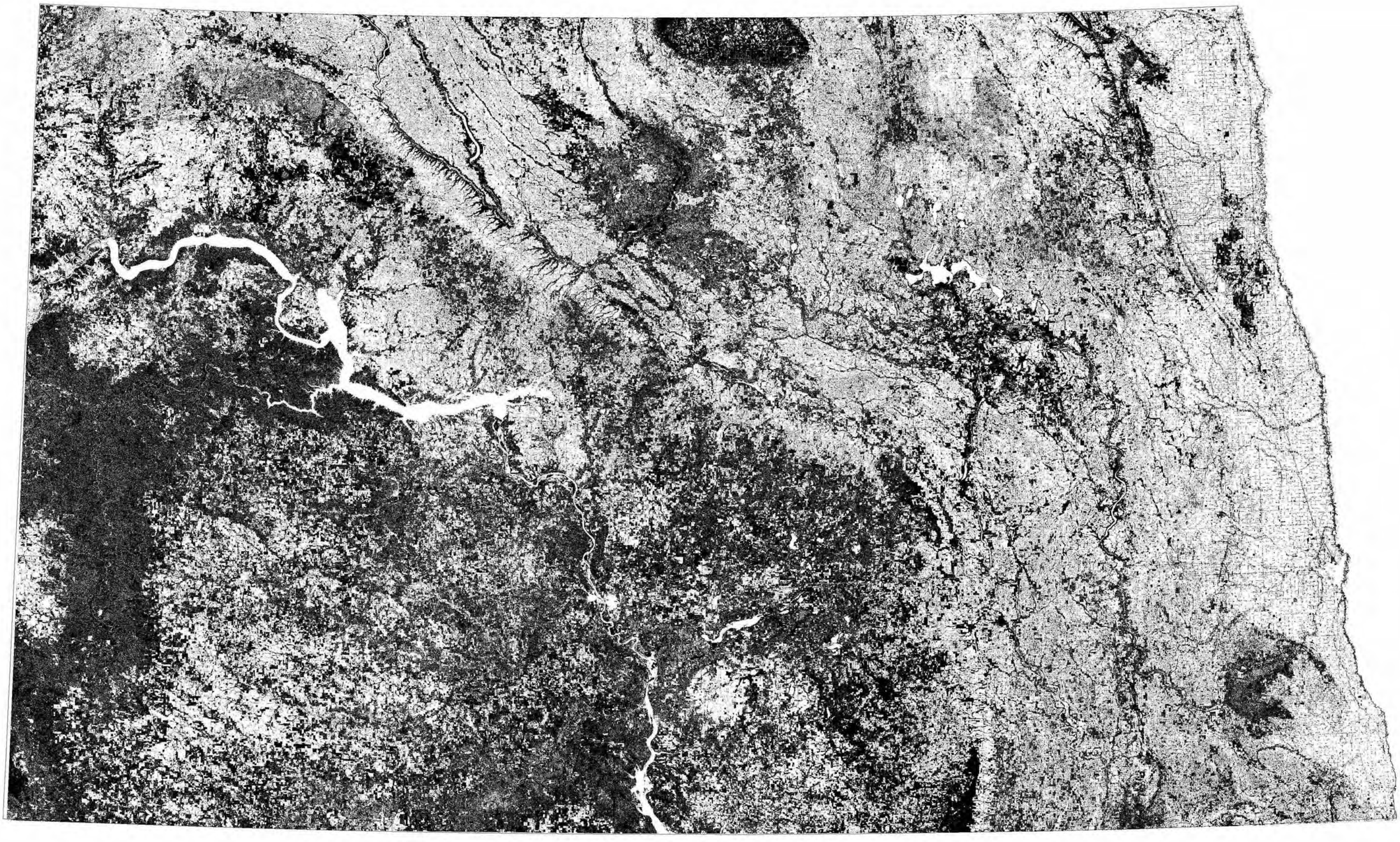


Common Porcupine(Erethizon dorsatum)

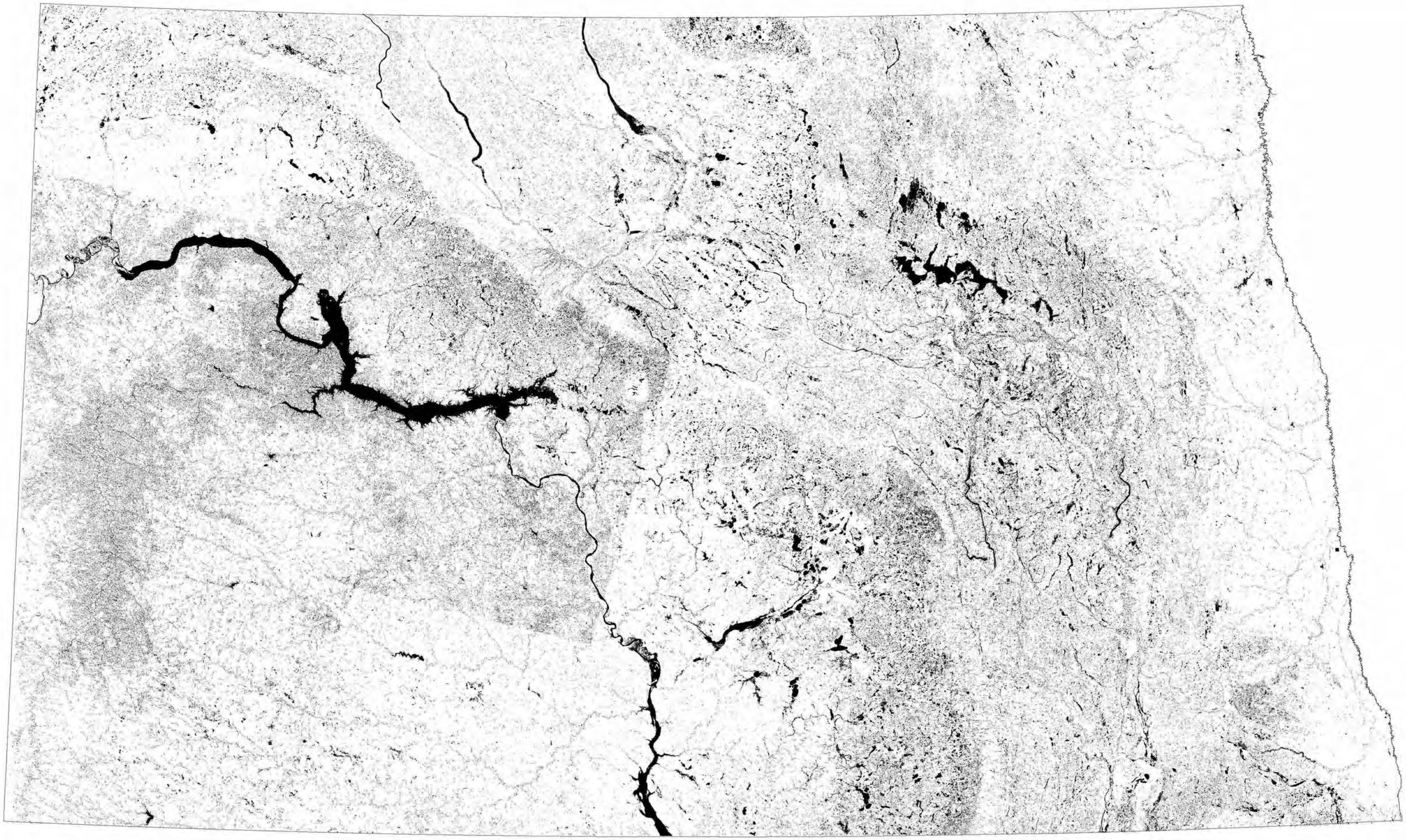


Western Jumping Mouse(Zapus princeps)

Meadow Jumping Mouse(Zapus hudsonius)

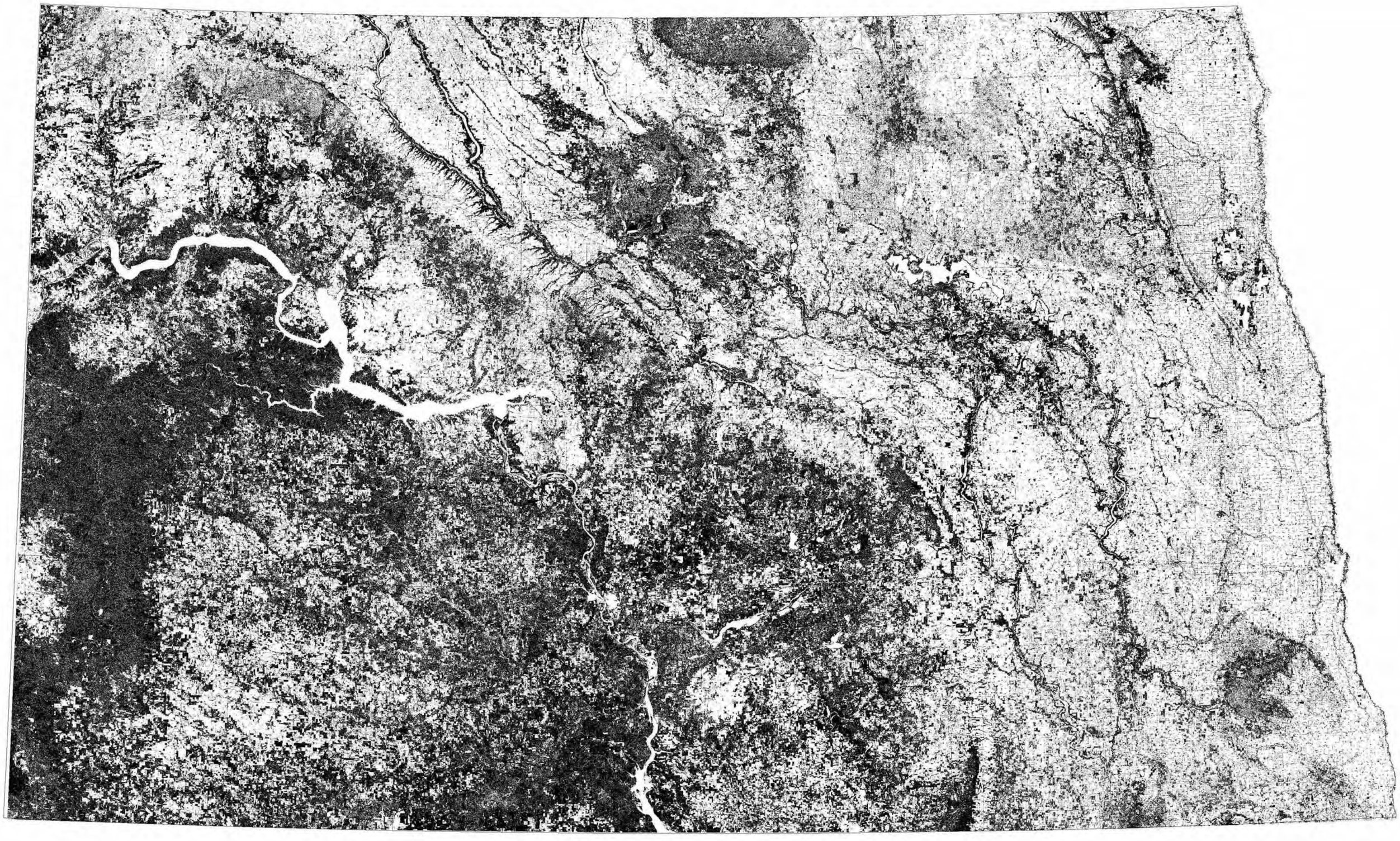


Muskrat(Ondatra zibethicus)

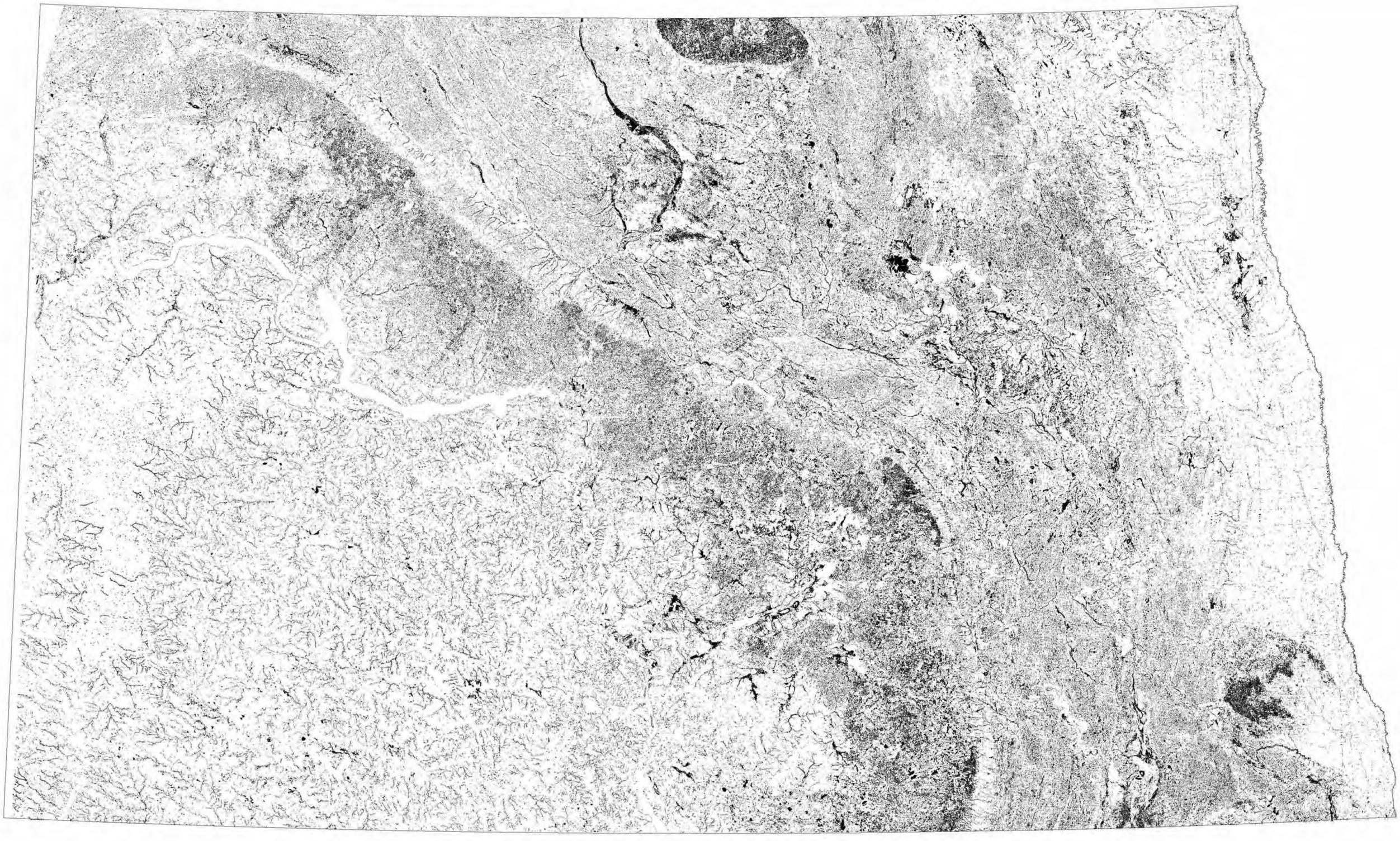


Sagebrush Vole(Lagurus curtatus)

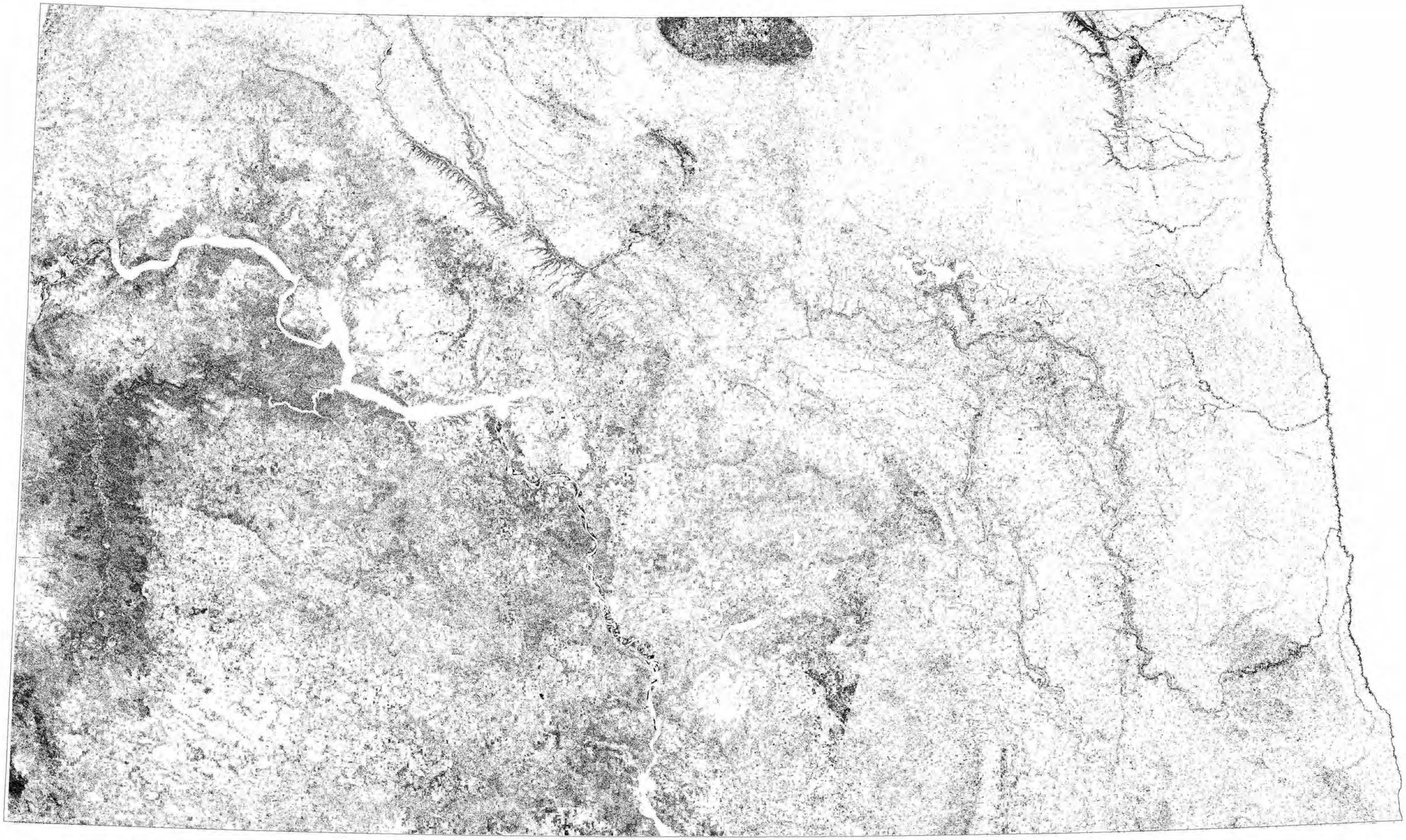
Prairie Vole(Microtus ochrogaster)



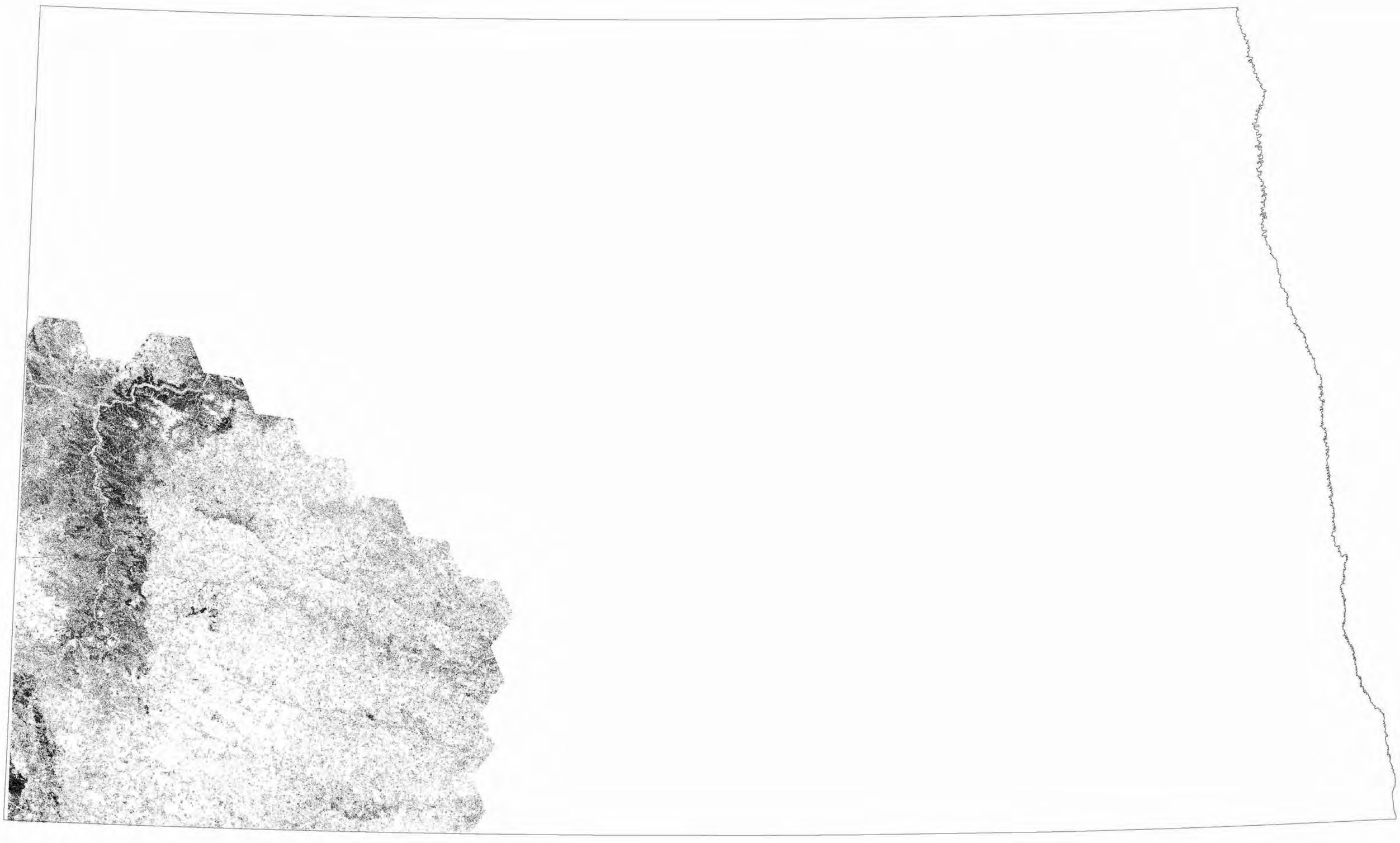
Meadow Vole(Microtus pennsylvanicus)



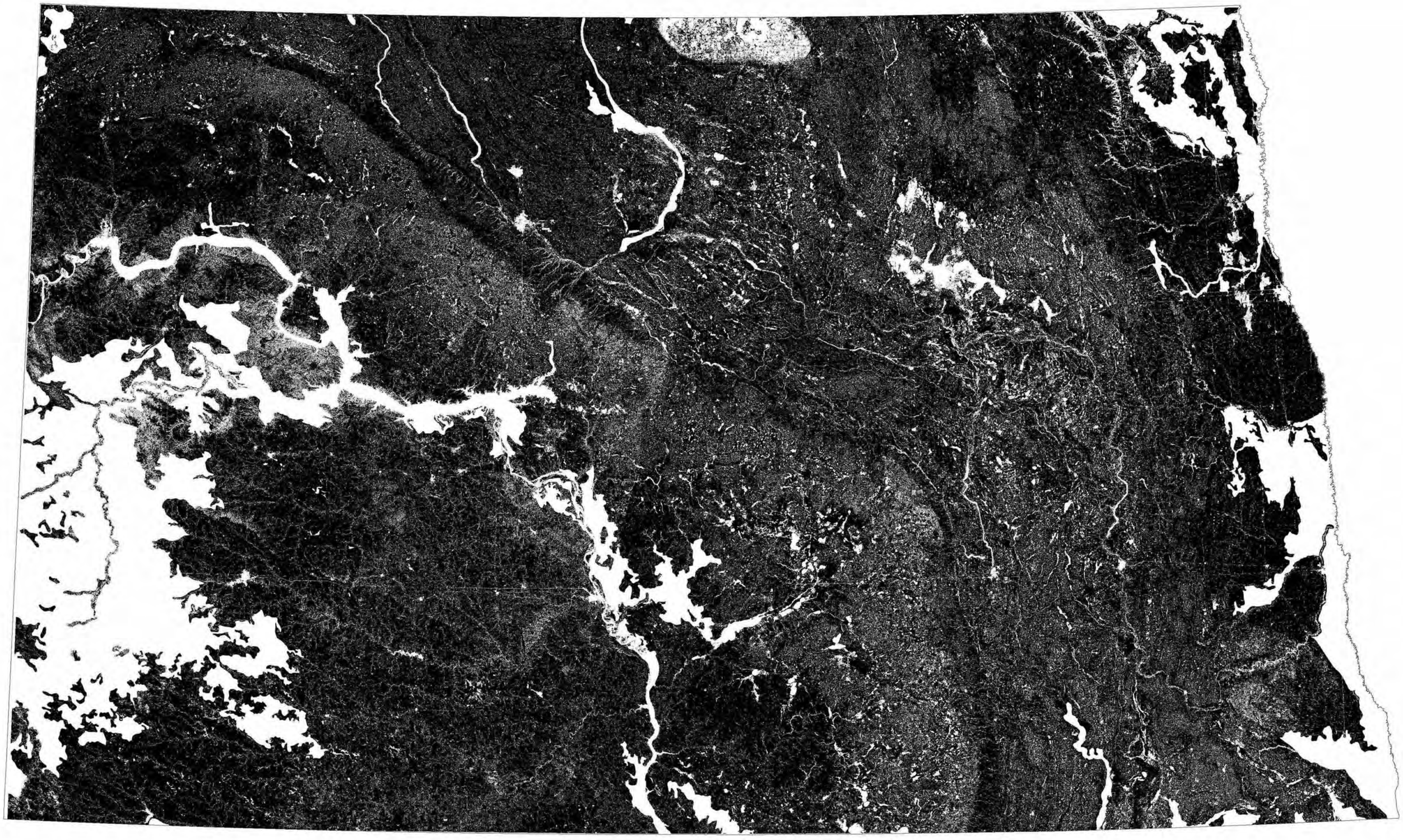
Southern Red-backed Vole(Clethrionomys gapperi)



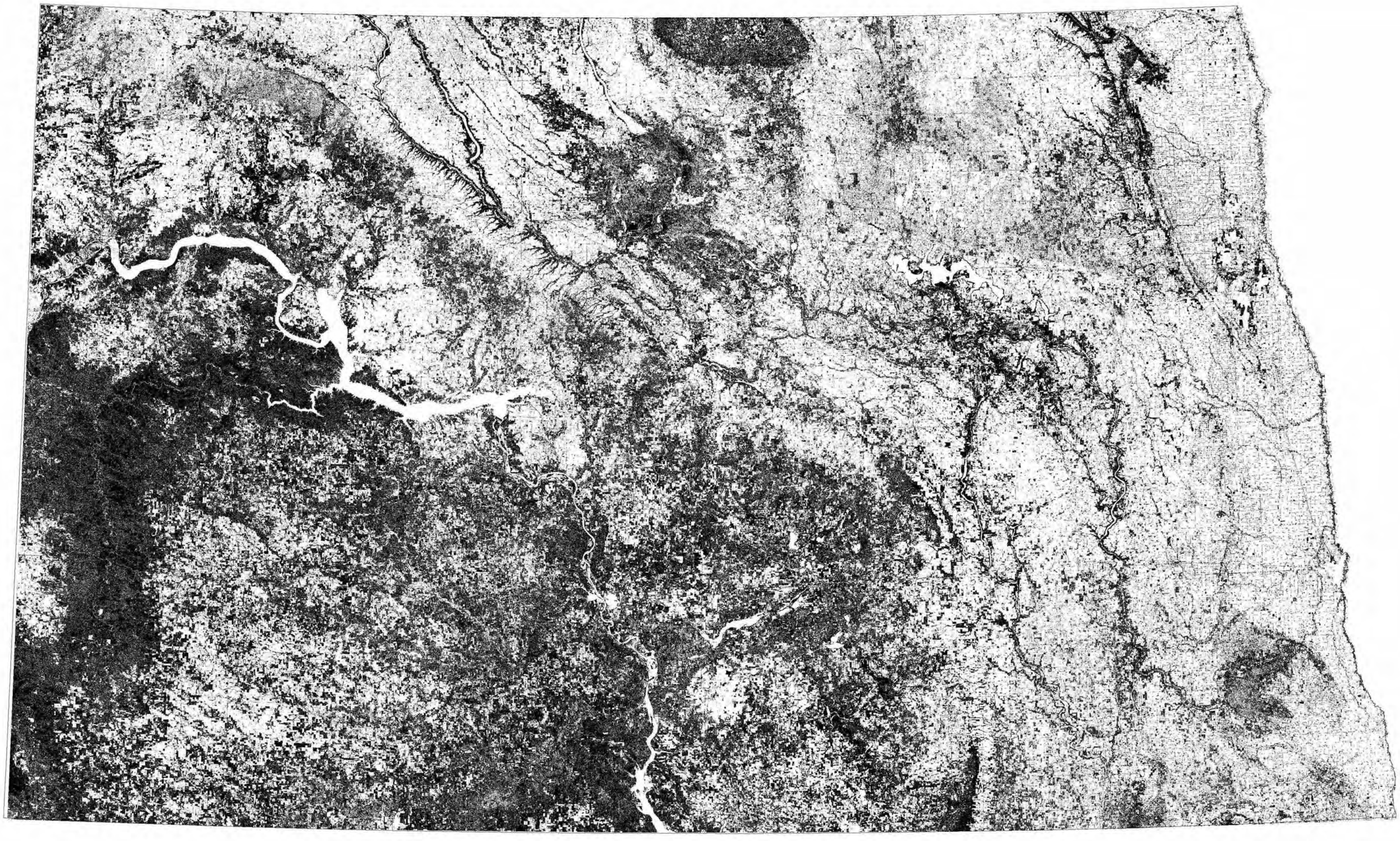
Bushy-tailed Woodrat(Neotoma cinerea)



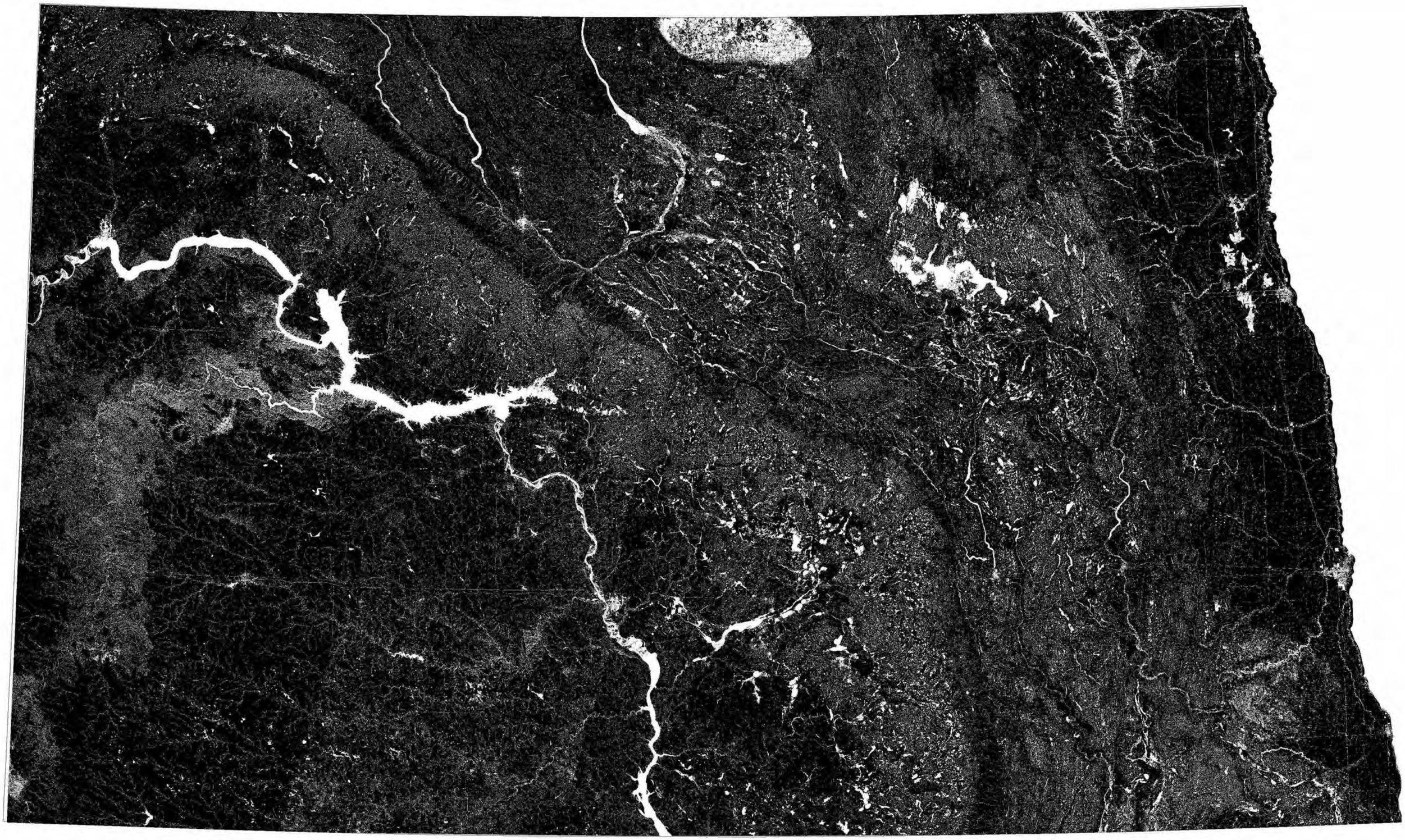
Northern Grasshopper Mouse(Onychomys leucogaster)



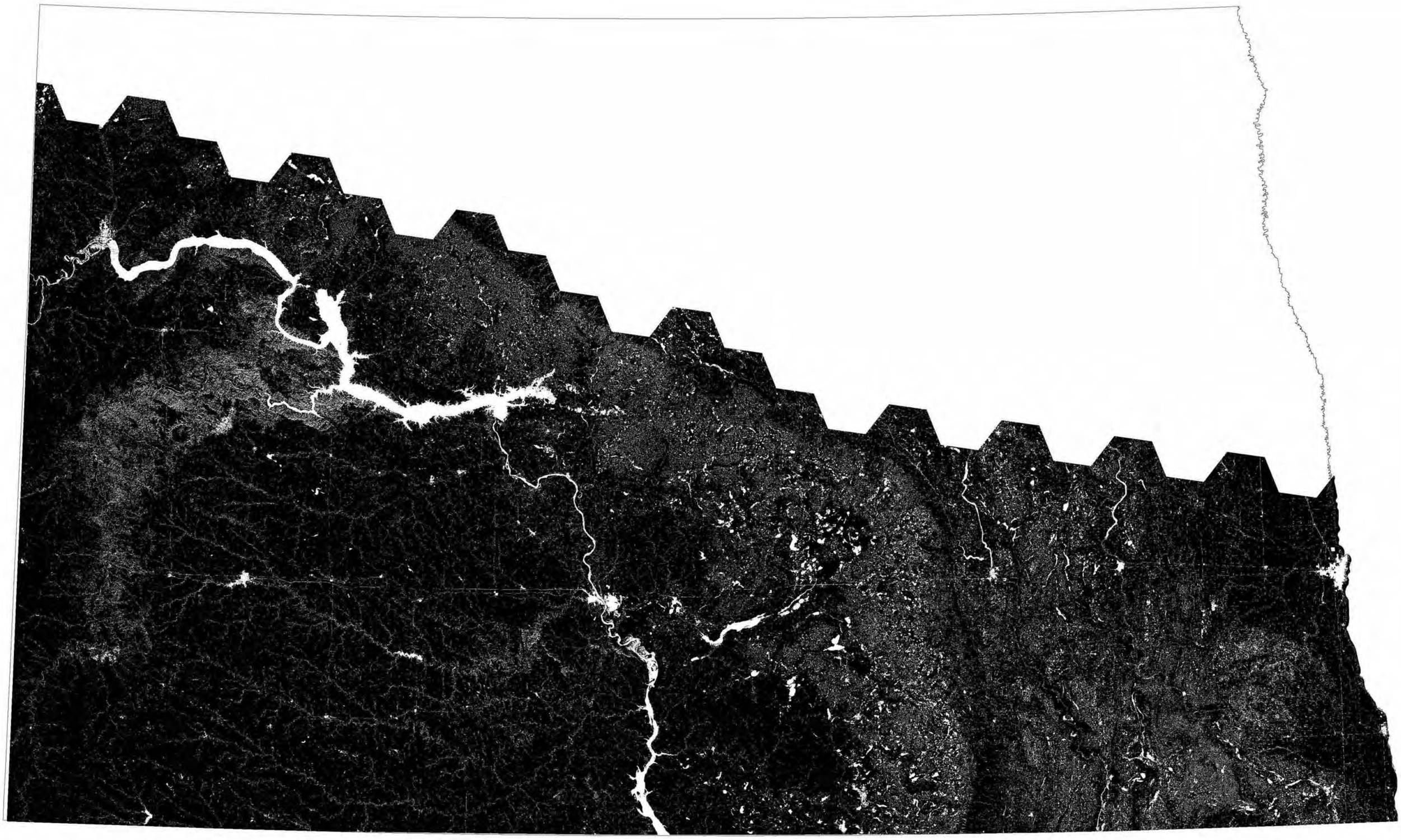
White-footed Mouse(Peromyscus leucopus)



Deer Mouse(Peromyscus maniculatus)

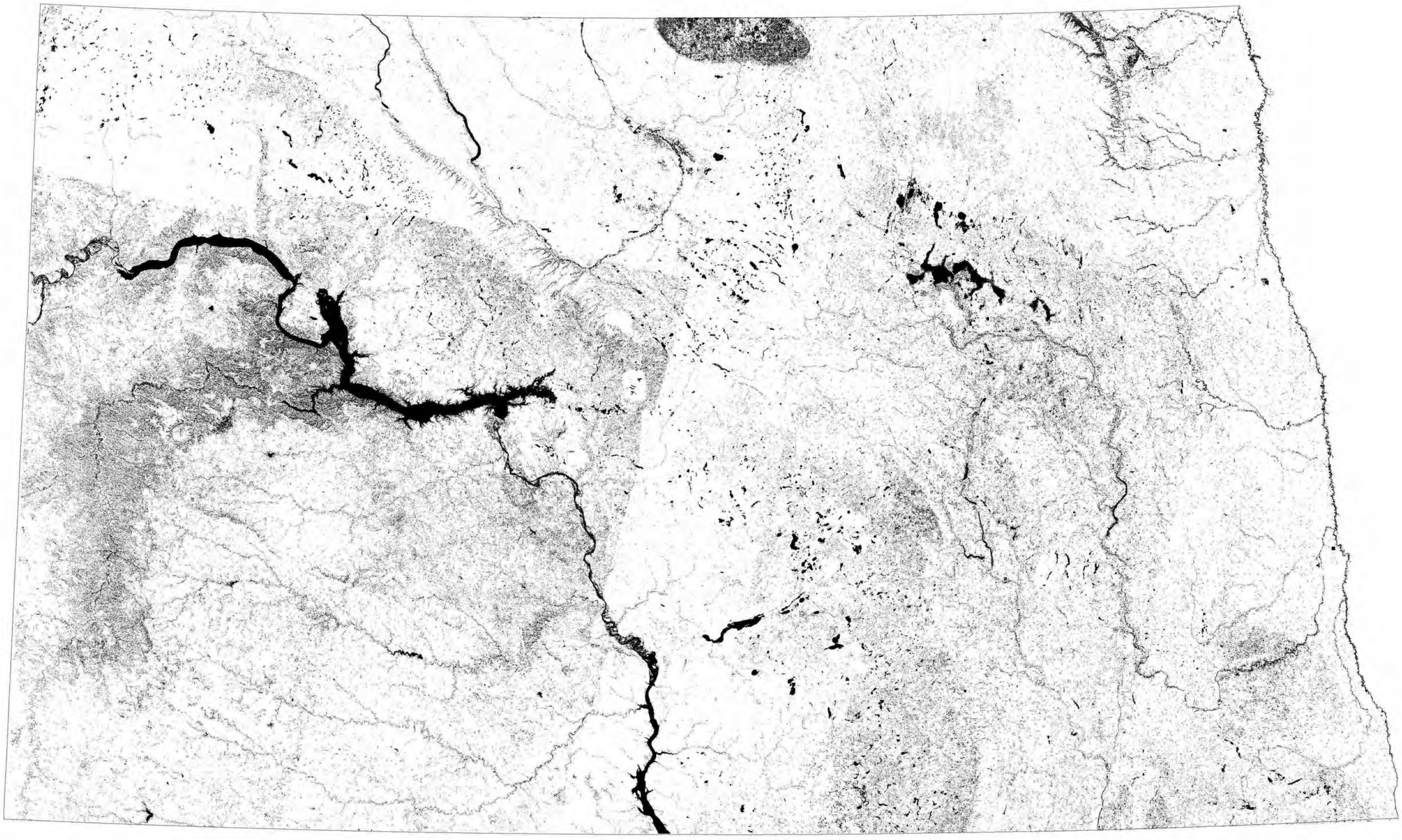


Western Harvest Mouse(Reithrodontomys megalotis)



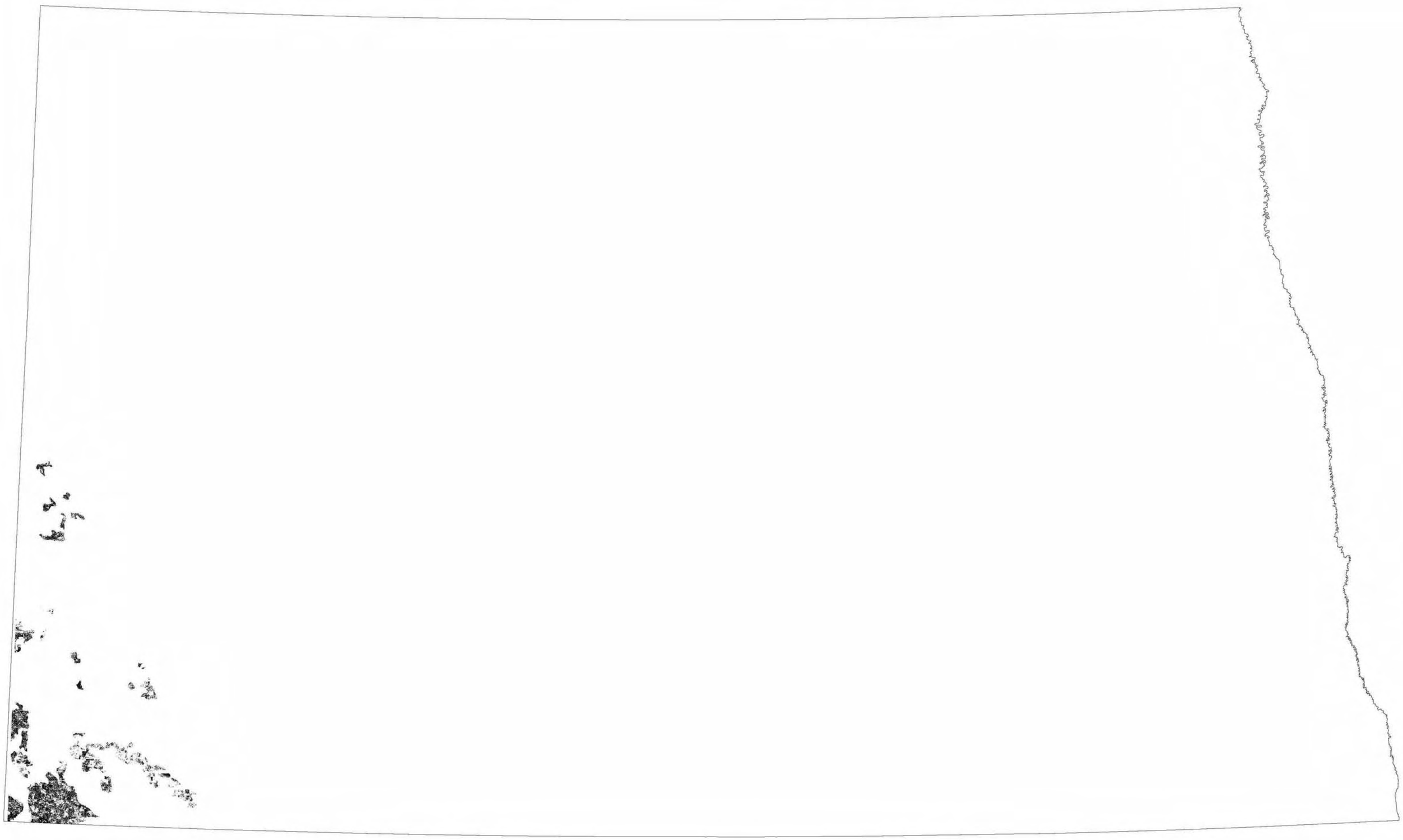
Plains Harvest Mouse(Reithrodontomys montanus)

American Beaver(Castor Canadensis)



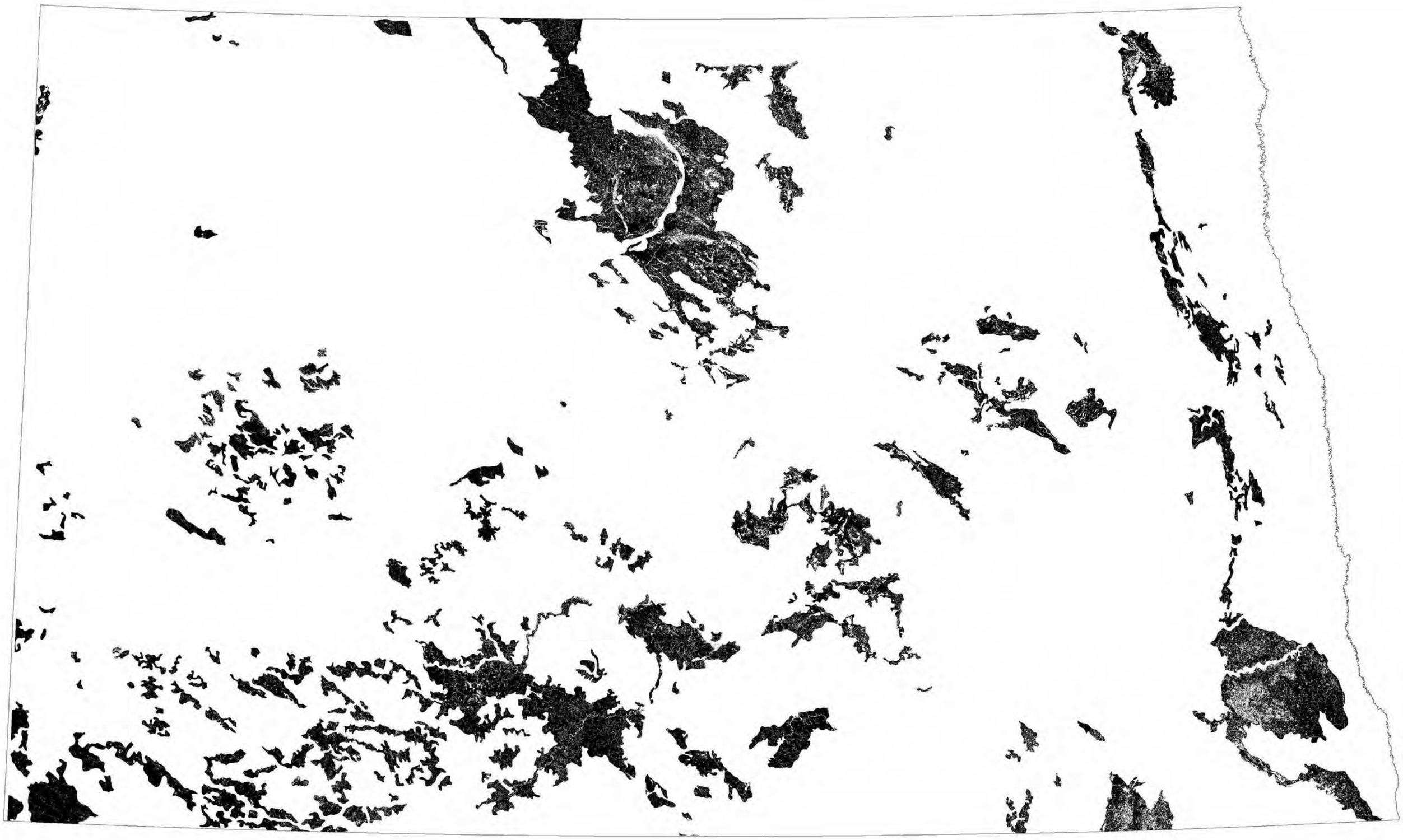
Hispid Pocket Mouse(Perognathus hispidus)

Ord's Kangaroo Rat(Dipodomys ordii)

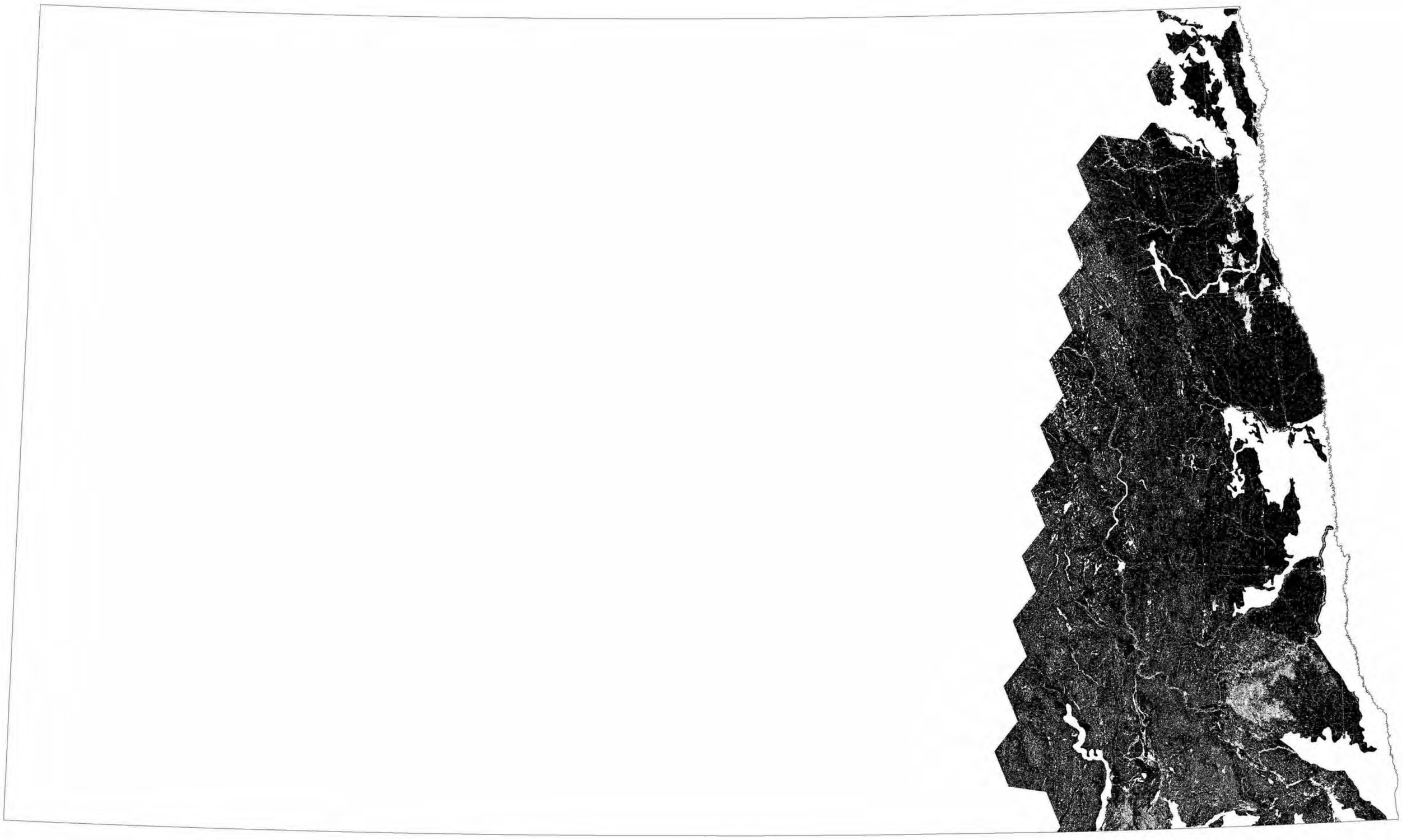


Plains Pocket Mouse(Perognathus flavescens)

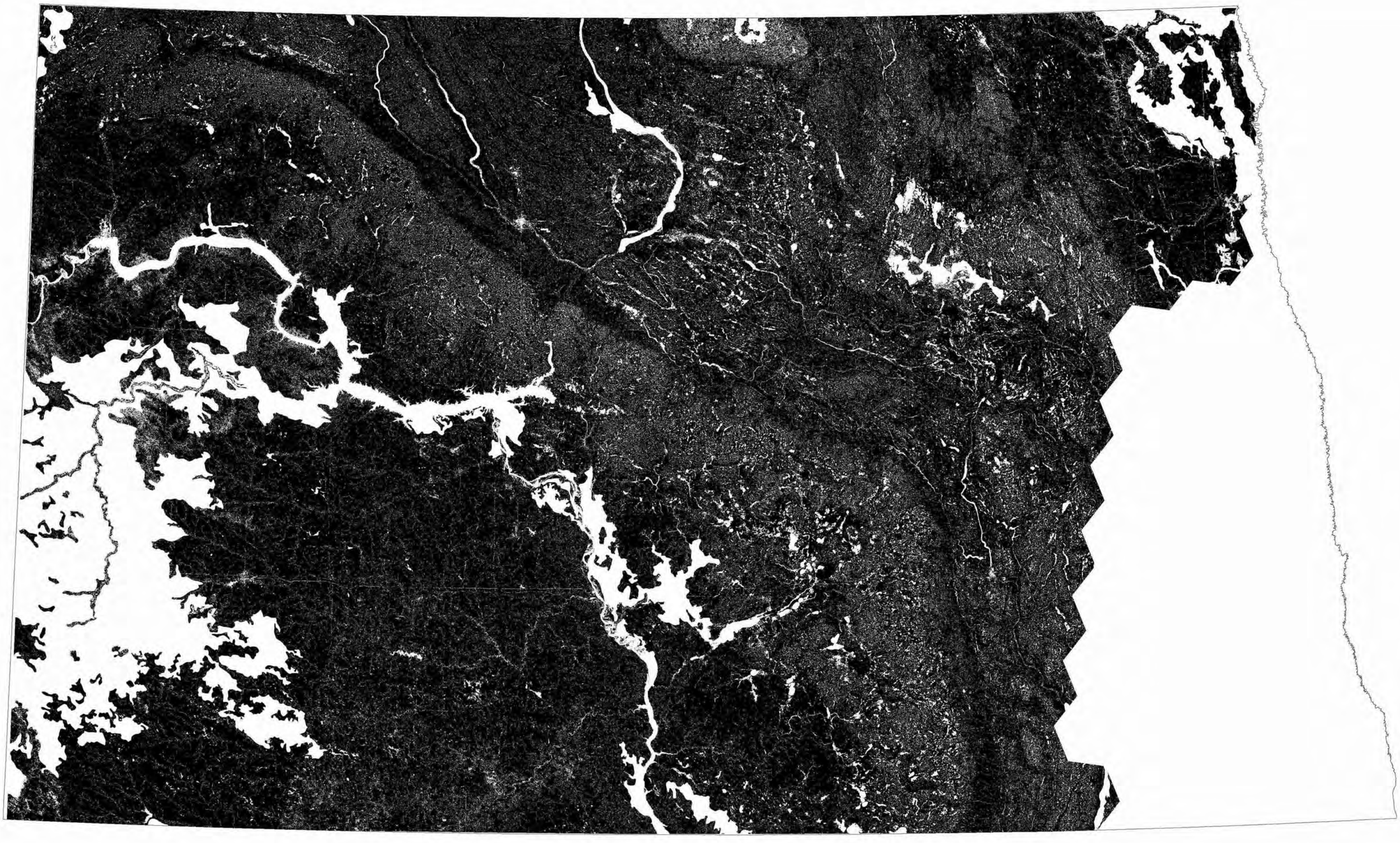
Olived-backed Pocket Mouse(Perognathus fasciatus)



Plains Pocket Gopher(Geomy bursarius)

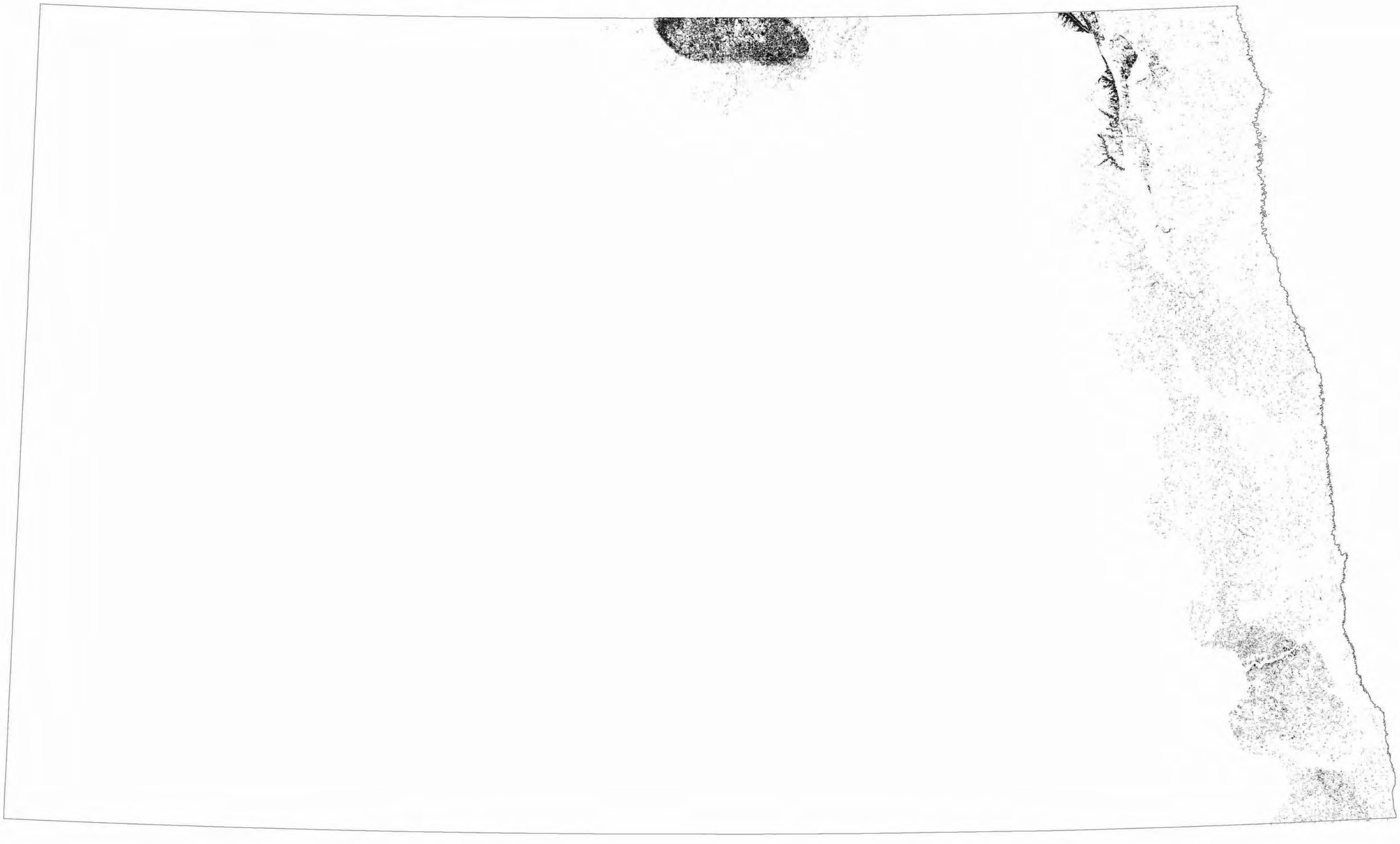


Northern Pocket Gopher(Thomomys talpoides)

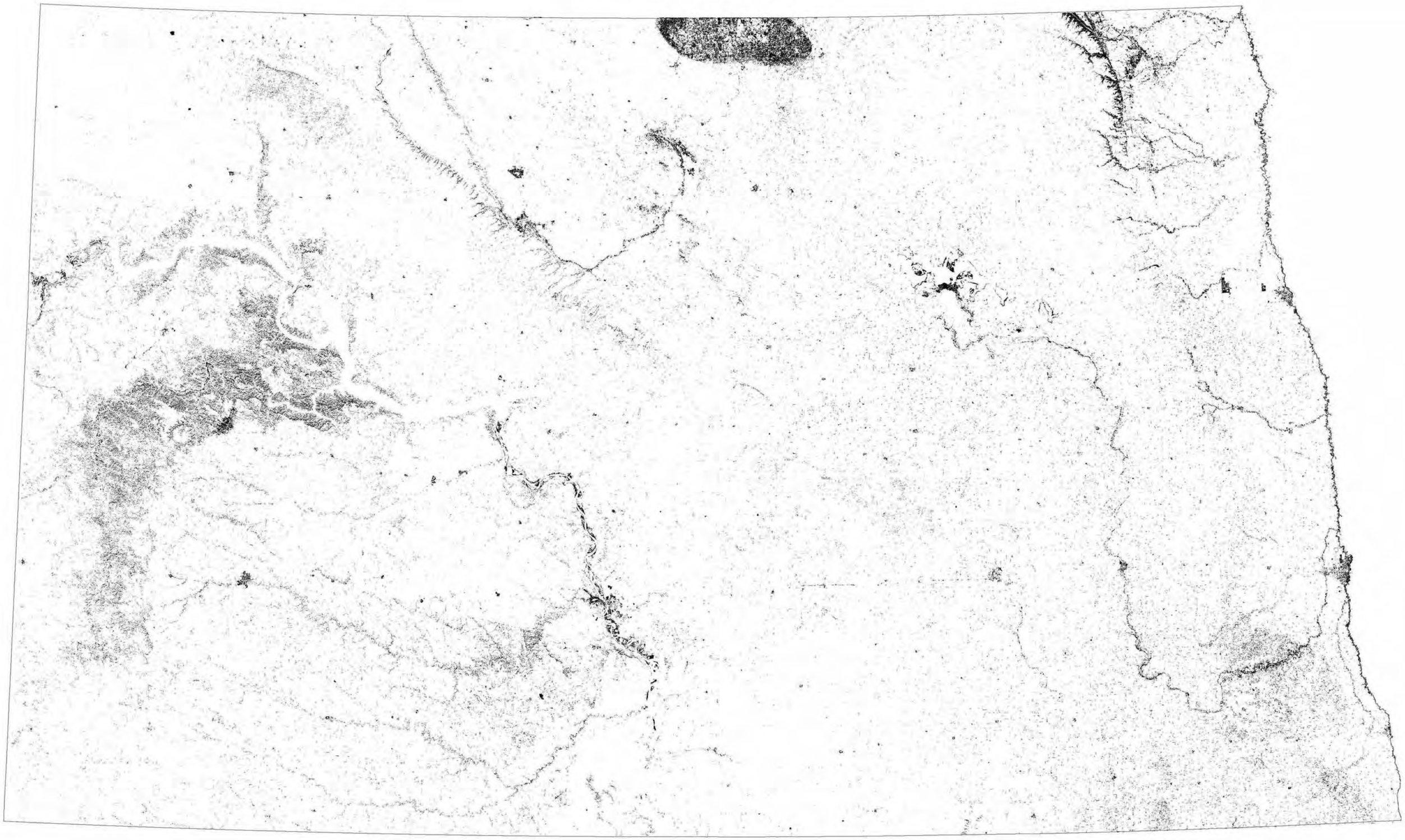


Northern Flying Squirrel(Glaucomys sabrinus)

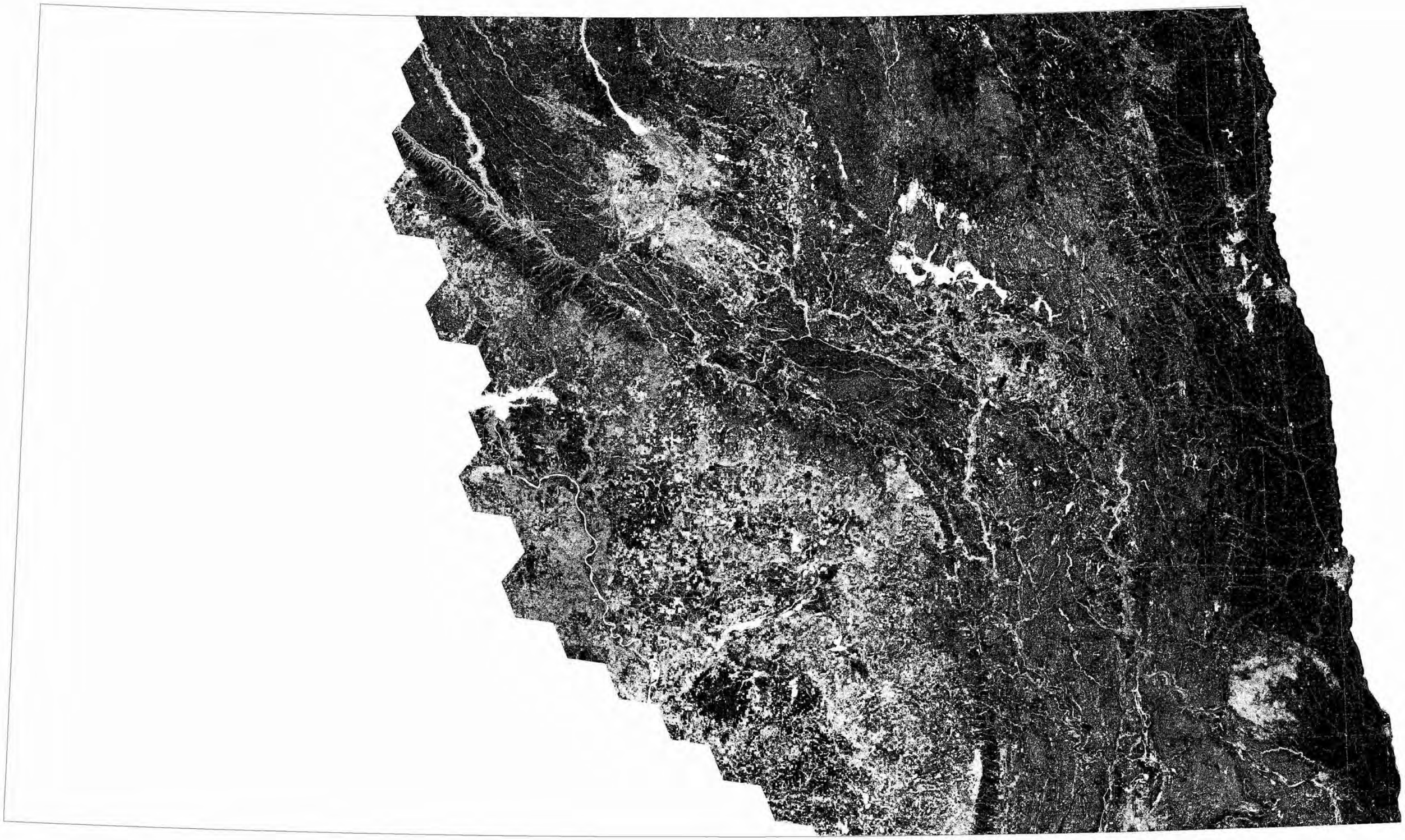
Red Squirrel(Tamiasciurus hudsonicus)



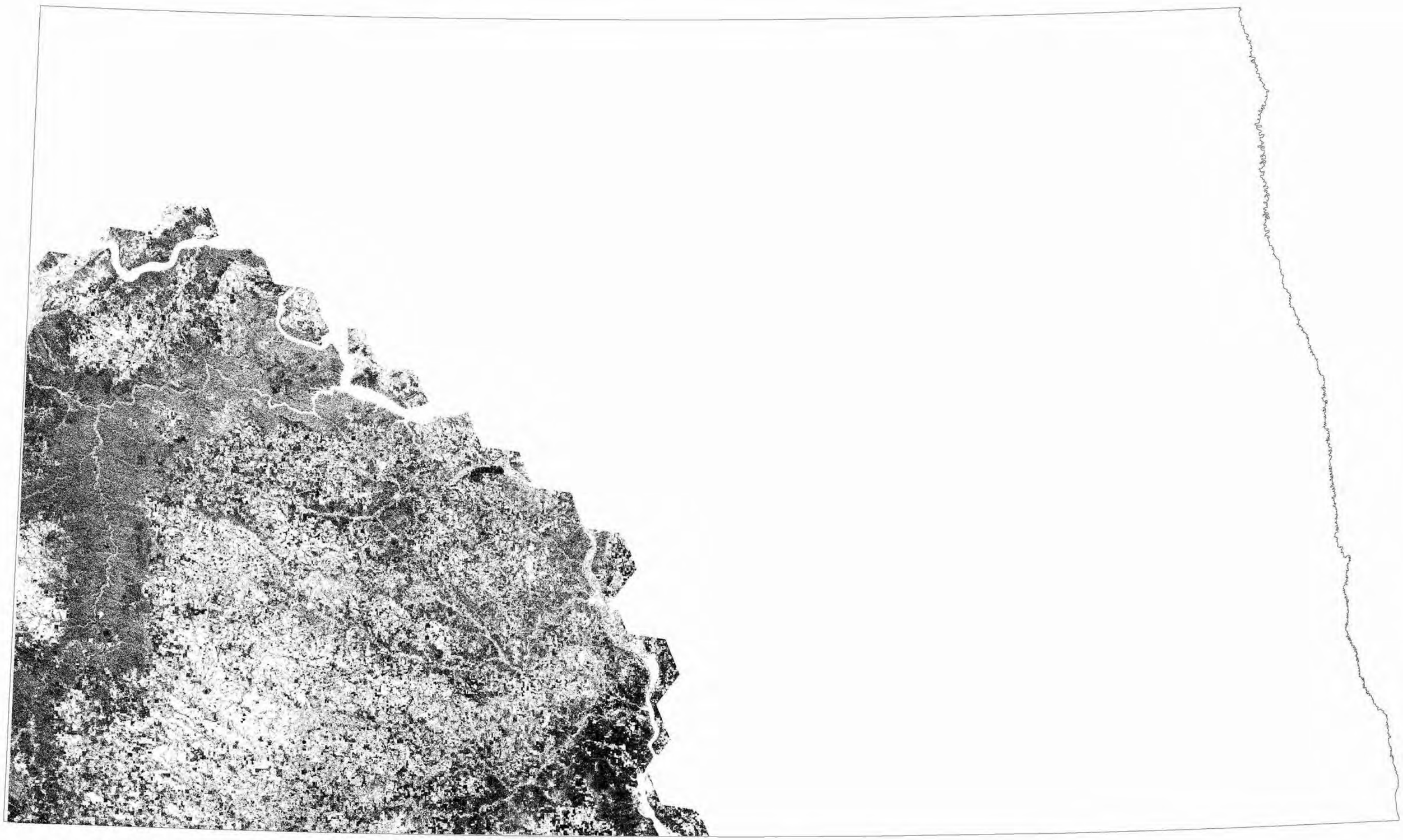
Eastern Fox Squirrel(Sciurus niger)



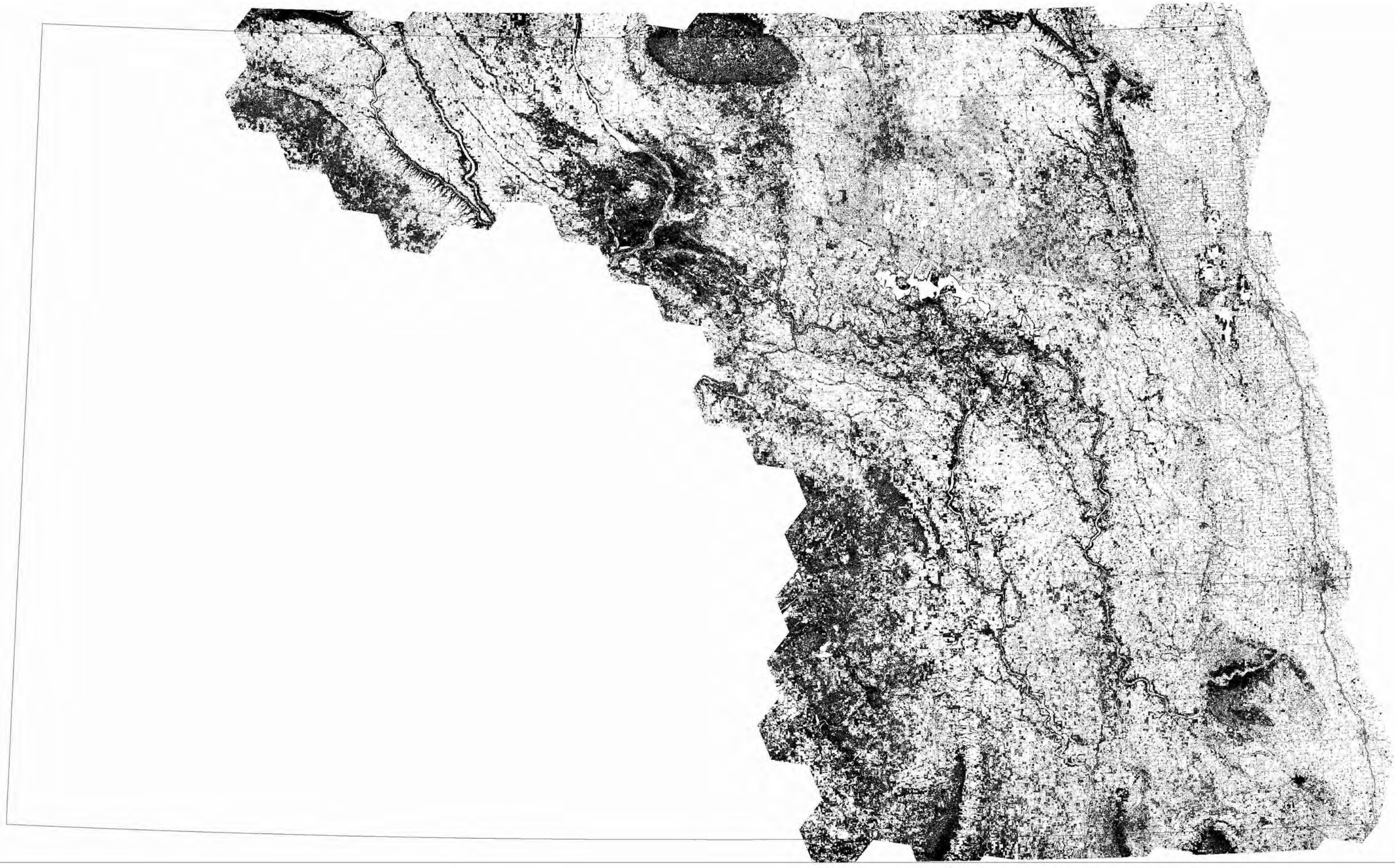
Gray Squirrel(Sciurus carolinensis)



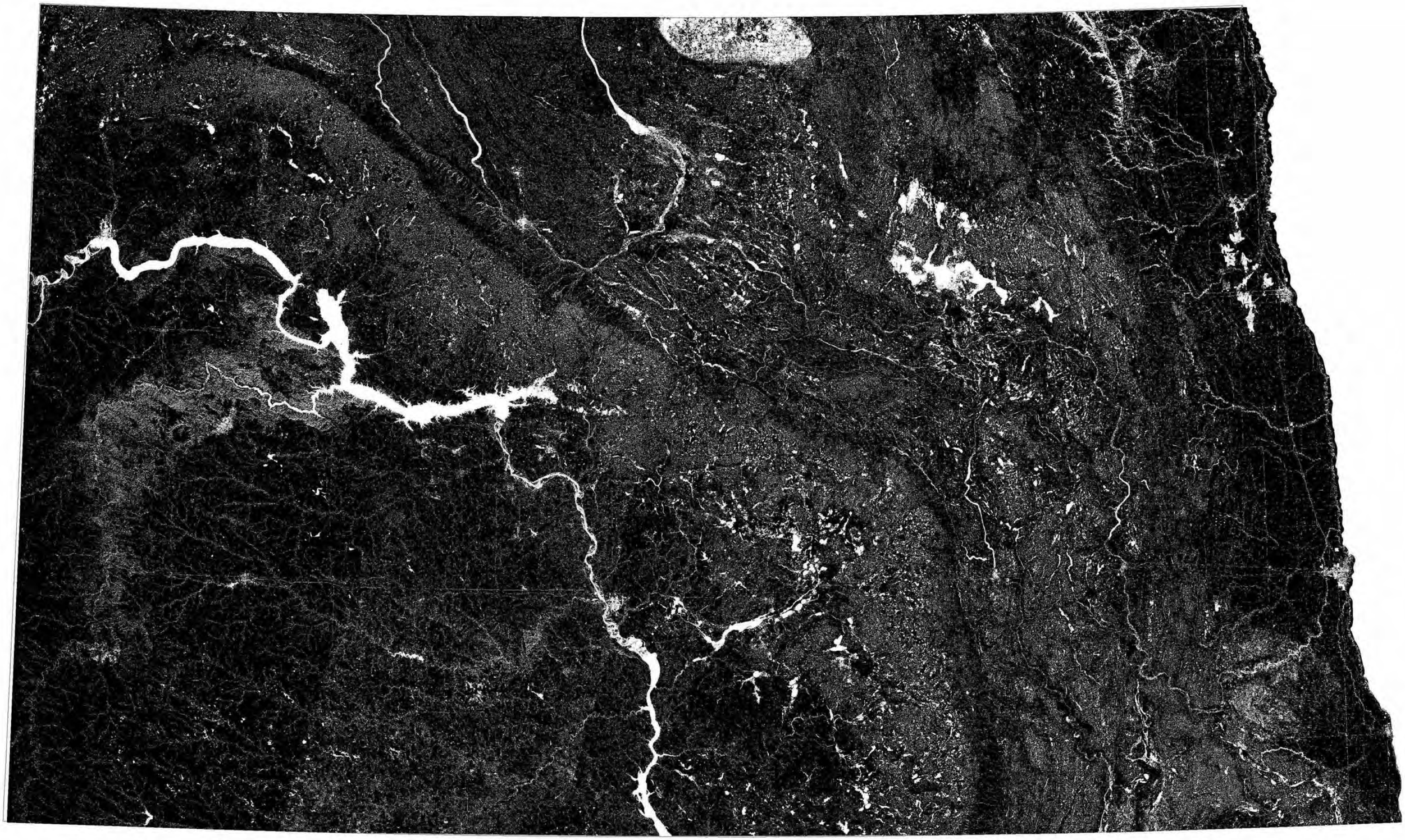
Black-tailed Prairie Dog(Cynomys ludovicianus)



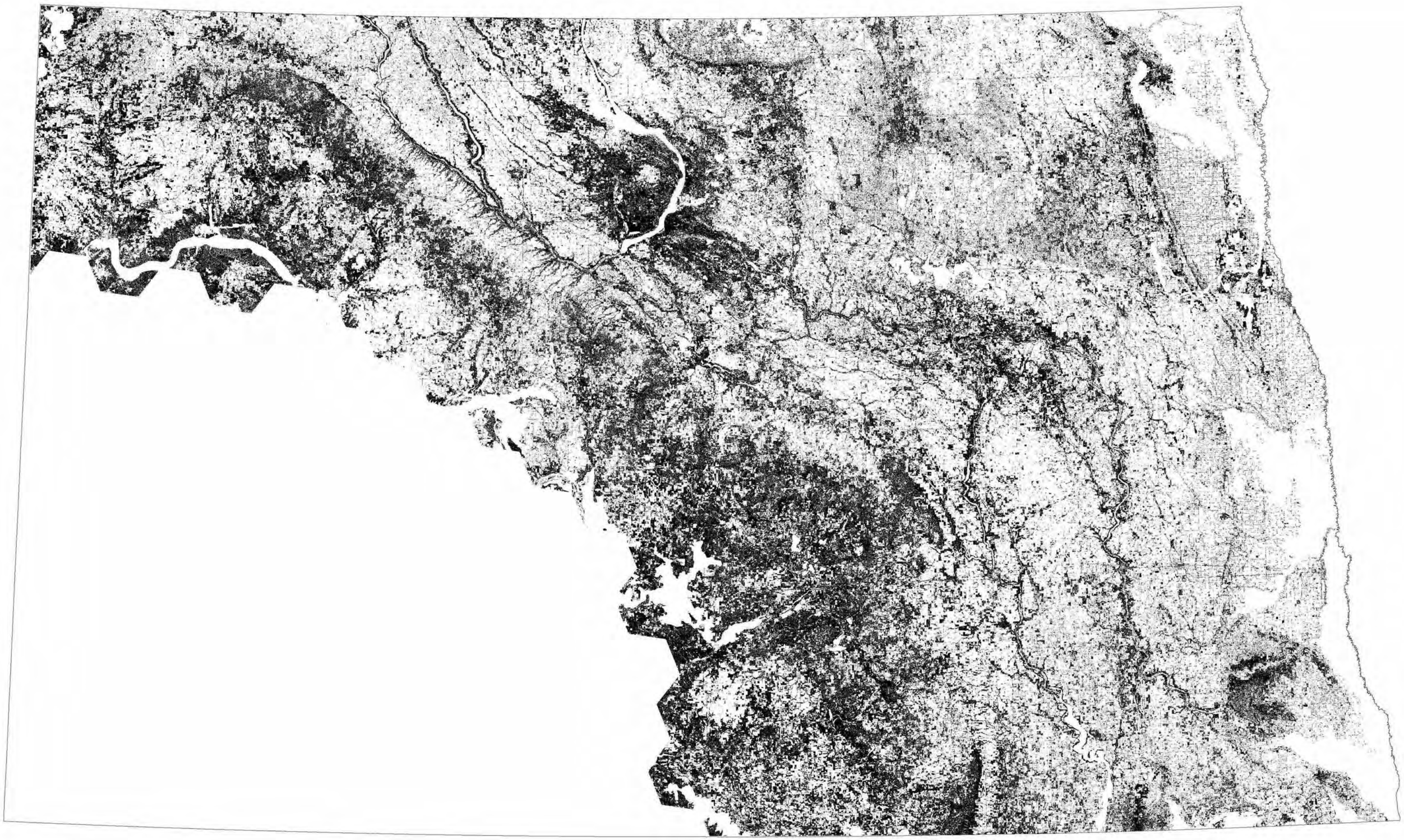
Franklin's Ground Squirrel(Spermophilus franklinii)



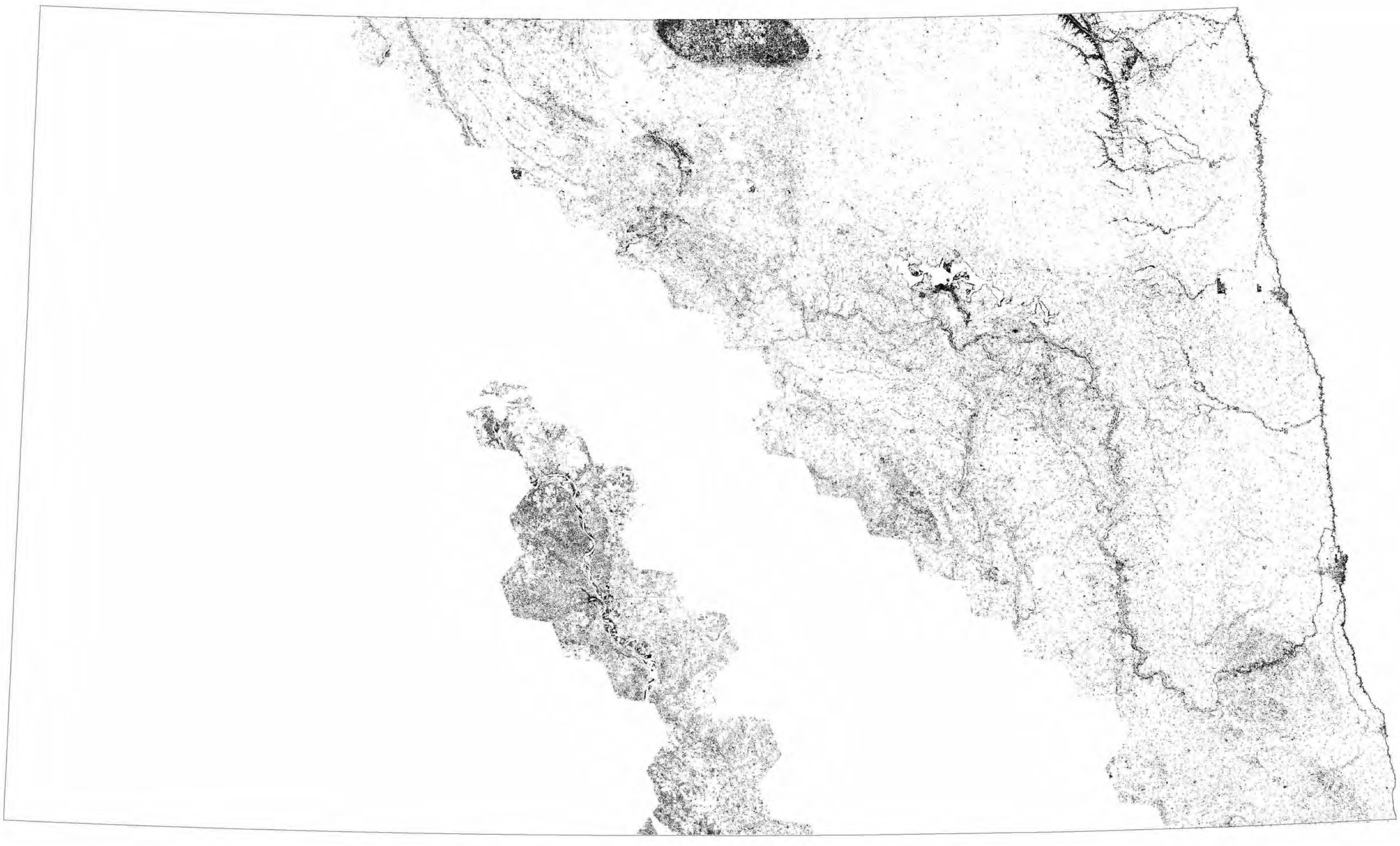
Thirteen-lined Ground Squirrel(Spermophilus tridecemlineatus



Richardson's Ground Squirrel(Spermophilus richardsonii)

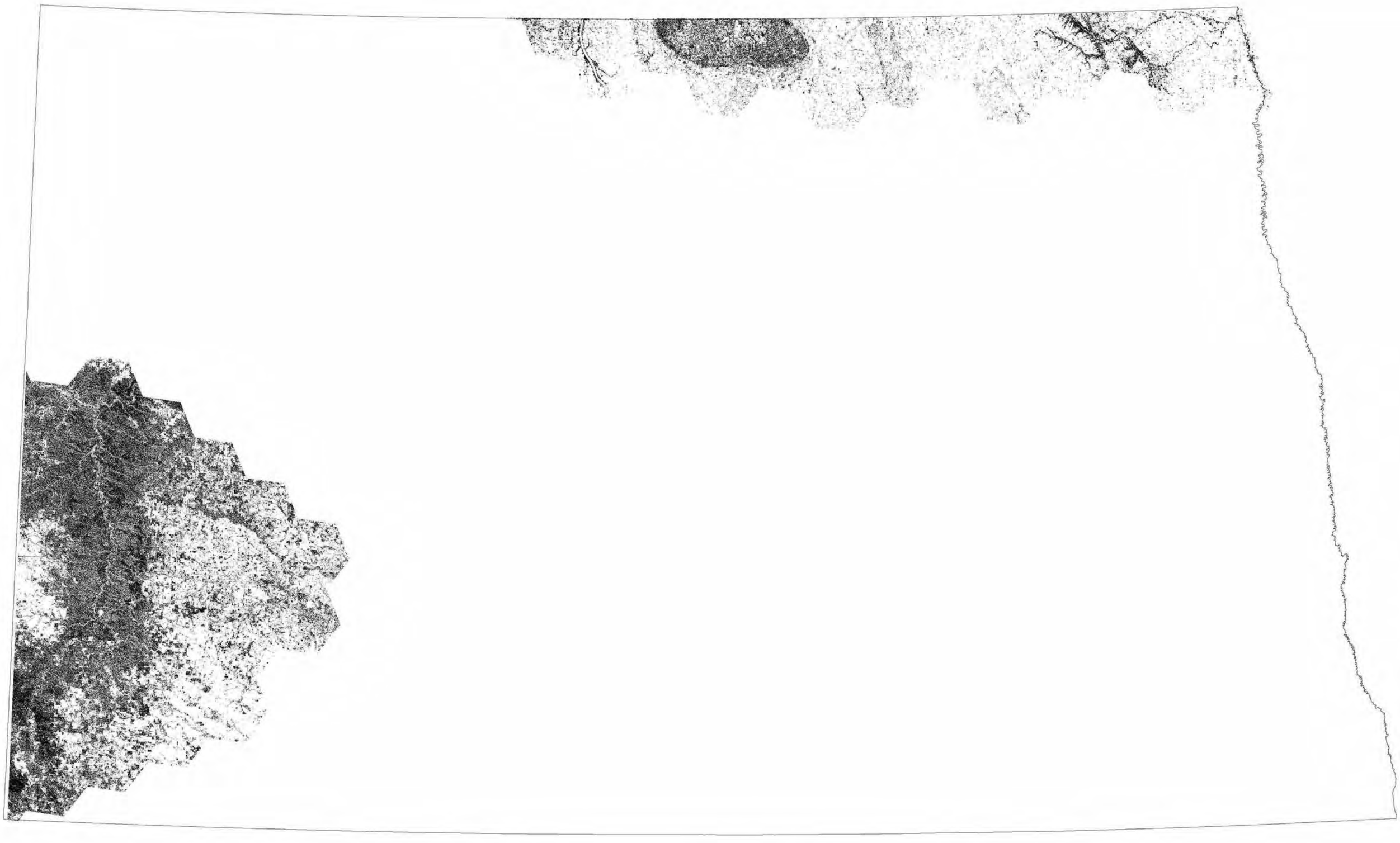


Woodchuck(Marmota monax)

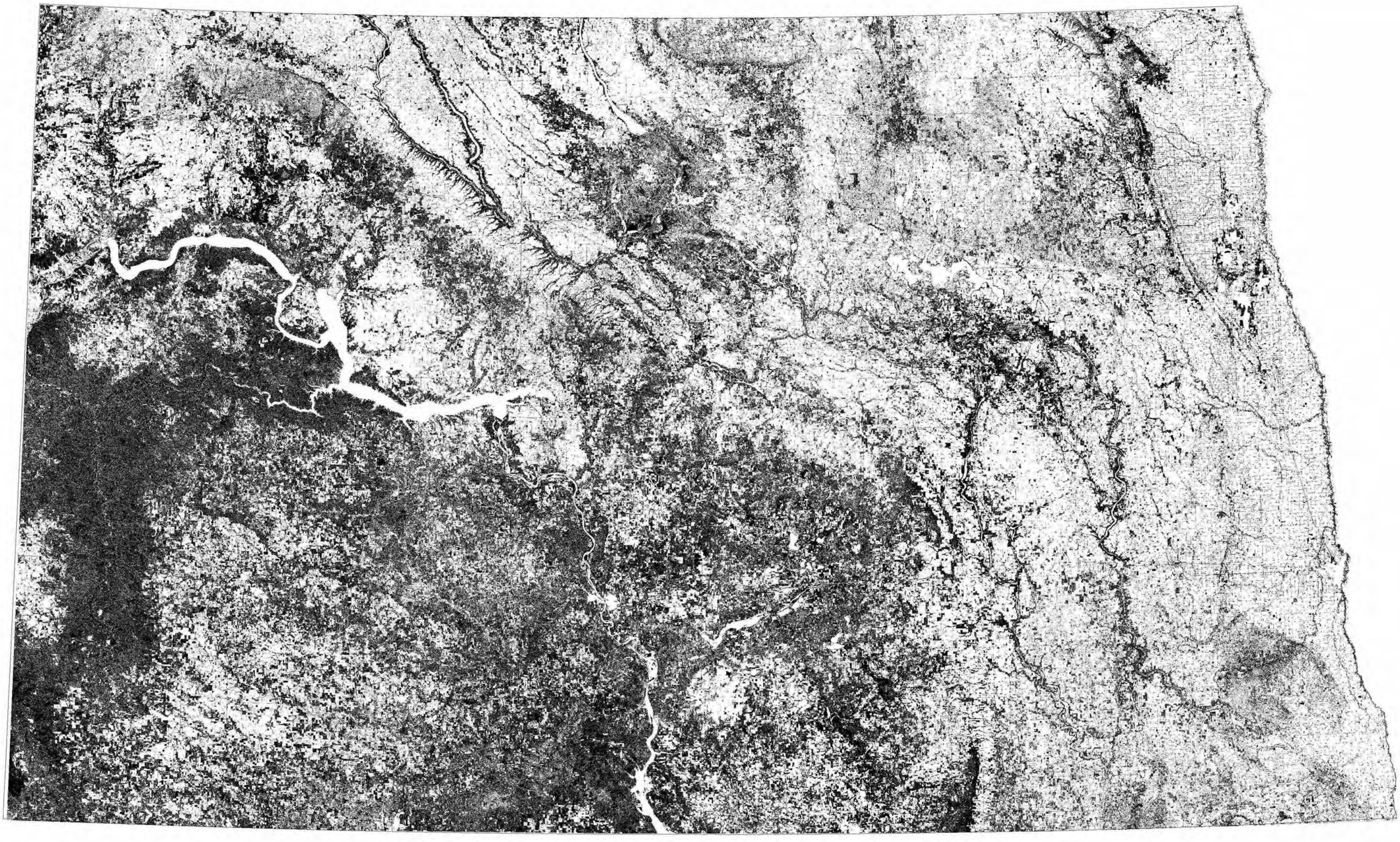


Eastern Chipmunk(Tamias striatus)

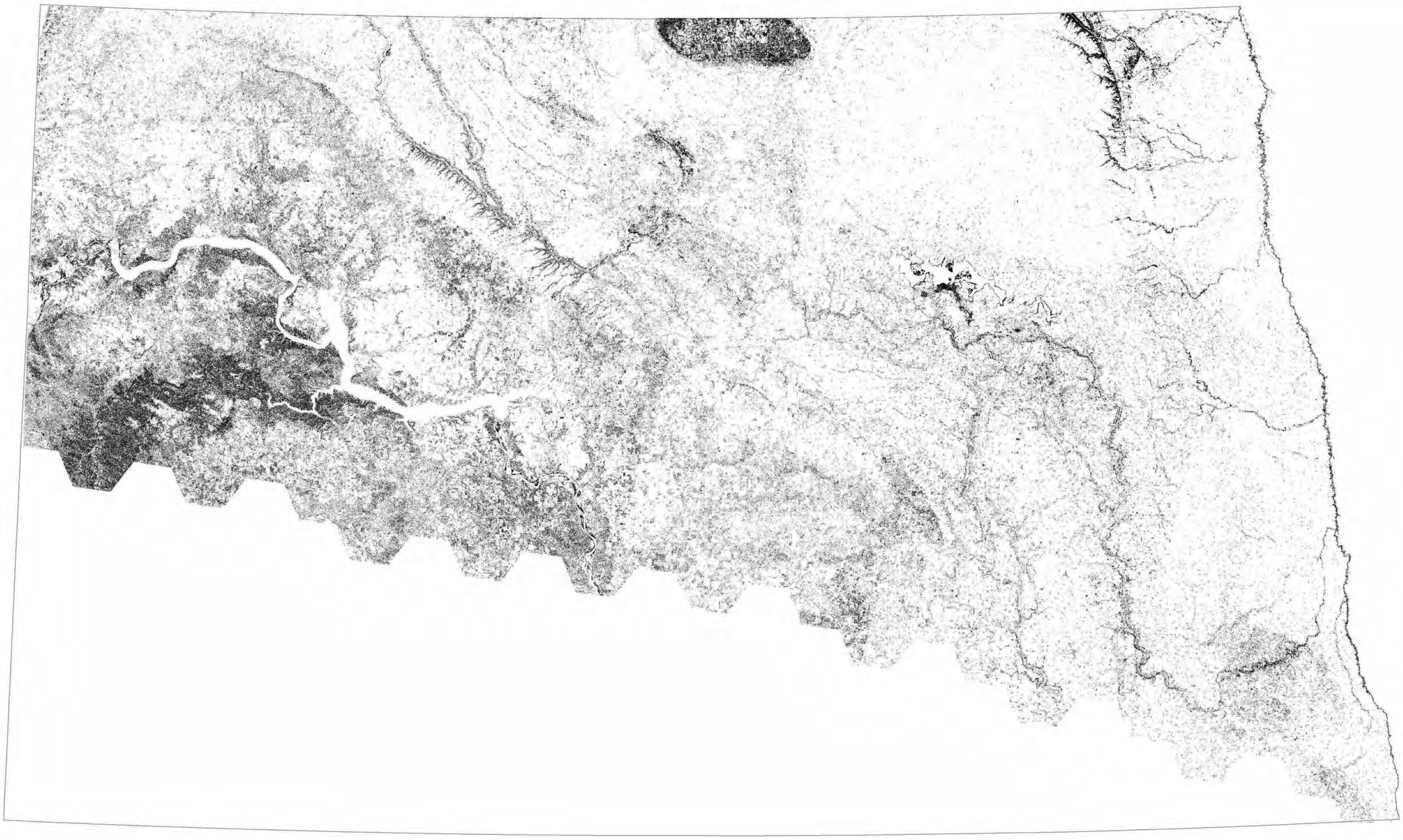
Least Chipmunk(Eutamius minimus)



White-tailed Jack Rabbit(Lepus townsendii)



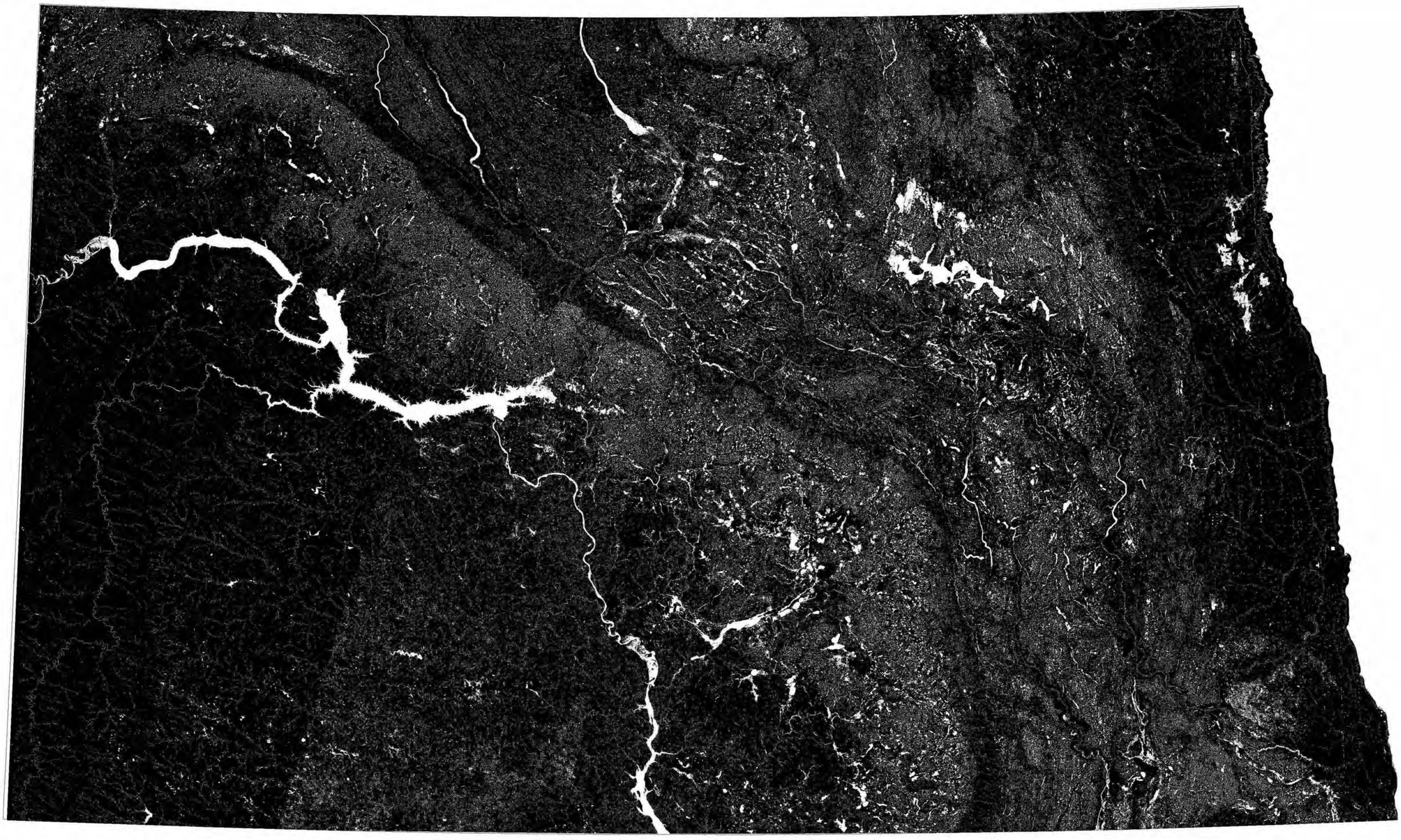
Snowshoe Hare(Lepus americanus)



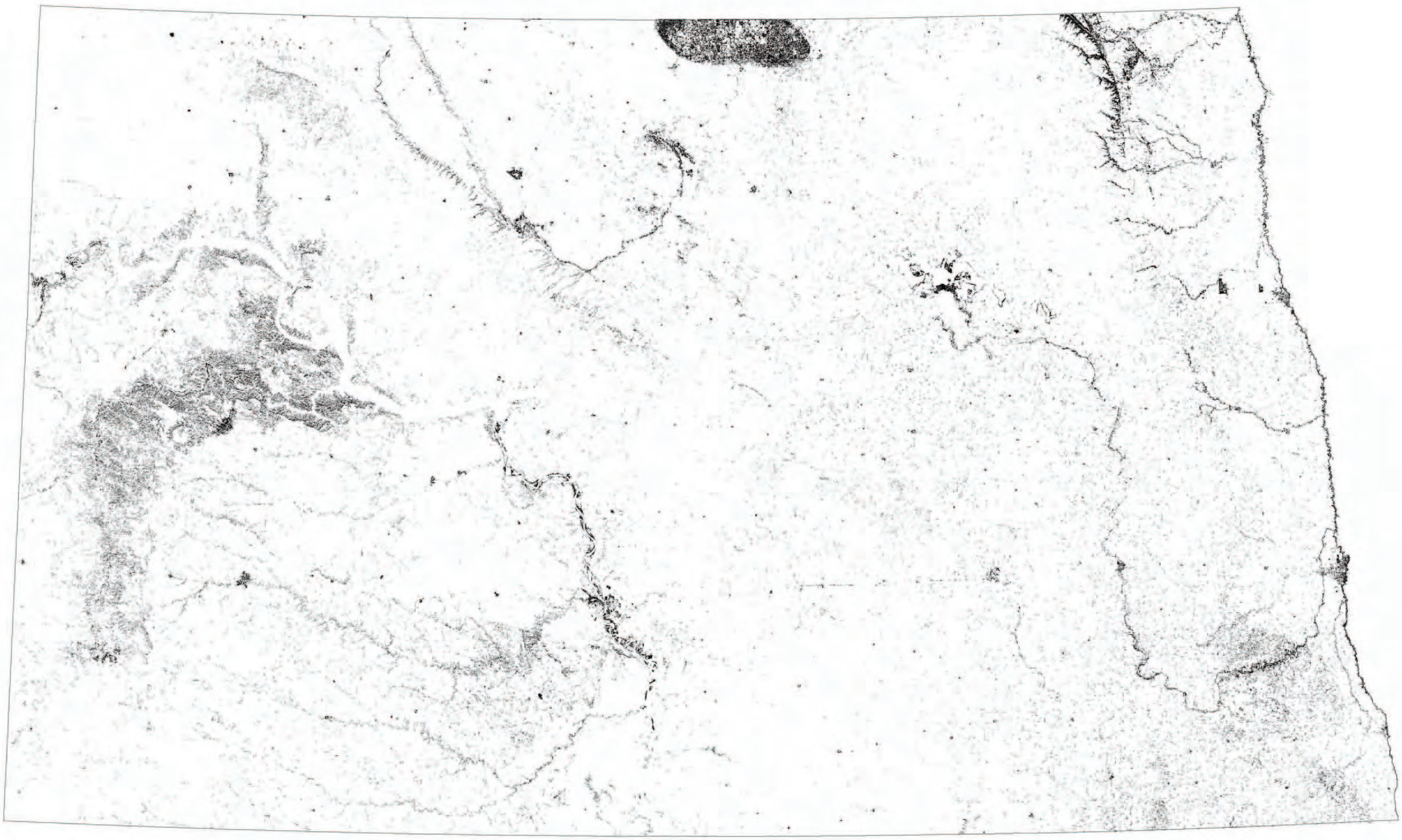
Desert Cottontail(Sylvilagus audubonii)

Nuttall's Cottontail(Sylvilagus nuttallii)

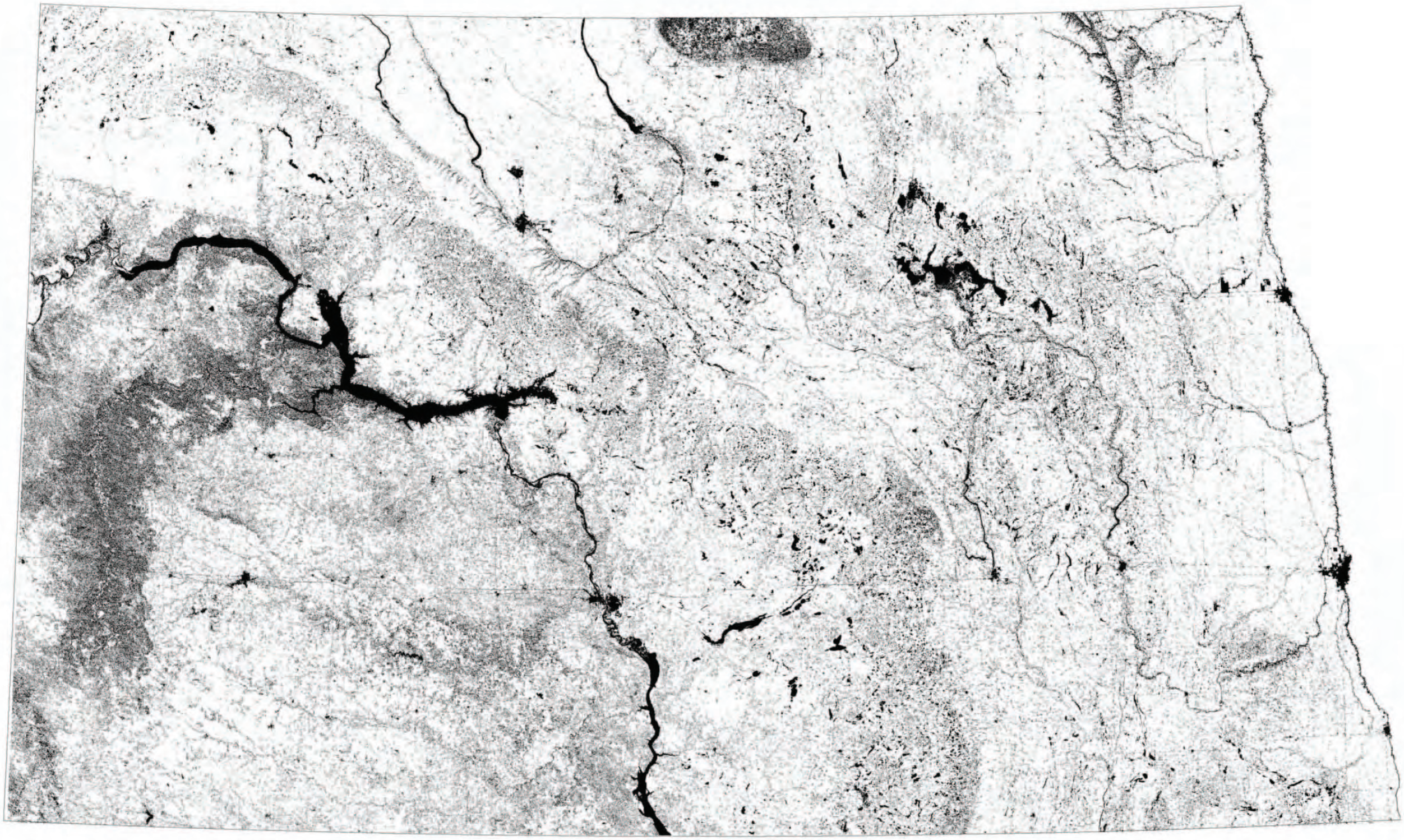
Eastern Cottontail(Sylvilagus floridanus)



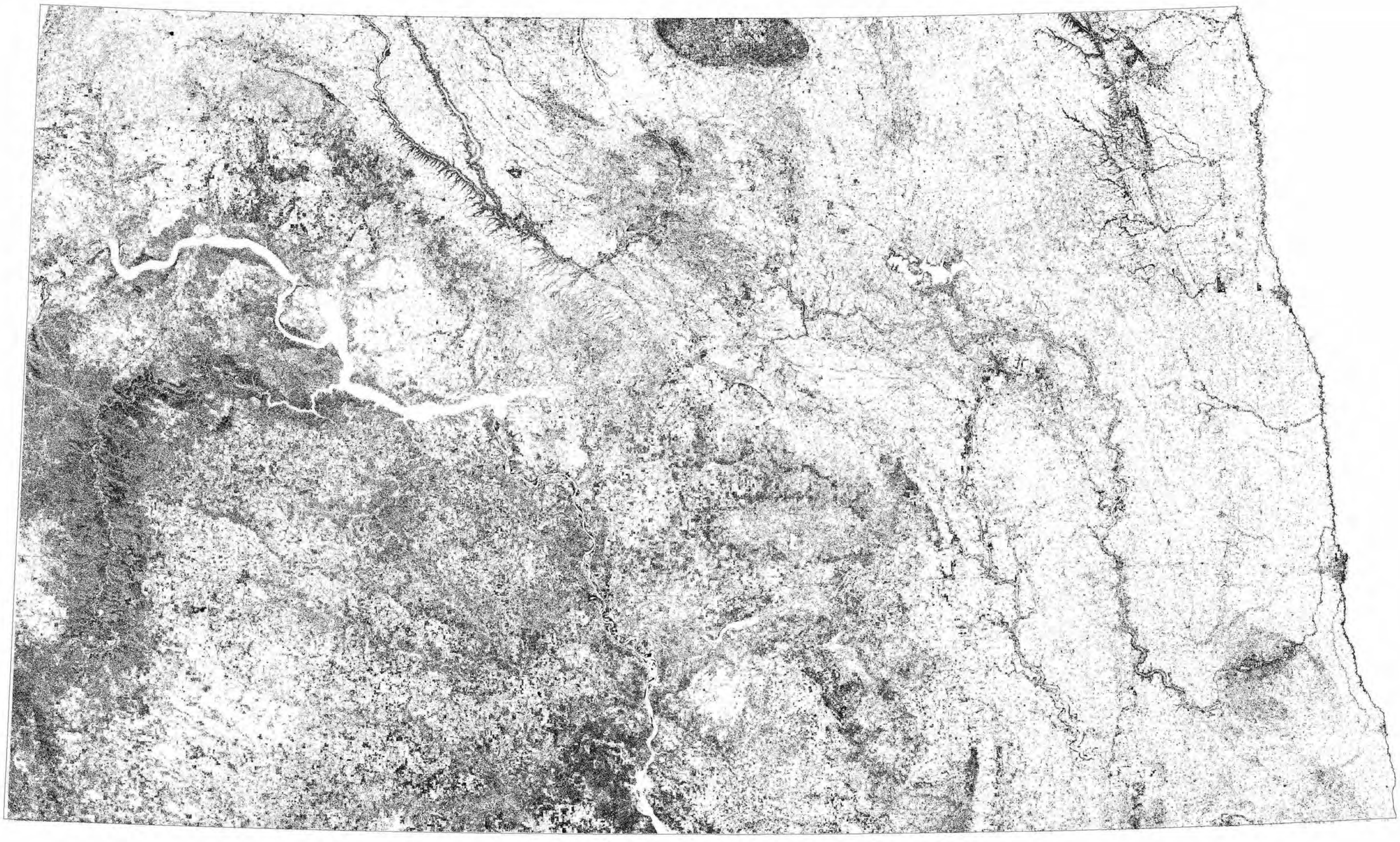
Hoary Bat (Lasiurus cinereus)



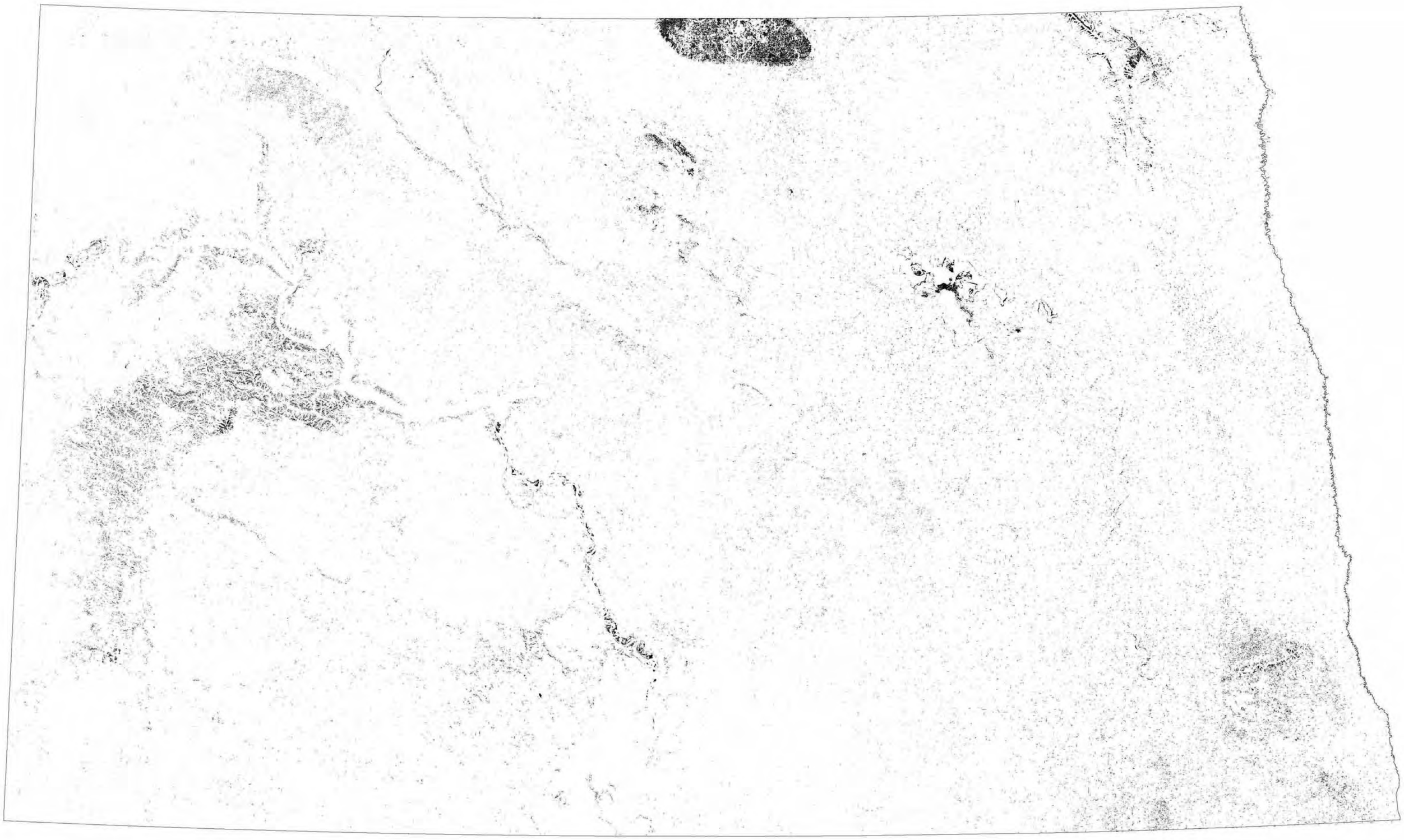
Eastern Red Bat(Lasiurus borealis)



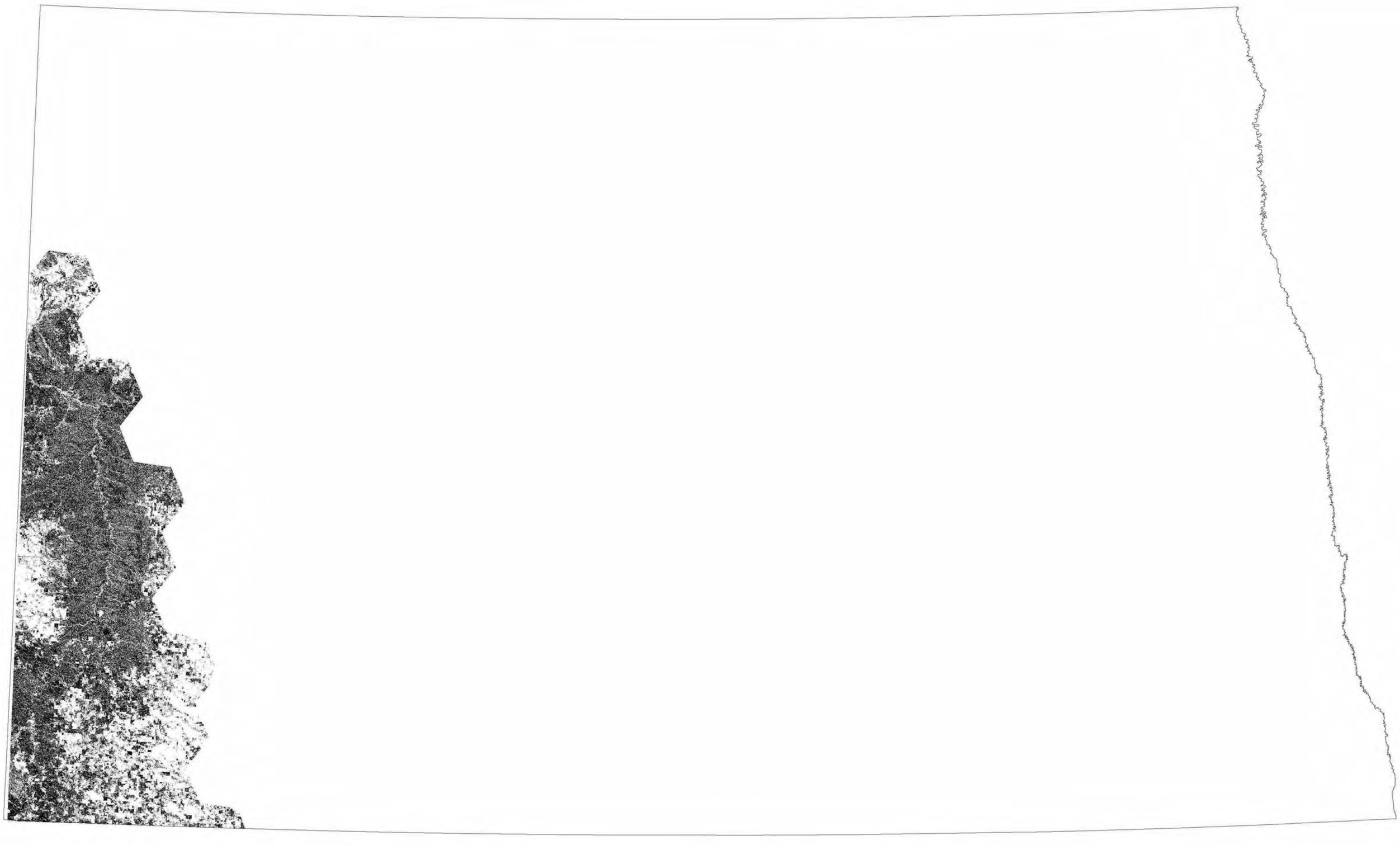
Big Brown Bat(Eptesicus fuscus)



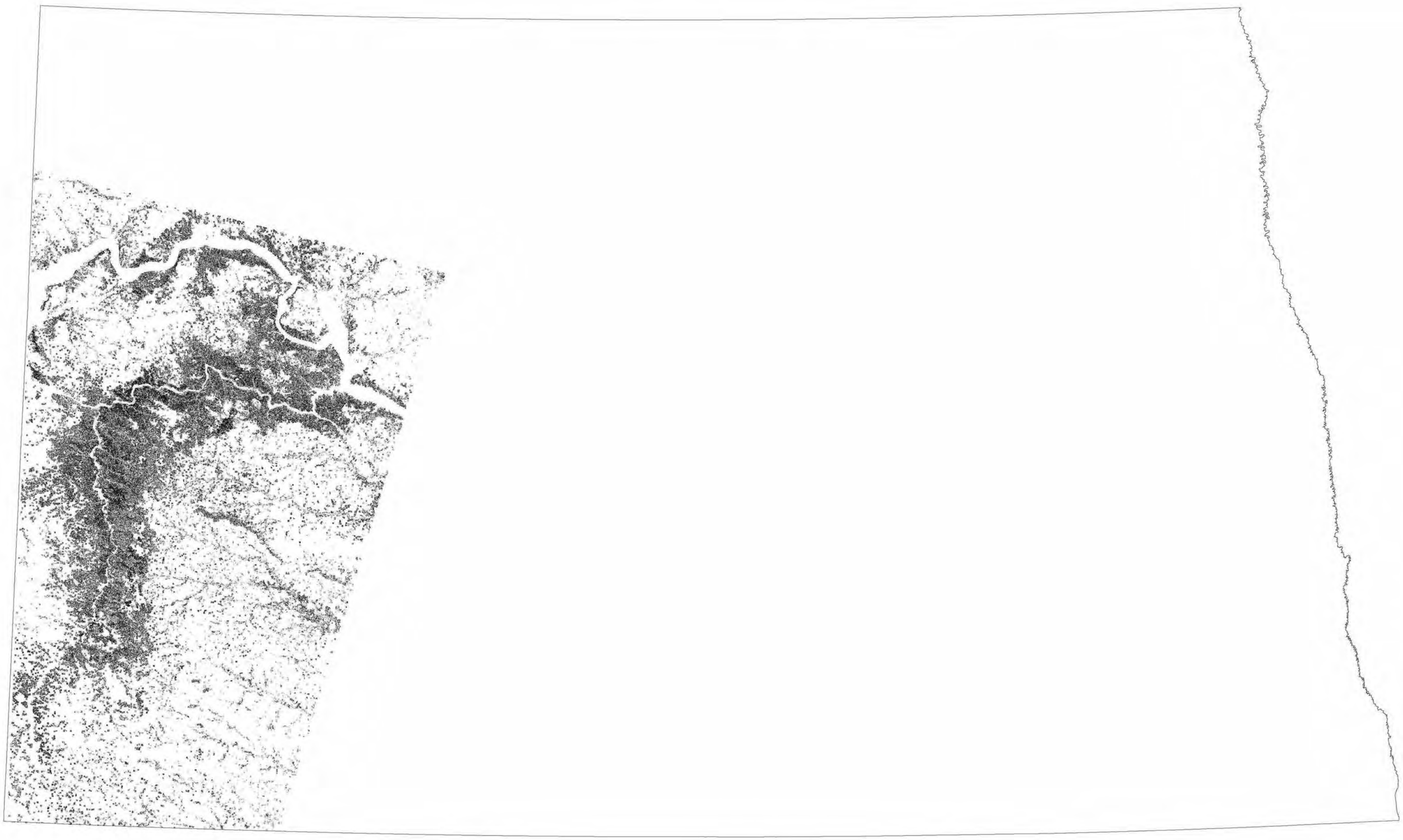
Silver-haired Bat(Lasionycteris noctivagans)



Small-footed Myotis(Myotis leibii)

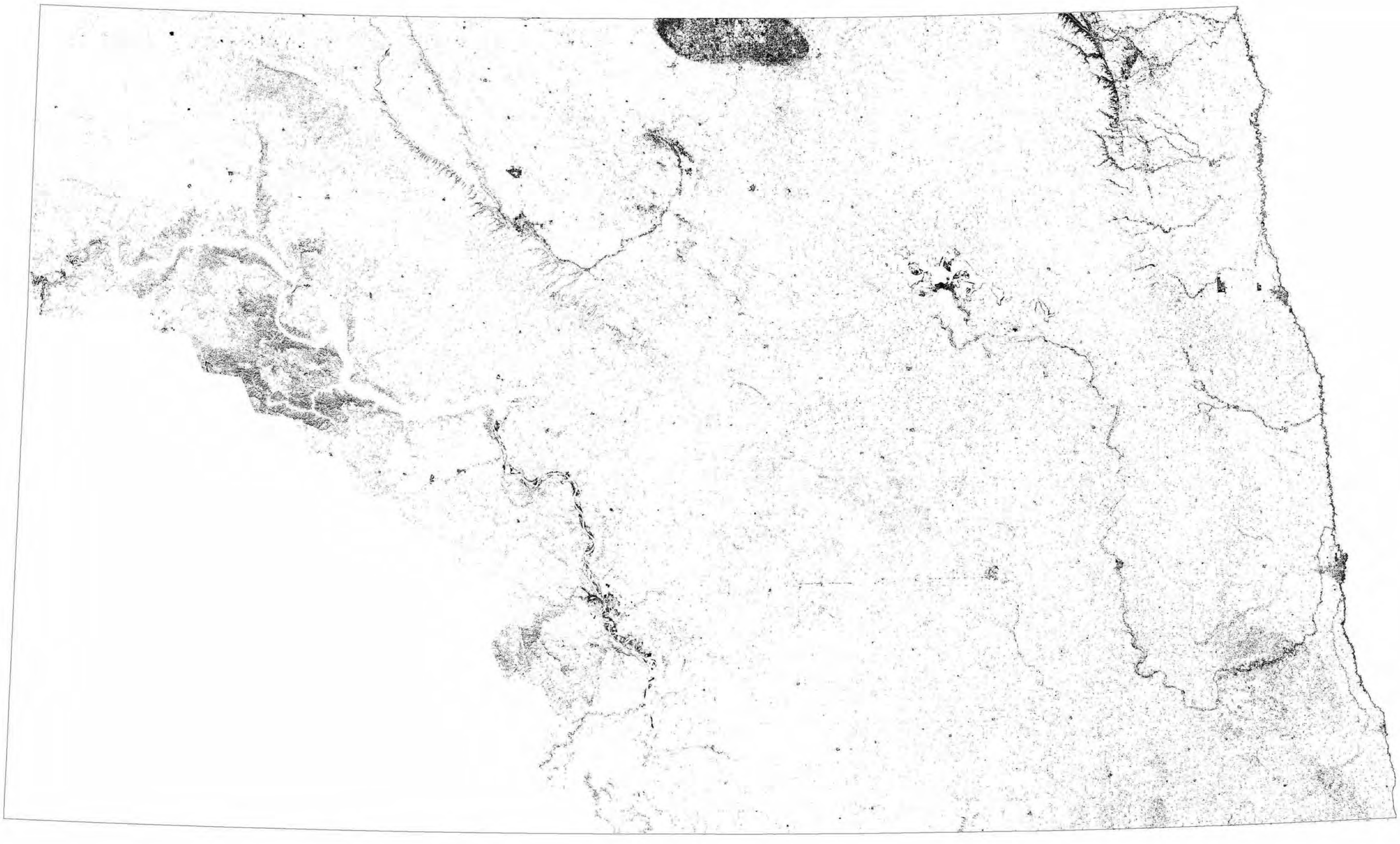


Long-legged Myotif(Myotis volans)

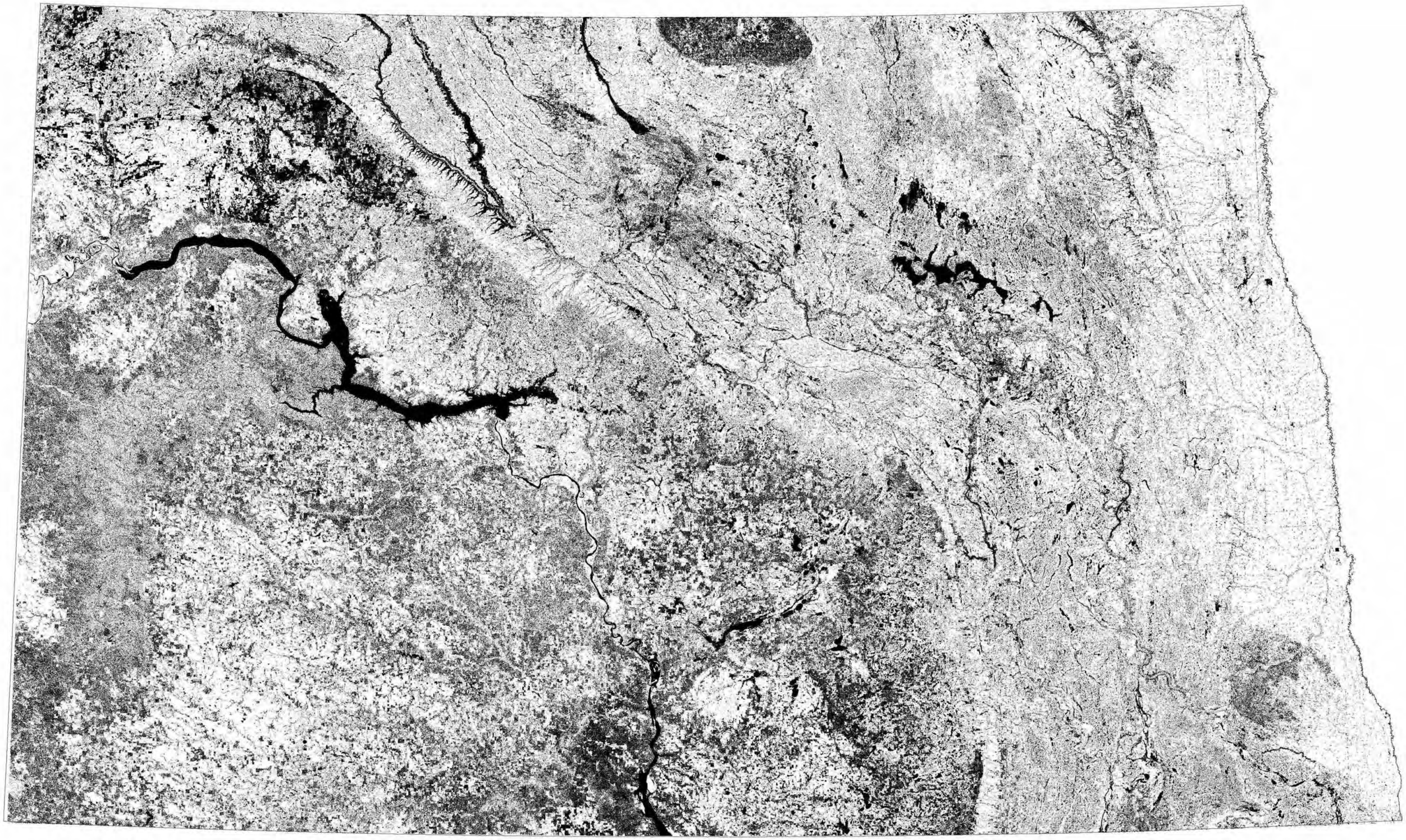


Long-eared Myotis(Myotis evotis)

Keen's Myotis(Myotis keenii)



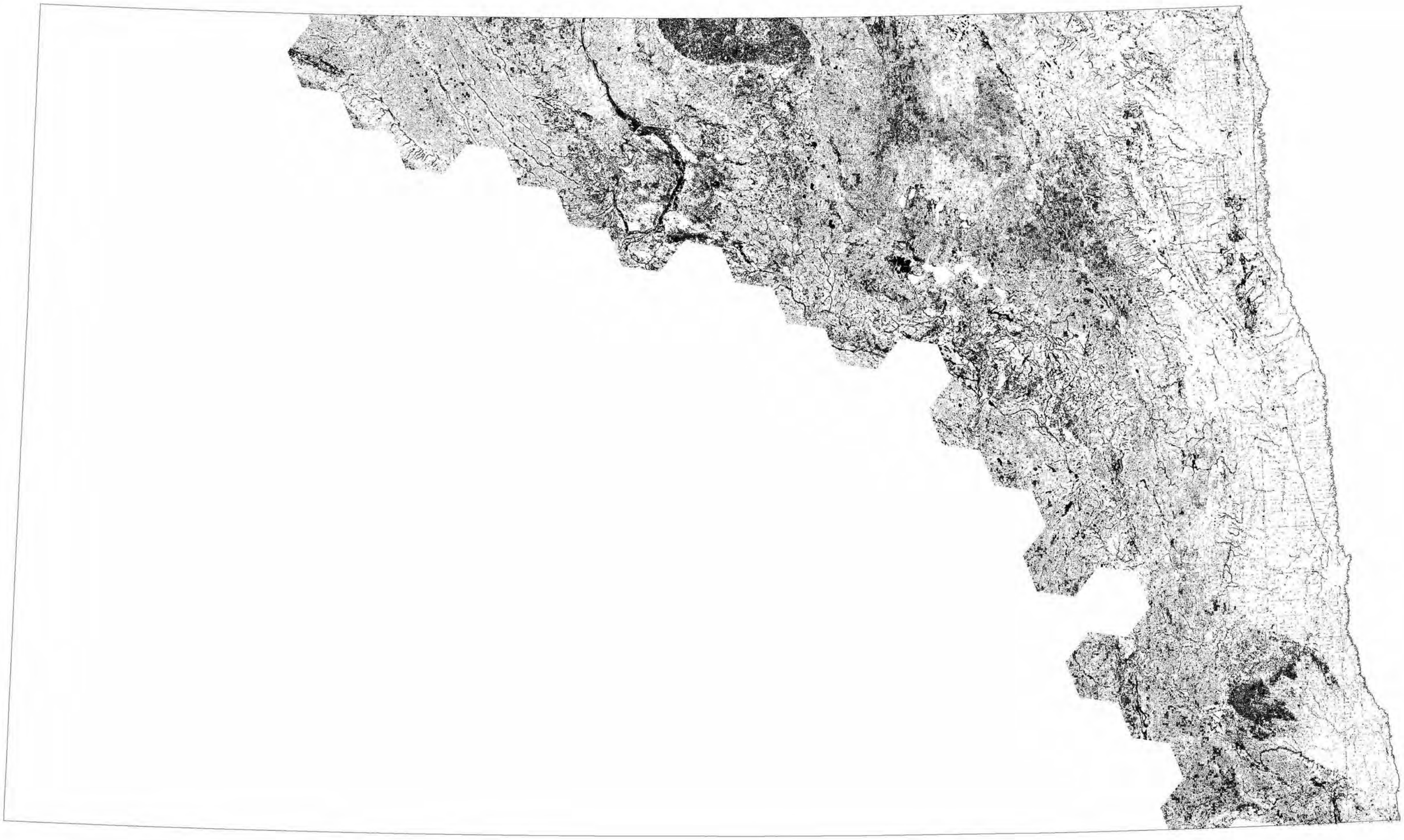
Little Brown Bat(Myotis lucifugus)



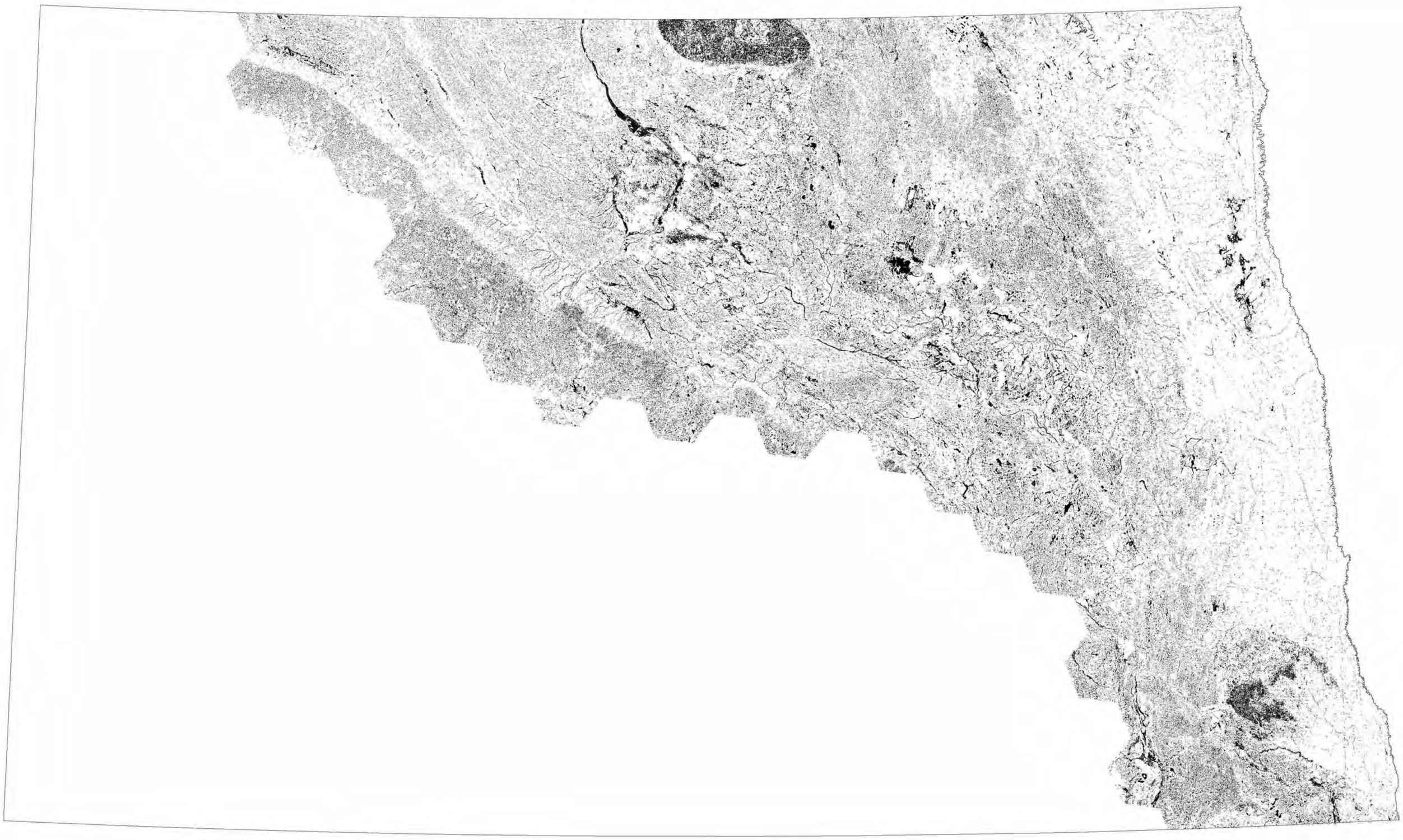
Northern Short-tailed Shrew(Blarina brevicauda)

Hayden's Shrew(Sorex haydenii)

Pigmy Shrew(Microsorex hoyi)

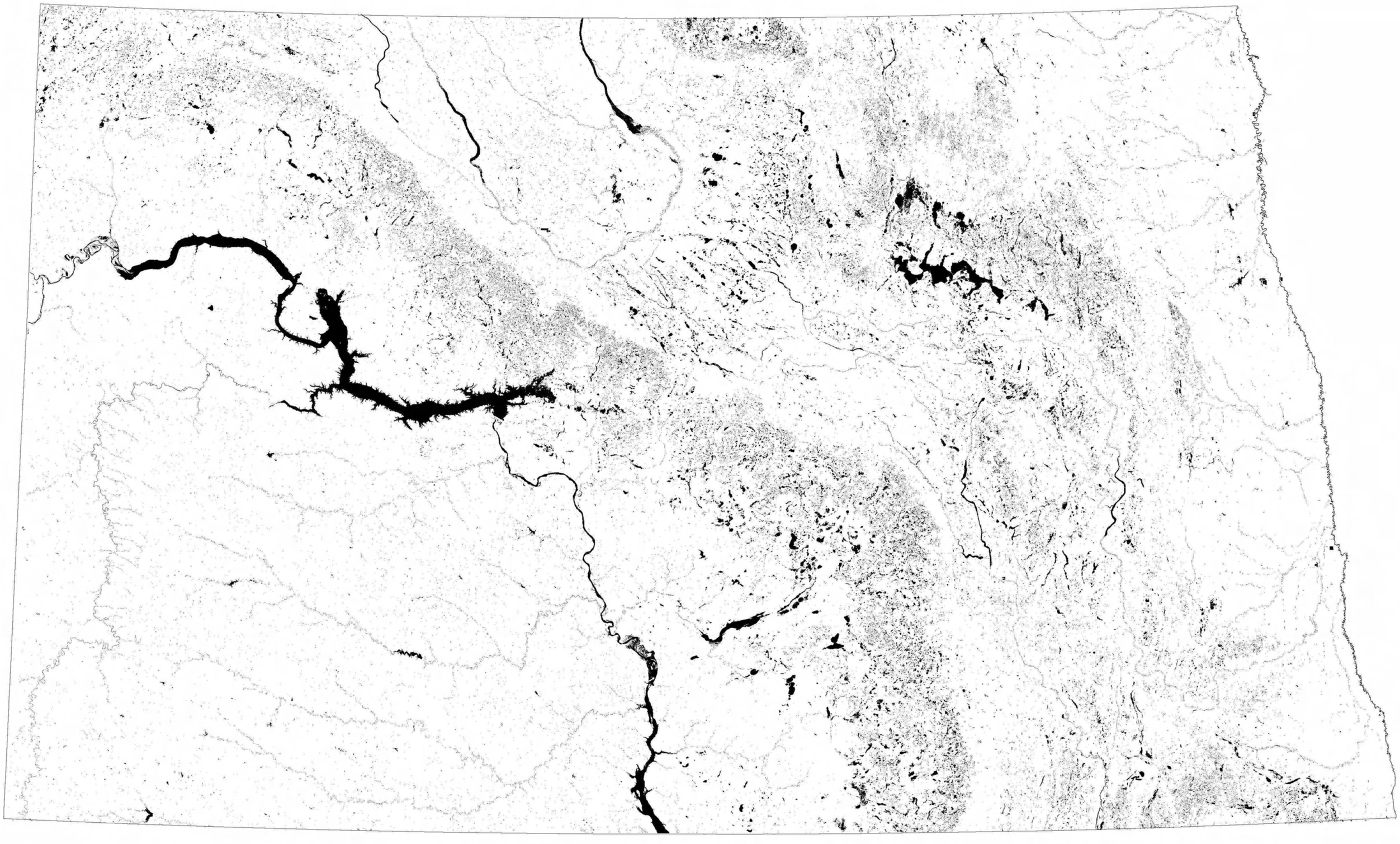


Arctic Shrew(Sorex articus)

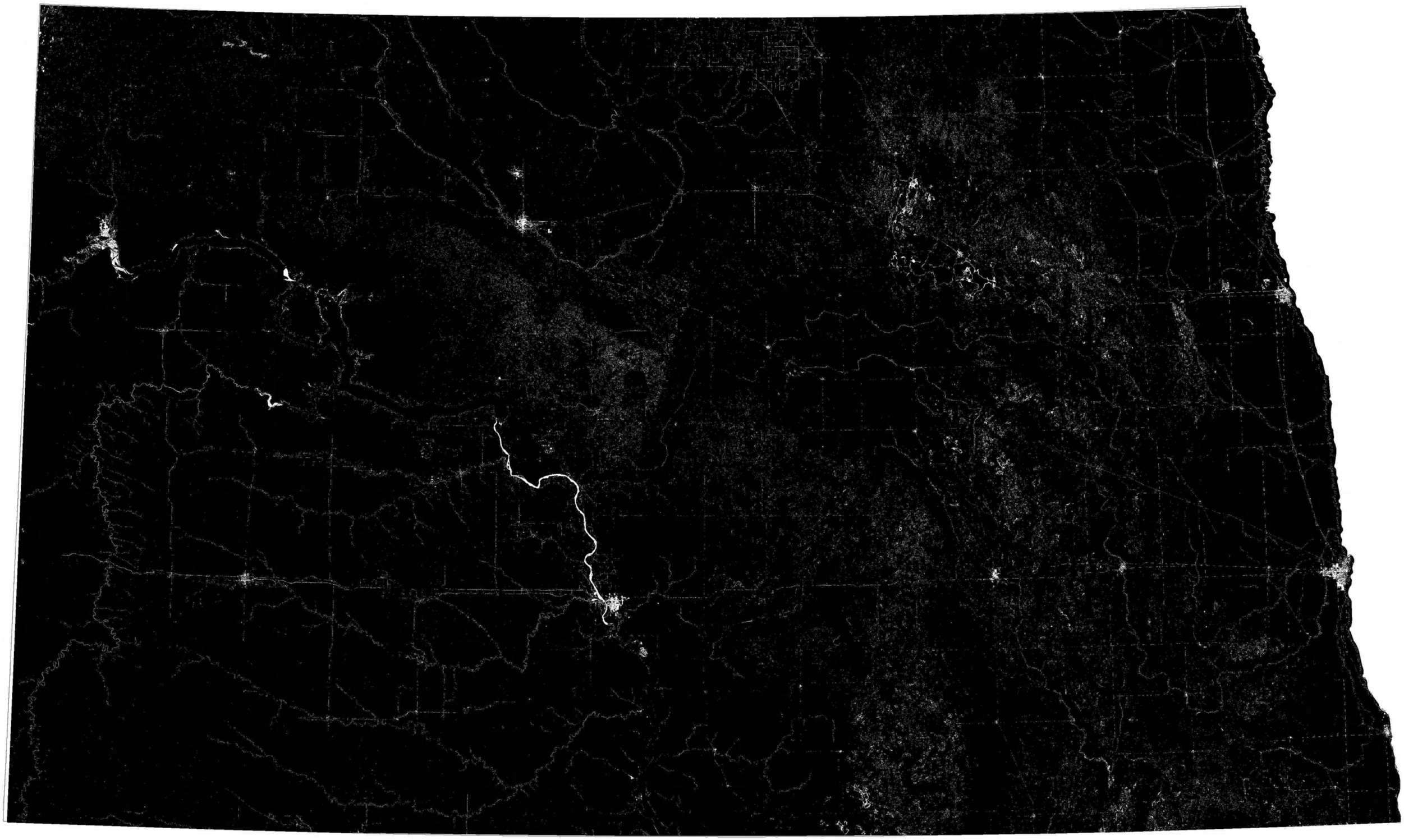


Bighorn Sheep (Ovis canadensis)

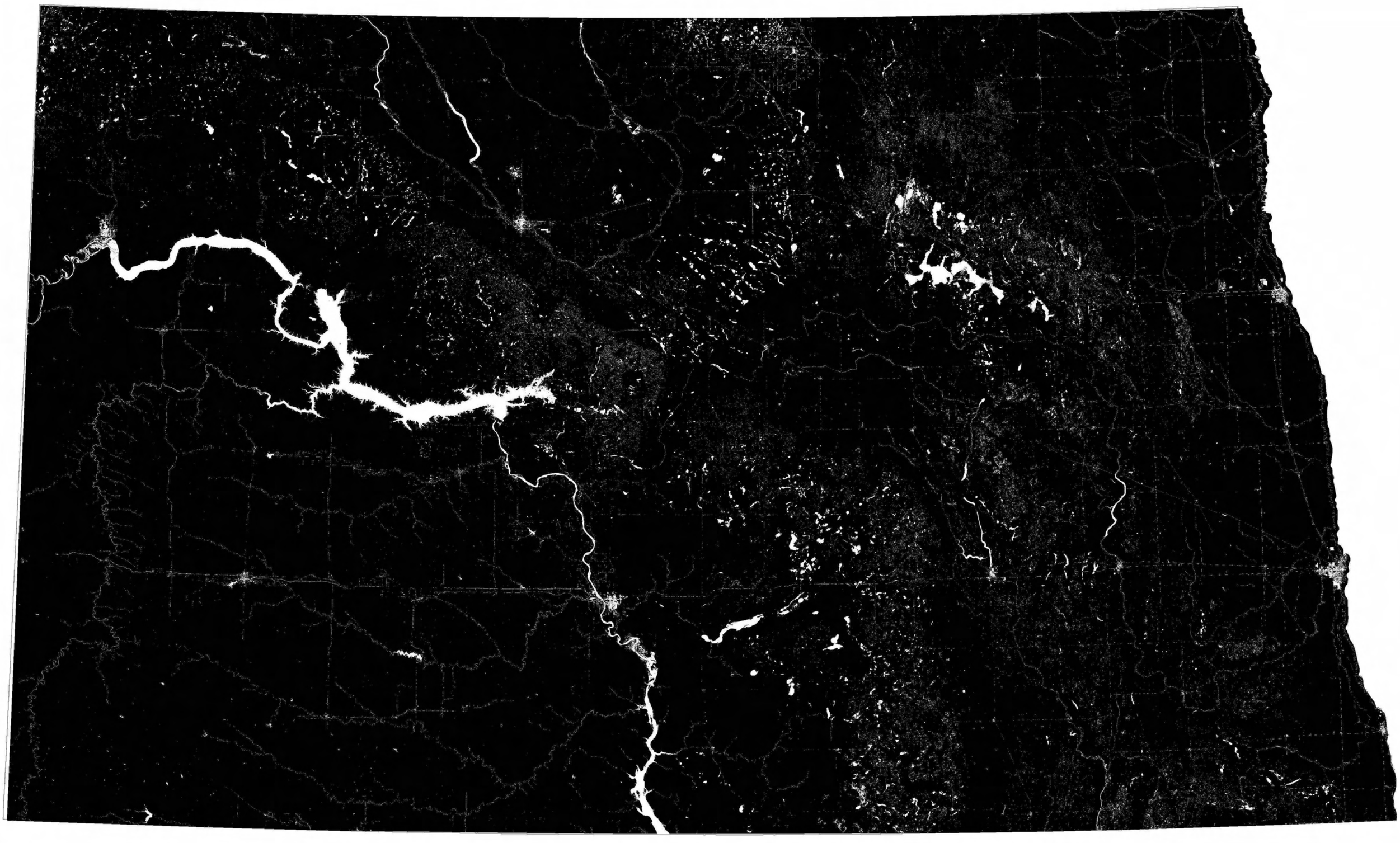
Common Snapping Turtle(Chelydra s. serpentina)



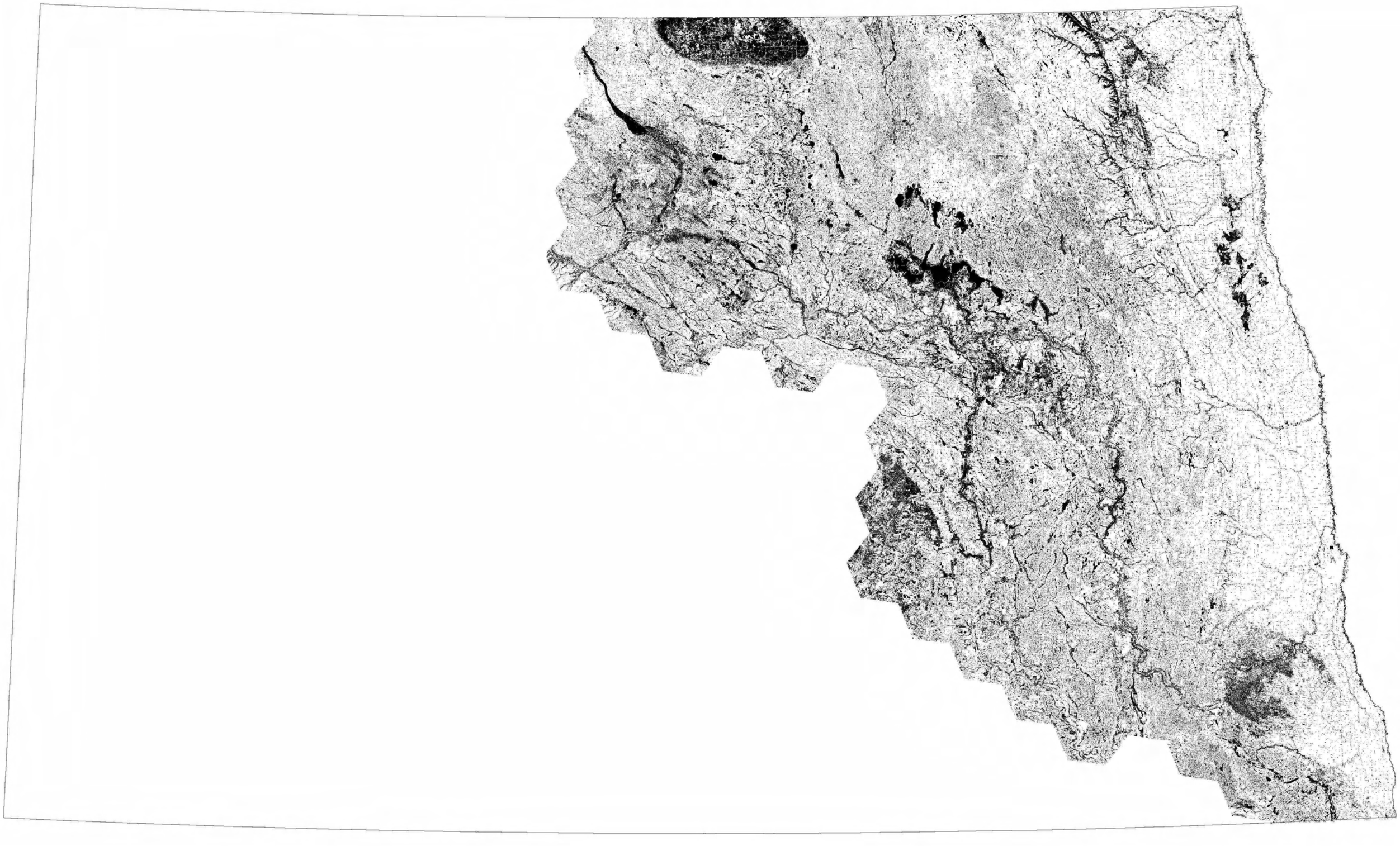
Red Sided Garter Snake(Thamnophis sirtalis parietalis)



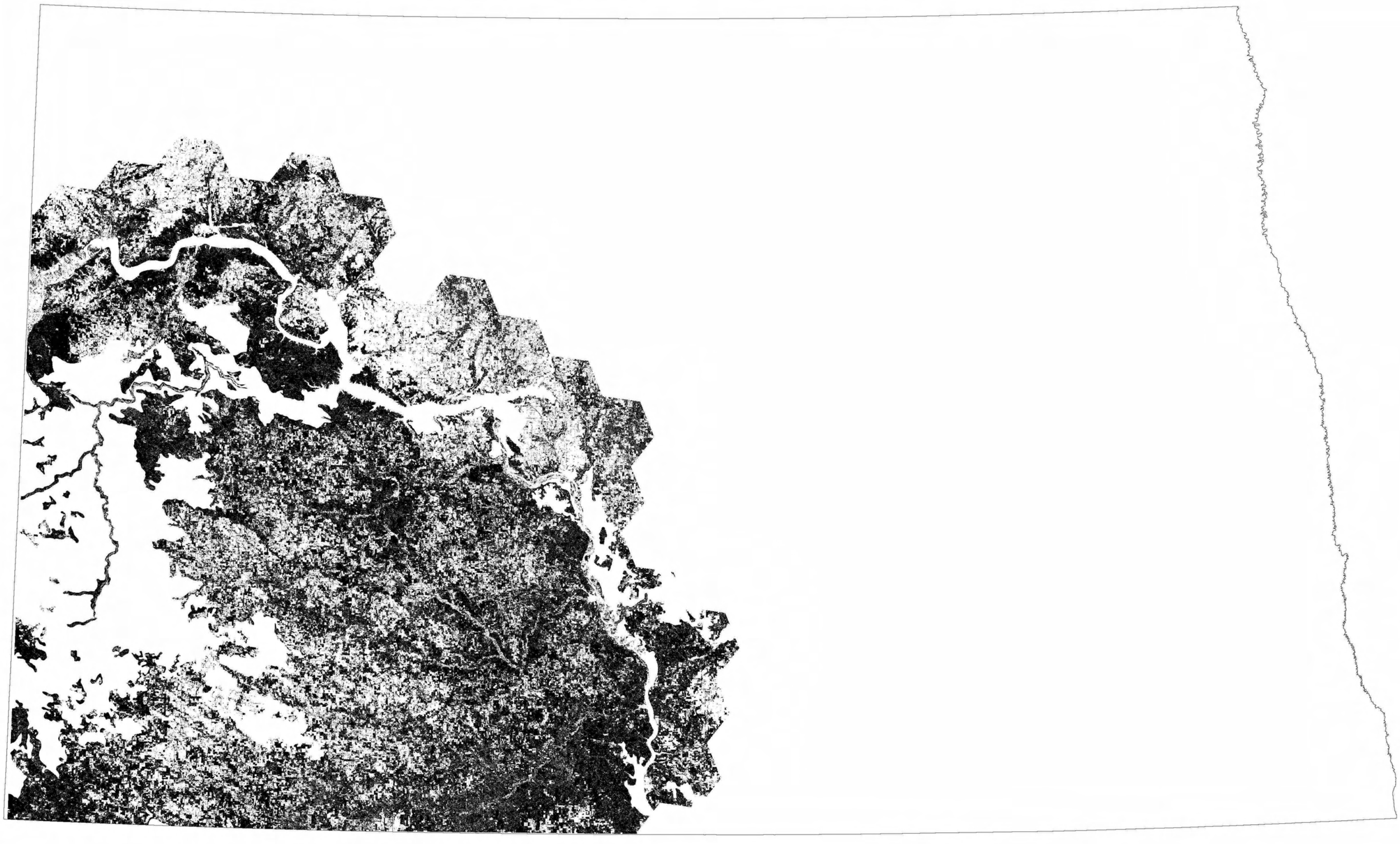
Plains Garter Snake(Thamnophis radix)



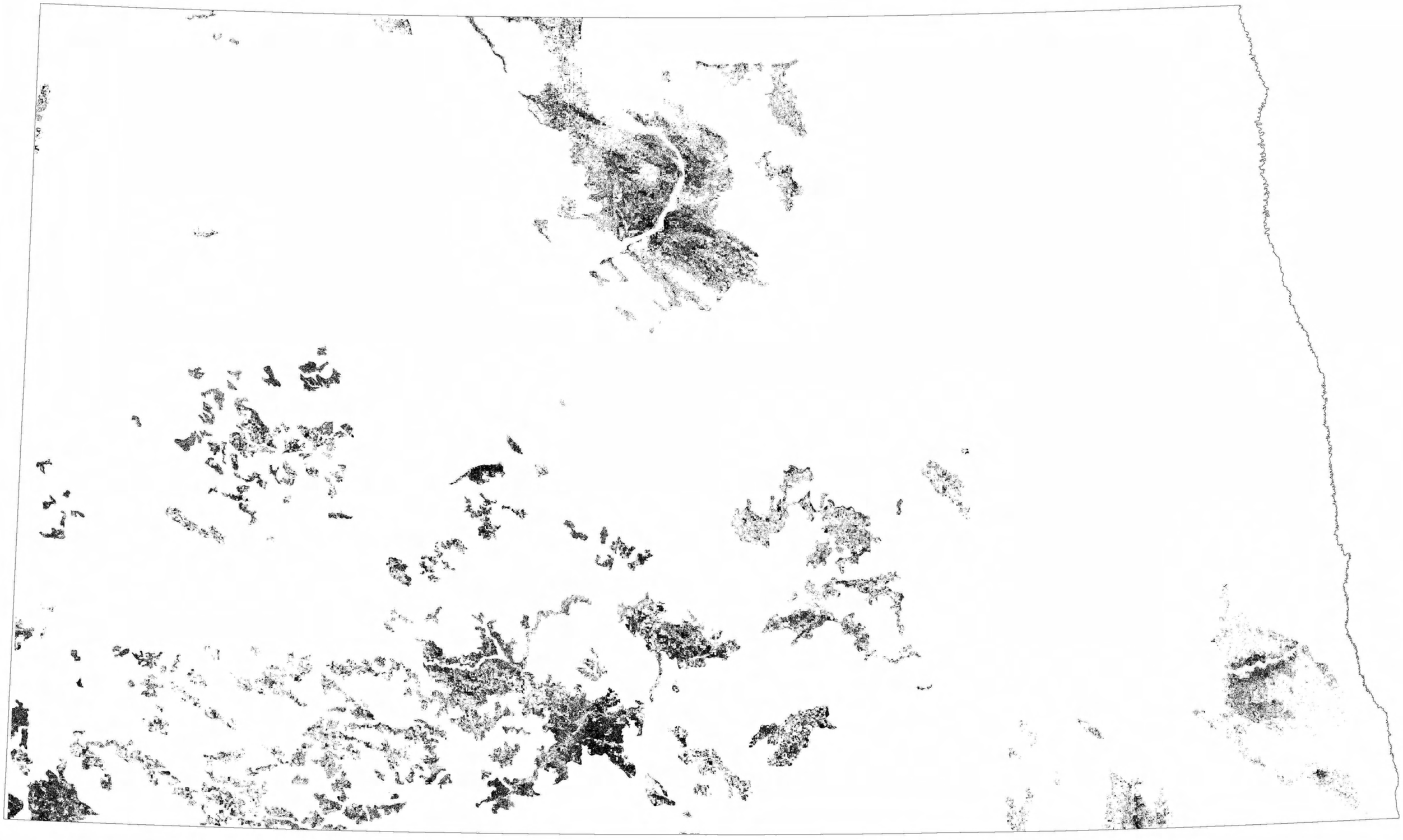
Northern Redbelly Snake(Storeria o. occipitomaculata)



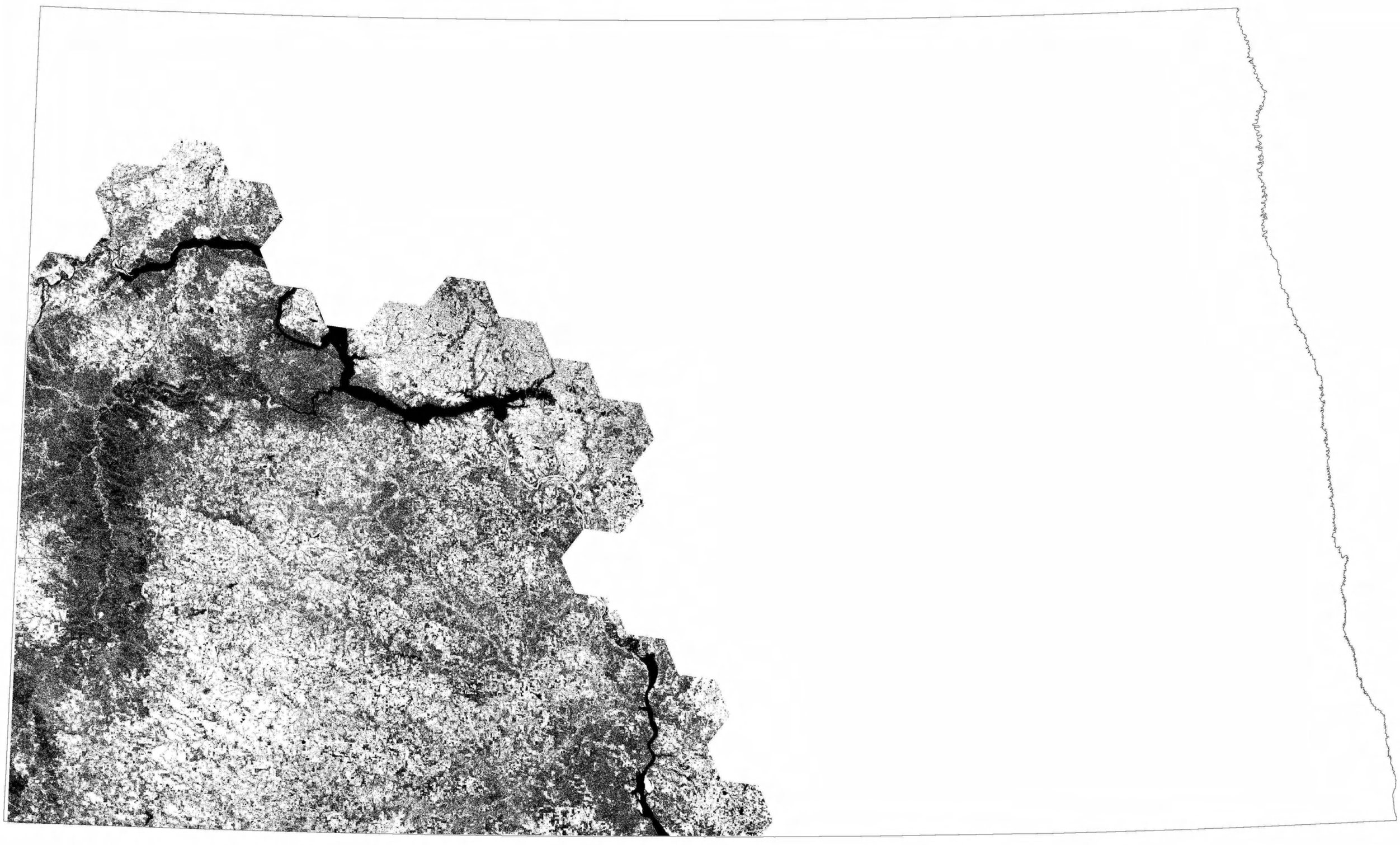
Bullsnake(Pituophis melanoleucus sayi)



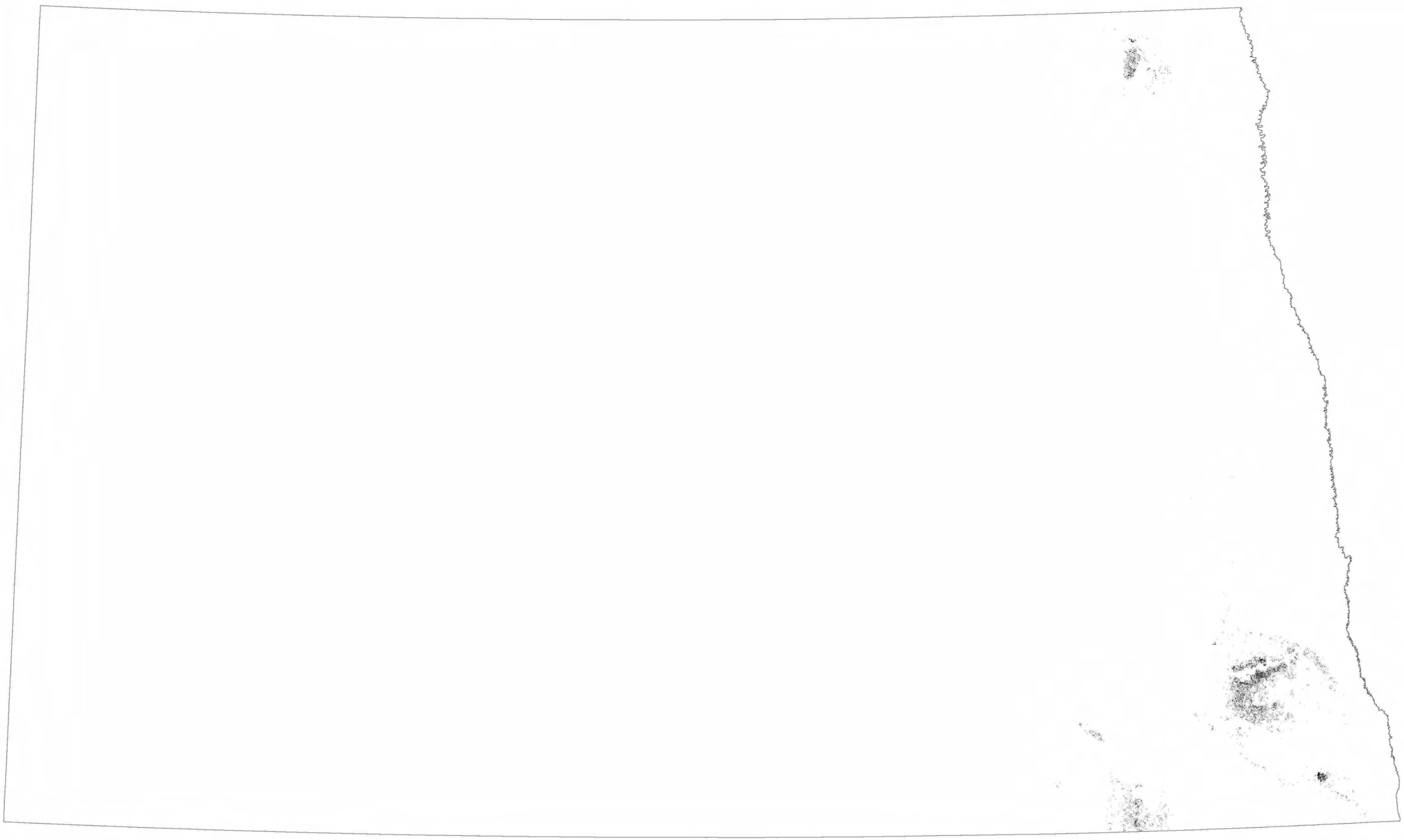
Western Hognose Snake(Heterodon nasicus)



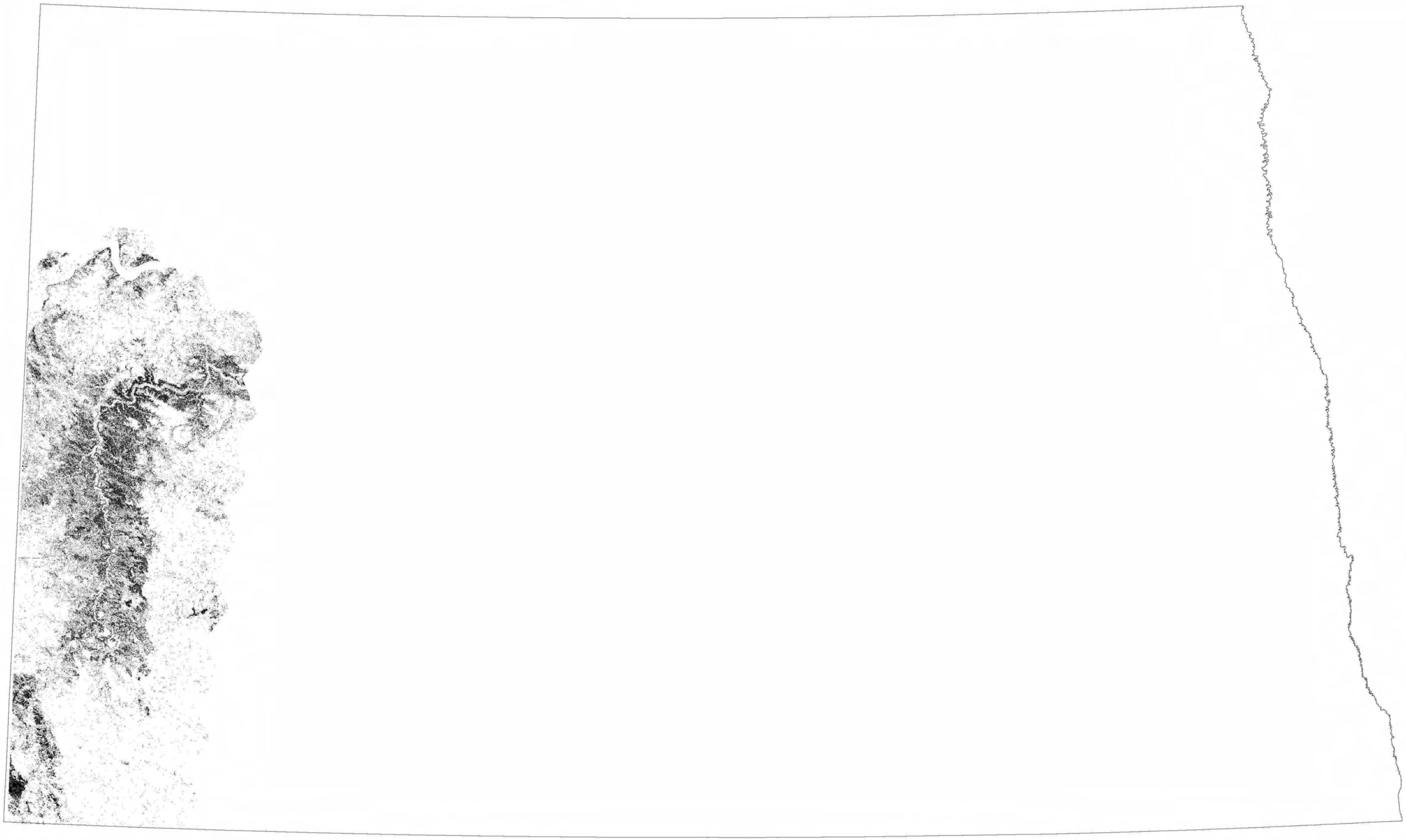
Eastern Yellowbelly Racer(Coluber constrictor flaviventris



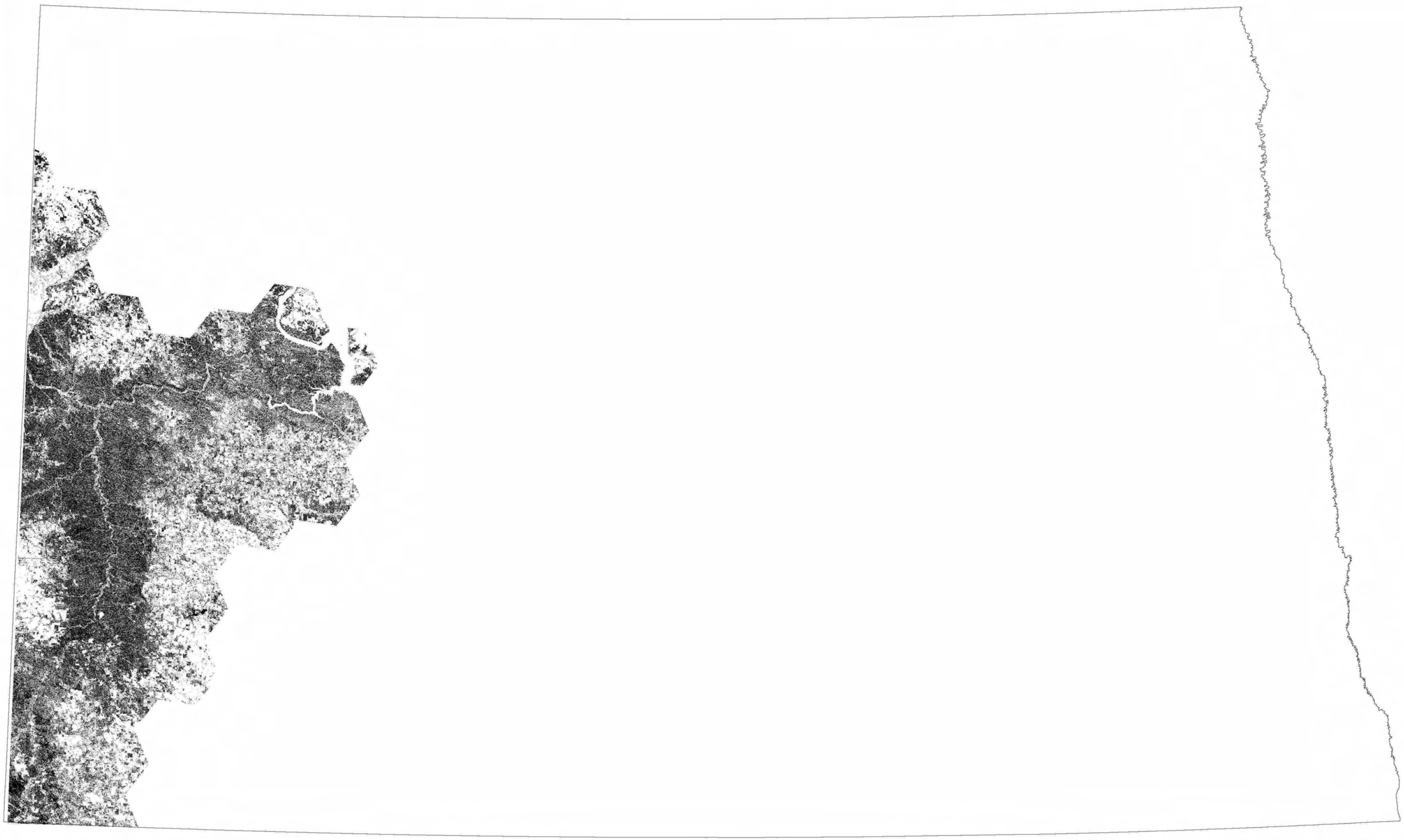
Northern Prairie Skink(Eumeces septentrionalis)



Northern Sagebrush Lizard(Sceloporus g. graciosus)

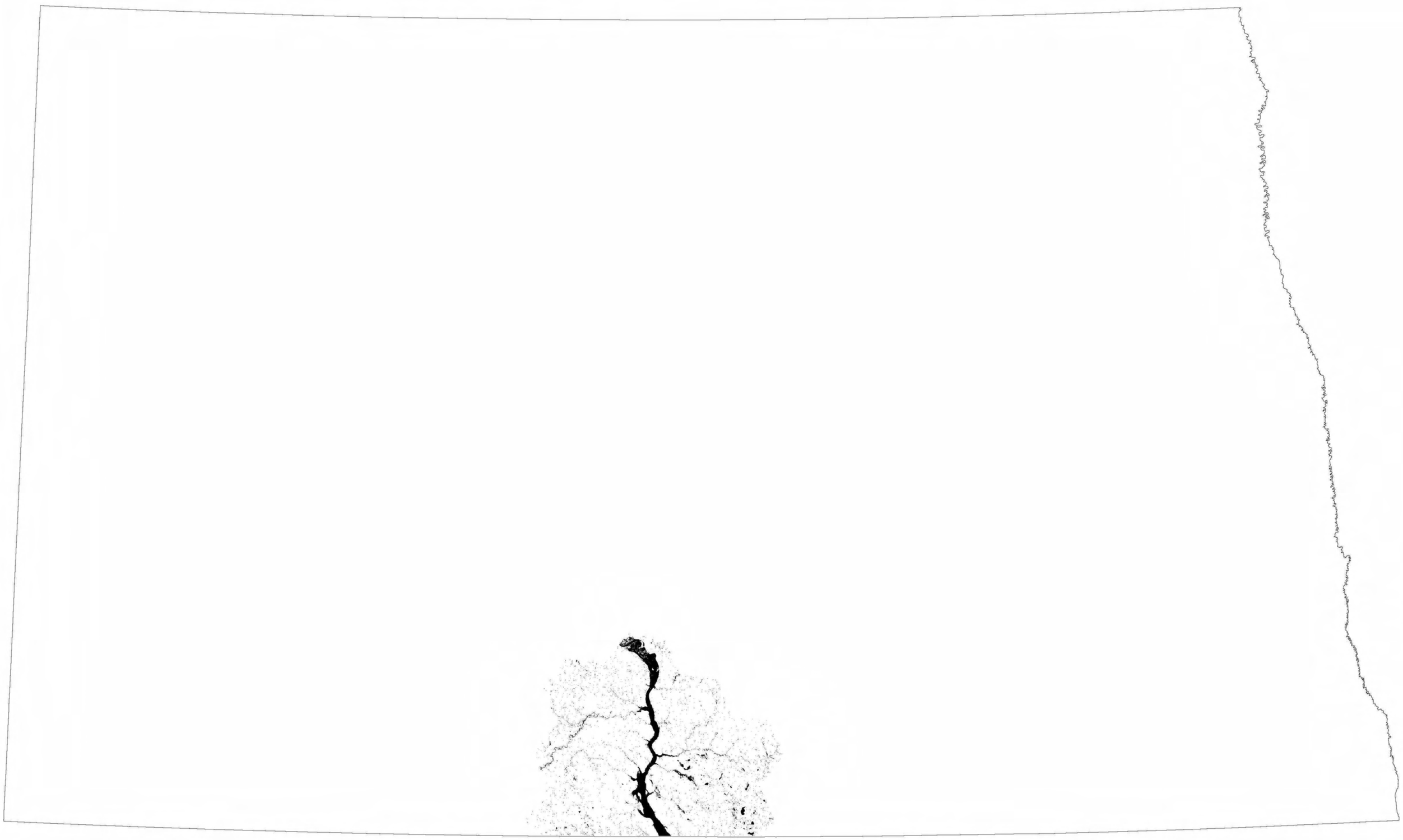


Eastern Short Horned Lizard(Phrynosoma douglassi brev



Midland Smooth Softshell Turtle(Apalone m. mutica)

False Map Turtle(Graptemys p. pseudogeographica)



Western Painted Turtle(Chrysemys picta belli)

Prairie Rattlesnake(Crotalus v. viridis)